MINISTRY OF HEALTH OF UKRAINE

ODESSA NATIONAL MEDICAL UNIVERSITY

Faculty of Pharmacy

Department of Pharmaceutical Chemistry and Drug Technology

APPROVED by

Vice-rector for scientific and pedagogical work

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_____, 202_

METHODOLOGICAL DEVELOPMENT
TO PRACTICAL LESSONS FROM THE EDUCATIONAL DISCIPLINE

Faculty, course Pharmaceutical, II course

Academic discipline Analytical chemistry

(name of academic discipline)

Approved:

Department meeting_____Pharmaceutical chemistry and Drug technology

Odessa National Medical University

Protocol No. _ dated August _____

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Practical lesson No. 1

Topic: Work and safety rules in a chemical analytical laboratory. Acid-base classification of cations. Analytical reactions of cations of analytical group I (K^+, Na^+, NH_4^+), conditions for their performance.

Goal: Familiarize yourself with the rules of work and safety in the chemical analytical laboratory. Familiarize yourself with and summarize information about the acid-base classification of cations. To study and consolidate knowledge about the identification reactions of the specified cations, to summarize information about the I analytical group of cations according to the acid-base classification,

Basic concepts:analysis, qualitative analysis, group reagent, specific reagent, group of cations, acid-base classification, acids, bases

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
     - ✓ principles and methods of qualitative analysis, classification of analysis methods;
     - ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
     - ✓ the concept of fractional and systematic analysis, the difference

between one and the other;

- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;

✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;

✓ choose the optimal method of qualitative and quantitative analysis of a substance;

✓ separate cations and anions by chemical and chromatographic methods;

✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;

✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;

✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on

the subject of the lesson.

1) How should you work with concentrated acids and alkalis?

2) How should you work with easily flammable substances (gasoline, diethyl ether, alcohols, benzene, acetone, etc.)?

3) First aid in the case of skin and eye contact with acids and alkalis.

4) First aid for cuts and burns.

5) Rules for using chemical reagents and dishes.

6) Rules for working with a centrifuge, electrical and heating devices.

7) Classification of cations into analytical groups. Group reagents.

8) And analytical group of cations. Reactions for the determination of sodium, potassium and ammonium cations.

3. Formation of professional abilities and skills (mastery of skills, conducting curation, determining the treatment scheme, conducting laboratory research, etc.):

– content of tasks (tasks, clinical situations, etc.)

1) What cations are included in group I according to the acid-base classification? Why 1 group of cations does not have a group reactant?

2) List the cations of the II analytical group according to the acid-base classification. What is a group reagent for cations of analytical group II (acid-base classification)? What is observed when an excess of group reagent is added?

3) Name the cations of the III analytical group. What is a group reagent for cations of analytical group III (acid-base classification)? How to increase the completeness of precipitation of CaSO4 under the action of a group reagent? Write the equations of the corresponding reactions.

4) What cations are included in the IV analytical group? What is a bulk reagent? Why do we add hydrogen peroxide?

5) Name the cations of analytical group V (acid-base classification), the group reagent, their reaction conditions and the expected analytical effect.

Name the cations of the VI analytical group (acid-base classification), the

group reagent, their reaction conditions and the expected analytical effect.

6) Why do cations of analytical group I have no group reagent?
7) Which of the reactions of the discovery of $NH4^+$- cations more specific? Justify the answer.
8) Conditions for detecting K+ ions by reaction with sodium hydrotartrate. Justify the answer.
9) Conditions for detecting K+ ions by reaction with $Na_3[Co(NO_2)_6]$. Justify the answer.
10) Conditions for detection of Na+ ions by reaction with K[Sb(OH)6]. Justify the answer.

– recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Rules and technique of performing laboratory work. First aid in case of accidents. 2. Qualitative analysis of cations. Acid-base classification of cations. Group reagents. 3. Qualitative analysis. Fractional and systematic analysis. 4. Qualitative reactions of the sodium cation (Na+). 5. Qualitative reactions of the potassium cation (K+). 6. Qualitative reactions of the ammonium cation (NN4+).	Qualitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

– requirements for work results, including before registration: state the basic rules of work in a chemical laboratory; to know the acid-base classification

of cations (group, cations, group reagent, reaction conditions, analytical effect).

- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1.Why do the cations of analytical group I (acid-basic classification) not have a group reagent?

A. most of their salts are soluble in water
B. have close ionic radii
C. have large ionic radii
D. have the ability to form soluble bases
E. are biologically important elements

2. The I analytical group of cations of the acid-base classification includes cations:

A. sodium, potassium, ammonium
B. calcium, strontium, barium
C. silver, lead, nickel
D. aluminum, magnesium, zinc
E. potassium, barium, bismuth

3.The II analytical group of cations of the acid-base classification includes cations:

A. silver, lead, mercury (I)
B. calcium, strontium, barium
C. aluminum, magnesium, zinc
D. zinc, aluminum, chromium
E. potassium, barium, bismuth

4.The III analytical group of cations of the acid-base classification includes cations:

A. calcium, strontium, barium
B. aluminum, magnesium, zinc
C. potassium, barium, bismuth
D. silver, lead, nickel
E. zinc, aluminum, chromium

5. Cations of the third analytical group (acid-basic classification) are separated in a systematic course of analysis using a group reagent:

A. 1 M solution of sulfuric acid in the presence of ethanol

B. Potassium chromate solution

C. Sodium carbonate solution

D. Ammonium oxalate solution

E. Ammonium carbonate solution

6. What general property of compounds of cations Al^{3+}, Zn^{2+}, Cr^{3+}, Sn^{2+} unites them in the IV analytical group (acidic - the main classification)?

A. Amphotericity of hydroxides.

B. Insolubility of salts in water.

C. Good solubility of some salts.

D. Solubility of hydroxides in acids.

E. Solubility of hydroxides in an excess of ammonia solution

7. The mixture being analyzed contains iron(III) and copper(II) cations. The action of which group reagent can separate these cations:

A. Concentrated ammonia solution

B. Sodium hydroxide solution and hydrogen peroxide

C. Hydrochloric acid solution

D. Sodium hydroxide solution

E. Sulfuric acid solution

8. The investigated solution of the drug contains magnesium (II) and aluminum (III) cations. Which reagent can be used to separate the indicated cations during the analysis of this drug?

A. alkali solution

B. of hydrogen peroxide in an acidic environment

C. silver nitrate solution

D. ammonia solution

E. hydrochloric acid solution

9. To separate cations of analytical group VI from cations of analytical group V (acid-basic classification) use:

A. Excess ammonia solution
B. Excess sodium hydroxide solution
C. Excess sulfuric acid solution
D. Acetic acid solution
E. Silver nitrate solution

10. When adding a solution of sodium hydroxide and a solution of hydrogen peroxide to an unknown mixture, a precipitate appeared, which disappeared after adding an excess of these substances. What does this indicate about the presence of cations of which analytical group?

A. IV
B. V
C. VI
D. II
E. III

11. The IV analytical group of cations of the acid-base classification includes cations:

A. aluminum, zinc, chromium(III), tin(II), tin(IV), arsenic(III), arsenic(V)
B. calcium, strontium, barium, potassium, bismuth
C. magnesium, calcium, strontium, barium
D. silver, lead, nickel, potassium, barium, bismuth
E. sodium, potassium, ammonium, silver, lead

12. For what purpose, in the systematic course of the analysis of group IV cations, along with the group reagent, hydrogen peroxide is added:

A. For the formation of hydroxo and oxoanions of these elements in higher degrees of oxidation
B. For the formation of hydroxo and oxoanions of these elements in low oxidation states
C. For more complete precipitation of these cations

D. For the formation of peroxide compounds of these cations

E. For the destruction of hydrate complexes

13. What cation is in solution if a gas with a pungent odor is released when heated with alkali?

A. Ammonia

B. Silver(I)

C. Mercury(II)

D. Mercury(I)

E. Lead(II)

14. The analyzed solution contains sodium and ammonium cations. Specify the reagent that allows you to detect sodium cations in the solution:

A. Zincuranyl acetate

B. Potassium oxalate

C. Potassium tetraiodomercurate (II)

D. Potassium hydrotartrate

E. Potassium benzoate

15. The studied solution contains potassium and ammonium cations. Specify the reagent that allows you to detect ammonium cations in this solution.

A. Potassium tetraiodomercurate (II)

B. Sodium chloride

C. Sodium acetate

D. Potassium hexacyanoferrate (II)

E. Zincuranyl acetate

16. In the laboratory, it is necessary to identify the ammonium cation. You can use a solution:

A. Potassium chromate

B. Nessler's reagent

C. Zinc uranyl acetate

D. Reactive Chugaev

E. Sodium sulfate

17. Which of the following reactions for the determination of ammonium cations is specific?

A. Reaction with potassium hexahydroxoctibate
B. Reaction with sodium hexanitrocobalt (III)
C. Reaction with alkali metal hydroxides upon heating
D. Reaction with potassium tetraiodohydrargyrate (II) in an alkaline medium
E. Reaction with sodium hexanitrocobalt (III) in an acidic environment

18. When the analyzed alkali solution is heated, a gas is released, which changes the color of the red wet litmus paper to blue. This indicates the presence in the solution:

A. lead ions
B. bismuth ions
C. chloride - ions
D. ammonium ions
E. carbonate - ions

19. The dry residue obtained after evaporation of the solution to be analyzed turns the colorless flame of the burner yellow, and when viewed through blue glass - purple. What cations were in the dry residue?

A. Ca^{2+}, K^{+}
B. Na^{+}, Sr^{2+}
C. Li^{+}, Ba^{2+}
D. Na^{+}, Ca^{2+}
E. Na^{+}, K^{+}

20. What analytical effect is observed when determining the potassium cation with a solution of sodium hexanitrocobaltate (III)?

A. Yellow crystalline precipitate
B. White crystalline precipitate
C. Yellow color of the solution
D. Black crystalline precipitate
E. Red crystalline precipitate

21. The I analytical group of cations of the acid-base classification includes cations:

A. calcium, strontium, barium

B. silver, lead, nickel

C. aluminum, magnesium, zinc

D. potassium, barium, bismuth

E. sodium, potassium, ammonium

22. Why do the cations of analytical group I (acidic-basic classification) not have a group reagent?

A. They have close ionic radii

B. have large ionic radii

C. have the ability to form soluble bases

D. most of their salts are soluble in water

E. are biologically important elements

23. In pharmacopoeial analysis, the reaction with:

A. diphenylamine

B. 8- oxyquinoline

C. 2-methoxy-2-phenylacetic acid

D. diacetyldioxime

E. tetraphenylborate

24. Volatile sodium salts color the flame in:

A. yellow-green color

B. brick-red color

C. yellow

D. violet

25. The color of the precipitate formed as a result of the reaction

$$2KCl + Na_2Pb[Cu(NO_2)_6] \rightarrow K_2Pb[Cu(NO_2)_6]\downarrow + 2NaCl:$$

A. white

B. light yellow

C. black

D. yellow-green

26. When opening potassium cations using sodium hexanitrocobaltate (III) in solution, the following conditions must be met:

A. the environment is neutral, weakly acidic, without ammonium ions

B. the environment is acidic, lack of ammonium ions

C. the environment is alkaline, the absence of ammonium ions

D. the environment is weakly acidic, the presence of ammonium

27. A red-brown precipitate with Nessler's reagent forms a cation.

A. NH_4^+;

B. K_+;

C. Na^+;

D. Li^+;

E. there is no correct answer

28. Nesler's reagent is

A. $K_2[HgI_4] + KOH$;

B. $Na_2Pb[Cu(NO_2)_6]$;

C. $K[Sb(OH)_6]$;

D. $K_2[FeIO_6]$;

E. $Na_3[Co(NO_2)_6]$

4. Summing up:

As a result of the lesson, the student got acquainted with the rules and safety techniques when working in a chemical laboratory; summarized information about the classification of cations (acid-base classification) and the 1st group of cations.

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.
3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.
4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 2

Topic: ***Laboratory work:*** Qualitative reactions of cations of the I analytical group.

Goal: Summarize information about the I analytical group of cations according to the acid-base classification, study and consolidate knowledge about the identification reactions of the specified cations.

Basic concepts:cation, group reagent (group reaction), specific reagent (specific reaction), analytical effect, flame reaction.

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:

- ✓ basic rules for working with acids and alkalis;
- ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
- ✓ principles and methods of qualitative analysis, classification of analysis methods;
- ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
- ✓ the concept of fractional and systematic analysis, the difference between one and the other;
- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;

- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. Why do cations of analytical group I have no group reagent?
2. Why NH_4^+- cations must be removed when analyzing a mixture of group I cations? How does this happen?
3. Why the definition of NH_4^+- cations are not hindered by K^+ and Na^+ ions?
4. Give a scheme of systematic analysis of cations of analytical group I(acid-base classification).

3. Formation of professional abilities and skills (mastery of skills, conducting curation, determining the treatment scheme, conducting laboratory research, etc.):

– content of tasks (tasks, clinical situations, etc.)

1.Na+ and NH_4^+ ions are present in the solution. What analytical effect will be observed when potassium hexahydroxostibate is added to this solution? Write the equations of the corresponding reactions.

2. K+ ions are present in the solution (pH>7). What analytical effect will be observed when sodium hexanitrocobaltate is added to this solution? Write the equations of the corresponding reactions.

3. K+ and NH_4+ ions are present in the solution (pH=7). What analytical effect will be observed when sodium hexanitrocobaltate is added to this solution? Write the equations of the corresponding reactions.

4. The studied solution contains potassium and sodium cations. Specify the reagent that allows you to detect potassium cations in this solution: tartaric acid, zincuranyl

acetate, benzoic acid, oxalic acid, salicylic acid. Write the equation of the corresponding reaction and indicate the analytical effect.

- recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Qualitative analysis. Fractional and systematic analysis. 2. Qualitative reactions of the sodium cation (Na+). 3. Qualitative reactions of the potassium cation (K+). 4. Qualitative reactions of the ammonium cation (HH4+). 5. Systematic course of analysis of cations of analytical group I.	Qualitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including for registration: the laboratory work registration form is attached.
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

4. Summing up:

1. How does the I group of cations differ from other groups of the coslot-basic classification?

2. Why is it necessary to remove NH_4+ cations from the solution before detecting Na+ cations, if they are also present in this solution? Confirm your answer with reaction equations in molecular and ionic forms.

3. Why is the precipitation of the Na+ cation by potassium pyroantimonate carried out in the cold and in a neutral environment, and not in acidic and alkaline ones?

4. With what reagent and under what conditions can the K+ cation be opened? Write the reaction equation for the interaction of potassium phosphate with this reagent in molecular and ionic forms.

5. What reactions are used to detect the NH_4+ ion? Which ones are specific? Write the appropriate reaction equations in molecular and ionic forms.

6. How can NH_4^+ cation be removed from the analyzed solution? Write the appropriate reaction equation.

7. How to check the complete removal of the NH_4+ ion?

8. Specify the order of detection of group I cations in the mixture.

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p p.

Practical lesson No. 3

Topic: II analytical group of cations (Ag^+, Hg_2^{2+}, Pb^{2+}). Group reagent, quality reactions, conditions for their performance. ***Laboratory work:*** Qualitative reactions of cations of the II analytical group.

Goal: Familiarize yourself with the main reactions used to identify cations of the II analytical group (acid-base classification); summarize information about fractional and systematic analysis of cations of the II analytical group.

Basic concepts:cation, group reagent (group reaction), specific reagent (specific reaction), analytical effect, flame reaction

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
     - ✓ principles and methods of qualitative analysis, classification of analysis methods;
     - ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
     - ✓ the concept of fractional and systematic analysis, the difference between one and the other;
     - ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
     - ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group

reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. List the cationsII analytical group. What is the group reactant of this group.
2. How can cations be separatedII of the analytical group after the action of the group reagent?
3. Which reaction is specific for silver cations?
4. Qualitative reactions of lead (plumbum) cations. What reactions can be used to prove the amphoteric nature of lead (plumbum)?

5. Qualitative reactions of silver (argentum) cations. What reagent dissolves most of the silver precipitates? Which silver precipitate is not soluble in this reagent?
6. Qualitative reactions of mercury cations.

3. Formation of professional abilities and skills (mastery of skills, conducting curation, determining the treatment scheme, conducting laboratory research, etc.):

– content of tasks (tasks, clinical situations, etc.)

1. The solution contains Ag^+ and Hg_2^{2+}- ions. Suggest how to separate these; ions, performing a systematic course of analysis. Write the equation and the corresponding reactions

2. The studied solution was subjected to 2 n. solution of HC1. A white precipitate is formed, which is soluble in an aqueous solution of ammonia. What cation of analytical group 2 (acid-base classification) does this analytical effect indicate? Write the equations of the corresponding reactions

3. The solution contains Ag+ and Hg_2^{2+} cations. The solution was treated with 2 n. solution of HC1. A precipitate fell out, which was transferred to a filter and treated with an excess of ammonia solution. What is observed? Write the equations of the corresponding reactions

4. The investigated solution was treated with a potassium chromate solution. A yellow precipitate was precipitated, poorly soluble in nitric acid, but easily soluble in an excess of alkali. What cation of analytical group 2 (acid-base classification) does this analytical effect indicate? Write the equations of the corresponding reactions.

5. The studied solution was treated with 2 n. solution of HC1. A white precipitate, soluble in sodium thiosulfate solution, fell out. What cation of analytical group 2 (acid-base classification) does this analytical effect indicate? Write the equations of the corresponding reactions.

– recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Qualitative analysis of cations. Cations of II analytical group. Action of group reagent. 2. Qualitative analysis of cations. Cations of II analytical group	Qualitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including for registration: the laboratory work registration form is attached.
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1. To determine the qualitative composition of the drug, the investigated solution was treated with a 2M HCl solution. A white precipitate, soluble in an aqueous solution of ammonia, fell out. What cations does this analytical effect indicate?

A. silver (I)
B. lead(II)
C. hydrargyrum(I)
D. hydrargyrum(II)
E. tin(II)

2. A 2M solution of HCl was added to the solution under study. At the same time, a white precipitate was formed, which turned black when treated with ammonia. What cation is present in the solution:

A. Ag^{+}
B. Pb^{2+}
C. Hg_2^{2+}
D. Ba^{2+}
E. Mg^{2+}

3. The II analytical group of cations of the acid-base classification includes cations:

A. aluminum, magnesium, zinc

B. zinc, aluminum, chromium

C. potassium, barium, bismuth

D. silver, lead, mercury (I)

E. calcium, strontium, barium

4. A solution of potassium dichromate was applied to the solution obtained after treatment of the precipitate of group II chloride cations with hot water. A yellow precipitate was formed, NOT soluble in acetic acid, but soluble in alkali. What cations did the studied solution contain?

A. mercury (II)

B. lead (II)

C. barium

D. silver (I)

E. calcium

5. Potassium iodide solution was added to the test solution. A golden-yellow precipitate, which dissolves in hot water, an excess of the reagent and acetic acid, fell out. this indicates the presence in the solution:

1. silver cations
2. bismuth cations
3. cations of mercury (II)
4. mercury (I) cations
5. lead cations

6. A 2M solution of HCl was added to the solution under study. At the same time, a white precipitate was formed, which turned black when treated with ammonia. What cation is present in the solution:

A. Ag^{+}

B. Pb^{2+}

C. Hg_2^{2+}

D. Ba^{2+}

E. Mg^{2+}

7. To determine the qualitative composition of the drug, the investigated solution was treated with a 2M HCl solution. A white precipitate, soluble in an aqueous solution of ammonia, fell out. What cations does this analytical effect indicate?

A. silver (I)

B. lead(II)

C. hydrargyrum(I)

D. hydrargyrum(II)

E. I will become(II)

8. In the laboratory, a reaction with lead cations was carried out to identify iodide ions in the solution. The formed precipitate was dissolved by heating in water, then the test tube was cooled. What analytical effect was observed in this case?

A. The formation of golden scales

B. Formation of brown sediment

C. The formation of a blue precipitate

D. The formation of a white precipitate

E. Release of gas bubbles

9. Analytical reaction signal

$$2AgNO_3+K_2CrO_4 \rightarrow 2KNO_3 + Ag_2CrO_4\downarrow$$

there is sediment:

A. brick-red color

B. dirty green color

C. yellow color

D. orange color

10. The group reagent for cations of the second analytical group is:

A. dilute sulfuric acid

B. dilute hydrochloric acid

C. concentrated sulfuric acid

D. dilute nitric acid

11. When the group reactant acts on the cations of the II analytical group, a precipitate of the color is formed:

A. yellow

B. gray-green

C. white

D. brown

12. Soluble sediment in hot water:

A. PbI_2

B. Hg_2Cl_2

C. AgCl

D. AgI

13. A mixture of AgCl and AgI can be separated using an aqueous solution:

A. NH_3;

B. H_2SO_4;

C. KOH;

D. HNO_3.

4. Summing up:

As a result of the lesson, the student got acquainted with the main reactions used to identify cations of analytical group I (acid-base classification); summarized the information on fractional and systematic analysis of cations of analytical group I.

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A.

E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 4

Topic: Solving tasks on the topic "Theory of strong electrolytes".

Goal: Familiarize yourself with and generalize knowledge about strong electrolytes, their effect on the pH value of the solution

Basic concepts:electrolyte, non-electrolyte, degree of dissociation, dissociation constant, hydrogen index, activity, ionic strength

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;

- ✓ principles and methods of qualitative analysis, classification of analysis methods;
- ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
- ✓ the concept of fractional and systematic analysis, the difference between one and the other;
- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on

analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. Theory of strong electrolytes. Activity and activity coefficient. Ionic strength of the solution. Calculate the ionic strength and activity of the chloride ion in a 0.1 M sodium chloride solution.
2. The ionic strength of the solution and its influence on the values of the activity coefficient. How will the ionic strength of the aluminum sulfate solution change when changing from a 0.02 M solution to 0.1 M; if there is 0.006 mol/dm3Na2SO4 in the solutions?
3. Dielectric permeability and influence on the value of other strength of the solution. Calculate the activity of K+ and Cl- ions in 100 cm3 of a solution containing 0.02 M potassium chloride and 0.001 M acetic acid.

4. Formation of professional abilities and skills (mastery of skills, conducting curation, determining the treatment scheme, conducting laboratory research, etc.):

– content of tasks (tasks, clinical situations, etc.)

1. Calculate the activity of magnesium and aluminum ions in a solution containing 0.1 mol of magnesium sulfate and 0.05 mol of aluminum nitrate in 1 dm3.
2. Why are the activities of Ba2+ and Cl- ions equal in 0,1 n. barium chloride solution?
3. Calculate the activity of S2- ions in a saturated solution of hydrogen sulphide $\left(C_{H_2S} = 0{,}1\ моль/л,\ K_{1H_2S} = 1\cdot10^{-7},\ K_{2H_2S} = 2{,}5\cdot10^{-13}\right)$at pH=2.
4. Calculate the activity of SO32- ions in a saturated solution of sulfuric acid $\left(C_{H_2SO_3} = 0{,}01\ моль/л,\ K_{1H_2SO_3} = 1{,}4\cdot10^{-2},\ K_{2H_2SO_3} = 6{,}2\cdot10^{-8}\right)$at pH = 3.

5. Calculate the pH and pH of a 0.001 M solution of hydrochloric acid, taking into account the ionic strength of the solution.
6. Calculate the pH of a 10% solution of HC1, as well as the concentration of hydrogen ions
7. Calculate the concentration of OH ions, pH and pH for 0.01 n. sodium hydroxide solution.
8. How will the pH of the solution change if 1 dm3 of a 0.1 M hydrochloric acid solution is diluted with water to 5 dm3?
9. How will the pH change in a 10-5 M solution of sodium hydroxide if potassium hydroxide with a mass of 0.056 g is added to 1 dm3 of it?
10. Calculate the pH and hydrogen ion concentration of 0.05 n. sulfuric acid solution.

– recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Protolytic equilibria in acid and alkali solutions.	Qualitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

– requirements for work results, including before registration: issue the solution to the problems in the workbook.
– control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1. Calculate the concentration of hydrogen ions and the pH of the solution obtained by diluting 10 cm3 of a 49% HHO3 solution with water to 500 cm3.
2. Calculate the pH and pH of a 0.05 M solution of hydrochloric acid, taking into account the ionic strength of the solution.
3. Calculate the pH of a 15% solution of HC1, as well as the concentration of

hydrogen ions

4. Calculate the concentration of OH ions, pH and pH for 0.03 n. potassium hydroxide solution.

5.How will the pH of the solution change if 1 dm3 of 0.1 M hydrochloric acid solution is diluted with water to 3 dm3?

6. How will the pH change in a 2·10-4M solution of sodium hydroxide if sodium hydroxide with a substance mass of 0.02 g is added to 0.5 dm3 of it?

5. Summing up:

As a result of the lesson, the student got acquainted with the basic concepts of the theory of strong electrolytes; consolidated the ability to solve problems on the topic "Theory of strong electrolytes".

6. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p

Practical lesson No. 5

Topic: III analytical group of cations (Ca^{2+}, Ba^{2+}, Sr^{2+}). Group reagent, quality reactions, conditions for their performance. ***Laboratory work:*** Qualitative reactions of cations of the III analytical group.

Goal: Familiarize yourself with the main reactions used to identify cations of the III analytical group (acid-base classification); to summarize information about the fractional and systematic analysis of cations of the III analytical group

Basic concepts:analysis, qualitative analysis, group reagent, specific reagent, group of cations, acid-base classification, acids, bases

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
     - ✓ principles and methods of qualitative analysis, classification of analysis methods;
     - ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
     - ✓ the concept of fractional and systematic analysis, the difference between one and the other;
     - ✓ characteristic of the sensitivity of analytical reactions (limit dilution,

limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);

- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. List the cationsIII analytical group. What is the group reactant of this group?

2. What cationIII of the analytical group with a group reagent will precipitate last? Why?
3. Why when the group reagent acts on cationsIII analytical group to add ethyl alcohol?
4. What is transplanting? What is it used for?
5. What reaction is used to separate calcium cations from other cationsIII analytical group?
6. What general precipitation reactions give cationsIII analytical group.
7. How to distinguish precipitates of carbonate cationsIII analytical group from precipitates of oxalates of these cations.
8. What reaction can be used to separate strontium cations from barium cations?
7. In what colors is the flame colored by cationsIII analytical group?

3. Formation of professional skills and abilities:
   – content of tasks (tasks, clinical situations, etc.)

1. Suggest the course of analysis by the acid-base method of a solution containing cations: Ba^{2+} and Sr^{2+}. Write the equations of the corresponding reactions.
2. Suggest the course of analysis by the acid-base method of a solution containing cations: Ba^{2+} and Ca^{2+}. Write the equations of the corresponding reactions.
3. Suggest the course of analysis by the acid-base method of a solution containing cations: Sr^{2+}, Ba^{2+} and Ca^{2+}. Write the equations of the corresponding reactions.
4. In what sequence will salts of cations of analytical group 3 (acid-base classification) precipitate under the action of a group reagent? Justify the answer. Write the equations of the corresponding reactions.
5. The investigated solution was treated with sodium hydrogen phosphate solution. A precipitate (indicate the color) is formed, which is well soluble in nitric and hydrochloric acids, but insoluble in acetic acid. This analytical effect indicates the presence of which cation of analytical group 3 (acid-base classification)? Write the equations of the corresponding reactions.

6. A solution of potassium ferrocyanide was added to the solution containing Ca^{2+} and Sr^{2+} cations. What is observed? Write the equations of the corresponding reactions. Can this reaction detect Ca^{2+} cations in the presence of Sr^{2+} cations? What color is the flame of strontium salt?
7. A solution containing Ca^{2+} and Sr^{2+} was treated with a solution of potassium chromate. What analytical effect is observed? Describe the properties of the reaction products. Write the equations of the corresponding reactions. What color are the flames of calcium salts?

– recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Qualitative analysis of cations. Cations of the III analytical group. Action of group reagent. 2. Qualitative analysis of cations. Cations of the III analytical group.	Qualitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

– requirements for work results, including for registration: the laboratory work registration form is attached.
– control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1. Potassium chromate solution was added to the solution under investigation. The yellow precipitate formed does not dissolve in acetic acid. This indicates the presence of cations in the solution:

A. barium
B. Calcium
C. sodium
D. Cobalt
E. Magnesium

2. Cations of the third analytical group (acid-basic classification) are separated in a systematic course of analysis using a group reagent:

A. 1 M solution of sulfuric acid in the presence of ethanol

B. Potassium chromate solution

C. Sodium carbonate solution

D. Ammonium oxalate solution

E. Ammonium carbonate solution

3. In the systematic course of the analysis, the following are used to convert sulfates $BaSO_4$, $SrSO_4$, $CaSO_4$ into carbonates:

A. saturated Na_2CO_3 solution, t

B. saturated solution of $CaCO_3$, t

C. saturated solution $(NH_4)_2CO_3$, t

D. saturated $MgCO_3$ solution, t

E. saturated CO_2 solution, t

4. What cation of the III analytical group (acidic-basic classification) is in the solution, if the solution becomes cloudy after some time when heated with gypsum water?

A. strontium

B. calcium

C. magnesium

D. lead (II)

E. mercury (II)

5. Calcium cations are part of some pharmaceutical preparations. The pharmacopoeial reaction to detect the calcium cation is a reaction with a solution:

A. Ammonium oxalate

B. Hydrochloric acids

C. Potassium iodide

D. Ammonium hydroxide

E. Sodium hydroxide

6. What analytical effect should be expected from the action of potassium hexacyanoferrate (II) on Ca^{2+} cations:

A. The formation of a white fine crystalline precipitate

B. The formation of yellow - green crystals

C. Brown color of the solution

D. The formation of a blue complex compound

E. The formation of a white gelatinous sediment

7. State the reason for reprecipitation of sulfate cations of the III analytical group (acid-base classification) into carbonates during a systematic analysis:

A. Insolubility of sulfates in acids and alkalis

B. Insolubility of sulfates in water

C. Solubility of sulfates in water

D. Solubility of sulfates in acids

E. Solubility of sulfates in alkalis

4. Summing up:

As a result of the lesson, the student got acquainted with the main reactions used to identify cations of the III analytical group (acid-base classification); summarized information on the fractional and systematic analysis of cations of the III analytical group.

5. List of recommended literature:

Main:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of

medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.
4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p

Practical lesson No. 6

Topic: Solving tasks on the topic "Heterogeneous equilibria".

Goal: Familiarize yourself with the concept of heterogeneous equilibrium and solubility product

Basic concepts: solubility product, ion product

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
     - ✓ principles and methods of qualitative analysis, classification of analysis methods;
     - ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
     - ✓ the concept of fractional and systematic analysis, the difference

between one and the other;

- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. Precipitation reactions, their importance in the analysis of cations. Fractional deposition. Solubility product. The completeness of sediment formation.
2. Solubility of sparingly soluble compounds. Effect of pH change on solubility. Regulation of sediment solubility.
3. Factors affecting the solubility of sparingly soluble compounds. Salt effect.
4. Calculations of the solubility of compounds based on the values of the solubility product.

3. Formation of professional skills and abilities:
   - content of tasks (tasks, clinical situations, etc.)

1. The solubility product of Ca3(P04)2 is equal to 2.0·10-29. Calculate disthe activity of this salt in g/dm3 and the concentration of each of the ions in the saturated solution.
2. At what concentration of calcium ions does calcium hydroxide precipitate from a solution with a pH of 13.0?
3. Will a precipitate form when equal volumes of 0.15 M silver nitrate solution and 0.2 M sodium chloride solution are mixed?
4. Calculate the solubility of strontium sulfate (mol/dm3) in water and in a 0.02 M solution of sodium sulfate.
5. Calculate the required concentration of hydroxide ions and pH of the solution for the precipitation of iron hydroxide (III) from a 0.1 M solution of iron chloride (III).

   - recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Equilibria in heterogeneous systems	Qualitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited

		by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including before registration: issue the solution to the problems in the workbook.
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1.Calculate the solubility product of manganese sulfide, if the concentration of its saturated solution is $1.38 \cdot 10^{-3}$ g/dm3

2. Calculate the solubility product of lead phosphate, if 250 cm3 of a supersaturated solution contains $3.03 \cdot 10^{-7}$ g of salt.

3. Will a precipitate form when mixing equal volumes of a 0.05 M sodium sulfate solution with a 0.01 M barium chloride solution?

4. Will a precipitate fall out when equal volumes of 0.02 M $Ca(NO_3)_2$ and 0.02 M K_2CO_3 are mixed?

5. The solubility product of $CaC_2O_4 \cdot H_2O$ is equal to 2.078·10-9. Compare the solubility of this salt in pure water and in 0.1 M ammonium oxalate solution.

6. Will a precipitate fall out if you mix 30 cm3 of a 0.003 M K2CrO4 solution and 20 cm3 of a 0.0002M $AgNO_3$ solution (DR(Ag_2CrO_4) = 8.8·10-12?

7. What precipitate will fall out first if silver nitrate solution is added dropwise to 0.1 M solutions of NaCl and NaI? (DR(AgC1)= $1.1 \cdot 10^{-10}$; DR(AgI)= $1.0 \cdot 10^{-16}$).

4. Summing up:

As a result of the lesson, the student got acquainted with the basic concepts of the theory of heterogeneous equilibria; consolidated the ability to solve problems on the topic "Heterogeneous equilibria".

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A.

E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p

Practical lesson No. 7

Topic: Analysis of a mixture of cations of I-III analytical groups.

Goal: Familiarize yourself with and summarize information about the analysis of cations of I-III analytical groups when they are simultaneously present in the sample

Basic concepts:analysis, qualitative analysis, group reagent, specific reagent, group of cations, acid-base classification, acids, bases

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;

- ✓ principles and methods of qualitative analysis, classification of analysis methods;
- ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
- ✓ the concept of fractional and systematic analysis, the difference between one and the other;
- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on

analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. Classification of cations into analytical groups.
2. Cations of analytical group I. A systematic course of analysis.
3. Cations of II analytical group. Group reagent. A systematic course of analysis.
4. Cations of the III analytical group. Group reagent. A systematic course of analysis.
5. Systematic analysis of cations of I-III analytical groups.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1.What cations are included in group I according to the acid-base classification? Why 1 group of cations does not have a group reactant?

2. Which cation should be identified first and removed in the combined cation analysis? How to do it?

2. List the cations of the II analytical group according to the acid-base classification. What is a group reagent for cations of analytical group II (acid-base classification)? How to distinguish sediments formed during this reaction?

3. Name the cations of the III analytical group. What is a group reagent for cations of analytical group III (acid-base classification)? How to increase the completeness of precipitation of $CaSO_4$ under the action of a group reagent? Why carry out reprecipitation of sulfates and with which reagent is it performed?

– recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Qualitative analysis of	Qualitative	Analytical chemistry: handbook / V.

cations. Acid-base classification of cations. Group reagents. 2. Systematic course of analysis of cations of analytical group I. 3. Systematic analysis of cations of the II analytical group. 4. Systematic course of analysis of cations of the III analytical group. 5. Systematic course of analysis of cations of I-III analytical groups.	analysis	V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including for registration: the laboratory work registration form is attached.
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1. Na^+, Ag^+ and Ba^{2+} ions are present in the solution. Suggest how to detect these ions by performing a systematic course of analysis (according to the acid-base classification). Write the equations of the corresponding reactions.

2. K^+ ;Pb^{2+}, Ca^{2+} ions are present in the solution. Suggest how to detect these ions by performing a systematic course of analysis (according to the acid-base classification). Write the equations of the corresponding reactions.

3. The solution contains ions NH_4^+, Ag^+ and Ca^{2+}. Suggest how to detect these ions by performing a systematic course of analysis (according to the acid-base classification). Write the equations of the corresponding reactions.

4. Na+, Hg_2^{2+} and Sr^{2+} ions are present in the solution. Suggest how to detect these ions by following a systematic course of analysis. Write the equations of

the corresponding reactions.

5. K+, Pb^{2+} and Ba^{2+} ions are present in the solution. Suggest how to detect these ions by performing a systematic course of analysis (according to the acid-base classification). Write the equations of the corresponding reactions

6. The solution contains ions NH_4+, Hg_2^{2+} and Ba^{2+}. Suggest how to detect these ions by performing a systematic course of analysis (according to the acid-base classification). Write the equations of the corresponding reactions.

4. Summing up:

As a result of the lesson, the student summarized information about the course of the analysis with the simultaneous presence of cations of I-III analytical groups.

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 8

Topic: ***Control work*** on the theory and practice of analysis of cations of I-III analytical groups.

Goal: Summarize information on the analysis of cations of I-III analytical groups with their simultaneous presence in the sample

Basic concepts:analysis, qualitative analysis, group reagent, specific reagent, group of cations, acid-base classification, acids, bases

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
     - ✓ principles and methods of qualitative analysis, classification of analysis methods;
     - ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
     - ✓ the concept of fractional and systematic analysis, the difference between one and the other;
     - ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);

- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. Classification of cations into analytical groups.
2. Analysis of cations of analytical group I. A systematic course of analysis.
3. Analysis of cations of the II analytical group. Group reagent. A systematic course of analysis.

4. Analysis of cations of the III analytical group. Group reagent. A systematic course of analysis.
5. Systematic analysis of cations of I-III analytical groups.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1.What cations are included in group I according to the acid-base classification? Why 1 group of cations does not have a group reactant?

2. What are the pharmacopoeial reactions for sodium, potassium and ammonium ions.

3. Which cation should be identified first and removed in the combined cation analysis? How to do it?

4. List the cations of the II analytical group according to the acid-base classification. What is a group reagent for cations of analytical group II (acid-base classification)? How to distinguish sediments formed during this reaction?

5. Name the cations of the III analytical group. What is a group reagent for cations of analytical group III (acid-base classification)? How to increase the completeness of precipitation of CaSO4 under the action of a group reagent? Why carry out reprecipitation of sulfates and with which reagent is it performed?

6. List the pharmacopoeial reactions for calcium cations. Terms of execution.

– recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Qualitative analysis of cations. Acid-base classification of cations. Group reagents. 2. Systematic course of analysis of cations of analytical group I. 3. Systematic analysis of	Qualitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

cations of the II analytical group. 4. Systematic course of analysis of cations of the III analytical group.		

- requirements for work results, including to registration: the final work registration form is attached.
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1. Na+, Hg2+2 and Sr2+ ions are present in the solution. Suggest how to detect these ions by following a systematic course of analysis. Write the equations of the corresponding reactions.

2. K+, Pb2+ and Ba2+ ions are present in the solution. Suggest how to detect these ions by performing a systematic course of analysis (according to the acid-base classification). Write the equations of the corresponding reactions

3. The solution contains ions NH_4^+, Hg_2^{2+}, and Ba^{2+}. Suggest how to detect these ions by performing a systematic course of analysis (according to the acid-base classification). Write the equations of the corresponding reactions.

4. Summing up:

As a result of the lesson, the student summarized information about the analysis of cations of I-III analytical groups.

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.
4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p

Practical lesson No. 9

Topic: IV analytical group of cations (Al^{3+}, Cr^{3+}, Zn^{2+}, As^{III}, As^{V}, Sn^{II}, Sn^{IV}). Group reagent, quality reactions, conditions for their performance.

Goal: Familiarize yourself with the main reactions used to identify cations of the IV analytical group (acid-base classification); summarize information about fractional and systematic analysis of cations of the IV analytical group.

Basic concepts:analysis, qualitative analysis, group reagent, specific reagent, group of cations, acid-base classification, acids, bases

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
     - ✓ principles and methods of qualitative analysis, classification of analysis

methods;

- ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
- ✓ the concept of fractional and systematic analysis, the difference between one and the other;
- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. List the cationsIV analytical group. What is the group reactant of this group?
2. What is formed when an excess of the group reagent is added to the formed hydroxides.
3. Qualitative reactions of aluminum cations.
4. Qualitative reactions of zinc cations.
5. Qualitative reactions of chromium cations.
6. Qualitative reactions of arsenic(III) and arsenic(v)
7. Qualitative reactions of stanium(II) and stanium(I) cationsv)

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1.Zn2+ and Sn2+ ions are present in the solution. How to separate these cations using a group reagent (acid-base classification)? Write the equations of the corresponding reactions.

2. Zn^{2+} and $A1^{3+}$ ions are present in the solution. What reaction allows you to detect zinc ions in the presence of aluminum ions? Write the equation of the corresponding reaction.

3. A group reagent was added to the solution containing the IV cation of the analytical group (acid-base classification). The solution turned yellow, after acidification an intense blue color appeared. Give an explanation. Write the equations of the corresponding reactions.

4. A concentrated solution of ammonium chloride was added to the solution containing the IV cation of the analytical group (acid-base classification). A green precipitate fell out. The presence of which cation is indicated by this analytical effect? Write the equations of the corresponding reactions.

– recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Qualitative analysis of cations. Cations of IV analytical group. Action of group reagent. 2. Qualitative analysis of cations. Cations of IV analytical group.	Qualitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including for registration: the laboratory work registration form is attached.
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1. A concentrated solution of ammonium chloride was added to the solution containing the IV cation of the analytical group (acid-base classification). A green precipitate fell out. The presence of which cation is indicated by this analytical effect? Write the equations of the corresponding reactions.

2. Alkali and bismuth nitrate solution were added to the solution containing the Sn^{2+} cation. A black velvety precipitate fell out. Give an explanation. Write the equations of the corresponding reactions.

3. A concentrated solution of ammonium chloride was added to the solution containing the IV cation of the analytical group (acid-base classification). A white precipitate fell out. The presence of which cation is indicated by this analytical effect? Write the equations of the corresponding reactions.

4. Summing up:

As a result of the lesson, the student got acquainted with the main reactions used to identify cationsIVanalytical group (acid-base classification); summarized information on fractional and systematic analysis of cationsIVanalytical group.

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.
2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.
3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.
4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 10

Topic:*Laboratory work:* Qualitative reactions of cations of the IV analytical group.

Purpose: Usummarize information on fractional and systematic analysis of cations of analytical group IV; to form practical skills for performing laboratory work

Basic concepts:analysis, qualitative analysis, group reagent, specific reagent, group of cations, acid-base classification, acids, bases

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)

– requirements for theoretical readiness of students to perform practical

classes (knowledge requirements, list of didactic units)

The student should know:

- ✓ basic rules for working with acids and alkalis;
- ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
- ✓ principles and methods of qualitative analysis, classification of analysis methods;
- ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
- ✓ the concept of fractional and systematic analysis, the difference between one and the other;
- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific

reactions and their analytical effects, draw up report documentation based on experimental data;

- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. List the cationsIV analytical group. What is the group reactant of this group?
2. What is formed when an excess of the group reagent is added to the formed hydroxides.
3. Qualitative reactions of aluminum cations.
4. Qualitative reactions of zinc cations.
5. Qualitative reactions of chromium cations.
6. Qualitative reactions of arsenic(III) and arsenic(v)
7. Qualitative reactions of stanium(II) and stanium(I) cationsv)

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1.A concentrated solution of ammonium chloride was added to the solution containing the IV cation of the analytical group (acid-base classification). A green precipitate fell out. The presence of which cation is indicated by this analytical effect? Write the equations of the corresponding reactions.

2. To the solution containing the Cr^{3+} cation, alkali was added, and then potassium permanganate solution and heated in a water bath. What analytical effect is observed? Write the equation for the corresponding reaction.

3. Zn^{2+} ions are present in the solution. What analytical effect will be observed when a group reagent (acid-base classification) is added to this solution? Write the equations of the corresponding reactions.

4. The "formation of colored pearls" reaction is used to detect which cation of analytical group IV (acid-base classification)? Write the equations of the corresponding reactions.

5. Suggest a qualitative reaction to arsenic (III) compounds. Write the equations of the corresponding reactions.

- recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Qualitative analysis of cations. Cations of IV analytical group. Action of group reagent. 2. Qualitative analysis of cations. Cations of IV analytical group.	Qualitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including for registration: the laboratory work registration form is attached.
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1. What is the common property of compounds of cations Al^{3+}, Zn^{2+}, Cr^{3+}, Sn^{2+} that unites them in the IV analytical group (acidic - the main classification)?

A. Amphotericity of hydroxides.
B. Insolubility of salts in water.
C. Good solubility of some salts.
D. Solubility of hydroxides in acids.
E. Solubility of hydroxides in an excess of ammonia solution

2. In a qualitative analysis, when an excess of a group reagent (sodium hydroxide solution) acts on cations of analytical group IV, chromium (III) ions form:

A. Sodium hexahydroxochromate (III)
B. Chromium (III) hydroxide
C. Chromium (III) oxide
D. Chromium (II) hydroxide
E. Chromium (II) oxide

3. An excess of 6M sodium hydroxide solution and 3% hydrogen peroxide solution were added to the test solution. The solution turned yellow when heated. This indicates the presence in the solution:

A. aluminum cations
B. zinc cations
C. tin (II) cations
D. lead cations
E. chromium (III) cations

4. Zinc and aluminum cations are present in the solution. Specify the reagent that allows you to detect zinc cations in this solution:

A. Potassium hexacyanoferrate (II) solution
B. Sodium hydroxide solution
C. Cobalt nitrate Co(NO3)2
D. An excess of 6M sodium hydroxide in the presence of hydrogen peroxide
E. Sulfuric acid solution

5. When the studied mixture of cations was treated with a KOH solution, a white precipitate was formed, which was dissolved in an excess of the reagent. A white precipitate was formed during the action of the $K_4[Fe(CN)_6]$ solution. What cation is present in the solution?

A. Cr^{3+}
B. Ca^{2+}
C. Ba^{2+}
D. Zn^{2+}

E. Fe^{3+}

6. When analyzing a mixture of cations of the IV analytical group, Zn cations can be determined under certain conditions by the fractional method with the following reagent:

A. Dithizon

B. Ammonia solution

C. Meadows

D. Carbonates of alkali metals

E. Dimethylglyoxime

7. Which of the IV cations of the analytical group can be detected by the drop method with alizarin using analytical masking?

A. Al^{3+}

B. Sn^{2+}

C. Zn^{2+}

D. Cr^{3+}

E. Sn [IV]

8. Filter paper impregnated with a solution of cobalt (II) nitrate and the investigated solution forms blue ash after burning. This proves the presence of ions:

A. Cr^{3+}

B. Ni^{3+}

C. Sb^{3+}

D. Al^{3+}

E. Zn^{2+}

4. Summing up:

As a result of the lesson, the student got acquainted with the main reactions used to identify cationsIVanalytical group (acid-base classification); summarized information on fractional and systematic analysis of cationsIVanalytical group.

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.
2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.
3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.
4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p

Practical lesson No. 11

Topic: V analytical group of cations (Mg^{2+}, Mn^{2+}, Fe^{2+}, Fe^{3+}, Bi^{3+}, Sb^{III}, Sb^{V}). Group reagent, quality reactions, conditions for their performance.

Goal: Familiarize yourself with the basic reactions used to identify cations of analytical group V (acid-base classification); to summarize information about fractional and systematic analysis of cations of analytical group V.

Basic concepts:analysis, qualitative analysis, group reagent, specific reagent, group of cations, acid-base classification, acids, bases

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)

– requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

The student should know:

- ✓ basic rules for working with acids and alkalis;
- ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
- ✓ principles and methods of qualitative analysis, classification of analysis methods;
- ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
- ✓ the concept of fractional and systematic analysis, the difference between one and the other;
- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;

- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. List the cationsV analytical group. What is the group reactant of this group.
2. Reactions of manganese cations. Balance with an electron-ion balance.
3. Reaction of iron(II, III) cations with sulfosalicylic acid. Effect of pH on the composition of the formed compound.
4. Qualitative reactions of iron(II) and iron(III) cations.
5. Qualitative reactions of magnesium cations. What cations can interfere with the course of the given reactions.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1. Properties of cations of analytical group V (acid-base classification) and conditions for their precipitation with a group reagent. Write the equations of reactions of the interaction of Bi^{3+}, Fe^{2+}, Mg^{2+} ions with a group reagent and the reactions of their detection. Transformation reactions and detection of manganese ions in the analysis of a mixture of group V cations.

2. Justify the choice of a group reagent for cations of analytical group VI (acid-base classification). Write the reaction equation for the detection of copper, nickel and cobalt cations during the analysis of a mixture of cations of this group.

3. What color are concentrated solutions of nickel (II) salts? Sodium fluoride

solution, ammonia solution and alcohol solution of dimethylglyoxime were added to the solution containing iron (III) and nickel (II) cations. What is observed? Write the equations of the corresponding reactions

- recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Qualitative analysis of cations. Cations of analytical group V. Action of group reagent. 2. Qualitative analysis of cations. Cations of analytical group V.	Qualitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including for registration: the laboratory work registration form is attached
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1. A solution containing cations of analytical group V (acidic - the main classification) is taken for analysis. An alkaline solution of sodium hydroxostanite was added to the mixture - a black precipitate was formed, indicating the presence of a cation:

A. Bi^{3+}

B. Fe^{2+}

C. Sb^{3+}

D. Fe^{3+}

E. Mg^{2+}

2. In the aqueous solution there are cations of analytical group V (acidic - the main classification). When the solution was diluted, a white amorphous precipitate was formed. What cations easily form hydrolysis products?

A. Bismuth and antimony cations

B. Iron (III) cations

C. Magnesium cations

D. Manganese cations

E. Iron (II) cations

3. Concentrated nitric acid and crystalline lead dioxide were added to the studied solution. The solution acquired a crimson color. The presence of which cation is indicated by this analytical effect:

A. manganese (II)

B. bismuth (III)

C. iron (III)

D. chromium (III)

E. tin(II)

4. A solution of ammonium thiocyanate was added to the studied solution. The solution turned red. The presence of which cation is indicated by this analytical effect:

A. iron (III)

B. mercury (II)

C. argentum

D. mercury (I)

E. lead (II)

5. Indicate what ions are in the solution if, when heated with (NH4)2S2O8 in the presence of AgNO3, the solution acquires a crimson color?

A. Mn^{2+}

B. Fe^{3+}

C. Fe^{2+}

D. Co^{2+}

E. Cu^{2+}

6. In a qualitative analysis under certain conditions, the specific reagent for Fe^{3+} cations is $K_4[Fe(CN)_6]$. What color is the precipitate formed?

A. blue

B. white

C. brown

D. red

E. black

7. To detect Co2+ ions in the presence of Fe3+, to mask Fe3+ ions, add to the solution:

A. fluoride - ions

B. chloride - ions

C. bromide - ions

D. nitrite ions

E. sulfate - ions

8. What cation of the V analytical group (acidic - basic classification) is in the solution, if a black precipitate falls out under the action of a tin (II) chloride solution in an alkaline medium?

A. Bismuth (III)

B. Iron (II)

C. Manganese (II)

D. Antimony (III)

E. Iron (III)

9. In qualitative analysis, the specific reagent for Fe2+ cations is:

A. $K_3[Fe(CN)_6]$

B. $K_2Na[Co(NO_2)_6]$

C. NaOH

D. $K_4[Fe(CN)_6]$

E. NH_4OH

10. The studied solution of the medicinal product contains magnesium (II) and aluminum (III) cations. Which reagent can be used to separate the indicated cations during the analysis of this drug?

A. alkali solution

B. of hydrogen peroxide in an acidic environment

C. silver nitrate solution

D. ammonia solution

E. hydrochloric acid solution

11. When adding ammonia buffer solution and sodium hydrogen phosphate solution to the analyzed solution, a white precipitate was formed. This indicates the presence of ions:

A. magnesium

B. aluminum

C. arsenic (III)

D. chromium (III)

E. potassium

4. Summing up:

As a result of the lesson, the student got acquainted with the main reactions used to identify cationsVanalytical group (acid-base classification); summarized information on fractional and systematic analysis of cationsVanalytical group.

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 12

Topic:*Laboratory work*: Qualitative reactions of cations of analytical group V

Goal: Familiarize yourself with the basic reactions used to identify cations of analytical group V (acid-base classification); to form practical skills for performing laboratory work

Basic concepts:analysis, qualitative analysis, group reagent, specific reagent, group of cations, acid-base classification, acids, bases

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
     - ✓ principles and methods of qualitative analysis, classification of analysis methods;
     - ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
     - ✓ the concept of fractional and systematic analysis, the difference between one and the other;
     - ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);

- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. List the cationsV analytical group. What is the group reactant of this group.
2. Reactions of manganese cations. Reaction conditions.
3. Reaction of iron(II, III) cations with sulfosalicylic acid. Effect of pH on the composition of the formed compound.

4. Qualitative reactions of iron(II) and iron(III) cations.
5. Masking of the Fe^{3+} cation
6. Qualitative reactions of magnesium cations. What cations can interfere with the course of the given reactions.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1. Transformation reactions and detection of manganese ions in the analysis of a mixture of group V cations with potassium bismuthate, ammonium persulfate, and lead dioxide.

2. Qualitative reactions of iron (II) and iron (III) cations. Reactions of the formation of "Turnbull blue" and "Berlin azure". Relationship of formed precipitates to acids and alkalis.

3. Qualitative reaction of iron (III) with ammonium thiocyanate. Masking the lady's fluoride.

4. Qualitative reactions of magnesium with 8-oxyquinoline and sodium hydrogen phosphate. Conditions of conduct.

- recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Qualitative analysis of cations. Cations of analytical group V. Action of group reagent. 2. Qualitative analysis of cations. Cations of analytical group V.	Qualitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.—Kharkiv: NUPh; Original, 2012.

– requirements for work results, including for registration: the laboratory work registration form is attached

– control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1. In the aqueous solution there are cations of analytical group V (acidic - the main classification). When the solution was diluted, a white amorphous precipitate was formed. What cations easily form hydrolysis products?

A. Bismuth and antimony cations
B. Iron (III) cations
C. Magnesium cations
D. Manganese cations
E. Iron (II) cations

2. Concentrated nitric acid and crystalline lead dioxide were added to the studied solution. The solution acquired a crimson color. The presence of which cation is indicated by this analytical effect:

A. manganese (II)
B. bismuth (III)
C. iron (III)
D. chromium (III)
E. tin(II)

3. A solution of ammonium thiocyanate was added to the studied solution. The solution turned red. The presence of which cation is indicated by this analytical effect:

A. iron (III)
B. mercury (II)
C. argentum
D. mercury (I)
E. lead (II)

4. Indicate what ions are in the solution if, when heated with (NH4)2S2O8 in the presence of AgNO3, the solution acquires a crimson color?

A. Mn^{2+}
B. Fe^{3+}
C. Fe^{2+}
D. Co^{2+}

E. Cu^{2+}

5. In a qualitative analysis under certain conditions, the specific reagent for Fe3+ cations is K4[Fe(CN)6]. What color is the precipitate formed?

A. blue

B. white

C. brown

D. red

E. black

6. To detect Co2+ ions in the presence of Fe3+, to mask Fe3+ ions, add to the solution:

A. fluoride - ions

B. chloride - ions

C. bromide - ions

D. nitrite ions

E. sulfate - ions

7. In qualitative analysis, the specific reagent for Fe2+ cations is:

A. $K_3[Fe(CN)_6]$

B. $K_2Na[Co(NO_2)_6]$

C. NaOH

D. $K_4[Fe(CN)_6]$

E. NH_4OH

8. When adding ammonia buffer solution and sodium hydrogen phosphate solution to the analyzed solution, a white precipitate was formed. This indicates the presence of ions:

A. magnesium

B. aluminum

C. arsenic (III)

D. chromium (III)

E. potassium

4. Summing up:

As a result of the lesson, the student got acquainted with the main reactions used to identify cationsVanalytical group (acid-base classification); summarized information on fractional and systematic analysis of cationsVanalytical group.

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 13

Topic: VI analytical group of cations (Cu^{2+}, Co^{2+}, Hg^{2+}, Ni^{2+}). Group reagent, quality reactions, conditions for their performance. ***Laboratory work:*** Qualitative reactions of cations of the VI analytical group.

Goal: Familiarize yourself with the main reactions used to identify cations of the VI analytical group (acid-base classification); summarize information about fractional and systematic analysis of cations of the VI analytical group.

Basic concepts:analysis, qualitative analysis, group reagent, specific reagent, group of cations, acid-base classification, acids, bases

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)

– requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

The student should know:

- ✓ basic rules for working with acids and alkalis;
- ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
- ✓ principles and methods of qualitative analysis, classification of analysis methods;
- ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
- ✓ the concept of fractional and systematic analysis, the difference between one and the other;
- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out

qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;

- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. List the cationsVI analytical group. What is the group reactant of this group? Precipitates of what composition are formed when an equimolar amount of a group reagent is added? What happens to the precipitates when an excess of group reagent is added?
2. How to distinguish copper(II) and mercury(II) cations from other cations of this group? How then to separate them from each other?
3. Qualitative reactions of nickel cations.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1. Justify the choice of a group reagent for cations of analytical group VI (acid-base classification). Write the reaction equation for the detection of copper, nickel and cobalt cations during the analysis of a mixture of cations of this group.

2. Group reagent for cations of analytical group VI (acid-base classification). Conditions of their use. Write the reaction equation for the interaction of Cu^{2+} and Hg^{2+} ions with a group reagent. Reactions of separation of these ions in the systematic course of analysis of the mixture of group VI cations and reactions of their detection.

3. What color do concentrated solutions of copper (II) salts have? A solution of sodium hydroxide was added to the solution containing the VI group cation (acid-base classification). A white precipitate soluble in ammonia fell out. What cation is present in the solution? Write the equations of the corresponding reactions.

4. What color do concentrated solutions of nickel (II) salts have? Sodium fluoride solution, ammonia solution and alcohol solution of dimethylglyoxime were added to the solution containing iron (III) and nickel (II) cations. What is observed? Write the equations of the corresponding reactions.

- recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Qualitative analysis of cations. Cations of analytical group VI. Action of group reagent. 2. Qualitative analysis of cations. Cations of analytical group VI.	Qualitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including for registration: the laboratory work registration form is attached
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1. Indicate what cations are in the solution, if a red crimson precipitate is formed when Chugaev's reagent and ammonia buffer solution are added to it:

A. Nickel cations

B. Aluminum cations

C. Copper cations

D. Cobalt cations

E. Iron cations

2.During the analysis of cations of the VI analytical group (acidic - basic classification) under the action of a group reagent, it is possible not only to separate the group, but also to identify the ions:

A. Cu(II)

B. Co(II)

C. Ni(II)

D. Hg(II)

E. Cd(II)

3.Separation of cations of V and VI analytical groups (acid-basic classification) in the systematic course of the analysis is carried out under the action of:

A. an excess of concentrated ammonia solution

B. an excess of sodium hydroxide solution

C. an excess of hydrochloric acid solution

D. an excess of potassium hydroxide solution

E. excess sulfuric acid solution

4.The most selective reaction for determining nickel cations is the interaction reaction with:

A. Chugaev's reagent

B. sodium hydroxide solution

C. potassium hydroxide solution

D. sulfuric acid solution

E. Nessler's reagent

5.To separate cations of analytical group 6 from cations of analytical group 5 (acid-basic classification) use:

A. Excess ammonia solution

B. Excess sodium hydroxide solution

C. Excess sulfuric acid solution

D. Acetic acid solution

E. Silver nitrate solution

6. What cations form an orange-red precipitate with a solution of potassium iodide, soluble in an excess of the reagent to form a colorless solution?

A. mercury (II)

B. mercury (I)

C. bismuth

D. trumpets (V)

E. lead

7. The mixture being analyzed contains cations of iron (III) and copper (II). The action of which group reagent can separate these cations:

A. Concentrated ammonia solution

B. Sodium hydroxide solution and hydrogen peroxide

C. Hydrochloric acid solution

D. Sodium hydroxide solution

E. Sulfuric acid solution

8. To detect Co^{2+} ions in the presence of Fe^{3+}, to mask Fe^{3+} ions, add to the solution:

A. fluoride - ions

B. chloride - ions

C. bromide - ions

D. nitrite ions

E. sulfate - ions

9.When an excess of ammonia is added to the analyzed solution, the solution will turn bright blue. This indicates the presence of ions in the solution:

A. copper

B. silver

C. lead

D. bismuth

E. mercury (II)

10. A characteristic reaction for the detection of mercury (II) cations is the reaction with potassium iodide. During the reaction, observe:

A. Bright red sediment
B. Bright red solution
C. Dirty green sediment
D. Black sediment
E. White precipitate

11. Under the action of dimethylglyoxime on a solution containing cations of the VI analytical group (acid-basic classification), a crimson coloration of the sediment was observed. What cation caused this analytical effect?

A. nickel(II) cation
B. mercury (II) cation
C. cuprum (II) cation
D. cadmium (II) cation
E. cobalt(II) cation

4. Summing up:

As a result of the lesson, the student got acquainted with the main reactions used to identify cationsVIanalytical group (acid-base classification); summarized information on fractional and systematic analysis of cationsVIanalytical group.

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of

medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.
4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 14

Topic: Solving tasks on the topic "Acid-base equilibria in analytical chemistry."

Goal: Get acquainted with the main theories of protolytic reactions. Get acquainted and generalize about acid-base balance in chemical reactions and its meaning

Basic concepts:protolyte, ampholyte, hydrogen index, ion product of water

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
     - ✓ principles and methods of qualitative analysis, classification of analysis methods;
     - ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
     - ✓ the concept of fractional and systematic analysis, the difference

between one and the other;

- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. Define the terms "acid" and "base (alkali)" according to the theory of Arrhenius, Brønsted-Lowry, Lewis, Pearson, Usanovich

2. What is the hydrogen index? Its relationship with the ionic product of water.

3. pH calculations for strong/weak acids/bases, salts, buffer systems

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1. Calculate the pH of the sulfuric acid solution taking into account the activity coefficients at $c(H_2SO_4)=0.005$ mol/dm^3.

2. Calculate the pH concentration in a 0.01 M solution of formic acid, if the degree of its dissociation is 3%.

3. Calculate the concentration of H+ ions and the pH of solutions with a pH of 8.3; 5.8; 6.6.

4. How will the pH change in a 10^{-5} M solution of sodium hydroxide if potassium hydroxide with a mass of 0.056 g is added to 1 dm^3 of it?

5. Calculate the pH of a 10^{-5} mol/dm^3 nitric acid solution.

6. Calculate [OH-], [H+], pOH and pH in 0.5% solutions of sodium hydroxide and ammonium hydroxide.

7. Calculate the pH of the solution if sulfuric acid weighing 1 g is dissolved in water with a volume of 3.5 dm^3 (density 1.84 g/cm^3)

– recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Theories of protoliths 2. Hydrogen index	Protolytic equilibria in solutions of acids and bases	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

– requirements for work results, including before registration: solving

problems according to the sample in the workbook.

- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1. Calculate the pH of the sulfuric acid solution taking into account the activity coefficients at $c(H_2SO_4)=0.005$ mol/dm^3.

2. Calculate the pH concentration in a 0.2 M solution of acetic acid, if the degree of its dissociation is 5%.

3. Calculate the concentration of H+ ions and the pH of solutions with a pH of 1.3; 3.8; 11.6.

4. How will the pH change in a 10^{-4} M solution of sodium hydroxide if potassium hydroxide with a mass of 0.112 g is added to 100 ml of it?

5. Calculate the pH of 10^{-5} mol/dm^3 sodium hydroxide solution.

6. Calculate [OH-], [H+], pOH and pH in 0.9% solutions of sodium hydroxide and ammonium hydroxide.

4. Summing up:

As a result of the lesson, the student got acquainted with the main theories of protolytic reactions and generalized knowledge about acid-base equilibrium in chemical reactions and its meaning

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p

Practical lesson No. 15

Topic: Analysis of a mixture of cations of IV, V, VI analytical groups

Goal: Familiarize yourself with and summarize information about the analysis of cations of IV - VI analytical groups when they are simultaneously present in the sample

Basic concepts:analysis, qualitative analysis, group reagent, specific reagent, group of cations, acid-base classification, acids, bases

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
     - ✓ principles and methods of qualitative analysis, classification of analysis methods;
     - ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
     - ✓ the concept of fractional and systematic analysis, the difference

between one and the other;

- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. Classification of cations into analytical groups.
2. Cations of IV analytical group. Group reagent. A systematic course of analysis.
3. Cations of analytical group V. Group reagent. A systematic course of analysis.
4. Cations of analytical group VI. Group reagent. A systematic course of analysis.
5. Systematic analysis of cations of IV - VI analytical groups.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1. What cations are included in the IV analytical group? What is a bulk reagent? Why do we add hydrogen peroxide?

2. Name the cations of analytical group V (acid-base classification), the group reagent, their reaction conditions, and the expected analytical effect.

3. Name the cations of the VI analytical group (acid-base classification), the group reagent, their reaction conditions, and the expected analytical effect.

4. Properties of hydroxides of IV - V cations of analytical groups (acid-base classification). Using the example of a mixture of $A1^{3+}$, Zn^{2+}, Bi^{3+}, and Mn^{2+} ions, show the use of different properties of hydroxides for their separation. Write the equations of the corresponding reactions.

5. Chromium (III), iron (III), copper (II) cations are present in the solution. Sodium fluoride was added to this solution, and then sodium thiocyanate solution. What is observed? Write the equations of the corresponding reactions.

- recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Qualitative analysis of cations. Acid-base classification of cations. Group reagents.	Qualitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A.

2. Systematic course of analysis of cations of IV analytical group. 3. Systematic course of analysis of cations of analytical group V. 4. Systematic course of analysis of cations of analytical group VI. 5. Systematic course of analysis of cationsIV - VIanalytical groups.		Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including before registration: give the main reactions for determining cations of IV - VI analytical groups; to know the course of the analysis with the simultaneous presence of cations of the above groups
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1. To a solution containing cationsIV - VIgroups (acid-base classification), potassium thiocinate solution was added. What is observed? Write the equations of the corresponding reactions.

2. Suggest the course of analysis of a solution containing cations: Cu^{2+}, Sb^{3+}, Mn^{2+} (acid-base classification).

3. To a solution containing cationsIV - VIgroups (acid-base classification), a solution of yellow blood salt was added. What is observed? Write the equations of the corresponding reactions.

4. Suggest the course of analysis of a solution containing cations: Cd^{2+}, Al^{3+}, Bi^{3+} (acid-base classification).

5. To a solution containing cationsIV - VIgroups (acid-base

classification), an excess of ammonia solution was added, and then rhodanide solution ammonium and amyl alcohol. What is observed? Write the equation corresponding reactions.

6. 3propose the course of analysis of a solution containing cations: Co^{2+}, Sn^{2+}, Mg^{2+} (acid-base classification).

7. 3propose the course of analysis of a solution containing cations: Mn^{2+}, Bi^{3+}, Hg^{2+} (acid-base classification).

4. Summing up:

As a result of the lesson, the student summarized information about the course of the analysis with the simultaneous presence of cations of IV-VI analytical groups.

5. List of recommended literature:

Main:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 16

Topic: ***Control work*** on the theory and practice of analysis of cations of IV-VI analytical groups.

Purpose: Ugeneralize and systematize information on the analysis of cations of IV - VI analytical groups when they are simultaneously present in the sample

Basic concepts:analysis, qualitative analysis, group reagent, specific reagent, group of cations, acid-base classification, acids, bases

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
     - ✓ principles and methods of qualitative analysis, classification of analysis methods;
     - ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
     - ✓ the concept of fractional and systematic analysis, the difference between one and the other;
     - ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);

- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. Classification of cations into analytical groups.
2. Cations of IV analytical group. Action of group reagent. Individual reactions.
3. Systematic analysis of cations of the IV analytical group.

4. Cations of analytical group V. Action of group reagent. Individual reactions.
5. Systematic course of analysis of cations of analytical group V.
6. Cations of analytical group VI. Action of group reagent. Individual reactions.
7. Systematic course of analysis of cations of analytical group V.
8. Systematic analysis of cations of IV - VI analytical groups.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1. What cations are included in the IV analytical group? What is a bulk reagent? Why do we add hydrogen peroxide?

2. Pharmacopoeial reactions of zinc cations. Performance conditions, chemistry, analytical effect.

3. Analytical reactions of iron(II) and iron(III) cations. Performance conditions, chemistry, analytical effect.

4. Name the cations of analytical group V (acid-base classification), the group reagent, their reaction conditions, and the expected analytical effect.

5. Analytical reactions of manganese cations. Performance conditions, reaction chemistry, analytical effect.

6. Name the cations of the VI analytical group (acid-base classification), the group reagent, their reaction conditions, and the expected analytical effect.

7. Properties of hydroxides of IV - V cations of analytical groups (acid-base classification). Using the example of a mixture of $A1^{3+}$, Zn^{2+}, Bi^{3+}, and Mn^{2+} ions, show the use of different properties of hydroxides for their separation. Write the equations of the corresponding reactions.

- recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Qualitative analysis of cations. Acid-base	Qualitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L.

classification of cations. Group reagents. 2. Systematic course of analysis of cations of IV analytical group. 3. Systematic course of analysis of cations of analytical group V. 4. Systematic course of analysis of cations of analytical group VI. 5. Systematic course of analysis of cationsIV - VIanalytical groups.		Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including before registration: give the main reactions for determining cations of IV - VI analytical groups; to know the course of the analysis with the simultaneous presence of cations of the above groups
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1. To a solution containing cationsIV - VIgroups (acid-base classification), potassium thiocinate solution was added. What is observed? Write the equations of the corresponding reactions.

2. Suggest the course of analysis of a solution containing cations: Cu^{2+}, Sb^{3+}, Mn^{2+} (acid-base classification).

3. To a solution containing cationsIV - VIgroups (acid-base classification), a solution of yellow blood salt was added. What is observed? Write the equations of the corresponding reactions.

4. Suggest the course of analysis of a solution containing cations: Cd^{2+}, Al^{3+}, Bi^{3+} (acid-base classification).

5. To a solution containing cationsIV - VIgroups (acid-base classification), an excess of ammonia solution was added, and then rhodanide solution ammonium and amyl alcohol. What is observed? Write the equation corresponding reactions.

6. 3propose the course of analysis of a solution containing cations: Co^{2+}, Sn^{2+}, Mg^{2+} (acid-base classification).

7. 3propose the course of analysis of a solution containing cations: Mn^{2+}, Bi^{3+}, Hg^{2+} (acid-base classification).

4. Summing up:

As a result of the lesson, the student summarized information about the course of the analysis with the simultaneous presence of cations of IV-VI analytical groups.

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 17

Topic: Group reagents in the analysis of anions and their purpose. Analytical reactions of anions of analytical group I, conditions for their performance.

Goal: Familiarize yourself with group reagents used in the analysis of anions. Familiarize yourself with and summarize information about anions of analytical group I and analytical reactions.

Basic concepts:analysis, qualitative analysis, group reagent, specific reagent, group of anions

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
     - ✓ principles and methods of qualitative analysis, classification of analysis methods;
     - ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
     - ✓ the concept of fractional and systematic analysis, the difference between one and the other;
     - ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution,

detection limit (detection minimum);

- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. Groups of anions. What anions are included in the I, II and III analytical groups? What are the group reagents for these groups?

2. What reagents can be used to determine oxidizing anions and reducing anions?
3. And analytical group of anions. List the anions, indicate the group reactant.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1.How to separate and identify arsenate and arsenite ions?

2. Why is the determination of anions started after the determination of cations? Describe the preparation of a special "soda fume hood" solution for anion analysis. Write the reaction equations for the cations Ag^{+}, Ca^{2+}, Sn^{2+}, Bi^{3+}, Co^{2}+ in the manufacture of "soda fume hood".

3. Test for anions that exhibit oxidizing properties relative to potassium iodide — AsO_4^{3-}, NO_2^{-}, NO_3^{-}, $C_2O_4^{2-}$. Test for reducing anions, which decolorize iodine solution $S_2O_3^{2-}$, SO_3^{2-}. Write the equations of the corresponding reactions.

4. Why is it necessary to precipitate the anions of the first group with the group reagent $BaCl_2$ in a neutral or weakly alkaline solution?

5. What will happen if a solution containing S^{2}- and SO_3^{2-} anions is acidified with an acid?

6. Why does detection of CO_3^{2-} interfere with SO_3^{2-}?

- recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Qualitative analysis. Methods of performing analytical reactions. 2. Qualitative analysis of anions. Group reagents. 3. Qualitative analysis of analytical group I anions.	Qualitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

– requirements for work results, including for registration: the laboratory work

registration form is attached

- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1.A sodium arsenate solution can be distinguished from an arsenite solution using the following reagent:

A. magnesium mixture
B. potassium sulfate
C. potassium nitrate
D. sodium chloride
E. sodium fluoride

2. When adding a solution of barium chloride to the analyzed solution, a white precipitate was formed, insoluble in acids and alkalis. This indicates the presence in the analyzed solution:

A. sulfate ions
B. chloride ions
C. nitrate - ions
D. permanganate ions
E. iron (II) ions

3.The analytical effect of potassium iodide solution on colorless oxidizing anions in the presence of chloroform is:

A. Appearance of free iodine coloration
B. White precipitation
C. Change of aggregate state
D. Release of gas bubbles
E. The appearance of a precipitate and its dissolution in an excess of reagent

4.Arsenite and arsenate ions are part of some pharmaceutical preparations. The pharmacopoeial reaction for detecting the named ions is the reaction with the solution:

A. silver (I) nitrate
B. antipyrine

C. potassium iodide

D. ammonium hydroxide

E. sodium hydroxide

5. Select reagents for detecting sulfate ions in a solution containing carbonate, sulfate, and phosphate ions:

A. $Ba(NO_3)_2$, HCl

B. $Ba(NO_3)_2$, NaOH

C. $BaCl_2$, H2O

D. $CaCl_2$, NH_4OH

E. $AgNO_3$, HNO_3

6. The studied solution with a solution of barium chloride formed a white precipitate NOT soluble in either acids or alkalis. What is the composition of the obtained sediment?

A. barium sulfate

B. barium sulfite

C. barium carbonate

D. barium oxalate

E. barium phosphate

7. The first analytical group of anions includes anions that form water-insoluble salts:

A. barium

B. lead

C. ammonium

D. bismuth

E. mercury

8. Determination of anions of analytical group I is carried out under the action of:

A. solution of $BaCl_2$ in a neutral or weakly alkaline environment

B. solution of $BaCl_2$ in an acidic environment

C. $AgNO_3$ solution in an acidic environment

D. mineral acid solution

E. alkali solution

9. The pharmacopoeial reaction to phosphate ions is the action of a magnesium mixture. As a result, a white crystalline precipitate of MgNH4PO4 is formed. The composition of the magnesium mixture is as follows:

A. $MgCl_2$, $NH_3 \cdot H_2O$, NH_4Cl

B. $MgCl_2$, NaOH, NaCl

C. $MnCl_2$, $NH_3 \cdot H_2O$, NaCl

D. $MgCl_2$, $MnSO_4$, NH_4Cl

E. $MgCl_2$, NH_4Cl

4. Summing up:

As a result of the lesson, the student got acquainted with group reagents used in the analysis of anions and summarized information about anions of analytical group I and analytical reactions.

5. List of recommended literature:

Main:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 18

Topic: ***Laboratory work:*** Qualitative reactions of I analytical group of anions.

Goal: Summarize information about anions of analytical group I and analytical reactions. To form practical skills of performing laboratory work

Basic concepts:analysis, qualitative analysis, group reagent, specific reagent, group of anions

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
     - ✓ principles and methods of qualitative analysis, classification of analysis methods;
     - ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
     - ✓ the concept of fractional and systematic analysis, the difference between one and the other;
     - ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
     - ✓ analytical classifications of cations by groups, acid-base classification

of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. Groups of anions. What anions are included in the I, II and III analytical groups? What are the group reagents for these groups?
2. What reagents can be used to determine oxidizing anions and reducing anions?
3. And analytical group of anions. List the anions, indicate the group reactant.

3. Formation of professional skills and abilities:

- content of tasks (tasks, clinical situations, etc.)

1. Propose the course of analysis of a mixture of anions (classification is based on the solubility of barium and silver salts). Write the equations of the corresponding reactions, indicate the conditions for their performance, analytical effects, interfering ions.

a) $B_4O_7^{2-}$, PO_4^{3-}, SO_4^{2-}

b) PO_4^{3-}, AsO_3^{3-}, AsO_4^{3-}.

c) SO_3^{2-}, CO_3^{2-}, $C_2O_4^{2-}$

d) PO_4^{3-}, SO_3^{2-}, CO_3^{2-}

2. Write the equation for the detection reactions of group 1 anions (classification is based on the solubility of barium and silver salts) using a group reagent. State the analytical effects.

3. Suggest qualitative reactions for the phosphate ion. Write the equations of the corresponding reactions.

4. Propose characteristic reactions for the detection of SO_4^{2-} anion. Write the reaction equations and indicate the analytical effects.

- recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Qualitative analysis. Methods of performing analytical reactions. 2. Qualitative analysis of anions. Group reagents. 3. Qualitative analysis of analytical group I anions.	Qualitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.—Kharkiv: NUPh; Original, 2012.

- requirements for work results, including for registration: the laboratory work registration form is attached
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if

necessary):

4. Summing up:

As a result of the lesson, the student got acquainted with group reagents used in the analysis of anions and summarized information about anions of analytical group I and analytical reactions.

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 19

Topic: Analytical reactions of anions of the II analytical group, conditions for their performance.

Goal: Familiarize yourself with group reagents used in the analysis of anions. Familiarize yourself with and summarize information about anions of analytical group II and analytical reactions.

Basic concepts:analysis, qualitative analysis, group reagent, specific reagent, group of anions

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
     - ✓ principles and methods of qualitative analysis, classification of analysis methods;
     - ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
     - ✓ the concept of fractional and systematic analysis, the difference between one and the other;
     - ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
     - ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

     The student should be able to:
     - ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;

- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. Which anions belong to II analytical group? What is a bulk reagent?
2. Qualitative reactions to chloride, iodide, bromide and sulfide ions.
3. Systematic course of analysis with the simultaneous presence of chloride, bromide and iodide ions.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1.In what sequence are Br-, Cl-, and I- ions precipitated from a solution under the action of a group reagent (classification is based on the solubility of barium and silver salts), and in what sequence will silver halides dissolve in an ammonium hydroxide solution? Justify the answer.

2. Explain the necessity of carrying out a systematic analysis of chloride, bromide, and iodide ions when they are present together. Write the equations for the reactions of separation and detection of these ions in the mixture.

3. Detection of nitrite and nitrate ions in their simultaneous presence. What ions interfere with the detection of these ions and why? Write the equations of the corresponding reactions.

- recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Qualitative analysis. Methods of performing analytical reactions. 2. Qualitative analysis of anions of the II analytical group. Group reagents. 3. Systematic course of analysis with the simultaneous presence of chloride, bromide, and iodide ions	Qualitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including for registration: the laboratory work registration form is attached
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1.When anions were detected in the solution by the fractional method, a reaction with a flame retardant was carried out - an emerald-green color of the solution appeared. What anion caused this analytical effect?

A. nitrite ion

B. chromate ion

C. nitrate ion

D. bromide ion

E. iodide is an ion

2. Chloroform and chlorine water were added drop by drop to the investigated solution. The chloroform layer turned yellow - a hot color. This indicates the presence in the solution:

A. Bromide - ions

B. Sulfite - ions

C. Sulfate - ions

D. Nitrate - ions

E. Iodide - ions

3.Diphenylamine was added to the test solution to determine nitrate anions. What analytical effect is observed in this case:

A. The solution is blue

B. The precipitate is yellow

C. The precipitate is blue

D. Release of brown gas

E. The appearance of a characteristic smell

4.The studied solution of the medicinal substance contains iodide, bromide, chloride and sulfide anions. What reagent is group for these anions (the second analytical group of anions)?

A. Argentum nitrate in 2M nitric acid.

B. Barium chloride.

C. Barium nitrate.

D. There is no group reagent

E. Argentum nitrate in a neutral medium.

5. Cl- and Br- anions are present in the solution. Name the reagent for detecting Br-:

A. chlorine water

B. bromine water

C. gypsum water

D. lime water

E. barite water

6. Chloroform and chlorine water were added dropwise to the analyzed solution. The chloroform layer turned orange. This indicates the presence in the solution:

A. bromide - ions

B. iodide - ions

C. sulfite - ions

D. sulfate - ions

E. nitrate - ions

7. Chloroform and sodium nitrite solution were added to the acidified analyzed solution. The chloroform layer turned red-violet, which indicates the presence in the solution:

A. iodide - ions

B. carbonate - ions

C. chloride - ions

D. sulfate - ions

E. fluoride - ions

8. A solution of silver nitrate was added to the solution containing anions of the second analytical group. A black precipitate formed, insoluble in ammonia solution, but soluble when heated in dilute nitric acid. What anions are present in the solution:

A. sulfide - ions

B. iodide ions

C. chloride - ions

D. bromide - ions

E. arsenites are ions

9. A solution of silver nitrate was added to the solution containing anions of the second analytical group. A pale yellow precipitate was formed, insoluble in nitric acid and partially soluble in ammonia solution. What anions are present in the solution:

A. bromide - ions

B. iodide ions

C. chloride - ions

D. sulfide - ions

E. arsenites are ions

4. Summing up:

As a result of the lesson, the student familiarized himself with and summarized information about anions of the II-III analytical group and analytical reactions.

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 20

Topic: ***Laboratory work:*** Qualitative reactions of anions of the II analytical group.

Goal: Familiarize yourself with and summarize information about anions of analytical group II and analytical reactions. To form practical skills of performing laboratory work

Basic concepts:analysis, qualitative analysis, group reagent, specific reagent, group of anions

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)

– requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

The student should know:

- ✓ basic rules for working with acids and alkalis;
- ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
- ✓ principles and methods of qualitative analysis, classification of analysis methods;
- ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
- ✓ the concept of fractional and systematic analysis, the difference between one and the other;
- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of

performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;

- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. The action of the group reagent on the anions of the II analytical group.
2. Qualitative reaction of iodide and bromide ions with oxidants in the presence of chloroform.
3. Systematic course of analysis with the simultaneous presence of chloride, bromide and iodide ions.

4. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1.In what sequence are Br-, Cl-, and I- ions precipitated from a solution under the action of a group reagent (classification is based on the solubility of barium and

silver salts), and in what sequence will silver halides dissolve in an ammonium hydroxide solution? Justify the answer.

2. Explain the necessity of carrying out a systematic analysis of chloride, bromide, and iodide ions when they are present together. Write the equations for the reactions of separation and detection of these ions in the mixture.

3. Detection of nitrite and nitrate ions in their simultaneous presence. What ions interfere with the detection of these ions and why? Write the equations of the corresponding reactions.

- recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Qualitative analysis. Methods of performing analytical reactions. 2. Qualitative analysis of anions of the II analytical group. Group reagents. 3. Qualitative analysis of anions of analytical group III.	Qualitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including for registration: the laboratory work registration form is attached
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1.When anions were detected in the solution by the fractional method, a reaction with a flame retardant was carried out - an emerald-green color of the solution appeared. What anion caused this analytical effect?

A. nitrite ion

B. chromate ion

C. nitrate ion

D. bromide ion

E. iodide is an ion

2. Chloroform and chlorine water were added drop by drop to the investigated solution. The chloroform layer turned yellow - a hot color. This indicates the presence in the solution:

A. Bromide - ions

B. Sulfite - ions

C. Sulfate - ions

D. Nitrate - ions

E. Iodide - ions

3.Diphenylamine was added to the test solution to determine nitrate anions. What analytical effect is observed in this case:

A. The solution is blue

B. The precipitate is yellow

C. The precipitate is blue

D. Release of brown gas

E. The appearance of a characteristic smell

4.The studied solution of the medicinal substance contains iodide, bromide, chloride and sulfide anions. What reagent is group for these anions (the second analytical group of anions)?

A. Argentum nitrate in 2M nitric acid.

B. Barium chloride.

C. Barium nitrate.

D. There is no group reagent

E. Argentum nitrate in a neutral medium.

5. Cl- and Br- anions are present in the solution. Name the reagent for detecting Br-:

A. chlorine water

B. bromine water

C. gypsum water

D. lime water

E. barite water

6. Chloroform and chlorine water were added dropwise to the analyzed solution. The chloroform layer turned orange. This indicates the presence in the solution:

A. bromide - ions

B. iodide - ions

C. sulfite - ions

D. sulfate - ions

E. nitrate - ions

7. Chloroform and sodium nitrite solution were added to the acidified analyzed solution. The chloroform layer turned red-violet, which indicates the presence in the solution:

A. iodide - ions

B. carbonate - ions

C. chloride - ions

D. sulfate - ions

E. fluoride - ions

8. A solution of silver nitrate was added to the solution containing anions of the second analytical group. A black precipitate formed, insoluble in ammonia solution, but soluble when heated in dilute nitric acid. What anions are present in the solution:

A. sulfide - ions

B. iodide ions

C. chloride - ions

D. bromide - ions

E. arsenites are ions

9. A solution of silver nitrate was added to the solution containing anions of the second analytical group. A pale yellow precipitate was formed, insoluble in nitric acid and partially soluble in ammonia solution. What anions are present in the solution:

A. bromide - ions

B. iodide ions

C. chloride - ions

D. sulfide - ions

E. arsenites are ions

4. Summing up:

As a result of the lesson, the student familiarized himself with and summarized information about anions of the II-III analytical group and analytical reactions.

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 21

Topic: Solving tasks on the topic "Redox equilibrium in analytical chemistry".

Goal: Summarize knowledge about the basic regularities of redox reactions, the equilibrium constant of the redox process. Get acquainted with methods of determining the direction of redox reactions and the influence of various factors on it.

Basic concepts:analysis, redox reaction, oxidizer, reducing agent, oxidation process, reduction, standard redox potential, real redox potential

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)

– requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

The student should know:

- ✓ basic rules for working with acids and alkalis;
- ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
- ✓ principles and methods of qualitative analysis, classification of analysis methods;
- ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
- ✓ the concept of fractional and systematic analysis, the difference between one and the other;
- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of

performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;

- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. What is a redox reaction?
2. Define the terms "oxidizing agent", "reducing agent", "oxidation", "reduction"
3. The Nernst equation. Factors affecting the redox potential of the system.
4. How to determine the direction of the redox reaction? How to determine the completeness of the course of the reaction?

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1. In which direction will the reaction between PbO_2 and KI go in an acidic environment if the concentration of all substances is 1 mol/l. $E^0{}_{PbO_2/Pb^{2+}} = 1{,}68\,V$, $E^0{}_{I_2/2I^-} = 0{,}53\,V$?

2. Calculate the electrode potential of the system at pH = 0.1:

$$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O.$$

3. Factors affecting the flow of redox reactions. Show their influence with an example reaction:

$$MnO_4^- + H_2C_2O_4 + H^+ \rightarrow$$

4. Determine the direction and completeness of the reaction

$$2Fe^{3+} + Sn^{2+} \rightarrow 2Fe^{2+} + Sn(IV),$$

if $E^0{}_{Fe^{3+}/Fe^{2+}} = 0{,}77\,V$, a $E^0{}_{Sn(IV)/Sn^{2+}} = 0{,}15\,V$

5. Determine the direction and completeness of the reaction between pairs MnO_4^-/Mn^{2+} (Eo=1.51*V*) and $Cr_2O_7^{2-}/2Cr^{3+}$ (Eo=1.31*V*) at pH = 1 and pH = 7.

- recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Redox equilibria	Redox equilibria	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including to registration: solving problems in a workbook.
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1. Determine the direction and completeness of the reaction between pairs MnO_4^-/Mn^{2+} and Cl_2/Cl^- (Eo=1.36*V*) at pH=0 and pH=8.

2. In which direction is the equilibrium of the $Ni^{2+} + Fe \leftrightarrow Ni + Fe^{2+}$ process shifted according to the state of the art? Specify the order of the numerical value of the equilibrium constant.($E^0(Ni^{2+}/Ni^o)$= -0.25 V, $E^0(Fe^{2+}/Fe)$= - 0.44 V)

3. Standard electrode potential of a redox pair. Write the reaction equation: $Cr_2O_7^{2-}+I^-+H^+$ —> and calculate the potential of the redox pair $Cr_2O_7^{2-}/ 2Cr^{3+}$ if the equilibrium concentration $[Cr_2O_7^{2-}]$= 0.01 mol/dm^3, and $[Cr^{3+}]$ =0.1 mol/dm^3 , at pH=2 and t=25C°.

4. Summing up:

As a result of the lesson, the student summarized his knowledge of the basic patterns of redox reactions, the equilibrium constant of the redox process, and familiarized himself with the methods of determining the direction of redox reactions and the influence of various factors on it.

5. List of recommended literature:

Main:

1. 1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 22

Topic: Analytical reactions of anions of the III analytical group, the conditions for their performance.

Goal: Familiarize yourself with group reagents used in the analysis of anions. Familiarize yourself with and summarize information about anions of analytical group III and analytical reactions.

Basic concepts:analysis, qualitative analysis, group reagent, specific reagent, group of anions

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
     - ✓ principles and methods of qualitative analysis, classification of analysis methods;
     - ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
     - ✓ the concept of fractional and systematic analysis, the difference between one and the other;
     - ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution,

detection limit (detection minimum);

- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. What anions belong to the III analytical group? Why does this group lack a group reagent?

2. Qualitative reactions to nitrate and nitrite anions. What reactions will give the same analytical effect?
3. Qualitative reactions to acetate anion.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1.A solution of iron (III) chloride was added to the solution containing the anion of the 3rd group (classification is based on the solubility of barium and silver salts). The formation of a red-brown precipitate is observed. What anion is present in the solution? Write the equation for the corresponding reaction.

2. A solution of potassium iodide was added to a solution acidified with sulfuric acid containing an anion of the 3rd group (classification is based on the solubility of barium and silver salts). Release of free iodine is observed. What anion is present in the solution? Write the equation for the corresponding reaction.

- recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Qualitative analysis. Methods of performing analytical reactions. 2. Qualitative analysis of anions of analytical group III.	Qualitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

– requirements for work results, including before registration: to be able to draw up a scheme for the analysis of a mixture of cations of the 3rd analytical group.

– control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1.Diphenylamine was added to the test solution to determine nitrate anions. What analytical effect is observed in this case:

A. The solution is blue

B. The precipitate is yellow

C. The precipitate is blue

D. Release of brown gas

E. The appearance of a characteristic smell

2.When anions were detected in the solution by the fractional method, a reaction with a flame retardant was carried out - an emerald-green color of the solution appeared. What anion caused this analytical effect?

A. nitrite ion

B. chromate ion

C. nitrate ion

D. bromide ion

E. iodide is an ion

3. Chloroform and sodium nitrite solution were added to the acidified analyzed solution. The chloroform layer turned red-violet, which indicates the presence in the solution:

A. iodide - ions

B. carbonate - ions

C. chloride - ions

D. sulfate - ions

E. fluoride - ions

4. To a solution of FeSO4 in the presence of H_2SO_4 conc. the test solution was added. The formation of a brown ring indicates the presence in the solution:

A. nitrate - ions

B. acetate - ions

C. carbonate - ions

D. oxalate - ions

E. phosphate - ions

5. A solution of potassium iodide was added to a solution acidified with sulfuric acid containing anions of the third analytical group. Release of free iodine is observed. What anions are present in the solution?

A. nitrite - ions

B. carbonate - ions

C. sulfate - ions

D. bromide - ions

E. acetate - ions

6. Which anions with iron (II) salts form a brown ring in the presence of concentrated sulfuric acid?

A. nitrate - ions

B. acetate - ions

C. bromate - ions

D. citrate - ions

E. thiocyanate - ions

4. Summing up:

As a result of the lesson, the student familiarized himself with and summarized information about anions of the III analytical group and analytical reactions.

5. List of recommended literature:

Main:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] /

I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p

Practical lesson No. 23

Topic: Laboratory work: Qualitative reactions of anions of the III analytical group.

Goal: Familiarize yourself with group reagents used in the analysis of anions. Familiarize yourself with and summarize information about anions of analytical group III and analytical reactions.

Basic concepts:analysis, qualitative analysis, group reagent, specific reagent, group of anions

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
     - ✓ principles and methods of qualitative analysis, classification of analysis methods;
     - ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
     - ✓ the concept of fractional and systematic analysis, the difference between one and the other;

- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. Specify the anions of the III analytical group. Why does this group lack a group reagent?
2. Qualitative reactions to nitrate and nitrite anions. What reactions will give the same analytical effect?
3. Specify the conditions for the "brown ring" reaction.
4. Conditions for the reaction of nitrite ions with fire retardant.
5. Qualitative reactions to acetate anion.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1.A solution of iron (III) chloride was added to the solution containing the anion of the 3rd group (classification is based on the solubility of barium and silver salts). The formation of a red-brown precipitate is observed. What anion is present in the solution? Write the equation for the corresponding reaction.

2. A solution of potassium iodide was added to a solution acidified with sulfuric acid containing an anion of the 3rd group (classification is based on the solubility of barium and silver salts). Release of free iodine is observed. What anion is present in the solution? Write the equation for the corresponding reaction.

- recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Qualitative analysis. Methods of performing analytical reactions. 2. Qualitative reactions of nitrate ions. 3. Qualitative reactions of nitrite ions. 4. Qualitative reactions of acetate ions.	Qualitative analysis	Analytical chemistry: teaching. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

– requirements for work results, including for registration: the laboratory work registration form is attached

– control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

4. Summing up:

As a result of the lesson, the student familiarized himself with and summarized information about anions of the III analytical group and analytical reactions.

5.List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p

Practical lesson No. 24

Topic: Solving tasks on the topic "Equilibrium in complexation reactions".

Goal: Familiarize and summarize information about the structure of complexes, their dissociation, stability and instability constants

Basic concepts:complex compound, outer and inner sphere, ligand, instability constant

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)

– requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

The student should know:

- ✓ basic rules for working with acids and alkalis;
- ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
- ✓ principles and methods of qualitative analysis, classification of analysis methods;
- ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
- ✓ the concept of fractional and systematic analysis, the difference between one and the other;
- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out

qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;

- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. Structure of complexes
2. What quantitative characteristics are used for complex compounds.
3. Why are complex compounds used in chemical analysis? Give examples

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1.Calculate the equilibrium concentrations of ions in a 0.05 M solution of $K_2[HgI_4]$.

2. Calculate the concentration of each of the ions in a 1 M solution of $[Ni(NH_3)_4]C1_2$.

3. Calculate $[Cu^{2+}]$ and $[NH_3]$ in a 1 M solution of $[Cu(NH_3)_4]SO_4$.

4. Calculate $[Al^{3+}]$ and $[OH^-]$ in a 0.1 M solution of $Na[A1(OH)_4]$.

– recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Complex compounds. Building The instability constant. Calculations	Equilibria in solutions of complex compounds	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including for registration: the laboratory work registration form is attached.
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1.Calculate the equilibrium concentrations of ions in a 0.1 M solution of $K_2[HgI_4]$.

2. Calculate the concentration of each of the ions in a $3 \cdot 10^{-4}$ M solution of $[Ni(NH_3)_4]SO_4$.

3. Calculate $[Cu^{2+}]$ and $[Cl^-]$ in a 0.2M solution of $K_2[CuCl_4]$.

4. Calculate $[Al^{3+}]$ and $[OH^-]$ in a 0.1 M solution of $Na_3[A1(OH)_6]$.

4. Summing up:

As a result of the lesson, the student got acquainted with information about the structure of complexes, their dissociation, and the instability constant

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of

medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.
4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 25

Topic: ***Control work*** on the theory and practice of analysis of anions of groups I-III..

Goal: Summarize information on the analysis of a mixture of anions of analytical groups I-III

Basic concepts:analysis, qualitative analysis, group reagent, specific reagent, group of anions

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
     - ✓ principles and methods of qualitative analysis, classification of analysis methods;
     - ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group

reagent), methods of qualitative reactions;

- ✓ the concept of fractional and systematic analysis, the difference between one and the other;
- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. I-III analytical groups of anions. Group reagents.
2. List the anions of analytical group I. What is a bulk reagent?
3. List the anions of II analytical group. What is a bulk reagent?
4. List the anions of the III analytical group. What is a bulk reagent?

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1.To the solution containing the anions of the 2nd and 3rd groups (classification is based on the solubility of barium and silver salts), 2-3 cr. sulfuric acid solution and 2-3 drops of diluted potassium permanganate solution. The solution became discolored. What anions does this analytical effect indicate? Write the equations of the corresponding reactions.

2. Suggest the course of analysis of a solution containing sulfite and carbonate ions (classification is based on the solubility of barium and silver salts). Write the equations of the corresponding reactions.

3. Propose a diagram of the course of the analysis and write the reaction equations for the opening of the following anions: SO42-, PO43-, SO32- (classification is based on the solubility of barium and silver salts).

4. Propose a diagram of the course of the analysis and write the reaction equations for the opening of the following anions: S2O32-, CO32-, SO32- (classification is based on the solubility of barium and silver salts).

5. Propose a diagram of the course of the analysis and write the reaction equations for the opening of the following anions: CO32-, S2O32-, SO32- (classification is based on the solubility of barium and silver salts).

– recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Qualitative analysis of a mixture of anions.	Qualitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu.

		Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including for registration: the laboratory work registration form is attached
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

Suggest a course of analysis of a mixture of anions (classification is based on the solubility of barium and silver salts). Write the equations of the corresponding reactions, indicate the conditions for their performance, analytical effects, interfering ions.

1. PO_4^{3-}, AsO_4^{3-}, Cl^-.
2. CrO_4^{2-}, $C_2O_4^{2-}$, NO_3^-.
3. Cl^-, I^-, Br^-
4. $C_2O_4^{2-}$, SO_4^{2-}.
5. CO_3^{2-}, SO_3^{2-}, $S_2O_3^{2-}$, S^{2-}.
6. NO_3^-, NO_2^-, AsO_4^{3-}.
7. CH_3COO^-, $C_2O_4^{2-}$.
8. CrO_4^{2-}, NO_3^-, PO_4^{3-}.

4. Summing up:

As a result of the lesson, the student summarized information about the analysis of a mixture of anions of analytical groups I-III

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A.

E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.
3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.
4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 26

Topic: The essence and tasks of quantitative analysis. Classification of methods of quantitative analysis. Errors in quantitative analysis. Correctness, reproducibility and accuracy of the analysis. Equipment and technique for performing basic operations in quantitative analysis. Scales and weighing technique.

Goal: Get acquainted with the essence, tasks and classification of methods of quantitative analysis. Familiarize yourself with and summarize information about the statistical processing of the results of quantitative analysis.

Basic concepts:analysis, quantitative analysis, chemical methods of analysis, physical methods of analysis, physicochemical methods of analysis, reproducibility, convergence, reliability, sensitivity, confidence interval, Student's criterion, detection limit, detection limit.

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)

– requirements for theoretical readiness of students to perform practical

classes (knowledge requirements, list of didactic units)

The student should know:

- ✓ basic rules for working with acids and alkalis;
- ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
- ✓ principles and methods of qualitative analysis, classification of analysis methods;
- ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
- ✓ the concept of fractional and systematic analysis, the difference between one and the other;
- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific

reactions and their analytical effects, draw up report documentation based on experimental data;

- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. What is quantitative analysis? What is it used for in analytical chemistry?
2. Classification of methods of quantitative analysis. Give a brief description of the methods (chemical, physical, physico-chemical).
3. Classification of chemical methods of analysis (gravimetry and titrimetry). A brief description of the above methods.
4. Classification of errors in quantitative analysis and their causes.
5. Statistical data processing. Metrological characteristics – reproducibility, convergence, sensitivity.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1.Accuracy and reproducibility of analysis results. When determining nickel in steel by weight, the following results were obtained in percent: 4.63, 4.66, 4.67, 4.68, 4.75. Calculate the confidence interval.

2. During acid titration of the same volume of alkali, the following volumes of acid were consumed (cm3): 15.26; 15,18; 15,22; 15.36; 15.43; 15.43. Calculate statistical data with reliability P = 0.95.

3. During the analysis of copper ore, the following data on the copper content in percent were obtained: 38.71, 38.62, 38.74, 38.90. Calculate the mean squared error and confidence interval at P=0.95.

4. A substance containing 10.00% of the element under study was analyzed by two methods, the following results were obtained in percentages:

1 method: 9.76, 9.97, 10.09, 10.23, 9.87, 9.97;

2 method: 10.06, 10.27, 10.42, 9.95, 10.37, 10.17.

To characterize the accuracy and correctness of the methods. To draw a conclusion about the presence of a systematic error (P=0.95).

- recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Quantitative analysis. Subject and tasks of quantitative analysis. 2. Quantitative analysis. Classification of methods of quantitative analysis. 3. Statistical analysis of the results of a chemical experiment.	Quantitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including to registration: solving problems in a workbook
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1.In the case of photometric determination of chromium in steel (chromium content 2.85%), the results in percent were obtained: 2.80, 2.81, 2.85, 2.90, 2.93. Characterize the correctness of the method and draw a conclusion about the presence or absence of a systematic error.

2. Electrochemical analysis of tin ore for tin content yielded the following percentage results: 0.14, 0.18, 0.16, 0.21, 0.19. Calculate the boundaries of the average result.

3. Setting the titer of HC1 by borax gave the following values of the normality of this acid: 0.1706, 0.1705, 0.1708, 0.1706, 0.1707, 0.1705, 0.1712. Calculate the mean deviation and mean squared error of one titration.

4. Reproducibility of analysis results.Atdetermination of oxalic acid by the method of permanganatometry (1) and by the method of acid-base titration (2) yielded the following results in percentages:

1) 99.04; 99.07; 99.23; 99.25; 99.36;

2) 99.18; 99.20; 99.23; 99.24; 99.26.

To characterize the accuracy and correctness of the methods. To draw a conclusion about the presence of a systematic error (P=0.95).

5. When iodometric determination of active chlorine in bleaching lime (which contains 32.05% of active chlorine) using chemical dishes without grinding, the following results were obtained, %: 30.94; 31.19; 31.20; 31,22; 31,35. Indicate the presence or absence of a systematic error. If it is, calculate its value.

6. When determining ascorbic acid by iodochlorimetric (I) and bromatometric (II) methods, the following results were obtained, %:

I. 99.00; 99.15; 99.20; 99.38; 99.39

II. 98.98; 99.03; 99.13; 99.15; 99.32.

Give an estimate of the reproducibility of the two methods of analysis ((P=0.95 for both methods).

4. Summing up:

As a result of the lesson, the student got acquainted with the rules for choosing substances for a specific case of chromatographic determination; learned how to calculate the concentration of substances using the chromatography method on paper; to quantitatively determine substances used in pharmacy by the method of chromatography on paper.

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.
3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.
4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 27

Topic: Gravimetric analysis. Application of gravimetry for the analysis of medicinal substances.

Goal: Get acquainted with gravimetric analysis, classification of gravimetric methods and learn how to apply these methods in the analysis of chemical substances, learn how to calculate work results.

Basic concepts:analysis, quantitative analysis, gravimetric analysis, distillation, precipitation, occlusion, coprecipitation

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:

- ✓ basic rules for working with acids and alkalis;
- ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
- ✓ principles and methods of qualitative analysis, classification of analysis methods;
- ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
- ✓ the concept of fractional and systematic analysis, the difference between one and the other;
- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;

- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. The essence of the gravimetric method of analysis. Value of gravimetric analysis methods for medicine, pharmacy and industry.

2. Classification of gravimetric analysis methods.

3. Conditions for obtaining crystalline and amorphous sediments.

4. Precipitated form. Requirement to the precipitated form.

5. Gravimetric form. Requirements for gravimetric form.

6. Weighing technique on analytical scales.

7. The formula for calculating the gravimetric (analytical) factor.

8. Assessment of accuracy of results, absolute and relative errors. Expression of measurement results in significant numbers.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1.Calculate the percentage of hygroscopic moisture in kaolin, if the weight of the substance is 0.5037 g after calcination is reduced to 0.4528 g.

2. What volume of 10% H_2SO_4 solution should be taken for almost complete precipitation of Sr from a weight of the analyzed substance of 0.6327 g of $SrCl_2$?

3. What volume of 3.9% $AgNO_3$ solution should be taken for almost complete precipitation of Cl from a weight of 1.5495 g of sylvinite containing 53.2% Cl?

– recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers

1. Gravimetric analysis (gravimetry) 2. Distillation method 3. Deposition method 4. Selection method	Quantitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including before registration: write calculation tasks in a notebook.
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1.What volume of a 3.2% $(NH_4)_2C_2O_4$ solution should be taken for almost complete precipitation of Ca from a weight of 0.3542 g of CaO

2. Calculate the mass fraction (%) of Fe in Mohr's salt, if a weight of 6.5648 g was taken for analysis, which was dissolved in a volumetric flask with a capacity of 500 ml, and from an aliquot of 40 ml, 0.0811 g of gravimetric form was obtained

4. Summing up:

As a result of the lesson, the student got acquainted with gravimetric analysis, classification of gravimetric methods and learned to apply these methods in the analysis of chemical substances and calculate work results.

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of

medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.
4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 28

Topic: ***Laboratory work***: Determination of crystallization water in $BaCl_2 \cdot nH_2O$.

Goal: To master the method of quantitative determination of the content of crystallization water in $BaCl_2 \cdot nH_2O$ by the gravimetric method.

Basic concepts:analysis, quantitative analysis, gravimetric analysis, distillation, precipitation, occlusion, coprecipitation

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
     - ✓ principles and methods of qualitative analysis, classification of analysis methods;
     - ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;

- ✓ the concept of fractional and systematic analysis, the difference between one and the other;
- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on

the subject of the lesson.

1. The essence of the gravimetric method of analysis. Value of gravimetric analysis methods for medicine, pharmacy and industry.

2. Classification of gravimetric analysis methods.

3. Conditions for obtaining crystalline and amorphous sediments.

4. Precipitated form. Requirement to the precipitated form.

5. Gravimetric form. Requirements for gravimetric form.

6. Weighing technique on analytical scales.

7. The formula for calculating the gravimetric (analytical) factor.

8. Assessment of accuracy of results, absolute and relative errors. Expression of measurement results in significant numbers.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1.Calculate the percentage of hygroscopic moisture in kaolin, if the weight of the substance of 1.5037 g after calcination is reduced to 0.9834 g.

2. Calculate the mass fraction (%) of Mg in the alloy, if a weight of 5.2160 g was taken for analysis, which was dissolved in a volumetric flask with a capacity of 250 ml, and from an aliquot of 50 ml, 0.1218 g of the gravimetric form of $Mg_2P_2O_7$ was obtained

3. Calculate the mass fraction (%) of Al in limestone, if 4.9600 g of weight was taken for analysis, which was dissolved in a measuring flask with a capacity of 250 ml, and 0.0180 g of the gravimetric form of Al_2O_3 was obtained from an aliquot of 50 ml.

– recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Gravimetric analysis (gravimetry) 2. Distillation method	Quantitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V.

3. Deposition method 4. Selection method		Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.—Kharkiv: NUPh; Original, 2012.

- requirements for work results, including to registration: the test registration form is attached
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1.The gravimetric method was used to determine the mass fraction of aluminum in the medicinal product. A solution of ammonium hydroxide was used as a precipitant. The gravimetric form in this case is:

A. aluminum oxide
B. aluminum hydroxide
C. ammonium chloride
D. ammonium nitrate
E. aluminum carbonate

2.Gravimetric determination of moisture in pharmaceutical preparations is carried out by the method:

A. indirect distillation
B. selection
C. sedimentation
D. direct distillation
E. selection and indirect distillation

3.Analysis of sodium sulfate crystal hydrate was performed by the gravimetric method, precipitating sulfate ions with a barium chloride solution. After ripening, the barium sulfate precipitate is washed by decantation using as a washing liquid:

A. Dilute solution of sulfuric acid
B. Distilled water
C. Barium chloride solution
D. Sodium sulfate solution
E. Ammonium sulfate solution

4.For the gravimetric determination of sulfate ions, a solution is used as a precipitant:

A. barium chloride
B. magnesium chloride
C. zinc chloride
D. silver nitrate
E. iron (II) chloride

5.In the case of gravimetric determination of the mass fraction of sulfate ions in the magnesium sulfate drug, precipitation is carried out with a barium chloride solution. The precipitated form of barium sulfate should be washed:

A. A dilute solution of sulfuric acid
B. Distilled water
C. Barium chloride solution
D. Sodium sulfate solution
E. Hydrochloric acid solution

6.The gravimetric precipitation method was used to determine the mass fraction of calcium in the drug. A solution of ammonium oxalate was used as a precipitant. The gravimetric form in this case is:

A. calcium oxide
B. calcium oxalate anhydrous
C. calcium oxalate monohydrate
D. calcium carbonate
E. calcium hydroxide

7.Indicate which precipitating reagent is advisable to use in the gravimetric determination of calcium salts:

A. $(NH_4)_2C_2O_4$
B. $K_2C_2O_4$
C. $Na_2C_2O_4$
D. Na_2CO_3
E. K_2CO_3

8.The quantitative characteristic of the solubility of sparingly soluble electrolytes (such as AgCl or $BaSO_4$) is a constant called:

A. The solubility product
B. The instability constant
C. Ionization constant
D. Stability constant
E. Acidity constant

4. Summing up:

As a result of the lesson, the student got acquainted with gravimetric analysis, classification of gravimetric methods and learned to apply these methods in the analysis of chemical substances and calculate work results.

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 29

Topic: Introduction to titrimetric analysis. Weighing technique on analytical scales. Measuring glassware. Checking the capacity of measuring glassware.

Goal: Familiarize yourself with titrimetric analysis, classification of titrimetric methods and learn how to apply these methods in the analysis of chemical substances, calculate work results. Familiarize yourself with the technique of conducting the analysis, the measuring utensils that are used.).

Basic concepts:analysis, quantitative analysis, thyrimetric analysis, titrant, molar concentration, normal concentration, titer, titer by substance to be determined, equivalence point, end point of titration, indicator, titration curve

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
     - ✓ principles and methods of qualitative analysis, classification of analysis methods;
     - ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
     - ✓ the concept of fractional and systematic analysis, the difference between one and the other;

- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. The essence of the titrimetric method of analysis. Importance of thyrimetric analysis methods for medicine, pharmacy and industry.

2. Classification of titrimetric analysis methods.

3. Requirements for reactions used in titrimetry.

4. Titration accuracy, indicator titration index and equivalence point; change in concentrations of reactants near the equivalence point.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1.The essence and classification of titrimetric methods of analysis (by type of chemical reaction, by titrant)

2.Requirements for reactions in titrimetric methods of analysis.

3.Methods of titration: direct, reverse, substitute.

4.Distillation methods: individual measurements, aliquots.

5.Measuring cup

- recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Titrimetric analysis. General characteristics. 2. Methods of titration. 3. Shooting methods 4. Measuring cup	Quantitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

– requirements for work results, including before registration: answers to tests.

– control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1. Various titration methods are used in titrimetric analysis. If there is a choice, which method should be used to get a more accurate result?

A. Direct titration

B. Back titration
C. Substitute titration
D. Reverse titration
E. Combined titration

2. Indicate the method of titration, in which a standard titrant solution is gradually added to the investigated solution of substances until the end point of the titration is established:

A. Direct titration
B. Back titration
C. Substitute titration
D. Reverse titration
E. Combined titration

3. Choose a suitable method if the substance reacts with the titrant quickly, but not stoichiometrically:

A. Direct titration method
B. The method of reverse titration
C. Substitute titration method
D. Titration with instrumental fixation of the equivalence point
E. The method of separate overhangs

4. Choose the appropriate method if the substance reacts with the titrant stoichiometrically, but slowly:

A. Direct titration method
B. The method of reverse titration
C. Substitute titration method
D. Titration with instrumental fixation of the equivalence point
E. The method of individual measurements

5. What titration method is used to determine the concentration of volatile compounds (CH_3COOH, H_2S)

A. Direct titration
B. Surrogate titration

C. Reversible titration

D. Combined titration

E. Back titration

6. Choose the appropriate titration method if the substance to be determined is volatile:

A. Direct titration method

B. The method of reverse titration

C. Substitute titration method

D. Titration with instrumental fixation of the equivalence point

E. The method of individual measurements

4. Summing up:

As a result of the class, the student got acquainted with titrimetric analysis, classification of titrimetric methods and learned to apply these methods in the analysis of chemical substances, to calculate work results. I got acquainted with the technique of conducting the analysis, the measuring utensils that are used. Mastered the methods of calculations and preparation of working solutions (titrants).

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 30

Topic: Titrant preparation. Primary and secondary standards. Calculations during their preparation.

Goal: Familiarize yourself with titrimetric analysis, classification of titrimetric methods and learn how to apply these methods in the analysis of chemical substances, calculate work results. Master the methods of calculations and preparation of working solutions (titrants).

Basic concepts:analysis, quantitative analysis, thyrimetric analysis, titrant, molar concentration, normal concentration, titer, titer by substance to be determined, equivalence point, end point of titration, indicator, titration curve

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
     - ✓ principles and methods of qualitative analysis, classification of analysis methods;
     - ✓ analytical characteristics of substances, analytical reactions,

requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;

- ✓ the concept of fractional and systematic analysis, the difference between one and the other;
- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text

- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. The essence and tasks of quantitative analysis. Fields of application of quantitative analysis.

2. Classification of methods of quantitative analysis.

3. The essence of titrimetric methods of analysis. Basic concepts.

4. Classification of methods of titrimetric analysis according to the type of chemical reaction.

5. Measurement of volumes. Measuring cup. Checking the capacity of measuring dishes.

6. Titrated solutions. Methods of their preparation. Primary and secondary standards. Requirements for primary standards. Methods of expressing the concentration of titrated solutions.

7. Calculations in titrimetric analysis. Expression of measurement results

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1. Standard substances and requirements for them.
2. What are the methods of making standard solutions?
3. Rules for choosing an indicator based on reaction products and titration curves. Explain the answer.
4. Write how to prepare standard solutions of borax, hydrochloric acid, sodium hydroxide and how to store them?
5. What are fixanals, standard samples (normal) and what are they used for?

- recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Titrimetric analysis. General characteristics. 2. Ways of expressing	Quantitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T.

concentration 3. Primary and secondary standards		V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including before registration: solving problems in the workbook
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1. What a dare NaOH, which contains 6% of indifferent impurities, should be taken for preparation: a) 1,l of solution T(*NaOH) =0.0050 g/cm*^{3}; b) 500*cm*^{3} 0.15 M solutionNaOH; c) 1.2 l of solution with T(*NaOH/CaO) = 0.0035 g/cm*^{3}.

2. Calculate the titer of 0.1 n. of HCl solution for each of the substances: a) HCl; b) NaOH; c) Na_2CO_3.

3. In a volumetric flask with a capacity of 500.0 cm^3, a solution of 2.5000 g of Na_2CO_3 was prepared. Calculate for its solution: a) molar concentration, b) normal concentration, c) titer, d) titer by HCl.

4. To what volume should 150 cm^3 of 1.24 N HCl solution be diluted to obtain a 0.100 N solution of this acid?

4. Summing up:

As a result of the class, the student got acquainted with titrimetric analysis, classification of titrimetric methods and learned to apply these methods in the analysis of chemical substances, to calculate work results. I got acquainted with the technique of conducting the analysis, the measuring utensils that are used. Mastered the methods of calculations and preparation of working solutions (titrants).

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.
3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.
4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 31

Topic: Acid-base titration. Titration of strong acids and strong bases.

Goal: Get acquainted with the theoretical and practical principles of the neutralization method (acid-base titration), summarize information about the titrants and indicators of the method, the method of choosing an indicator (graphical and calculated).

Basic concepts:analysis, quantitative analysis, titrimetric analysis, neutralization method, indicator, hydrogen indicator (pH), primary standard, secondary standard, equivalence point, titration end point (TTP)

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

The student should know:

- ✓ basic rules for working with acids and alkalis;
- ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
- ✓ principles and methods of qualitative analysis, classification of analysis methods;
- ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
- ✓ the concept of fractional and systematic analysis, the difference between one and the other;
- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation

based on experimental data;

- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. What reactions are the basis of the acid-base titration method?

2. What is the essence of acid and alkalimetry?

3. What substances can be determined by acid-base titration?

4. In what direction do acid-base reactions take place. At what value of the equilibrium constant do the reactions go to the end?

5. What is the basis for fixing the end point of the titration?

6. Theory of acid-base indicators. Ionic, chromoform and ion-chromophoric theories explaining the nature of the color change of indicators. What is the transition interval of the acid-base indicator titration indicator pT?

7. What are the methods of selecting indicators for fixing the end point of the titration?

8. Titration curves. How to calculate the pH value for building a titration curve of a strong acid with a strong base and vice versa. What do such titration curves look like?

9. What is a jump titration? How are pH indicators selected after a titration jump?

10. How are acid and alkali solutions prepared? What substances are used as primary standards?

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1. Calculate and plot a titration curve of 0.1 N hydrochloric acid solution. sodium hydroxide solution.

2. Calculate and plot the titration curve of 50.00 cm^3 0.05 M hydrochloric acid solution 0.1 M sodium hydroxide solution.

3. Calculate and plot a titration curve of 0.1 n. benzoic acid solution 0.1 N sodium hydroxide solution. pK (C_6H_5COOH = 4.20).

- recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Quantitative analysis. Titrimetric analysis 2. Acid-base titration 3. Selection of the indicator	Quantitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including before registration: solving test and calculation tasks in a notebook.
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1.The titrants of the neutralization method are standard solutions of acids and bases, which are secondary standard solutions. Select the substance by which the hydrochloric acid solution is standardized:

A.Na_2CO_3

B.$H_2C_2O_4$

C.$CaCO_3$

D.HNO_3

E.$Na_2S_2O_3$

2.Reverse acid-base titration is used to determine substances:

A.NH_3

B.H_2SO_4

C.NaOH

D.HI

E.KOH

3.In titrimetry, the titer of the titrant for the substance to be determined is often used for calculations. What does the titer for the substance to be determined indicate?

A.per mass of the substance to be determined, which corresponds to 1 ml of the titrant solution

B.per mass of the substance to be determined, which corresponds to 1 g of titrant solution

C.per mass of the titrant substance, which corresponds to 1 g of the substance to be determined

D.per mass of the titrant substance, which corresponds to 1 ml of the solution of the substance to be determined

E.per mass of titrant corresponding to 1 ml of the substance to be determined

4.Specify which characteristic in titrimetric methods of analysis is used when choosing an indicator:

A.Transition interval

B.Indicator constant

C.Jump titration

D.Titration index

E.Neutralization point

5.Titration curves are a graphical dependence of the pH of the solution on the volume of the working solution (acid-base titration). State what titration curves are used for in titrimetric analysis.

A.Correct choice of indicator during titration

B.Theoretical treatment of titration

C.Setting the end of the titration

D.Illustrating the equivalence point

E.Illustration of the point of neutrality

6.Which titration method should be used if the determined substance is volatile (for example, H_2S in hydrogen sulfide mineral waters):

A.Back titration (residual titration)

B.Direct titration

C.Substituent titration

D.Combination of forward and reverse titration

E.Combination of direct titration with surrogate titration

7.In which dish should you dissolve a measuring scale to prepare a solution of the exact concentration?

A.In a measuring flask.

B.In a cylinder

C.In a measuring cup

D.In a beaker

E.In a test tube

8.Specify the type of chemical reaction during the titration of acetic acid with sodium hydroxide solution.

A.Acid-base

B.Oxidation-reduction

C.Electrophilic substitution

D.Sedimentation

E.Complex formation

9.Indicators are used to determine the end point of the titration in the acid-base titration method:

A.pH indicators

B.redox indicators

C.adsorption indicators

D.metal indicators

E.fluorescent indicators

10.A primary standard solution was prepared from a portion of borax $Na_2B_4O_7 \cdot 10H_2O$. In which method and for the standardization of which substance can it be used?

A.Acid-base titration, HCl

B.Oxidation-reduction titration, $KMnO_4$

C.Precipitation titration, $AgNO_3$

D.Complexometric titration, trilon B

E.Acid-base titration, NaOH

11. The phenolphthalein indicator is often used in titrimetric analysis. Specify the titration method in which it is used?

A.Acid-base titration

B.Redox titration

C.Precipitation titration

D.Complexometric titration

E.Permanganatometry method

4. Summing up:

As a result of the lesson, the student got acquainted with the theoretical and practical principles of the neutralization method (acid-base titration), summarized information about the titrants and indicators of the method, the method of indicator selection (graphical and calculated).

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of

medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.
4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 32

Topic: Acid-base titration. Acidimetry. ***Laboratory work:*** "Standardization of HCl solution according to primary standards."

Goal: Get acquainted with the theoretical and practical principles of the acidimetry method, summarize information about the titrants and indicators of the method, the method of indicator selection (graphical and calculated).

Basic concepts:analysis, quantitative analysis, titrimetric analysis, neutralization method, indicator, hydrogen indicator (pH), primary standard, secondary standard, equivalence point, titration end point (TTP)

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
     - ✓ principles and methods of qualitative analysis, classification of analysis methods;

- ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
- ✓ the concept of fractional and systematic analysis, the difference between one and the other;
- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. What is "titrimetric analysis", "titration", "titrant", "equivalence point", "end point of titration"?

2. Ways of expressing the concentration of solutions used in titrimetric analysis? Formulas for calculation, units of measurement.

3. List the dishes used in the titration process.

4. Classification of titration methods according to the type of chemical reaction taking place

5. Acid-base titration. What is the underlying reaction. What methods of acid-base titration (KOT) are distinguished depending on the titrant.

6. Primary and secondary standard solutions. Conditions for assigning solutions to primary standards.

7. Titrants and primary standards for acidimetry.

8. Indicators used in acidimetry.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1. Up to 20 ml0.1M10 ml of NaOH solution was added0.1Mof HCl solution. Calculate the pH of the resulting solution.

2. Determine the molar mass of Na_3PO_4 equivalent during titration with standard HCl solution with methyl orange indicator;

3. Determine the molar concentration of the equivalent of the titrated Na_3PO_4 solution, if 300 ml of 0.1 M HCl solution were needed to titrate 100 ml of this solution.

4. Determine the titer of the HCl solution by KOH, if it is known that 25.00 ml of it can interact with 0.4290 g of sodium tetraborate decahydrate

- recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Quantitative analysis. Titrimetric analysis 2. Acid-base titration 3. Acidimetry	Quantitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including for registration: the laboratory work registration form is attached
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1. Calculate the mass of sodium hydroxide, if 12.45 ml of 0.1152 M nitric acid solution was consumed in its titration.

2. Determine the pH of the beginning and end of the titration jump without taking into account the dilution of the solution when titrating 75.00 ml of 0.1500 N ammonium hydroxide solution 0.1500 N. solution of hydrochloric acid.

3. Indicate which of the following indicators is suitable for titration in problem #2: methyl green, methyl red, tropeolin 00, a-naphtholphthalein.

5. Determine the mass fraction of sodium hydroxide in the sample, if a suspension of sodium hydroxide weighing 0.1095 g is dissolved in water and 25.50 cm3 of 0.1002 N H2SO4 solution is spent on titration of the resulting solution.

6. What weight of technical NaOH containing 40% impurities should be taken for the determination of NaOH, if 30.00 cm3 of 0.1000 N HCl solution was used to determine the resulting solution.

4. Summing up:

As a result of the lesson, the student got acquainted with the theoretical and practical principles of the acidimetry method, summarized information about the titrants and indicators of the method, the method of indicator selection (graphical and calculated).

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.
2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.
3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.
4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 33

Topic: Ac Acid-base titration. Alkalimetry. ***Laboratory work:*** "Standardization of NaOH solution according to primary standards."

Goal: Get acquainted with the theoretical and practical principles of the acidimetry method, summarize information about the titrants and indicators of the method, the method of indicator selection (graphical and calculated).

Basic concepts:analysis, quantitative analysis, titrimetric analysis, neutralization method, indicator, hydrogen indicator (pH), primary standard, secondary standard, equivalence point, titration end point (TTP)

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal

survey, etc.)

– requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

The student should know:

- ✓ basic rules for working with acids and alkalis;
- ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
- ✓ principles and methods of qualitative analysis, classification of analysis methods;
- ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
- ✓ the concept of fractional and systematic analysis, the difference between one and the other;
- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;

- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. What is "titrimetric analysis", "titration", "titrant", "equivalence point", "end point of titration"?

2. Ways of expressing the concentration of solutions used in titrimetric analysis? Formulas for calculation, units of measurement.

3. List the dishes used in the titration process.

4. Classification of titration methods according to the type of chemical reaction taking place

5. Acid-base titration. What is the underlying reaction. What methods of acid-base titration (ABT) are distinguished depending on the titrant.

6. Primary and secondary standard solutions. Conditions for assigning solutions to primary standards.

7. Titrants and primary standards for alkalimetry.

8. Indicators used in alkalimetry.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1. Calculate the volume of sodium hydroxide solution with a mass fraction of 18.6% and a density of 1.12 g/ml, required to prepare 250 ml of a solution with a molar concentration of 0.1 mol/l.

2. Calculate the molar concentration of the equivalent, the titer and the correction factor of the sodium hydroxide solution, if the titration is 20.00 ml0.05075 Moxalic acid solution, 19.50 ml of this solution was used.

3. 20 ml of 0.1n. the hydrochloric acid solution is titrated to 0.1 n. sodium hydroxide solution. Determine the titration points and construct the titration curve.

- recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Quantitative analysis. Titrimetric analysis 2. Acid-base titration 3. Alkalimetry	Quantitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including for registration: the laboratory work registration form is attached
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1. Calculate the mass of sodium hydroxide, if 12.45 ml of 0.1152 M nitric acid solution was consumed in its titration.

2. Determine the pH of the beginning and end of the titration jump without taking into account the dilution of the solution when titrating 75.00 ml of 0.1500 N ammonium hydroxide solution 0.1500 N. solution of hydrochloric acid.

3. Indicate which of the following indicators is suitable for titration in problem #2: methyl green, methyl red, tropeolin 00, a-naphtholphthalein.

4. Determine the mass fraction of sodium hydroxide in the sample, if a suspension of sodium hydroxide weighing 0.1095 g is dissolved in water and 25.50 cm^3 of 0.1002 N H_2SO_4 solution is spent on titration of the resulting solution.

5. What weight of technical NaOH containing 40% impurities should be taken for the determination of NaOH, if 30.00 cm3 of 0.1000 N HCl solution was used to determine the resulting solution.

6. Summing up:

As a result of the lesson, the student got acquainted with the theoretical and practical principles of the acidimetry method, summarized information about the titrants and indicators of the method, the method of indicator selection (graphical and calculated).

7. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 34

Topic: Acid-base titration. Titration of weak acids with alkalis and weak bases with strong acids. Determination of ammonia content and mass fraction (in percent) of acetic acid in analytical samples.

Goal: Get acquainted with the theoretical and practical principles of the neutralization method (acid-base titration), summarize information about titrants

and indicators of the method, the use of reverse titration when determining volatile compounds

Basic concepts:analysis, quantitative analysis, titrimetric analysis, neutralization method, indicator, hydrogen indicator (pH), primary standard, secondary standard, equivalence point, titration end point (TEP)

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
     - ✓ principles and methods of qualitative analysis, classification of analysis methods;
     - ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
     - ✓ the concept of fractional and systematic analysis, the difference between one and the other;
     - ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
     - ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group

reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. What substances belong to weak electrolytes? How do weak electrolytes dissociate in solutions? What is the degree of dissociation (ionization), dissociation constant, indicator of acidity or basicity?

2. On the basis of what can be concluded about the possibility of titration in aqueous media with indicator fixation of the end of the titration of weak electrolytes?

3. How is the pH calculated at different moments of titration (before the start of titration, at the moment of half-neutralization, at the beginning of the titration jump, at the equivalence point, at the end of the titration jump) when titrating weak acids and weak bases?

4. What are the titration curves of weak acids and weak bases? Compare them with the titration curves of strong acids and bases.

5. Why does the pH to the equivalence point change slowly when titrating weak acids and weak bases?

6. Does the pH at the equivalence point when titrating weak acids and weak bases coincide with the neutrality line?

7. What is the relationship between the value of the titration jump and the acidity or basicity constants of the specified substances?

8. What is the essence and when can direct titration, reverse titration, substitute titration be used?

9. What are the essence, advantages, and disadvantages of pipetting methods and separate measurements? What formulas are used to calculate the result of titrimetric analysis?

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1. The $(NH_4)_2SO_4$ solution was treated with a concentrated solution in the device for determining ammonium salts using the distillation method NaOH. Ammonia was driven off in 50.00 cm3 of H_2SO_4 solution with a concentration of ($1/2H_2SO_4$ = 0.2000 mol/dm3). Then the resulting solution was titrated with 22.50 cm^3 of alkali. How many grams of ammonium sulfate are contained in the tested solution?

2. 25.00 cm^3 of NH_4Cl solution was poured into the device for determining ammonium salts by the distillation method and treated with a concentrated solution NaOH. Ammonia was driven off in 50.00 cm^3 of HC1 solution (T(HCl) = 0.003646 g/cm^3). Then the excess of HC1 was titrated with 23.05 cm^3 of alkali with T(NaOH) = 0.004015 g/cm^3. How many grams of ammonium chloride are contained in the studied sample?

- recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Quantitative analysis. Titrimetric analysis 2. Acid-base titration 3. Titration of ammonia	Quantitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including for registration: the laboratory work registration form is attached
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1. Which of the following solutions is used as a working (titrant) in the alkalimetry method:

A. potassium hydroxide
B. hydrochloric acid
C. oxalic acid
D. sodium tetraborate
E. ammonium hydroxide

2. For the quantitative determination of sodium carbonate in the preparation by the method of acid-base titration, the indicator is used:

A. methyl orange
B. murexide
C. methylene blue
D. diphenylamine
E. ferroin

3. For the quantitative determination of medicinal substances, the method of acidimetry is used, the titrant of which is a secondary standard solution of hydrochloric acid. The exact concentration of hydrochloric acid is set by:

A. sodium tetraborate

B. oxalic acid

C. potassium dichromate

D. sodium thiosulfate

E. magnesium sulfate

4. Specify the standard substances that are used to standardize solutions - titrants (NaOH, KOH) of the alkalimetry method:

A. oxalic and succinic acids

B. acetic and succinic acids

C. formic and acetic acid

D. sulfanilic and oxalic acids

E. sulfanilic and salicylic acids

5. The method of acid-base titration determines:

A. acids, bases and salts that are hydrolyzed

B. only strong acids

C. only strong foundations

D. only strong acids and weak bases

E. only salts that are hydrolyzed

6. To select an indicator in the acid-base titration method, a titration curve is constructed, which represents the dependence:

A. pH of the solution from the volume of added titrant

B. The pH of the solution depends on the concentration of the solution of the added titrant

C. pH of the solution from the volume of the analyzed solution

D. the concentration of the analyzed solution from the pH of the solution

E. pH of the solution as a function of temperature

7. Indicate which pair of substances should be determined by the reverse acid-base titration method:

A. $NH_3 \cdot H_2O$, CH_3COOH

B. NaOH, KOH

C. KOH, K_2CO_3

D. $NaHCO_3$, NaOH

E. Na_2CO_3, NaCl

8. Select a pair of titrants for quantitative determination of ammonia in solution by back titration

A. HCl, NaOH

B. HCl, H_2SO_4

C. KOH, NaOH

D. NaOH, KCl

E. H_2SO_4, K_2SO_4

9. Standardization of the hydrochloric acid solution is carried out using the primary standard solution:

A. Na_2CO_3

B. KMnO4

C. NaOH

D. I_2

E. KI

10. Determination of boric acid in a medicinal product is carried out by the method:

A. acid-base titration

B. redox titration

C. precipitation titration

D. complexonometry

E. photometry

11. To determine the mass-volume fraction of ammonia in the solution, use the solution:

A. hydrochloric acid

B. sulfuric acid

C. potassium permanganate

D. iodine

E. sodium hydroxide

4. Summing up:

As a result of the lesson, the student got acquainted with the theoretical and practical principles of the neutralization method (acid-base titration), summarized information about the titrants and indicators of the method, the method of indicator selection (graphical and calculated), and also learned the reverse titration method using the example of ammonia.

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 35

Topic: Acid-base titration. Titration of polybasic acids, bases, mixtures of acids, bases. Determination of the mass fraction (in percent) of a mixture of $NaHCO_3$ and Na_2CO_3.

Goal: Get acquainted with the theoretical and practical principles of the neutralization method (acid-base titration), summarize information about the

titrants and indicators of the method, the method of choosing an indicator (graphical and calculated).

Basic concepts:analysis, quantitative analysis, titrimetric analysis, neutralization method, indicator, hydrogen indicator (pH), primary standard, secondary standard, equivalence point, titration end point (TEP)

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
     - ✓ principles and methods of qualitative analysis, classification of analysis methods;
     - ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
     - ✓ the concept of fractional and systematic analysis, the difference between one and the other;
     - ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
     - ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group

reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. What is the peculiarity of the titration curves of salts formed by weak acids and strong bases?

2. What formulas are used to calculate the pH of salt solutions formed by weak acids and strong bases ($NaHCO_3$, Na_2CO_3, NaH_2PO_4, Na_2HPO_4, etc.)?

3. What is the essence and method of determining NaOH and Na_2CO_3 in case of their simultaneous presence in the analyzed solution?

4. What is the essence of determining the mass of $NaHCO_3$ and Na_2CO_3 in the case of their combined presence in the analyzed solution.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1. Boldness 0.3580 g mixture of Na_2CO3 and NaOH is dissolved in a volumetric flask with a capacity of 100.0 cm3. For the titration of an aliquot part of the solution (25.00 cm^3) in the presence of phenolphthalein, 19.85 cm^3 was used, and with the indicator methyl orange 20.95 cm^3 0.1030 n. HCl solution. Calculate the mass fraction of Na_2CO_3 in the studied sample.

2. Calculate the percentage of KOH and K_2CO_3 in a solution of technical caustic potash, if this solution is titrated with HCl solution ($T(HCl/Na_2CO_3)$ = 0.005300 g/cm^3) using two indicators. The reading of the burette when titrating with phenolphthalein is 21.36 cm^3, the reading of the burette when titrating in the presence of methyl orange is 25.76 cm^3.

3. In a volumetric flask with a capacity of 500.0 cm^3, a solution is prepared from the sample2.5000 g Na_2CO_3.Calculate for its solution: a) molar concentration, b) normal concentration, c) titer, d) titer by HCl.

4. Calculate the weight of the weight Na_2CO_3 in 250.0cm^3 solution, if for titration 25.00cm^3 20.20 of its solution with methyl orange indicator was usedcm^3 0.1010 M of HCl solution.

– recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Quantitative analysis. Titrimetric analysis 2. Acid-base titration 3. Selection of the indicator	Quantitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

– requirements for work results, including for registration: the laboratory work

registration form is attached

- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1. By the method of acid-base titration, boric and hydrochloric acid in the presence of each other are determined:

A. using two titrants;

B. using methyl orange and phenolphthalein;

C. regarding the reaction of boron-ethyl ether formation;

D. after converting boric acid into glyceroboric acid

2. Analysis of a mixture of carbonate and sodium hydroxide is carried out:

A. by acid-base titration;

B. by the complexonometry method;

C. with the use of two indicators (phenolphthalein and methyl orange);

D. by Mohr's method

3. Choose an indicator and method of titrimetric analysis to determine hydrogen carbonate ions in pharmaceuticals:

A. methyl orange, acidimetry

B. phenolphthalein, acidimetry

C. methyl orange, alkalimetry

D. phenolphthalein, alkalimetry

E. murexid, acidimetry

4. Determination of boric acid in a medical preparation is carried out by the method:

A. acid-base titration

B. redox titration

C. precipitation titration

D. complexonometry

E. photometry

5. Specify the value of the equivalence factor of Na_2CO_3 in quantitative determination according to the reaction: $Na_2CO_3 + HCl = NaCl + NaHCO_3$

A. f=1

B. f=1/2

C. f = 2

D. f=1/4

E. f=4

6. It is necessary to carry out a quantitative determination of sodium bicarbonate in the preparation. Which of the titrimetric methods of analysis can determine it?

A. acid-base titration

B. complexiметric titration

C. precipitation titration

D. non-aqueous titration

E. redox titration

7. For the quantitative determination of sodium carbonate in the preparation by the method of acid-base titration, the indicator is used:

A. methyl orange

B. murexide

C. methylene blue

D. diphenylamine

E. ferroin

8. For the quantitative determination of medicinal substances, the method of acidimetry is used, the titrant of which is a secondary standard solution of hydrochloric acid. The exact concentration of hydrochloric acid is set by:

A. sodium tetraborate

B. oxalic acid

C. potassium dichromate

D. sodium thiosulfate

E. magnesium sulfate

4. Summing up:

As a result of the lesson, the student got acquainted with the theoretical and practical principles of the neutralization method (acid-base titration), summarized information about the titrants and indicators of the method, the method of indicator selection (graphical and calculated).

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 36

Topic: ***Control class*** on topic "Gravimetric analysis. Titrimetric methods of analysis. Acid-base titration".

Goal: Summarize the theoretical and practical principles of gravimetry and neutralization methods (acid-base titration), summarize information about titrants and indicators of the method

Basic concepts:analysis, quantitative analysis, titrimetric analysis, neutralization method, indicator, hydrogen indicator (pH), primary standard, secondary standard, equivalence point, titration end point (TEP), ampholyte

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
     - ✓ principles and methods of qualitative analysis, classification of analysis methods;
     - ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
     - ✓ the concept of fractional and systematic analysis, the difference between one and the other;
     - ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
     - ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

     The student should be able to:
     - ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;

- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. What is "titrimetric analysis", "titration", "titrant", "equivalence point", "end point of titration"?

2. Ways of expressing the concentration of solutions used in titrimetric analysis? Formulas for calculation, units of measurement.

3. Classification of titration methods according to the type of chemical reaction taking place

4. Acid-base titration. General characteristics of the method.

5. Selection of the indicator. Graphical method. Calculation method.

6. Alkalimetry. Characteristics: titrant, primary standard, titration curves, method capabilities.

7. Acidimetry. Characteristics: titrant, primary standard, titration curves, method capabilities.

8. Indicator errors of acid-base titration: proton (hydrogen), hydroxide, acid, basic. Causes of occurrence.

9. Calculation of indicator errors.

10. Gravimetry. General characteristics. Classification. Possibilities of the method.

11. Deposition method. Stages of the deposition method. Precipitation and gravimetric form.

12. Distillation method. Direct and indirect distillation.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1.What amount of NaOH must be taken so that 22.00 ml of HCl solution (T(HCl/NaOH) = 0.003514 g/ml)?

2.To standardize the sodium hydroxide solution, 200.00 ml of the primary standard solution of oxalic acid was prepared with an accurate weight of m=1.2607 g. Calculate the molar concentration and molar equivalent concentration, titer and titer with NaOH of the prepared oxalic acid solution.

3.To substantiate the possibility of using the acid-base titration method for the quantitative analysis of formic acid. Write the corresponding reaction equations, indicate the indicator.

4.To substantiate the possibility of using the acid-base titration method for the quantitative determination of each component in a mixture of KOH with K_2CO_3. Write the corresponding reaction equations, indicate the indicator.

- recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Quantitative analysis. Gravimetry. Deposition method. Distillation method. 2. Quantitative analysis.	Quantitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V.

Titrimetric analysis. 3. Acid-base titration. Indicator selection. 4. Acidimetry. Alkalimetry.		Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including to registration:
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

4. Summing up:

As a result of the lesson, the student summarized theoretical and practical knowledge about gravimetric analysis and the method of neutralization (acid-base titration), summarized information about titrants and indicators of the method, the method of indicator selection (graphical and calculated).

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 37

Topic: Methods of redox titration. Classification of methods. Requirements for the reactions. Classification and characteristics of indicators used in redox measurement. Indicatorless methods of analysis.

Goal: Get acquainted with redox titration, classification of redox titration methods and learn how to apply these methods in the analysis of chemical substances, learn how to calculate work results.

Basic concepts:analysis, quantitative analysis, titrimetric analysis, redox titration method, indicator, standard redox potential, real redox potential, primary standard, secondary standard, equivalence point, titration end point (TEP)

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
     - ✓ principles and methods of qualitative analysis, classification of analysis methods;
     - ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
     - ✓ the concept of fractional and systematic analysis, the difference between one and the other;

- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. The essence and classification of redox (redoxsymmetric) titration methods.

2. Redox potential. Standard redox potential. Calculate the oxidation potential of the Sn^{4+}/Sn^{2+} pair, if the concentration of Sn^{4+} ions is 0.1 mol/dm^3, and Sn^{2+} ions is 0.0001 mol/dm^3.

3. Requirements for reactions used in redoximetry.

4. Fixing the end point of titration in redox measurement. Indicator errors.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1.Set the direction of the reaction

$2NaCl + Fe_2(SO_4)_3 \leftrightarrow Cl_2 + Na_2SO_4 + 2FeSO_4$

2. Set the direction of the reaction

$2Hg + Ag^+ \leftrightarrow 2Hg_2^{2+} + Ag$

at ion concentration (mol/dm3): a) [Ag+] = 10^{-4}, $[Hg_2^{2+}] = 10^{-1}$;

b) $[Ag^+] = 10^{-1}$, $[Hg_2^{2+}] = 10^{-4}$.

3. Effect of solution pH on redox potential.

4. Inductive (conjugate) reactions of oxidation and reduction.

5. Characteristics of the main types of redox indicators. Give examples.

6. The equilibrium constant of the redox reaction, its influence on the course of the reaction. Calculate the equilibrium constant for the oxidation of iron sulfate (II) with potassium permanganate.

7. Equilibrium constants of redox reactions. Derive formulas for calculating reaction equilibrium constants*mol/dm3*):

A) $Sn^{2+} + I_2 \leftrightarrow Sn^{4+} + 2I^-$

B) $5Fe^{2+} + MnO_4^- + 8H^+ \leftrightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$;

B) $Cr^{2+} + [Fe(CN)_6]_6^{3-} \leftrightarrow Cr^{3+} + [Fe(CN)_6]_6^{4-}$

and find their numerical values (if necessary, it will admit that$[H^+]$ is equal to 1 mol/dm3.

8. Methods of fixing the equivalence point in redoximetry. Reversible and irreversible redox indicators.

9. Calculate the transition interval of the color of the indicators: a) diphenylamine; b) phenylanthranilic acid.

- recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Quantitative analysis. Titrimetric analysis 2. Redox titration 3. Selection of the indicator 4. Titration curves	Quantitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including to registration: solving problems in a workbook
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1. Calculate the weight of potassium dichromate required to prepare 250.00 ml of a solution with a molar concentration of salt of 0.1000 mol/l.

2. Calculate the mass of crystalline iodine sample required to prepare 750 ml of a solution with a molar concentration of iodine of 0.05000 mol/l.

3. 18.00 ml of potassium permanganate solution was used for the titration of 15.00 ml of oxalic acid solution with a molar concentration of 0.02500 mol/l in sulfuric acid medium. Calculate the molar concentration of the titrant in the solution.

4. 0.3500 g of oxalic acid dihydrate was dissolved in water and 100.0 ml of solution was obtained. 10.00 ml of the obtained solution was titrated with 12.00 ml of potassium permanganate solution. Calculate the molar concentration of the titrant in the solution.

5. A measure of potassium dichromate weighing 0.1233 g was dissolved in dilute sulfuric acid. An excess of potassium iodide was added to the resulting solution. 20.33 ml of sodium thiosulfate solution was used for the titration of the released iodine. Calculate the concentration of the titrant solution.

6. 15.00 ml of potassium permanganate solution with a molar concentration of 0.07500 mol/l was used for the titration of Mohr's salt concentration. What is the weight of Mohr's salt?

7. 12.00 ml of sodium thiosulfate solution was used for the titration of 30.00 ml of iodine solution with a molar concentration of 0.1000 mol/l. Determine the molar concentration of sodium thiosulfate solution.

8. A measure of potassium dichromate weighing 0.2893 g was dissolved in a volumetric flask with a capacity of 100.0 ml. 20.00 ml of sodium thiosulfate Na2S2O3 was used for the titration of iodine isolated from 25.00 ml of the obtained solution from potassium iodide. Calculate the concentration of sodium thiosulfate.

9. 10.8 ml of 0.01102 M $KMnO_4$ solution was used for titration of 10 ml of $FeSO_4$ in an acidic medium. Find the mass of $FeSO_4$ in a flask with a capacity of 100 ml.

10. 12.1 ml of 0.00972 M $KMnO_4$ solution was used for the titration of 10 ml of oxalic acid solution. Find the mass of oxalic acid ($H_2C_2O_4 \cdot 2H_2O$) in a 100 ml flask.

4. Summing up:

As a result of the lesson, the student got acquainted with redox titration, the classification of redox titration methods and learned to apply these methods in the analysis of chemical substances and to calculate the results of the work.

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of

medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.
4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p

Practical lesson No. 38

Topic: Permanganatometric titration. Titrants and primary standards. Possibilities of the method (determination of reductants, oxidizers, indifferent substances). ***Laboratory work:*** "Standardization of potassium permanganate solution by oxalic acid."

Goal: Get acquainted with redox titration, classification of redox titration methods and learn how to apply these methods in the analysis of chemical substances, learn how to calculate work results.

Basic concepts:analysis, quantitative analysis, titrimetric analysis, redox titration method, indicator, standard redox potential, real redox potential, primary standard, secondary standard, equivalence point, titration end point (TEP)

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;

- ✓ principles and methods of qualitative analysis, classification of analysis methods;
- ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
- ✓ the concept of fractional and systematic analysis, the difference between one and the other;
- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on

analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

A. Titrant of the permanganatometry method. What substances are used for its standardization?

1. How is the equivalence factor calculated in redox reactions? Calculate the equivalence factor for potassium permanganate in acidic, neutral and alkaline media.
2. Conditions of permanganatometric titration. Why is dilute sulfuric acid used to create the required pH?
3. Fixation of TET in permanganatometry.
4. Calculate the mass of oxalic acid needed to prepare 250.0 ml of its 0.05N solution, if its titer will be set using a 0.05N solution of potassium permanganate.
5. Calculate the redox potential of the system for the process of titration of a 0.05N solution of potassium permanganate with a 0.05N solution of oxalic acid.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1. Permanganatometry. The essence of the method, titrant, its preparation and standardization, titration conditions.

2. Derive the equation for calculating the potential at a pointtitration equivalence for the reaction:

$$5Fe^{2+} + MnO_4^- + 8H^+ = 5Fe^{3+} + Mn^{2+} + 4H_2O$$

3. Determine the redox potential of the solution$FeSO_4$, if it is titrated with $KMnO_4$ solution: a) by 95%; b) with an excess of 5% at $[H^+] = 1$ mol/dm^3.

4. Using normal potentials and neglecting the activity coefficient, determine the potential at the titration equivalence point at pH = 0 and pH = 1 of the system

$$5Fe^{2+} + MnO_4^- + 8H^+ = 5Fe^{3+} + Mn^{2+} + 4H_2O$$

5. Calculate: a) the region of the titration jump; b) the position of the equivalent point at a titration of 0.1 n. of a solution of iron (II) salt 0.1 n. $KMnO_4$ solution under the condition that $[H^+]$ at the equivalence point is equal to 1 mol/dm3.

6. Calculate the region of the jump when titrating a Fe^{2+} $KMnO_4$ solution in an acidic medium at the concentrations of the solutions (mol/dm^3): a) 0.01; b) 0.001.

7. 100 cm^3 of 0.1 N was taken for titration. $FeSO_4$ solution, titrant - 0.1 N. potassium permanganate solution. Find the corresponding values of the electrode potential when adding 50; 99; 99.9; 100.1; 101 and 200% of $KMnO_4$ from the equivalent amount at $[H^+]$ = 1 mol/dm^3.

- recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Quantitative analysis. Titrimetric analysis 2. Redox titration 3. Permanganatometry	Quantitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including for registration: the laboratory work registration form is attached
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1. Calculate the indicator error of the titration of the HNO2 solution with the KMnO4 solution in the presencephenylanthranilic acid; pH = 0; E0ind= +1.08 V.

2. Prepared0.02 MsolutionKMnO4. What is the molar concentration of the equivalent of this solution for reactions:

a) $5Fe^{2+} + MnO_4^- + 8H^+ = 5Fe^{3+} + Mn^{2+} + 4H_2O$;

b) $3Mn^{2+} + 2MnO_4^- + 2H_2O = 3MnO_2 + 4H^+$?

3. When preparing the working solution $KMnO_4$ to get rid of impurities of manganate ions, it is oxidized with chlorine. Is it possible to use bromine or iodine as an oxidizer?

4. What is the equivalence factor of $KMnO_4$ when titrating in acidic, neutral and alkaline media? Give half-reaction equations.

5. Why does the reaction between potassium permanganate and oxalic acid take place very slowly at first and then accelerate? How can you influence the speed of this reaction?

6. What starting substances are used to establish the normality of the potassium permanganate solution? What masses of water and oxalic acid H2C2O4·2H2O must be taken in order to obtain it during recrystallization20 gacid dihydrate by cooling a solution saturated at 90 0C to 10 0C? The solubility of anhydrous acid at 90 and 10 0C, respectively, is 120 and5.3 gon100 gwater

7. Calculate the electrode potential of the system at pH=0.1:

$$MnO_4^- + 8H^+ + 5e = Mn^{2+} + 4H_2O$$

8. Determine the direction and completeness of the reaction between pairs

MnO_4^-/ Mn^{2+} (E^o=1.51 V) and $Cr_2O_7^{2-}/ Cr^{3+}$ (E^o=1.31*V*) at pH = 1 and pH = 7.

9. Calculate the sequence in which $KMnO_4$ will oxidize SO_3^{2-}, S^{2-}, I^-, Fe^{2+}, Mn^{2+}, Cr^{3+} and Cl^- ions in an acidic medium, if the concentrations of reducing agents are the same. Compose ion-electron equations of reactions.

10. Factors affecting the flow of redox reactions. Show their influence with an example reaction:

$$MnO_4^- + H_2C_2O_4 + H^+ \rightarrow$$

11. Why is the determination of a number of reducing agents performed by permanganatometry in an acidic environment? Which acid is better to use in this case: hydrochloric, nitric or sulfuric? Give an explanation.

4. Summing up:

As a result of the lesson, the student got acquainted with redox titration, the classification of redox titration methods and learned to apply these methods in the analysis of chemical substances and to calculate the results of the work.

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p

Practical lesson No. 39

Topic: Method of iodine and iodometric titration. Titrants of the method. Possibilities of the method. ***Laboratory work:*** "Determination of Cu(II) ions."

Goal: Familiarize yourself with iodine and iodimetric titration, learn how to use these methods in the analysis of chemical substances, learn how to calculate work results.

Basic concepts:analysis, quantitative analysis, titrimetric analysis, redox titration method, indicator, standard redox potential, real redox potential, primary standard, secondary standard, equivalence point, titration end point (TEP)

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)

– requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

The student should know:

- ✓ basic rules for working with acids and alkalis;
- ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
- ✓ principles and methods of qualitative analysis, classification of analysis methods;
- ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
- ✓ the concept of fractional and systematic analysis, the difference between one and the other;
- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out

qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;

- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. Titrants of the iodometric method. Features of preparation, storage, standardization.
2. Possibilities of the method. What substances can be determined by iodometric titration?
3. Direct iodometric titration. Terms of use.
4. Reverse iodometric titration. Terms of use.
5. Substitute iodometric titration. Terms of use.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1. Calculate the mass of iodine required for the preparation of 2 dm3 of 0.01 n. iodine solution.

2. What volume of water should be added to 25.0 cm^3 of I_2 solution with a concentration of C(1/2 I_2) = 0.0250 mol/dm3 in order to obtain a solution with a concentration of C(1/2 I_2) = 0.0200 mol/dm^3?
3. Calculate the normality, the titer of the sodium thiosulfate solution, if 24.00 cm3 of the sodium thiosulfate solution was spent on the titration of the iodine released when adding 0.1200 g of $K_2Cr_2O_7$ (dissolved in water, an acidic medium) to the weight.
4. Calculate the mass of crystalline iodine required to prepare 750 ml of a solution with a molar concentration of iodine of 0.05000 mol/l.
5. 12.00 ml of sodium thiosulfate solution was used for the titration of 30.00 ml of iodine solution with a molar concentration of 0.1000 mol/l. Determine the molar concentration of sodium thiosulfate solution

- recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Quantitative analysis. Titrimetric analysis 2. Redox titration 3. Iodometric titration	Quantitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including for registration: the laboratory work registration form is attached
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1. Technical sodium sulfite (0.9350 g) was dissolved in an arbitrary volume of water and 50.00 cm3 of 0.1000 N was added. iodine solution. For the titration of excess iodine, 21.20 cm3 of sodium thiosulfate solution was used, 1 cm3 of which is equivalent to the amount of iodine released from0.01574 g potassium iodide. Determine the mass fraction (%) of sodium sulfite.

2. Calculate the normality, the titer of the sodium thiosulfate solution, if for the titration of the iodine released when added to the weight0.1200 g $K_2Cr_20_7$ (dissolved in water, acidic medium) excess KI in, 24.00 cm3 of sodium thiosulfate solution was used.

3.How many grams of $K_2Cr_2O_7$ should be weighed to make 500 cm^3 of a solution that is used to determine the normality of ≈ 0.05 n. $Na_2S_2O_3$ $5H_2O$?

4.Determine the mass fraction (%) of active chlorine, if the concentration of perchloric lime (0.2004) was dissolved in water, KI and H_2SO_4 were added to the solution, and 20.04 cm^3 of 0.1000 n were lost for titration of the released iodine. sodium thiosulfate solution

5. Technical iodine has 25% impurities that do not oxidize. Calculate the amount of iodine that should be taken for analysis if 0.1000 N. sodium thiosulfate solution was poured into a 25 cm^3 burette.

6.Weight of sodium sulfite by mass0.7340 g dissolved in an arbitrary volume of water and added 50.00 cm^3 of 0.1000 n. iodine solution. Excess iodine was titrated with sodium thiosulfate solution. 21.20 cm^3 of solution was used for titration, 1 cm3 of which is equivalent to the amount of iodine released from0.01574 g potassium iodide. Determine the mass fraction (%) of sodium sulfite.

4. Summing up:

As a result of the lesson, the student got acquainted with redox titration, the classification of redox titration methods and learned to apply these methods in the analysis of chemical substances and to calculate the results of the work.

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.
4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p

Practical lesson No. 40

Topic: Dichromatometric titration method. Titrants. Indicators of the method. Possibilities of the method. ***Laboratory work:*** "Determination of the mass fraction (in percent) of iron(II) salts."

Goal: Get acquainted with redox titration, classification of redox titration methods and learn how to apply these methods in the analysis of chemical substances, learn how to calculate work results.

Basic concepts:analysis, quantitative analysis, titrimetric analysis, redox titration method, indicator, standard redox potential, real redox potential, primary standard, secondary standard, equivalence point, titration end point (TEP)

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:

     ✓ basic rules for working with acids and alkalis;

     ✓ subject and problems of analytical chemistry, basic concepts of

analytical chemistry;

- ✓ principles and methods of qualitative analysis, classification of analysis methods;
- ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
- ✓ the concept of fractional and systematic analysis, the difference between one and the other;
- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;

- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. Titrant of the dichromatometry method. Is it necessary to standardize it? Why?
2. How is the equivalence factor calculated in redox reactions? Calculate the equivalence factor for potassium dichromate in an acidic medium.
3. Conditions of dichromatometric titration.
4. Calculate the redox potential of the $Cr_2O_7^{2-}/Cr^{3+}$ pair at $[H^+]$ = 1 mol/dm^3; $[Cr_2O_7^{2-}]$ = 0.01 mol/dm^3; $[Cr^{3+}]$ = 0.001 mol/dm^3. Preparation of iodine solution and establishing its normality.
5. Characteristics of indicatorsdichromatometry method. Diphenylamine.Transition intervalthe color of diphenylamine depending on the redox potential of the system.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1.Calculate the normal concentration and titer of a solution of potassium dichromate obtained by dissolving a portion of potassium dichromate2.4515 gin 500 cm3 of water.

2. What is the weight of the technical preparationK2Cr2O7it is necessary to take 2 dm^3 of a solution with a concentration $(1/6K_2Cr_2O_7)$ = 0.10 mol/dm^3. The drug contains 98.3% of potassium dichromate.

3. Calculate the indicator error of $FeSO_4$ titration with $K_2Cr_2O_7$ solution with diphenylamine (DPA) indicator: a) in the presence of H_3PO_4; b) in the absence of H_3PO_4.

4. Calculate the region of the jump when titrating a Fe^{2+} $K_2Cr_2O_7$ solution in an acidic environment at the concentrations of the solutions (mol/dm3): a) 0.01; b) 0.001.

5. Calculate the weight of potassium dichromate required to prepare 250.00 ml of a solution with a molar salt concentration of 0.1000 mol/l.

- recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Quantitative analysis. Titrimetric analysis 2. Redox titration 3. Dichromatometric titration	Quantitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including for registration: the laboratory work registration form is attached
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1. The solution was prepared in a 2.0 dm3 volumetric flask from fixanal, which contains 0.1 mol equivalent of the substance $K_2Cr_2O_7$ ($f_{eq.}$ = 1/6). Calculate the titer of the obtained solution.

2. Calculate the molar concentration of the equivalent and the iron (II) titer of the potassium dichromate solution obtained by dissolving a portion of potassium dichromate1.2258 g in 250 cm^3 of water.

3. Derive the equation for calculating the potential at a pointtitration equivalence for the reaction:

$$6Fe^{2+} + Cr_2O_7^{2-} + 14H^+ = 6Fe^{3+} + 2Cr^{3+} + 7H_2O$$

4. In what medium should the oxidation of chromium (III) to chromium (VI) be carried out, and which compounds of chromium (VI) are used as an oxidant? Justify the answer.

4. Summing up:

As a result of the lesson, the student got acquainted with redox titration, the classification of redox titration methods and learned to apply these methods in the analysis of chemical substances and to calculate the results of the work.

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p

Practical lesson No. 41

Topic: Bromatometric titration method. Titrants of the method. Examples of definitions. Possibilities of the method. Method of nitritometric titration. Titrants. Possibilities of the method. Examples of definitions. Conditions of nitritometric determinations.

Goal: Get acquainted with redox titration, classification of redox titration methods and learn how to apply these methods in the analysis of chemical substances, learn how to calculate work results.

Basic concepts:analysis, quantitative analysis, titrimetric analysis, redox titration method, indicator, standard redox potential, real redox potential, primary standard, secondary standard, equivalence point, titration end point (TEP)

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   – requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

   The student should know:

   - ✓ basic rules for working with acids and alkalis;
   - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
   - ✓ principles and methods of qualitative analysis, classification of analysis methods;
   - ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
   - ✓ the concept of fractional and systematic analysis, the difference between one and the other;
   - ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
   - ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

   The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. Titrants of the bromo- and bromatometry method. What substances are used for standardization?
2. How is the equivalence factor calculated in redox reactions? Calculate the equivalence factor for potassium bromate in an acidic medium.
3. Conditions of bromo- and bromatometry.
4. Fixation of KTT in bromo- and bromatometry. Indicator errors.
5. Possibilities of the method. What substances can be determined by the above methods?

6. To what volume should 10 cm3 of a potassium bromate solution with a molar concentration of 0.1000 mol/dm3 be added to obtain a solution with a titer for arsenic (III) equal to 0.000375 g/cm3.
7. Titrant of the nitritometry method. What substances are used for its standardization?
8. How is the equivalence factor calculated in redox reactions? Calculate the equivalence factor for sodium nitrite.
9. Conditions of nitritometric titration.
10. Fixation of KET in nitritometry. Internal and external indicators. Indicator errors.
11. Calculate the mass of sodium nitrite needed to prepare 250.0 ml of its 0.05N solution, if its titer will be set using a 0.05N solution of potassium permanganate.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1 For the bromatometric determination of As_2O_3 in the preparation, 60 cm^3 of the solution was prepared, in which the weight of the preparation by mass was dissolved0.1014 g. For the titration of 20.00 cm^3 of this solution, 6.80 cm^3 of a standard solution of potassium bromate with a titer according to As_2O_3 of 0.004946 g/cm^3 was used. Calculate the mass fraction of As_2O_3 in the dosage of the drug.

2.Mixed 400 cm^3 of a 0.0405 mol/dm^3 solution of potassium bromate and 250 cm^3 of a solution of potassium bromate with a molar concentration equivalent to $KBrO_3$ of 0.222 mol/dm^3. The volume of the mixture is diluted with water to 1000 cm^3. Calculate the molar concentration of the equivalent of the resulting solution.

3. Calculate the equivalent molar mass, the mass of sodium salicylate in its bromatometric determination, if the reaction produces tribromophenol $HOC_6H_2Br_3$.

4.To prepare a series of standard solutions, a weight of sodium nitrite weighing 0.324 g was dissolved in a 250 cm^3 volumetric flask (the solution was brought up to the mark). 10 colored solutions containing 5.0 to 5.00 cm^3 of solution in 20.00

cm^3 of water were prepared from the flask with the addition of α-naphthylamine and sulfanilic acid. 1.04 g of sodium nitrite was dissolved in 500 cm^3 of water, 10 cm^3 was taken and, after appropriate processing, diluted with water to 20.00 cm^3. The color intensity of the obtained solution is equal to the color intensity of the sixth standard. Calculate the mass fraction of nitrite ion in sodium nitrate.

5. A weight of 0.3025 g of a sample of novocainamide (M = 271.79 g/mol) was dissolved in 10 ml of water. 20 ml of water, the required amount of KBr were added to the resulting solution and titrated with a standard $NaNO_2$ solution. 11.00 ml of titrant solution was used for titration. Calculate the mass fraction of novocainamide in the analyzed sample if 25.00 ml of the standard $NaNO_2$ solution used can react with 0.4330 g of sulfanilic acid (M = 173.19 g/mol).

- recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Quantitative analysis. Titrimetric analysis 2. Redox titration 3. Bromometry 4. Bromatometry 5. Nitritometry	Quantitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including for registration: the laboratory work registration form is attached
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1. A sample of potassium bromate solution with a volume of 25.00 ml was placed in a flask with a polished stopper, and the required amount of water was added. HCl and KI. After 5 minutes, the released iodine was titrated with 0.1033 M Na2S2O3. Calculate the molar concentration of $KBrO_3$ in the solution being standardized if 24.70 ml of sodium thiosulfate solution is used for the titration.

2. A weight of 0.4985 g of thymol sample (M = 150.22 g/mol) was dissolved in water in the presence of the required amount of NaOH, obtaining 100 ml of solution. The required amount of potassium bromide and HCl solution was added to 10.00 ml of the resulting solution. For the titration of the obtained mixture in the presence of methyl orange, 13.15 ml of 0.1005 M 1/6 $KBrO_3$ was required. Calculate the mass fraction of thymol in the sample being analyzed.

3. State the basic conditions of nitritometric determinations.

4. Write the reaction equations underlying the nitritometric determination:

a) primary aromatic amine;

b) secondary aromatic amine;

c) aromatic nitro derivative.

5. Write the equations of the reactions occurring during the standardization of the NaNO2 solution with sulfanilic acid and potassium permanganate.

6. What is meant by external indicators? Write the equations of the reactions that take place when the $NaNO_2$ solution acts on iodostarch paper.

7. For what purpose is KBr added to the flasks before titration by nitritometry?

8. Why titration by nitritometry is carried out in the cold?

9. Write a formula by which you can calculate the mass of novocaine in a solution and explain it.

10. Why is titration by the nitritometry method carried out at a slow speed?

11. What medicinal substances can be determined by the nitritometry method?

4. Summing up:

As a result of the lesson, the student got acquainted with redox titration, the classification of redox titration methods and learned to apply these methods in the analysis of chemical substances and to calculate the results of the work.

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.
3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.
4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 42

Topic: ***Control work*** on topic "Methods of redox titration.".

Goal: Get acquainted with redox titration, classification of redox titration methods and learn how to apply these methods in the analysis of chemical substances, learn how to calculate work results.

Basic concepts:analysis, quantitative analysis, titrimetric analysis, redox titration method, indicator, standard redox potential, real redox potential, primary standard, secondary standard, equivalence point, titration end point (TEP)

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:

- ✓ basic rules for working with acids and alkalis;
- ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
- ✓ principles and methods of qualitative analysis, classification of analysis methods;
- ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
- ✓ the concept of fractional and systematic analysis, the difference between one and the other;
- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;

- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. Theoretical principles of redox titration. Redox potential. The Nernst equation.
2. How is the equivalence factor calculated in redox reactions? Calculate the equivalence factor for potassium permanganate in alkaline, acidic and neutral media.
3. Permanganatometry. Titrant, titrant standardization. Titration conditions, fixing the end point of titration. Possibilities of the method.
4. Iodometry. Titrant, titrant standardization. Titration conditions, fixing the end point of titration.
5. Iodometry. Possibilities of the method are the use of direct, reverse, substitutional titration for the determination of reducing agents and oxidizing agents.
6. Dichromatometry. Titrant, titrant standardization. Titration conditions, fixing the end point of titration. Possibilities of the method.
7. Bromatometry. Titrant, titrant standardization. Titration conditions, fixing the end point of titration. Possibilities of the method.
8. Nitritometry. Titrant, titrant standardization. Titration conditions, fixing the end point of titration. Possibilities of the method.
9. Cerimetry. Titrant, titrant standardization. Titration conditions, fixing the end point of titration. Possibilities of the method.

3. Formation of professional skills and abilities:

- content of tasks (tasks, clinical situations, etc.)

1.To prepare a series of standard solutions, a weight of sodium nitrite weighing 0.324 g was dissolved in a 250 cm^3 volumetric flask (the solution was brought up to the mark). 10 colored solutions containing 5.0 to 5.00 cm^3 of solution in 20.00 cm^3 of water were prepared from the flask with the addition of α-naphthylamine and sulfanilic acid. 1.04 g of sodium nitrite was dissolved in 500 cm^3 of water, 10 cm^3 was taken and, after appropriate processing, diluted with water to 20.00 cm^3. The color intensity of the obtained solution is equal to the color intensity of the sixth standard. Calculate the mass fraction of nitrite ion in sodium nitrate.

2. A weight of 0.3025 g of a sample of novocainamide (M = 271.79 g/mol) was dissolved in 10 ml of water. 20 ml of water, the required amount of KBr were added to the resulting solution and titrated with a standard $NaNO_2$ solution. 11.00 ml of titrant solution was used for titration. Calculate the mass fraction of novocainamide in the analyzed sample if 25.00 mL of the standard $NaNO_2$ solution used can react with 0.4330 g of sulfanilic acid (M = 173.19 g/mol).

.Calculate the normal concentration and titer of a solution of potassium dichromate obtained by dissolving a portion of potassium dichromate2.4515 g in 500 cm^3 of water.

3. What is the weight of the technical preparation$K_2Cr_2O_7$ it is necessary to take 2 dm^3 of a solution with a concentration $(1/6K_2Cr_2O_7)$ = 0.10 mol/dm^3. The drug contains 98.3% of potassium dichromate.

4. Calculate the indicator error of $FeSO_4$ titration with $K_2Cr_2O_7$ solution with diphenylamine (DPA) indicator: a) in the presence of H_3PO_4; b) in the absence of H_3PO_4.

- recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Quantitative	Quantitative	Analytical chemistry: handbook / V. V.

analysis. Titrimetric analysis 2. Redox titration 3. Nitritometry 4. Permanganatometry 5. Bromatometry 6. Iodometry 7. Dichromatometry	analysis	Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including for registration: the test form is attached
- control materials for the final stage of the lesson: assignments, tasks, tests, etc. (if necessary).

4. Summing up:

As a result of the lesson, the student summarized his knowledge on the topic "Redox titration".

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 43

Topic: Precipitation titration methods. Requirements for reactions used in the method. Mercurometric titration. Titrants. Indicators. Examples of definitions.

Goal: Get acquainted with precipitation titration, classification of methods of precipitation titration and learn how to apply these methods in the analysis of chemical substances, learn how to calculate work results.

Basic concepts:analysis, quantitative analysis, titrimetric analysis, redox titration method, indicator, solubility product, primary standard, secondary standard, equivalence point, end point of titration (TEP)

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
     - ✓ principles and methods of qualitative analysis, classification of analysis methods;
     - ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
     - ✓ the concept of fractional and systematic analysis, the difference between one and the other;
     - ✓ characteristic of the sensitivity of analytical reactions (limit dilution,

limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);

- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. Classification of precipitation titration methods.
2. Argentometry. Titrant. Storage conditions. Standardization

3. Fixation of TET in argentometry. Indicator errors.
4. Rhodanometry. Direct and reverse titration.
5. Mercurometry. Titrant, titrant standardization. Possibilities of the method. Fixing TET.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1. What are the requirements for precipitation reactions in titrimetric analysis?
2. In what coordinates is the sediment titration curve constructed?
3. How does the titration jump depend on the product of solubility, temperature and concentration of the solution?
4. How to calculate the solubility of the compound MxRy based on data on its DR?
5. What titration reactions are based on the formation of a precipitate?
6. Mercurometric titration. The essence of the method. Method titrant, its preparation, standardization. Possibilities of the method.
7. Indicators of the mercurometry method. The mechanism of action of the iron thiocyanate indicator in the mercurometric determination of halides.

- recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Quantitative analysis. Titrimetric analysis 2. Precipitation titration 3. Mercurometry	Quantitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

– requirements for work results, including before registration: solving problems in a notebook.

– control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if

necessary):

1.For the titration of 20.00 ml of sodium chloride (T(NaCl/Ag) = 0.005750 g/ml), 25.00 ml of $Hg_2(NO_3)_2$ solution were used. Determine the molar concentration of the equivalent and the titer of the $Hg_2(NO_3)_2$ solution.

2. Titration errors in the precipitation method. Calculate the indicator error of the titration of 50 cm^3 0.1 n. solution of KCl 0.1 n. with a solution of $AgNO_3$ (50 cm^3) in the presence of $1 \cdot 10^{-4}$ mol/dm^3 indicator K_2CrO_4.

3. What mass of KCl is contained in 250.0 ml of solution, if 17.00 ml of 0.05252 M $Hg_2(NO_3)_2$ (f_{eq} = 1/2) is used for the titration of 25.00 ml

4. A sample of brine with a volume of 10.00 ml was diluted with water to 250.0 ml and 20.00 ml was mercurometrically titrated with the indicator $FeSCN^{2+}$. Calculate the concentration of NaCl in the brine (g/l), if 18.98 ml of 0.04805 M $Hg_2(NO_3)_2$ solution (f_{eq} = 1/2) were spent on the titration, and 0.52 ml were spent on the titration of the indicator in the "blank" sample ml of the same $Hg_2(NO_3)_2$ solution.

4. Summing up:

As a result of the lesson, the student got acquainted with precipitation titration, the classification of precipitation titration methods, with the method of mercurometric titration and learned to apply these methods in the analysis of chemical substances and calculate the results of the work.

5. List of recommended literature:

Main:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of

medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.
4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 44

Topic: Argentometry, Mohr's method. Essence and possibilities of the method. Titrants. Indicators. Titration conditions. ***Laboratory work:*** "Standardization of $AgNO_3$ solution according to Mohr's method."

Goal: Familiarize yourself with Mohr's method and learn how to use this method in the analysis of chemical substances, learn how to calculate work results.

Basic concepts:analysis, quantitative analysis, titrimetric analysis, redox titration method, indicator, solubility product, primary standard, secondary standard, equivalence point, end point of titration (TEP)

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
     - ✓ principles and methods of qualitative analysis, classification of analysis

methods;

- ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
- ✓ the concept of fractional and systematic analysis, the difference between one and the other;
- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. Mohr's method. General characteristics. Possibilities of the method.
2. Mohr's method indicator. Explain the mechanism of action of the indicator based on the DR value.
3. In what environment are determinations made according to Mohr's method (justify)?
4. Which of the ions – Cl^-, Br^-, I^-, SCN^-– can be determined by titration according to Mohr's method? Justify the choice.
5. Is it possible to determine chloride and bromide ions in hydrolyzable salts?

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1. 20 cm3 of 0.3500 mol/dm3 silver nitrate solution was added to 35 cm3 of 0.1000 mol/dm3 sodium chloride solution during the titration process. Calculate the pCl of the resulting solution.

2. Boldly1.4987 gsodium chloride was dissolved in a volumetric flask with a volume of 250.0 cm^3. For the titration of 20.00 cm^3 of this solution, 20.20 cm^3 of 0.0985 N is spent. silver nitrate solution. Calculate the mass fraction (%) of impurities in the preparation.

3.Preparation and determination of the normality of the silver nitrate working solution.How to prepare 800 cm^3 0.05 N silver nitrate solution and standardize it by NaC1.

4. Which substance (NaBr or KBr) was taken for analysis, if 18.77 ml of 0.1044 M $AgNO_3$ solution was used for the titration of 0.2332 g of it according to Mohr's method

- recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Quantitative analysis. Titrimetric analysis 2. Precipitation titration 3. Mohr's method	Quantitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including for registration: the laboratory work registration form is attached
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1. An analytical chemist needs to determine the quantitative content of hydrochloric acid in a mixture containing nitric acid. What titrimetric method of analysis can he use:

A.* Argentometry.

B.Iodometry.

C.Complexonometry.

D.Acid-base titration.

E.Permanganotometry.

2.To determine the mass fraction of sodium chloride in a physiological solution, the analytical chemist used Mohr's method, the titrant of which is:

A.* Argentum nitrate.

B.Ammonium thiocyanate.

C.Sodium tetraborate.

D.Mercury (I) nitrate.

E.Mercury (II) nitrate.

3.To determine the mass fraction of chloride ions in a sample of table salt, a solution was prepared and titrated with argentum nitrate solution in the presence of the potassium chromate indicator. What analysis method was used:

A.*Mor's method.

B.Folgard's method.

C.Fayans-Khodakov method.

D.Mercurometric titration.

E.Trilonometry.

4.Choose an indicator for argentometric determination of chloride ions by Mohr's method.

A.*Potassium chromate.

B.Diphenylcarbazone.

C.Eosin.

D.Fluorescein.

E.Methyl red.

5.To determine the mass fraction of sodium chloride in the drug, the Fayans-Khodakov method is used. Titration is carried out in the presence of an indicator solution:

A.* Fluorescein.

B.Methyl red.

C.Potassium chromate.

D.Ammonium ferrum (III) sulfate.

E.Phenolphthalein.

6.For the quantitative determination of potassium chloride in the preparation, the method of mercurometry was used. As an indicator, we used:

A.* diphenylcarbazone

B.methyl red

C.phenolphthalein

D.fluorescein

E.ferroin

7.What working solutions (titrants) are used in the precipitation titration method - Folgard's method?

A.$AgNO_3$ and NH_4SCN

B. H_2SO_4 and NaOH

C. $Na_2S_2O_3$ and $K[I_3]$

D. $KMnO_4$ and $KBrO_3$

E. $HClO_4$ and KOH

8. A solution of potassium iodide is titrated with a standard solution of silver nitrate (direct titration), using as an indicator:

A. * fluorescein

B. methyl orange

C. iron-ammonium alum

D. starch solution

E. tropeolin 00

9. Choose the analysis method that can be used to determine the total content of $CaCl_2$ and NaBr in the solution:

A. * argentometry

B. acidimetry

C. complexonometry

D. permanganatometry

E. alkalimetry

10. When calculating the results of the analysis of compounds through the titrant of the test substance, enter:

A. *correction factor to molar concentration

B. conversion factor

C. correction index

D. ratio coefficient

E. deviation coefficient

11. To determine the volume of titrant during titrimetric analysis, use:

A. *Burettes

B. Measuring flasks

C. Measuring cups

D. Cylinders

E.Beakers

4. Summing up:

As a result of the lesson, the student got acquainted with Mohr's method and learned to apply these methods in the analysis of chemical substances and to calculate the results of the work.

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 45

Topic: Thiocyanatometric titration. Titrants. Volgard's method, its essence and titration conditions. ***Laboratory work:*** "Standardization of NH_4SCN solution by standard $AgNO_3$ solution."

Goal: Get acquainted with the Volgard method and learn how to apply this method in the analysis of chemical substances, learn how to calculate the results of work.

Basic concepts:analysis, quantitative analysis, titrimetric analysis, redox titration method, indicator, solubility product, primary standard, secondary standard, equivalence point, end point of titration (TEP)

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   – requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

   The student should know:

   - ✓ basic rules for working with acids and alkalis;
   - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
   - ✓ principles and methods of qualitative analysis, classification of analysis methods;
   - ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
   - ✓ the concept of fractional and systematic analysis, the difference between one and the other;
   - ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
   - ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

   The student should be able to:

   - ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize

solutions of analytical reagents;

- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. Folgard's method: method of titration, titrant of the method, indicator of the method, reaction equations, possibilities of the method.
2. Why titration according to the Folgard method is carried out in an acidic environment? What acid creates an environment and why?
3. Peculiarities of determination of chloride and iodide ions by the Folgard method.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1. After dissolution and appropriate processing of 0.9860 g of fertilizer, an aqueous solution containing HPO_4^{2-} was obtained, which was quantitatively precipitated by adding 40.00 ml of 0.2040 M $AgNO_3$ solution. 8.72 ml of a 0.1170

M solution of KSCN was required for the titration of the excess Ag^+ in the filtrate and washing waters after separation of the precipitate. Calculate the percentage of P_2O_5 in the sample.

2. What mass of aniline $C_6H_5NH_2$ was contained in the sample taken, if after precipitation of $Cu(C_6H_5NH_2)_2(SCN)_2$ by adding excess $CuSO_4$ and 50.00 ml of 0.1 M NH_4SCN (K = 1.042), the mixture was diluted to 100.0 ml, took 50.00 ml of the filtrate and titrated the unreacted ammonium thiocyanate with 15.45 ml of 0.1 M $AgNO_3$ (K = 0.9815) according to the Folgard method?

4. A sample of perchlordivinyl C_4Cl_6 weighing 0.1212 g (M = 260.79 g/mol) was dissolved in 250.0 ml of dilute nitric acid after combustion with hydrogen peroxide. To 50.00 ml of this solution was added 25.00 ml of 0.05 M $AgNO_3$ (K = 1.025), the excess of which was titrated with 13.24 ml of 0.05 M KSCN (K = 1.107). Determine the mass fraction (%) of chlorine in the studied sample and compare it with the theoretical one.

- recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Quantitative analysis. Titrimetric analysis 2. Precipitation titration 3. Folgard's method	Quantitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including for registration: the laboratory work registration form is attached
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1. An analytical chemist needs to determine the quantitative content of hydrochloric acid in a mixture containing nitric acid. What titrimetric method of analysis can he use:

A.* Argentometry.

B.Iodometry.

C.Complexonometry.

D.Acid-base titration.

E.Permanganotometry.

2.To determine the mass fraction of sodium chloride in a physiological solution, the analytical chemist used Mohr's method, the titrant of which is:

A.* Argentum nitrate.

B.Ammonium thiocyanate.

C.Sodium tetraborate.

D.Mercury (I) nitrate.

E.Mercury (II) nitrate.

3.To determine the mass fraction of chloride ions in a sample of table salt, a solution was prepared and titrated with argentum nitrate solution in the presence of the potassium chromate indicator. What analysis method was used:

A.*Mor's method.

B.Folgard's method.

C.Fayans-Khodakov method.

D.Mercurometric titration.

E.Trilonometry.

4.Choose an indicator for argentometric determination of chloride ions by Mohr's method.

A.*Potassium chromate.

B.Diphenylcarbazone.

C.Eosin.

D.Fluorescein.

E.Methyl red.

5.To determine the mass fraction of sodium chloride in the drug, the Fayans-Khodakov method is used. Titration is carried out in the presence of an indicator solution:

A.* Fluorescein.

B.Methyl red.

C.Potassium chromate.

D.Ammonium ferrum (III) sulfate.

E.Phenolphthalein.

6.For the quantitative determination of potassium chloride in the preparation, the method of mercurometry was used. As an indicator, we used:

A.* diphenylcarbazone

B.methyl red

C.phenolphthalein

D.fluorescein

E.ferroin

7.What working solutions (titrants) are used in the precipitation titration method - Folgard's method?

A.$AgNO_3$ and NH_4SCN

B.H_2SO_4 and NaOH

C.$Na_2S_2O_3$ and $K[I_3]$

D.$KMnO_4$ and $KBrO_3$

E.$HClO_4$ and KOH

8.A solution of potassium iodide is titrated with a standard solution of silver nitrate (direct titration), using as an indicator:

A.* fluorescein

B.methyl orange

C.iron-ammonium alum

D.starch solution

E.tropeolin 00

9.Choose the analysis method that can be used to determine the total content of $CaCl_2$ and NaBr in the solution:

A.* argentometry

B.acidimetry

C.complexonometry

D.permanganatometry

E.alkalimetry

10. When calculating the results of the analysis of compounds through the titrant of the test substance, enter:

A.*correction factor to molar concentration

B.conversion factor

C.correction index

D.ratio coefficient

E.deviation coefficient

11. To determine the volume of titrant during titrimetric analysis, use:

A.*Burettes

B.Measuring flasks

C.Measuring cups

D.Cylinders

E.Beakers

4. Summing up:

As a result of the lesson, the student got acquainted with the Folgard method and learned to apply these methods in the analysis of chemical substances and to calculate the results of the work.

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of

medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.
4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 46

Topic:T The Fayans-Khodakov method, its essence and titration conditions. Adsorption indicators in argentometry. ***Laboratory work:*** "Determination of the mass percentage of sodium chloride by the Fayans-Khodakov method."

Goal: Get acquainted with the Volgard method and learn how to apply this method in the analysis of chemical substances, learn how to calculate the results of work.

Basic concepts:analysis, quantitative analysis, titrimetric analysis, redox titration method, indicator, solubility product, primary standard, secondary standard, equivalence point, end point of titration (TEP)

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
     - ✓ principles and methods of qualitative analysis, classification of analysis methods;

- ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
- ✓ the concept of fractional and systematic analysis, the difference between one and the other;
- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. Fayans-Khodakov method: method of titration, titrant of the method, indicators of the method, reaction equations, possibilities of the method.
2. With which indicator and at what pH value is chloride ions determined according to the Fayans-Khodakov method?
3. With what indicator and at what pH value is the determination of iodide and bromide ions carried out by the Fayans-Khodakov method? Justify the answer

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1. Dissolve 7.500 g of the sample containing $BaCl_2$, I_2 and inert material, and dilute the solution in a volumetric flask to 250.0 ml. An aliquot with a volume of 25.00 ml was titrated with 0.0847 M $AgNO_3$ solution. The indicator was the adsorption indicator bromophenol blue, which changes color after

quantitative precipitation, when I^- and $C1^-$ fall out. An aliquot with a volume of 50.00 ml was titrated with a solution of $AgNO_3$ with the indicator eosin, which is adsorbed only after precipitation of I^-. The first titration required 41.20 ml of $AgNO_3$ solution, the second 38.30 ml. Calculate the percentage content of $BaCl_2$ and BaI_2 in the original sample.

2. A sample of technical KBr weighing 0.3838 g was dissolved in water and the solution was titrated with 23.80 ml of $AgNO_3$ solution ($T(AgNO_3/Cl) = 0.003546$). Calculate the mass fraction (%) of KBr in the sample.

3. What volume of a solution containing 55 g/l of NaCl should be taken to prepare 250.0 ml of the solution so that 15.00 ml of 0.1000 M $AgNO_3$ solution is used for the titration of 20.00 ml of it.

- recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Quantitative analysis. Titrimetric analysis 2. Precipitation titration 3. The Fayans-Khodakov method.	Quantitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including for registration: the laboratory work registration form is attached
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1. An analytical chemist needs to determine the quantitative content of hydrochloric acid in a mixture containing nitric acid. What titrimetric method of analysis can he use:

A.* Argentometry.

B.Iodometry.

C.Complexonometry.

D.Acid-base titration.

E.Permanganotometry.

2.To determine the mass fraction of sodium chloride in a physiological solution, the analytical chemist used Mohr's method, the titrant of which is:

A.* Argentum nitrate.

B.Ammonium thiocyanate.

C.Sodium tetraborate.

D.Mercury (I) nitrate.

E.Mercury (II) nitrate.

3.To determine the mass fraction of chloride ions in a sample of table salt, a solution was prepared and titrated with argentum nitrate solution in the presence of the potassium chromate indicator. What analysis method was used:

A.*Mor's method.

B.Folgard's method.

C.Fayans-Khodakov method.

D.Mercurometric titration.

E.Trilonometry.

4.Choose an indicator for argentometric determination of chloride ions by Mohr's method.

A.*Potassium chromate.

B.Diphenylcarbazone.

C.Eosin.

D.Fluorescein.

E.Methyl red.

5.To determine the mass fraction of sodium chloride in the drug, the Fayans-Khodakov method is used. Titration is carried out in the presence of an indicator solution:

A.* Fluorescein.

B.Methyl red.

C.Potassium chromate.

D.Ammonium ferrum (III) sulfate.

E.Phenolphthalein.

6.For the quantitative determination of potassium chloride in the preparation, the method of mercurometry was used. As an indicator, we used:

A.* diphenylcarbazone

B.methyl red

C.phenolphthalein

D.fluorescein

E.ferroin

7.What working solutions (titrants) are used in the precipitation titration method - Folgard's method?

A.$AgNO_3$ and NH_4SCN

B. H_2SO_4 and NaOH

C. $Na_2S_2O_3$ and $K[I_3]$

D. $KMnO_4$ and $KBrO_3$

E. $HClO_4$ and KOH

8. A solution of potassium iodide is titrated with a standard solution of silver nitrate (direct titration), using as an indicator:

A. * fluorescein

B. methyl orange

C. iron-ammonium alum

D. starch solution

E. tropeolin 00

9. Choose the analysis method that can be used to determine the total content of CaCl2 and NaBr in the solution:

A. * argentometry

B. acidimetry

C. complexonometry

D. permanganatometry

E. alkalimetry

10. When calculating the results of the analysis of compounds through the titrant of the test substance, enter:

A. *correction factor to molar concentration

B. conversion factor

C. correction index

D. ratio coefficient

E. deviation coefficient

11. To determine the volume of titrant during titrimetric analysis, use:

A. *Burettes

B. Measuring flasks

C. Measuring cups

D. Cylinders

E.Beakers

4. Summing up:

As a result of the lesson, the student got acquainted with the Fayans-Khodakov method and learned to apply these methods in the analysis of chemical substances and to calculate the results of the work.

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p

Practical lesson No. 47

Topic: Complexiметric titration methods. Requirements for reactions in complexiметry.

Goal: Familiarize yourself with complexometric titration and learn how to use these methods in the analysis of chemical substances, learn how to calculate work results.

Basic concepts:analysis, quantitative analysis, titrimetric analysis, redox titration method, metallochromic indicators, primary standard, secondary standard,

equivalence point, end point of titration (TEP), complex compound, instability constant

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)

– requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

The student should know:

- ✓ basic rules for working with acids and alkalis;
- ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
- ✓ principles and methods of qualitative analysis, classification of analysis methods;
- ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
- ✓ the concept of fractional and systematic analysis, the difference between one and the other;
- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of

performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;

- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. Complex symmetric titration. The essence of the method. Requirements for reactions in complexiметric titration. Classification of complexiметric titration methods.
2. Complexonometry. Complexons used in titrimetric analysis, their properties.
3. Curves of complexometric titration. How does the titration jump depend on the stability constants of the complex compound, the pH of the medium?
4. Working solutions of complexonometry. Preparation and standardization of the working solution of trilon B.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1.Trilon B was taken to determine the titer of the working solution 1.3250 g of dried calcium carbonate and dissolved in a 250 volumetric flask cm^3. 25.00 for titration cm^3 26.45 of this solution was used cm^3 Trilon B solution. Determine the calcium titer of the working solution and the normality of the Trilon B solution.

2. 0.5 dm^3 of solution contains 2.0388 g trilon B. Calculate the molar concentration of the equivalent and the titer of this solution.

3. Determine the molar concentration, titer T(EDTA) and titer by the substance to be determined T(EDTA/CaO) of the working solution of EDTA (trilon B), if 18 were spent on the titration of a weight of metallic zinc weighing 0.0131 g after its dissolution in hydrochloric acid, 46 ml of working solution.

- recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Quantitative analysis. Titrimetric analysis 2.Complex symmetric titration. Complexonometry	Quantitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

– requirements for work results, including for registration: the laboratory work registration form is attached

– control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1.The concentration is determined by the method of direct complexonometry:

A.* Metal cations.

B.Anions of strong acids.

C.Anions of weak acids.

D.Hydroxide ions.

E.Hydrogen ions.

2.What method of analysis can an analytical chemist use to determine the aluminum content in the drug Alumag (maalox) by indirect titration:

A.* Complexonometry.

B.Dichromatometry.

C.Argentometry.

D.Mercurometry.

E.Iodometry.

3.The quantitative content of calcium chloride in the medicinal product is determined by the method of direct complexometric titration. Choose an indicator to fix the end point of the titration:

A.*Eriochrome black T

B.Starch.

C.Fluorescein.

D.Potassium chromate.

E.Eosin.

4.To standardize the titrated solution of trilon B, a standard solution is used:

A.* zinc sulfate.

B.sodium tetraborate.

C.sodium chloride.

D.potassium dichromate.

E.oxalic acid.

5.For the quantitative determination of magnesium sulfate in the solution, the following method can be used:

A.* complexonometry

B.nitritometry

C.argentometry

D.thiocyanatometry

E.acidimetry

6.A solution containing potassium chloride and magnesium chloride was taken for research. What titrimetric method can be used to determine the amount of magnesium chloride in a mixture?

A.*Complexonometry method

B.By the method of argentometry

C.By the method of mercurometry

D.By the method of permanganatometry

E.By the method of iodometry

7.Buffer solutions are widely used for the manufacture and analysis of medicinal products. Buffer solutions are used for:

A.*Maintaining a certain pH value of the solution.

B.Changes in the pH value of the solution.

C.Changes in the ionization constant of a substance.

D.Changes in the ionic strength of the solution.

E.Changes in the solubility product of a substance.

8.When determining the total hardness of water, the laboratory technician uses the indicator eriochrome black T. Indicate by which method the determination was made:

A.* Complexonometry

B.Argentometry

C.Permanganatometry

D.Bromatometry

E.Chromatometry

9.Choose a titrimetric method for the quantitative determination of magnesium sulfate in a solution for injection:

A.* Complexonometry.

B.Cerimetry.

C.Acid-base titration.

D.Iodine chlorimetry.

E.Nitritometry.

10. What method of titration is used if an accurately measured excess of the auxiliary titrant is added to the solution of the substance under investigation:

A.*Titration by residue

B.Non-aqueous titration

C.Direct titration

D.Surrogate titration

E.Any titration

11. When determining chlorides in drinking water, the mercurimetry method is used. The solution was used as a titrant:

A.* $Hg(NO_3)_2$

B.$Hg_2(NO_3)_2$

C.$HgCl_2$

D.$HgSO_4$

E.Hg_2Cl_2

12. For the quantitative determination of medicinal products containing alkaline earth and heavy metals, the following method is used:

A.*complexonometry

B.permanganatometry

C.acidimetry

D.mercurimetry

E.alkalimetry

4. Summing up:

As a result of the lesson, the student got acquainted with complexometric titration and learned to apply these methods in the analysis of chemical substances and to calculate the results of the work

5. List of recommended literature:

Main:

1. 1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.
3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.
4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p

Practical lesson No. 48

Topic: Complexometric titration. Indication of the titration end point. The principle of action of metallochrome indicators. ***Laboratory work:*** "Complexonrometric determination of water hardness."

Goal: Familiarize yourself with complexometric titration and learn how to use these methods in the analysis of chemical substances, learn how to calculate work results.

Basic concepts:analysis, quantitative analysis, titrimetric analysis, redox titration method, metallochromic indicators, primary standard, secondary standard, equivalence point, end point of titration (TEP), complex compound, instability constant

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)

– requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

The student should know:

- ✓ basic rules for working with acids and alkalis;
- ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
- ✓ principles and methods of qualitative analysis, classification of analysis methods;
- ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
- ✓ the concept of fractional and systematic analysis, the difference between one and the other;
- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;

- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. General characteristics of complex formation methods.
2. Chelatometric titration. Application of complexes. Why is complexon III used for titration?
3. Calculate the amount of trilon B needed to prepare 200 cm^3 of a 0.02 N solution. What substances can be used to standardize the EDTA solution.
4. Describemethod of preparation of a standard solution of trilon-B (0.05 M) - 250 ml
5. Complexometric determination of magnesium sulfate. Write the appropriate reaction equations, justify the choice of the indicator, determine the equivalent of the studied compound and its equivalent molar mass. Give the formula for calculating the quantitative content of magnesium sulfate in the preparation.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1.Trilon B was taken to determine the titer of the working solution1.3250 g of dried calcium carbonate and dissolved in a 250 volumetric flask *cm^3*. 25.00 for titration *cm^3* 26.45 of this solution was used*cm3*Trilon B solution. Determine the calcium titer of the working solution and the normality of the Trilon B solution.

2. 0.5 dm3 of solution contains 2.0388 g trilon B. Calculate the molar concentration of the equivalent and the titer of this solution.

3. Weight of the iron preparation by mass0.1000 gdissolved in water. The solution was titrated with 21.12 cm^3 of 0.0500 n. Trilon B solution. Calculate the mass fraction of iron in the preparation.

4. recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Quantitative analysis. Titrimetric analysis 2.Complex symmetric titration. Complexonometry	Quantitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including for registration: the laboratory work registration form is attached
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1. Fixation of TET in complexonometry. Metallochromic indicators, their mechanism of action and requirements for metallochromic indicators. Why are metallochromic indicators often used in the solid state in the form of triturations?
2. Describe the properties and use of metallochromic indicators: eriochrome black T, murexide, xylenol orange.
3. Conditions of complexometric titration. Why is the determination of cations with +3 and +4 charges carried out in an acidic environment? Why is the determination of Co^{2+}, Zn^{2+}, Cd^{2+}, Ni^{2+} ions carried out in an ammonia buffer?
4. Under what conditions (pH, temperature) should a direct titration with Trilon B solution be carried out in relation to:

- Ca2+ with murexide;

- Pb^{2+} with xylenol orange;

- Mg^{2+} and Zn^{2+} with eriochrome black T.

5. What substances are determined complexometrically by direct, reverse, and substitution titration methods?

6. Give examples of complexometric titration:

- cations in an alkaline medium at pH 10-13;
- cations in an ammonia buffer medium at pH 9-10;
- of cations in an acidic medium at pH 1-3;
- cations by the method of reverse titration;
- cations by means of substitution titration;
- of anions by the method of reverse titration.

7. Describe the features of complexometric determination by direct titration: a) Pb^{2+}; b) Zn^{2+}; c) Fe^{3+}; d) Bi^{3+}; e) Ca^{2+}; f) Ba^{2+}; g) Mg^{2+}; g) Al^{3+}.

4. Summing up:

As a result of the lesson, the student got acquainted with complexometric titration and learned to apply these methods in the analysis of chemical substances and to calculate the results of the work

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 49

Topic: ***Control work*** on topic "Precipitation titration methods. Complexiметric titration methods."

Goal: Familiarize yourself with complexometric titration and learn how to use these methods in the analysis of chemical substances, learn how to calculate work results.

Basic concepts:analysis, quantitative analysis, titrimetric analysis, redox titration method, metallochromic indicators, primary standard, secondary standard, equivalence point, end point of titration (TEP), complex compound, instability constant

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
     - ✓ principles and methods of qualitative analysis, classification of analysis methods;
     - ✓ analytical characteristics of substances, analytical reactions,

requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;

- ✓ the concept of fractional and systematic analysis, the difference between one and the other;
- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text

- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. Precipitation titration, Mohr's method. Titrant, indicator, conditions of use, possibilities of the method.
2. Precipitation titration, Fayans-Khodakov method. Titrant, indicator, conditions of use, possibilities of the method.
3. Precipitation titration, Folgard method. Titrant, indicator, conditions of use, possibilities of the method.
4. General characteristics of complex formation methods.
5. Chelatometric titration. Application of complexes. Why is complexon III used for titration?
6. Calculate the amount of trilon B needed to prepare 200 cm^3 of a 0.02 N solution. What substances can be used to standardize the EDTA solution.
7. Describemethod of preparation of a standard solution of trilon-B (0.05 M) - 250 ml
8. Complexometric determination of magnesium sulfate. Write the appropriate reaction equations, justify the choice of the indicator, determine the equivalent of the studied compound and its equivalent molar mass. Give the formula for calculating the quantitative content of magnesium sulfate in the preparation.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1.Trilon B was taken to determine the titer of the working solution1.3250 g of dried calcium carbonate and dissolved in a 250 volumetric flask *cm^3*. 25.00 for titration *cm^3* 26.45 of this solution was used *cm^3* Trilon B solution. Determine the calcium titer of the working solution and the normality of the Trilon B solution.

2 .0.5 dm^3 of solution contains 2.0388 g trilon B. Calculate the molar concentration of the equivalent and the titer of this solution.

3. Weight of the iron preparation by mass 0.1000 g dissolved in water. The solution was titrated with 21.12 cm^3 of 0.0500 N. Trilon B solution. Calculate the mass fraction of iron in the preparation.

4. recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Quantitative analysis. Titrimetric analysis 2. Precipitation titration. Mohr's method, Fayans-Khodakov's method, Folgard's method. Mercurometry. 3.Complex symmetric titration. Mercurimetry. Complexonometry	Quantitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including for registration: the form of test answers is attached
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary)

5. Summing up:

As a result of the lesson, the student got acquainted with complexometric titration and learned to apply these methods in the analysis of chemical substances and to calculate the results of the work

6. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A.

E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.
3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.
4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 50

Topic: Optical methods of analysis. Photocolorimetry and spectrophotometry. Conditions of photometric determination.

Goal: Get acquainted with optical methods of analysis, learn how to apply these methods in the analysis of chemical substances, learn how to calculate work results. Familiarize yourself with the analysis technique, the equipment used.

Basic concepts:analysis, qualitative analysis, quantitative analysis, instrumental analysis, optical methods, spectrophotometry, photocolorimetry, molar ratio, refractive index, specific rotation,

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:

     ✓ basic rules for working with acids and alkalis;

- ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
- ✓ principles and methods of qualitative analysis, classification of analysis methods;
- ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
- ✓ the concept of fractional and systematic analysis, the difference between one and the other;
- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical

processing of quantitative analysis results;

- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. Name the parts of a spectrophotometer and define their function.

2. Write the formula of the basic law of atomic light absorption

3. What is the difference between transmission and absorption?

4. In what units is optical density measured?

5. What is the relationship between optical density and light transmission?

6. Formulate the law of additivity of optical density for a multicomponent solution.

7. Define the molar absorption coefficient (ε). Specify its size. What does the molar absorption coefficient depend on?

8. What is the criterion for assessing the sensitivity of photometric measurements?

9. Name the main stages of photometric measurements.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1.When working according to the method of standard series for the preparation of a standard solution of $CuSO_4 \cdot 5H_2O$, a weight of this salt was taken (1.708 g) was dissolved in 1000 cm^3 of water. From the resulting solution, 10 colored solutions containing from 1.00 to 10.00 cm^3 of a standard solution in 20.00 cm^3 of water were obtained by adding ammonia. Then0.750 g the studied compound was dissolved in 250 cm^3 of water. After the interaction of 10.00 cm^3 of this solution with ammonia and dilution to 20.00 cm^3, the intensity of its color is equal to the

intensity of the color of the eighth standard. Calculate the mass fraction of copper in the studied compound.

2. To prepare a series of standard solutions, measure sodium nitrite by weight0.324 g dissolved in a 250 cm^3 volumetric flask (the solution was brought up to the mark). 10 colored solutions containing 5.0 to 5.00 cm^3 of solution in 20.00 cm^3 of water were prepared from the flask with the addition of α-naphthylamine and sulfanilic acid.1.04 gsodium nitrite was dissolved in 500 cm^3 of water, 10 cm^3 was taken and, after appropriate processing, diluted with water to 20.00 cm^3. The color intensity of the obtained solution is equal to the color intensity of the sixth standard. Calculate the mass fraction of nitrite ion in sodium nitrate.

3. Calculate the molar absorption coefficient of copper, if the optical density of a solution containing 0.24 mg of copper in 250 cm^3, at the thickness of the cuvette layer 2 cm is equal to 0.14.

4. When photometrically determining Fe^{3+} ions with sulfosalicylic acid, a standard solution with a concentration of 2.0 mg/dm^3 has an optical density of 0.285, and a solution with a concentration of 4.00 mg/dm^3 has an optical density of 0.56. The optical density of the investigated solution is 0.45. Determine the molar absorption coefficient and the concentration of Fe^{3+} ions (mg/dm^3) in the studied solution.

5. recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Quantitative analysis. 2.Physico-chemical analysis 3. Spectrophotometry 4. Photocolorimetry	Quantitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

– requirements for work results, including for registration: the laboratory work registration form is attached

– control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if

necessary):

1.What spectral method of analysis cannot be used to determine the qualitative composition of a substance?

a) atomic emission spectroscopy;

b) molecular absorption IR spectroscopy;

d) photocolorimetry;

e) spectrophotometry.

2. Which spectral method of analysis has high sensitivity and selectivity?

a) atomic absorption spectroscopy;

b) molecular absorption spectroscopy;

d) photocolorimetry;

e) atomic emission spectroscopy.

3. What spectral methods of analysis are based on light emission?

a) photocolorimetry;

b) spectrophotometry;

d) atomic absorption spectroscopy;

e) atomic emission spectroscopy.

4. What types of radiation are initiated by external valence transitions electrons?

a) IR radiation;

b) UV radiation;

c) γ-radiation;

d) visible radiation.

5. What kind of radiation initiates nuclear transitions in an atom?

a) IR radiation;

b) UV radiation;

c) γ-radiation;

d) visible radiation.

6. What types of radiation do not cause electronic transitions in an atom?

a) radio waves;

b) IR radiation;

c) γ-radiation;

d) visible radiation.

7. What kind of atomic radiation spectra are there?

a) continuous spectrum;

b) linear spectrum;

c) striped range.

8. What element of a spectral device is used for decomposition electromagnetic radiation in the spectrum?

a) source of excitation;

b) collimator with a slit;

c) diffraction gratings;

d) photocell.

9. What is the dispersive effect of a triangular prism based on?

a) depending on the refractive index of the prism material and the wavelength of its radiation;

b) depending on the refractive index of the prism and the wavelength of the radiation directed at it;

c) depending on the intensity of the glow of the prism material and the wavelength of its radiation;

d) depending on the light transmission coefficient of the prism and the frequency of the radiation directed at it.

10. What formula is used to calculate the optical density of a solution?

a) $A = -IgI/I0$;

b) $A = IgI/I0$

c) $A = I/I0$;

d) $A = -IgI0/I$.

11. What does the molar absorption coefficient depend on?

a) from temperature;

b) from the nature of the absorbing substance;

c) from the wavelength of incident light;

d) from concentration.

12. What equation corresponds to the Lambert-Booger-Behr law?

a) A = ε· L·C;

b) Azag = A1 + A2 + A3 ... + An;

c) I = a · Cb;

d) A = k ·L·C.

13. What parameter determines the sensitivity of photocolorimetry methods?

a) the thickness of the absorbing layer of the solution;

b) molar absorption coefficient;

c) pH of the solution;

d) excess photometric reagent added.

4. Summing up:

As a result of the lesson, the student got acquainted with the optical methods of analysis, learned how to apply these methods in the analysis of chemical substances, learned how to calculate the results of the work.

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 51

Topic: Determination of the concentration of the investigated solution by the methods of photocolorimetry and spectrophotometry.

Goal: Get acquainted with optical methods of analysis, learn how to apply these methods in the analysis of chemical substances, learn how to calculate work results. Familiarize yourself with the analysis technique, the equipment used.

Basic concepts:analysis, qualitative analysis, quantitative analysis, instrumental analysis, optical methods, spectrophotometry, photocolorimetry, molar ratio, refractive index, specific rotation

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
     - ✓ principles and methods of qualitative analysis, classification of analysis methods;
     - ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group

reagent), methods of qualitative reactions;

- ✓ the concept of fractional and systematic analysis, the difference between one and the other;
- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. Name the parts of a spectrophotometer and define their function.

2. Write the formula of the basic law of atomic light absorption

3. What is the difference between transmission and absorption?

4. In what units is optical density measured?

5. What is the relationship between optical density and light transmission?

6. Formulate the law of additivity of optical density for a multicomponent solution.

7. Define the molar absorption coefficient (ε). Specify its size. What does the molar absorption coefficient depend on?

8. What is the criterion for assessing the sensitivity of photometric measurements?

9. Name the main stages of photometric measurements.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1.When working according to the method of standard series for the preparation of a standard solution of $CuSO_4 \cdot 5H_2O$, a weight of this salt was taken (1.708 g) was dissolved in 1000 cm^3 of water. From the resulting solution, 10 colored solutions containing from 1.00 to 10.00 cm^3 of a standard solution in 20.00 cm^3 of water were obtained by adding ammonia. Then 0.750 g the studied compound was dissolved in 250 cm^3 of water. After the interaction of 10.00 cm^3 of this solution with ammonia and dilution to 20.00 cm^3, the intensity of its color is equal to the intensity of the color of the eighth standard. Calculate the mass fraction of copper in the studied compound.

2. To prepare a series of standard solutions, measure sodium nitrite by weight 0.324 g dissolved in a 250 cm^3 volumetric flask (the solution was brought up to the mark). 10 colored solutions containing 5.0 to 5.00 cm^3 of solution in 20.00 cm^3 of water were prepared from the flask with the addition of α-naphthylamine and sulfanilic acid. 1.04 gsodium nitrite was dissolved in 500 cm^3 of water, 10 cm^3 was

taken and, after appropriate processing, diluted with water to 20.00 cm^3. The color intensity of the obtained solution is equal to the color intensity of the sixth standard. Calculate the mass fraction of nitrite ion in sodium nitrate.

3. Calculate the molar absorption coefficient of copper, if the optical density of a solution containing 0.24 mg of copper in 250 cm^3, at the thickness of the cuvette layer 2 cm is equal to 0.14.

4. When photometrically determining Fe^{3+} ions with sulfosalicylic acid, a standard solution with a concentration of 2.0 mg/dm^3 has an optical density of 0.285, and a solution with a concentration of 4.00 mg/dm^3 has an optical density of 0.56. The optical density of the investigated solution is 0.45. Determine the molar absorption coefficient and the concentration of Fe^{3+} ions (mg/dm^3) in the studied solution.

6. recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Quantitative analysis. 2.Physico-chemical analysis 3. Spectrophotometry 4. Photocolorimetry	Quantitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including for registration: the laboratory work registration form is attached
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1.What spectral method of analysis cannot be used to determine the qualitative composition of a substance?

a) atomic emission spectroscopy;

b) molecular absorption IR spectroscopy;

d) photocolorimetry;

e) spectrophotometry.

2. Which spectral method of analysis has high sensitivity and selectivity?

a) atomic absorption spectroscopy;

b) molecular absorption spectroscopy;

d) photocolorimetry;

e) atomic emission spectroscopy.

3. What spectral methods of analysis are based on light emission?

a) photocolorimetry;

b) spectrophotometry;

d) atomic absorption spectroscopy;

e) atomic emission spectroscopy.

4. What types of radiation are initiated by external valence transitions electrons?

a) IR radiation;

b) UV radiation;

c) γ-radiation;

d) visible radiation.

5. What kind of radiation initiates nuclear transitions in an atom?

a) IR radiation;

b) UV radiation;

c) γ-radiation;

d) visible radiation.

6. What types of radiation do not cause electronic transitions in an atom?

a) radio waves;

b) IR radiation;

c) γ-radiation;

d) visible radiation.

7. What kind of atomic radiation spectra are there?

a) continuous spectrum;

b) linear spectrum;

c) striped range.

8. What element of a spectral device is used for decomposition

electromagnetic radiation in the spectrum?

a) source of excitation;

b) collimator with a slit;

c) diffraction gratings;

d) photocell.

9. What is the dispersive effect of a triangular prism based on?

a) depending on the refractive index of the prism material and the wavelength of its radiation;

b) depending on the refractive index of the prism and the wavelength of the radiation directed at it;

c) depending on the intensity of the glow of the prism material and the wavelength of its radiation;

d) depending on the light transmission coefficient of the prism and the frequency of the radiation directed at it.

10. What formula is used to calculate the optical density of a solution?

a) A = $-IgI/I0$;

b) A = $IgI/I0$

c) A = $I/I0$;

d) A = $-IgI0/I$.

11. What does the molar absorption coefficient depend on?

a) from temperature;

b) from the nature of the absorbing substance;

c) from the wavelength of incident light;

d) from concentration.

12. What equation corresponds to the Lambert-Booger-Behr law?

a) A = ε· L·C;

b) Azag = A1 + A2 + A3 ... + An;

c) I = a · Cb;

d) A = k ·L·C.

13. What parameter determines the sensitivity of photocolorimetry methods?

a) the thickness of the absorbing layer of the solution;

b) molar absorption coefficient;

c) pH of the solution;

d) excess photometric reagent added.

6. Summing up:

As a result of the lesson, the student got acquainted with the optical methods of analysis, learned how to apply these methods in the analysis of chemical substances, learned how to calculate the results of the work.

7. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p

Practical lesson No. 52

Topic: Optical analysis methods. Refractometry.

Goal: Get acquainted with optical methods of analysis, learn how to apply these methods in the analysis of chemical substances, learn how to calculate work results. Familiarize yourself with the analysis technique, the equipment used.

Basic concepts:analysis, qualitative analysis, quantitative analysis, instrumental analysis, optical methods, electrochemical methods, spectrophotometry, photocolorimetry, molar ratio, refractive index, specific rotation,

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:

     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
     - ✓ principles and methods of qualitative analysis, classification of analysis methods;
     - ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
     - ✓ the concept of fractional and systematic analysis, the difference between one and the other;
     - ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
     - ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

     The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. The essence of the refractometric method of analysis. Snelius' law of refraction.

2. Concept of refractive index (absolute and relative). Factors affecting the value of the refractive index. The formula for recalculating the value of the refractive index, taking into account the effect of temperature (for $t \neq 20°C$).

3. Refractometric factor F – physical meaning, method of finding (mathematical form).

4. What is the basis of the use of refractometry in quantitative analysis?

5. Determination of the concentration of one component in two- and multi-component solutions

6. Devices for measuring the refractive index. Refractive index measurement technique.

7. What is polarized light, plane of polarization called?

8. Optically active substances, the nature of optical activity. Examples of optically active substances.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1.Determine the normal concentration of formic acid, if the refractive index of its 12.21% solution is 1.3405, and the refractive index of the solution under study is 1.3375, taking into account the fact that there is a linear relationship between the concentration and the refractive index in this interval

2. Find the concentration (wt.%) of nitroethane in a mixture with nitrobenzene if the specific refraction of the mixture is 0.255 cm3/g, the density $\rho(C_2H_5NO_2)$ = 1.038 and $\rho(C_6H_5NO_2)$ = 1.1930 g/cm3; and the refractive indices$n(C_2H_5NO_2)$ = 1.3902and n $(C_6H_5NO_2)$ = 1.5526.

3. At a temperature of 250C, the refractive index of the solution is 1.3372, the refractive index factor is 0.0016. Calculate the concentration of the solution.

4.recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Quantitative analysis. 2.Physico-chemical analysis 3. Refractometry	Quantitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

– requirements for work results, including for registration: the laboratory work

registration form is attached

- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1. General characteristics of the refractometric method of analysis. Application of refractometry for identification of medicinal products, for quantitative analysis of concentrated solutions and medicinal products. Advantages and disadvantages of the method.
2. Refractive index of solution, factors affecting its value.
3. Refractive index factor, method of its determination.
4. Methods of calculating the concentration of a solution using the refractometric method of analysis.

5. Summing up:

As a result of the lesson, the student got acquainted with the optical methods of analysis, learned how to apply these methods in the analysis of chemical substances, learned how to calculate the results of the work.

6. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p

Practical lesson No. 53

Topic: Electrochemical methods of analysis. Potentiometric analysis. Potentiometric titration.

Goal: Get acquainted with electrochemical methods of analysis, learn how to apply these methods in the analysis of chemical substances, learn how to calculate work results. Familiarize yourself with the analysis technique, the equipment used.

Basic concepts:analysis, quantitative analysis, instrumental analysis, electrochemical methods, potentiometry, voltammetry, electrodes, ion-selective electrodes

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
     - ✓ principles and methods of qualitative analysis, classification of analysis methods;
     - ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
     - ✓ the concept of fractional and systematic analysis, the difference between one and the other;

- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. List the main electrochemical methods of analysis (EMA)

2. What physical parameters are used as analytical signals in electrochemical measurements?

3. What is the sensitivity of EMA? Name the method that has the highest sensitivity.

4. What electrochemical methods are characterized by high selectivity?

5. What is the advantage of electrochemical methods compared to optical methods of analysis?

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1.How long does it take to pass a current of 1 A to reduce to divalent all the trivalent iron contained in 80 ml of a 0.1 M solution?

2. Hydrochloric acid (4 ml) is coulometrically titrated with electrolytically generated OH– ions in the solution at a constant current of 50 mA. The equivalence point is reached after 5 min. 15 p. Calculate the titer of the tested NaOH solution.

3. At 18 oC, the specific electrical conductivity of a saturated AgCl solution is 1.259·10–6 Ω–1·cm–1, and the mobilities of Ag^+ and Cl^- ions are 54.4 and 65.5 Ω–1· (mol–eq)–, respectively. 1 ·cm2. Determine the mass of AgCl (g) contained in a liter of solution.

4. Calculate the standard potential of the electrode reaction Cu^{2+} + e = Cu+ from the values of the standard potentialsφ^{0}Su2$^+$/Cu0 = 0.337 V andφ^{0}Su$^+$/Cu0 = 0.521 V.

5. Calculate the EMF of the circuit Pt, CI_2 (1 atm) | $PbC1_2$ (w) | $C1_2$ (10 atm), Pt at 800 K. Is the element written correctly?

7. recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Quantitative analysis. 2.Physico-chemical analysis	Quantitative analysis	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T.

3. Potentiometry 4. Voltammetry		V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including for registration: the laboratory work registration form is attached
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1.Specify the reference electrode that can be used in the potentiometric study of a medicinal substance:

A.*Silver chloride

B.Glass

C.Anhydronic

D.Surmyany

E.Zinc

2.What does the height of a polarographic wave depend on?

A.*Reducible ion concentrations

B.The composition of the electrolyte

C.Capillary characteristics

D.Radius of the capillary

E.Capillary lengths

3.One of the electrochemical methods of analysis is potentiometry. Potentiometry is a method of analysis based on measuring (determining):

A.* The potential of the indicator electrode.

B.The potential of the diffuse layer.

C.Zeta potential.

D.Ox-red potential of the system.

E.The potential of the reference electrode.

4.For the identification of medicinal products by the polarographic method, the following are determined:

A.* Half-wave potential.

B.Allocation potential.

C.Schedule potential.

D.Limit diffusion current.

E.Residual current.

5.One of the electrochemical methods of analysis is polarography. The amount of substance in the studied system during polarographic analysis is determined by:

A.* The height of the polarographic wave.

B.The magnitude of electromotive force.

C.Current strength.

D.The position of the polarographic wave.

E.The width of the polarographic wave.

6.For the quantitative determination of ferric II sulfate by the method of potentiometric titration, the indicator electrode is used:

A.*Platinum electrode.

B.Silver chloride electrode.

C.Non-hydrogen electrode.

D.Antimony electrode.

E.Glass electrode.

7.Specify which parameter is measured during conductometric titration of electrolyte solutions:

A.*Conductivity

B.Electromotive force

C.Viscosity of the solution

D.Acidity of the environment

E.Concentration of the solution

8.Amperometric titration is used for the analysis of some pharmaceutical preparations. The amperometric titration method is based on:

AND.* determination of the equivalence point by a sharp change in the diffusion current during the titration process

B.measuring the potential difference between the electrodes during the titration process.

C.voltage measurements in the cell during titration.

D.ion exchange between the solution being analyzed and the cationite.

E.ion exchange between the anionite and the analyte solution

9.Specify electrochemical methods of analysis.

A.* Conductometry, potentiometry, polarography

B.Refractometry, polarimetry

C.Spectrophotometry, photoelectrocolorimetry

D.Turbidimetry, nephelometry

E.Colorimetry, photometry

10. The pharmacist determines the concentration of Zn^{2+} ions using amperometric titration. At the same time, the specialist registers the diffusion current passing through the electrochemical cell and constructs a graph of the dependence of the diffusion current on:

A.* Titrant volume

B.Titrant concentrations

C.Masses of titrant

D.Tensions

E.Half-wave potential

11. In a chemical-analytical laboratory, a specialist performs quantitative determination of a substance by measuring the electromotive force. What method does he use?

A.* Potentiometry

B.Conductometry

C.Coulometry

D.Voltammetry

E.Polarography

4. Summing up:

As a result of the lesson, the student got acquainted with the optical methods of analysis, learned how to apply these methods in the analysis of chemical substances, learned how to calculate the results of the work.

5. List of recommended literature:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p

Practical lesson No. 54

Topic: Chromatographic analytical methods. Determination of the content of alkali metal salts in solutions by the method of ion exchange chromatography. Thin-layer chromatography.

Goal: Learn how to carry out and justify the choice of substances for a specific case of chromatographic determination; calculate the value of the concentration of substances using the method of chromatography on paper; to quantitatively determine substances used in pharmacy by the method of chromatography on paper.

Basic concepts:chromatography, thin-layer chromatography, mobile phase, stationary phase, Rf

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   – requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

   The student should know:

   - ✓ basic rules for working with acids and alkalis;
   - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;
   - ✓ principles and methods of qualitative analysis, classification of analysis methods;
   - ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
   - ✓ the concept of fractional and systematic analysis, the difference between one and the other;
   - ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
   - ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

   The student should be able to:

   - ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize

solutions of analytical reagents;

- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. The essence of the paper chromatography method, its advantages and disadvantages. Justify the answer.
2. Classification of chromatographic methods of analysis. 3. Types of paper chromatography.
3. What determines the location of the zones of the components that are separated in the method of sediment chromatography on paper?
4. For what purposes are chromatographic methods of analysis used?
5. The main characteristics of paper chromatography.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1. Use of paper chromatography in qualitative analysis. Justify your answer and write it down.

2. Theoretical foundations of the chromatographic method of analysis.

3. Chromatography method sorbents, their characteristics and requirements for them.

4. What is a chromatogram, in what coordinates is it built? Justify your answer and write it down.

5. What are the requirements for media used in the paper chromatography method? Justify your answer and write it down.

6. Use of paper chromatography in the analysis of pharmaceutical preparations.

8. recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Classification of chromatographic methods of analysis. 2. Basic characteristics of paper chromatography. Types of paper chromatography	Paper and thin-layer chromatography	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

- requirements for work results, including for registration: a registration form for test tasks is attached
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

1. TLC is based on processes

A. adsorption due to the ability of substances to bind to the surface of the sorbent

B. distribution between mobile and stationary phases

C. ion exchange due to the substance's ability to form heteropolar bonds with the sorbent

D. gel filtration

2. TLC is used for

A. identification of substances

B. quantitative analysis

C. preparatory division

D. cleaning solvent

3. Chromatography types are used in pharmaceutical analysis

A. thin layer

B. ion exchange

C. gas-liquid

D. highly effective

4. They are used as solvents in TLC

A. chloroform

B. alcohols

C. ethers

D. water

5. The qualitative characteristic of TLC is

A. the distance from the start line to the middle of the spot of the substance under study

B. distance from the start line to the front line of the solvent

C. the ratio of the distance from the start line to the middle of the spot of the substance under study to the distance from the start line to the front line of the solvent

D. the ratio of the distance from the start line to the front line of the solvent to the distance from the start line to the middle of the spot of the substance under study

6. Rf in the TLC method is

A. qualitative characteristics of the substance under study

B. characteristic of the physical properties of the solvent

C. quantitative characteristics of the substance under study

D. the ratio of the distance traveled by the test substance to the distance traveled by the solvent

7. Rs is

A. the ratio of the path traveled by the tested substance to the path traveled by another substance taken as a standard sample

B. the ratio of the path traveled by the substance taken as a standard sample to the path traveled by the substance under investigation

8. TSH allows solving the following tasks

A. division of medicinal mixtures into individual substances

B. identification of ingredients of complex medicines

C. testing substances for purity

D. determination of the quantitative content of individual substances in medicinal products of complex composition

9. Chromatographic separation of substances by the TLC method is affected

A. sorbent properties

B. properties of the solvent system

C. properties of specified substances

D. amount of applied sample

10. TLC uses sorbents

A. aluminum oxide

B. silica gel

C. polyamide

D. activated carbon

11. Water activity of the sorbent

A. lowers

B. raises

C. does not affect

12. Samples are applied to the chromatographic plate

A. with a micropipette

B. capillary

C. syringe

D. Mohr's pipette

13. Methods of finding substances on a chromatographic plate

A. viewing in UV light

B. spraying with the appropriate detector reagent

C. treatment with iodine vapors in a closed vessel

D. spraying with water

14. Processing of the chromatogram with iodine vapor is carried out

A. in a crystallizer or desiccator with tightly closed lids saturated with iodine vapors

B. in a glass container in the air

C. applying iodine crystals to the chromatogram

15. The reason for the appearance of "tails" of the investigated substance on the chromatogram is

A. the substance under investigation is applied in an amount greater than it should be

B. the solvent system is incorrectly selected

C. incorrectly selected chromatographic plate (sorbent)

D. the shape of the chromatographic chamber is incorrectly selected

4. Summing up:

As a result of the lesson, the student got acquainted with the rules for choosing substances for a specific case of chromatographic determination; learned how to calculate the concentration of substances using the chromatography method on paper; to quantitatively determine substances used in pharmacy by the method of chromatography on paper.

5. List of recommended literature:

Main:

1. 1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A.

E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.

4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p.

Practical lesson No. 55

Topic: ***Control work*** on topic "Instrumental methods of analysis."

Goal: Summarize knowledge on the topic "Instrumental methods of analysis".

Basic concepts:chromatography, thin-layer chromatography, mobile phase, stationary phase, R_f, electrochemical methods, potentiometry, voltammetry, electrodes, ion-selective electrodes, optical methods, spectrophotometry, photocolorimetry, molar ratio, refractive index, specific rotation,

Equipment:visual material, multimedia projector

Plan:

1. Organizational activities (greetings, verification of those present, announcement of the topic, purpose of the lesson, motivation of higher education seekers to study the topic).
2. Control of the reference level of knowledge (written work, written test, frontal survey, etc.)
   - requirements for theoretical readiness of students to perform practical classes (knowledge requirements, list of didactic units)

     The student should know:
     - ✓ basic rules for working with acids and alkalis;
     - ✓ subject and problems of analytical chemistry, basic concepts of analytical chemistry;

- ✓ principles and methods of qualitative analysis, classification of analysis methods;
- ✓ analytical characteristics of substances, analytical reactions, requirements for them, types of analytical reactions and reagents (group reagent), methods of qualitative reactions;
- ✓ the concept of fractional and systematic analysis, the difference between one and the other;
- ✓ characteristic of the sensitivity of analytical reactions (limit dilution, limit concentration, minimum volume of a limit dilution solution, detection limit (detection minimum);
- ✓ analytical classifications of cations by groups, acid-base classification of cations (what is it based on, what substances are used as group reagents).

The student should be able to:

- ✓ use measuring utensils, analytical scales; to possess the technique of performing basic analytical operations in the qualitative and quantitative analysis of a substance, to prepare and standardize solutions of analytical reagents;
- ✓ select an average sample, draw up an analysis scheme, carry out qualitative and quantitative analysis of the substance within the limits of using the basic techniques and methods provided by the program;
- ✓ choose the optimal method of qualitative and quantitative analysis of a substance;
- ✓ separate cations and anions by chemical and chromatographic methods;
- ✓ conduct laboratory experiments, explain the essence of specific reactions and their analytical effects, draw up report documentation based on experimental data;
- ✓ perform initial calculations, final calculations using statistical processing of quantitative analysis results;
- ✓ work independently with educational and reference literature on

analytical chemistry.

List of didactic units:

- ✓ textbook text
- ✓ a bank of test tasks

– questions (test tasks, tasks, clinical situations) to check basic knowledge on the subject of the lesson.

1. Classification of physical and chemical methods of analysis Direct and indirect methods. Advantages of physical and chemical methods of analysis, scope of application.
2. Optical methods of analysis. Classification of methods.
3. Refractometry. Refractive index, its physical meaning. Dependence of refractive index on concentration. Refractometer device.
4. Polarimetry. Polarized light, its production and properties. Optically active substances. Polarimeter device. Qualitative and quantitative analysis.
5. Spectral methods of analysis. Origin of absorption and emission spectra. Qualitative and quantitative spectral analysis.
6. Flame photometry as a variant of emission spectral analysis. Processes occurring in the burner flame. Qualitative and quantitative analysis. Application of the method for the analysis of environmental objects and chemical products.
7. Absorption molecular analysis. Photoelectrocolorimetry. Spectrophotometry. The basic law of light absorption. Molar coefficient of light absorption. Optical density and light transmission. Selection of light filters. Qualitative and quantitative analysis. Objects of analysis.
8. Electrochemical methods of analysis. Classification of methods. Quantitative analysis. Fields of application.
9. Potentiometry. Electrode potential, factors influencing it. Standard and indicator electrodes, choice of electrode system. Direct and indirect potentiometry. Advantages and disadvantages of the method. Quantitative analysis.
10. Conductometry. Direct and indirect conductometry.

11. Chromatographic methods of separation and analysis. Classification of chromatographic methods
12. Ion exchange chromatography. Ionites, their properties, ion exchange reactions. Qualitative and quantitative analysis.
13. Chromatography on paper. Qualitative and quantitative analysis. Distribution coefficient and division factor.
14. Gas chromatography. Objects of analysis, carriers, adsorbents and stationary phases. The main components of a gas chromatograph, their purpose. Qualitative and quantitative analysis in gas chromatography.

3. Formation of professional skills and abilities:

– content of tasks (tasks, clinical situations, etc.)

1. Use of paper chromatography in qualitative analysis. Justify your answer and write it down.

2. Theoretical foundations of the chromatographic method of analysis.

3. Chromatography method sorbents, their characteristics and requirements for them.

4. What is a chromatogram, in what coordinates is it built? Justify your answer and write it down.

5. What are the requirements for media used in the paper chromatography method? Justify your answer and write it down.

6. Use of paper chromatography in the analysis of pharmaceutical preparations.

4. recommendations (instructions) for performing tasks

Main tasks	Instructions	Answers
1. Physico-chemical (instrumental) methods of analysis 2. Basic characteristics of paper chromatography. Types of paper	Paper and thin-layer chromatography	Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh;

chromatography 3. Optical methods (photocolorimetry, spectrophotometry, refractometry, polarimetry) 4. Electrochemical methods (potentiometry, conductometry)		Original, 2012.

- requirements for work results, including for registration: a registration form for test tasks is attached
- control materials for the final stage of the lesson: tasks, tasks, tests, etc. (if necessary):

5. Summing up:

As a result of the lesson, the student got acquainted with the rules for choosing substances for a specific case of chromatographic determination; learned how to calculate the concentration of substances using the chromatography method on paper; to quantitatively determine substances used in pharmacy by the method of chromatography on paper.

6. List of recommended literature:

Main:

1. Analytical chemistry: handbook / V. V. Bolotov, O. A. Yevtifeyeva, L. Yu. Klimenko, T. A. Kostina, T. V. Zhukova, E. Yu. Ahmedov , O. A. Brizicky; edited by V. V. Bolotov.— Kharkiv: NUPh; Original, 2012.

2. Analytical chemistry (Qualitative analysis). Part I / O. A. Ievtifieieva, V. V. Bolotov, T. A. Kostina, O. M. Svechnikova, T. I. Yuschenko, N. I. Kaminska, A. E. Kosareva, L. V. Slobodyanyuk, O. P. Yashchuk ; edited by O. A. Ievtifieieva. – Kharkiv : Publishing house the CLL «Generous farmstead plus», 2014. – 168 p.

3. Analytical chemistry. Part II. Quantitative analysis: the manual for foreign students of pharmaceutical higher schools and pharmaceutical departments of

medical higher schools of the III – IV accreditation levels / V. V. Bolotov, O. M. Svechnikova, T. A. Kostina et al. – Kharkiv: NUPh, 2010. – 160 p.
4. Analytical chemistry: textbook [the textbook for students of higher schools] / I.S. Grytsenko, V. V. Bolotov, L.Yu. Klimenko et al.; ed. by I.S. Grytsenko – Kharkiv: NUPh, Golden Pages, 2019. – 600 p