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

____________________Eduard BURYACHKIVSKY

_______________, 202_

METHODOLOGICAL DEVELOPMENT TO THE INDEPENDENT WORK OF HIGHER EDUCATION ACQUIRES FROM 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 _____________

Head of Department (__________________) Volodymyr HELMBOLDT

(signature) *(First Name Last Name)*

Developers:

Senior lecturer Nikitin O.V., assistant Holubchyk H.O., assistant Lytvynchuk I.V., assistant Ulizko I.V.

Independent work No. 1

Topic: Basic concepts of qualitative chemical analysis. Solving problems on the quantitative characteristics of the sensitivity of analytical reactions. Qualitative reactions for the determination of cations of analytical group I.

Goal: Get acquainted with the basic concepts of chemical analysis. Master the solution of problems on the topic "Quantitative characteristics of the sensitivity of analytical reactions." Familiarize yourself with analytical reactions for cations of analytical group I.

Basic concepts: cation, analytical reactions, analytical groups, reaction sensitivity, detection limit, limiting dilution, specific reagent, group reagent.

Plan

1. Theoretical questions:

1) Analytical chemistry
2) Qualitative analysis
3) Sensitivity of analytical reactions
4) Rules and technique of performing individual analytical operations
5) Qualitative reactions of cations of analytical group I

Questions for self-control:

1) Describe the methods of performing analytical reactions (dry and wet)
2) Name the performance conditions and sensitivity of analytical reactions
3) Formulate the rules and describe the heating and evaporation technique
4) Formulate the rules and describe the technique of sedimentation and filtration of sediments
5) List the chemical reagents and the rules for handling them
6) Give qualitative reactions for the determination of K^+ cations
7) Give qualitative reactions for the determination of Na^+ cations
8) Give qualitative reactions for the determination of NH_4^+ cations

Approximate tasks for processing the theoretical material:

- Compile a dictionary of basic concepts on the topic.

2. Practical works (tasks) to be performed:

Task 1.The limiting concentration of the Al3+ ion opening during microcrystalline opening is exactly 1,500,000 ml/g. The minimum solution volume required for the Al^{3+} ion opening is 0.06 ml. Calculate the opening minimum.

Task 2.Calculate the minimum volume of the solution, if the opening minimum is 0.3 µg, and the maximum dilution is 1000 ml.

Task 3.To determine the sensitivity of the reaction to the Pb^{2+} ion with potassium iodide, a lead nitrate solution containing 1 g of Pb^{2+} per 1 dm^3 was prepared. It was established that when this solution is diluted 14 times, the reaction occurs. Determine the opening minimum and limiting dilution for this reaction under the condition that it takes place with a droplet of $9.8 \cdot 10^{-4}$ ml.

Problem 4. The studied solution contains potassium and ammonium cations. Specify the reagent that allows you to detect ammonium cations in this solution: Nessler's reagent, sodium hydrotartrate, sodium hexanitrocobaltate, lead hexanitrocuprate(II), zincuranyl acetate. Write the equation of the corresponding reaction and indicate the analytical effect.

Problem 5. 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

3. Test tasks for self-control:

1. 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)

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

A. *Cincuranyl acetate
B. Potassium oxalate
C. Potassium tetraiodomercurate (II)
D. Potassium hydrotartrate
E. Potassium benzoate

3. 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

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

A. *Nessler's reagent
B. Potassium chromate
C. Zinc uranyl acetate
D. Reactive Chugaev
E. Sodium sulfate

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

A. *Reaction with hydroxides of alkali metals when heated
B. Reaction with potassium hexahydroxoctibate
C. Reaction with sodium hexanitrocobalt (III)
D. Reaction with potassium tetraiodohydrargyrate (II) in an alkaline medium
E. Reaction with sodium hexanitrocobalt (III) in an acidic environment

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

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

8. 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

9. 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

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

A. 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

11. In pharmacopoeial analysis, the reaction with:

A. diphenylamine
B. 8- oxyquinoline
C. *2-methoxy-2-phenylacetic acid
D. diacetyldioxime
E. tetraphenylborate

12. Volatile sodium salts color the flame in:

A. yellow-green color
B. brick-red color
C. *yellow
D. violet

13. 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

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

A. *the medium 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

15. 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

16. A white crystalline precipitate with $NaHC_4H_4O_6$ forms a cation

A. Ba^{2+};

B. K^+;

C. Na^+;

D. Li^+;

E. there is no correct answer

17. 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. Individual tasks for students of higher education on the topic:

1) Systematic analysis of cations of analytical group I.
2) The use of microcrystallographic reactions in analytical chemistry
3) Qualitative reactions used in chemical analysis and in pharmacopoeial analysis. Features and differences.

5. References:

General:

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.

Independent work No. 2

Topic: Chemical-analytical properties of cations of II analytical groups (acid-base classification) and characteristic reactions of determination.

Goal: Familiarize yourself with the analytical reactions for cations of the II analytical group.

Basic concepts: cation, analytical reactions, analytical groups, reaction sensitivity, detection limit, limiting dilution, specific reagent, group reagent.

Plan

1. **Theoretical questions:**

1) The action of the group reagent on the cations of the II analytical group.
2) Reactions of cations of the II analytical group.
3) Systematic course of analysis of cations of the II analytical group.

Questions for self-control:

1) The action of the group reagent on the cations of the II analytical group. How can the formed chloride precipitates be separated?

2) Reactions of cations of the II analytical group. Solubility of the obtained precipitates.
3) Systematic course of analysis of cations of the II analytical group.

Approximate tasks for processing the theoretical material:

– Fill in the table.

Reagent	Cation	Product	Analytical effect	Solubility of the precipitate obtained
1	2	3	4	5
1 M HCl	Ag^+			
	Pb^{2+}			
	Hg_2^{2+}			

2. Practical works (tasks) to be performed:

Task 1.The investigated solution was treated with an alkali solution. A black precipitate, insoluble in an excess of alkali, fell out. What cation of analytical group 2 (acid-base classification) does this analytical effect indicate? Write the equations of the corresponding reactions

Task 2.The solution contains ions Ag+ and Hg22+-. Suggest how to separate these ions by performing a systematic course of analysis. Write the equation and the corresponding reactions

Task 3. The solution contains Ag+ and Hg22+ 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

Task 4. The investigated solution was treated with a solution of potassium iodide. A yellow precipitate was formed, which practically does not dissolve in ammonia solution, but easily dissolves in solutions of potassium cyanide and sodium thiosulfate. What cation of analytical group 2 (acid-base classification) does this analytical effect indicate? Write the equations of the corresponding reactions

3. Test tasks for self-control:

1. What reagent can be used to separate argentum and mercury (I) chlorides in a systematic analysis and at the same time detect mercury (I) cations?

A. Nitric acid solution

B. Alkali solution

C. Hot water

D. Ammonia solution

E. Excess concentrated hydrochloric acid

2. 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)

3. 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. Hg^{2+}

4. The basis for separating lead (II) chloride from other chlorides of the II analytical group of cations (acid-base classification) is its solubility in:

A. hot water

B. hydrochloric acid

C. meadows

D. ammonia solution

E. sulfuric acid

5. 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

6. A solution of potassium iodide was added to the investigated solution. A golden-yellow precipitate, soluble in hot water, fell out. This indicates the presence in the solution:

A. Sodium cations

B. Silver cation

C. Lead cations

D. Mercury (II) cations.

E. Mercury (I) cations.

7. The reaction of the formation of a golden-yellow precipitate ("golden rain" reaction) is a reaction:

A. $PbCl_2$

B. AgI

C. PbI_2

D. HgI_2

E. Hg_2I_2

8. Choose a reagent for separating the PbSO4 precipitate from the precipitate of sulfate cations of the III analytical group:

A. 30% CH_3COONH_4 solution

B. 12% CH_3COONa solution

C. 20% Na_2CO_3 solution

D. 10% solution $(NH_4)_2SO_4$

E. 16% solution $(NH_4)_2CO_3$

4. Individual tasks for students of higher education on the topic:

1) Medicinal preparations containing cations of the II analytical group. Application, mechanism of action, analysis.
2) Biological role of cations of the II analytical group.

5. References:

General:

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.

Independent work No. 3

Topic: Theory of strong electrolytes. Solution of calculations by topic.

Goal:ATget acquainted with the basic provisions of the theory of strong electrolytes. Learn to solve problems on the topic "Theory of strong electrolytes and heterogeneous equilibrium". Get acquainted with the application of the law of active masses to heterogeneous systems.

Basic concepts:electrolyte, non-electrolyte, degree of dissociation, activity, heterogeneous system, saturated solution, solubility product

Plan

1. Theoretical questions:

1) Theory of strong electrolytes. Activity and activity coefficient. Ionic strength of the solution.

2) The ionic strength of the solution and its influence on the values of the activity coefficient.

3) Dielectric permeability and its effect on the value of the other strength of the solution.

4) Equilibrium in the "sediment-saturated solution" system. The concept of "solubility product"

Questions for self-control:

1) Theory of strong electrolytes. Activity and activity coefficient. Ionic strength of the solution. Calculate the ionic strength and activity of the chlorine ion $a\text{Cl}^-$ 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/dm^3 of Na_2SO_4 in the solution?
3) Dielectric permeability and its effect on the value of the other strength of the solution. Calculate the activity of K^+ and Cl^- ions in 100 ml of a solution containing 0.02 M potassium chloride and 0.001 M acetic acid.

Approximate tasks for processing the theoretical material:

- Compile a dictionary of basic concepts on the topic.

2. Practical works (tasks) to be performed:

Task 1.Calculate the ionic strength and activity of the chlorine ion aCl- in a 0.1 M sodium chloride solution.

Task 2. Calculate the activity of S^{2-} ions in a saturated solution of hydrogen sulfide $\left(C_{H_2S} = 0{,}1\, моль/л,\ K_{1H_2S} = 1 \cdot 10^{-7},\ K_{2H_2S} = 2{,}5 \cdot 10^{-13}\right)$at pH=2.

Task 3.Calculate the concentration of H+ and CN- ions in a 0.1 M solution, if the constantdissociation of hydrocyanic acid is $7.2 \cdot 10^{-10}$

Task 4. The concentration of H^+ ions in a 0.1 M solution of acetic acid is 1.3·10-3 mol/dm3. Calculate the constant and degree of acid dissociation.

Task 5. Will a precipitate form when mixing equal volumes of 0.15 M silver nitrate solution and 0.2 M sodium chloride solution?

Task 6. Establish the conditions for the beginning of the formation of a silver chloride precipitate under the action of 0.0001 n. silver nitrate solution (DR(AgC1) = $1.78 \cdot 10^{-10}$).

3. Test tasks for self-control:

1. The ionic strength of a 0.1 M sodium chloride solution is equal to:

A. * 0.1 M;

B. 0.01 M;

C. 0.001 M;

D. 0.0001 M

2. The ionic strength of a 0.01 M solution of hydrochloric acid is equal to:

A. 0.1 M;

B. *0.01 M;

C. 0.001 M;

D. 0.0001 M

3. The ionic strength of a 0.01 M solution of chromium(III) chloride is equal to:

A. 0.01 M;
B. 0.001 M;
C. 0.1 M;
D. *0.06 M.

4. The ionic strength of a 0.1 M solution of magnesium sulfate is equal to:

A. 0.1 M;
B. 0.2 M;
C. 0.3 M;
D. *0.4 M.

5. What is the molar concentration of hydrochloric acid in an aqueous solution if the ionic strength of the solution is 0.01 M?

A. 1.0 M;
B. 0.5 M;
C. *0.01 M;
D. 0.2 M

6. The ionic strength of the zinc sulfate solution is 0.4 M, what is the molar concentration of zinc sulfate in the solution?

A. *0.1 M;
B. 0.2 M;
C. 0.3 M;
D. 0.4 M

7. A precipitate of poorly soluble electrolyte falls out if:

A. The stoichiometric product of the molar concentrations of ions is less than the solubility constant;
B. *the stoichiometric product of the molar concentrations of ions is greater than the solubility constant;
C. the solubility constant is equal to the product of the molar concentrations of ions;

D. there is no correct answer.

8. If the molar concentration of copper(I) ions is $1 \cdot 10^{-6}$ M and iodide ions is $1 \cdot 10^{-6}$ M in one liter of aqueous solution, then KS(CuI) is equal to:

A. $1 \cdot 10^{-10}$;

B. $1 \cdot 10^{-9}$;

C. *$1 \cdot 10^{-12}$;

D. $1 \cdot 10^{-6}$

9. 1 liter of water contains 10^{-5} mol of silver ions and 10^{-5} mol of chloride ions. The solubility constant of silver chloride is equal to:

A. $1 \cdot 10^{-5}$;

B. $1 \cdot 10^{-8}$;

C. $1 \cdot 10^{-9}$;

D. *$1 \cdot 10^{-10}$

10. The solubility constant of AgSCN is equal to $1\ 10^{-12}$. At what value of the product of the molar concentrations of ions does a precipitate fall out?

A. *$1 \cdot 10^{-10}$;

B. $1 \cdot 10^{-13}$;

C. $1 \cdot 10^{-14}$;

D. $1 \cdot 10^{-15}$

11. The solubility constant of barium sulfate is 1·10 -10. Dissolution of the precipitate will occur at the following value of the stoichiometric product of the molar concentrations of ions:

A. $1 \cdot 10^{-4}$;

B. $1 \cdot 10^{-8}$;

C. $1 \cdot 10^{-10}$;

D. *$1 \cdot 10^{-12}$

12. Of the proposed sediments, the most soluble in water (thermodynamic solubility constants KS are indicated in parentheses) is:

A. barium carbonate ($4\ 10^{-10}$);

B. barium oxalate (1.1 10^{-7});

C. barium chromate (1.2 10^{-10});

D. * barium sulfite ($8 \cdot 10^{-7}$)

13. The solubility constant for silver chromate corresponds to the expression:

A. $Ks=[Ag^{+}]\cdot[CrO_4^{2-}]$;

B. *$Ks=[Ag^{+}]^2 [CrO_4^{2-}]$;

C. $Ks=[Ag^{+}] [CrO_4^{2-}]^2$;

D. $Ks=[Ag^{+}]^2 [CrO_4^{2-}]^2$

14. The solubility constant for calcium phosphate corresponds to the expression:

A. $Ks=[Ca^{2+}]^2 [PO_4^{3-}]^3$;

B. $Ks=[Ca^{2+}] [PO_4^{3-}]^3$;

C. $Ks=[Ca^{2+}]^2 [PO_4^{3-}]$;

D. *$Ks=[Ca^{2+}]^3 [PO_4^{3-}]^2$

4. Individual tasks for students of higher education on the topic:

1) Theory of electrolytic dissociation. The history of the discovery, the main provisions, advantages and disadvantages.
2) Modern aspects and directions of development of the theory of electrolytic dissociation
3) Heterogeneous systems. Reactions at the boundary of the phase distribution. Heterogeneous catalysis.

5. References:

General:

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.

Independent work No. 4

Topic: Chemical-analytical properties of cations of III analytical groups (acid-base classification) and characteristic reactions of determination.

Goal: Familiarize yourself with analytical reactions for cations of the III analytical group.

Basic concepts:cation, analytical reactions, analytical groups, reaction sensitivity, detection limit, specific reagent, group reagent.

Plan

1. Theoretical questions:

1) The action of the group reagent on the cations of the III analytical group.

2) Reactions of cations of the III analytical group.

3) Systematic course of analysis of cations of the III analytical group.

Questions for self-control:

1) The action of the group reagent on the cations of the III analytical group. Solubility of the obtained precipitates. How are transplants carried out?
2) Reactions of cations of the III analytical group. Solubility of the obtained precipitates.
3) Systematic course of analysis of cations of the III analytical group.

Approximate tasks for processing the theoretical material:

- Compile a dictionary of basic concepts on the topic.

2. Practical works (tasks) to be performed:

Task 1. Group reagent for cations of the third analytical group (acid-base classification) and conditions of its use. Write the equations of chemical reactions that allow you to separate and detect Ba2+ and Sr2+ cations when they are present together.

Task 2. The investigated solution was treated with a solution of potassium chromate. A yellow precipitate fell out, soluble in nitric acid, but not soluble 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.

3. Test tasks for self-control:

1. A solution of potassium chromate was added to the solution under study. 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 analysis, the following are used to convert sulfates $BaSO_4$, $SrSO_4$, $CaSO4$ 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. *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 in 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

8. 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

9. Which of the specified reagents should be used to determine the presence of the Ca^{2+}cation in the solution?

A. *$(NH_4)_2C_2O_4$

B. HCl

C. $HN O_3$

D. KCl

E. $NaBr$

4. Individual tasks for students of higher education on the topic:

1) Medicinal preparations containing cations of the III analytical group. Application, mechanism of action, analysis.
2) Biological role of cations of the III analytical group.

5. References:

General:

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.

Independent work No. 5

Topic: Heterogeneous equilibria in the sediment-saturated solution system.

Goal: Get acquainted with the application of the law of active masses to heterogeneous systems. Learn to solve problems on the topic "Heterogeneous equilibrium".

Basic concepts:electrolyte, non-electrolyte, degree of dissociation, activity, heterogeneous system, saturated solution, solubility product

Plan

1. Theoretical questions:

1) Equilibrium in the "sediment-saturated solution" system.
2) The concept of "solubility product"
3) The concept of solubility and its relationship with the solubility product

Questions for self-control:

1) What is the solubility constant (solubility product)? How are the thermodynamic and concentration constants of solubility related to each other?
2) What is solubility? How are the solubility product and ionic solubility related?
3) What is molecular solubility? How is it related to the solubility product?
4) How does the presence of a common ion in a solution affect the solubility of a sparingly soluble electrolyte?
5) What is the "salt effect"?

Approximate tasks for processing the theoretical material:

- Compile a dictionary of basic concepts on the topic.

2. Practical works (tasks) to be performed:

Task 1.Does $Mg(OH)_2$ precipitate form if the same volume of ammonia buffer solution obtained by mixing equal volumes of 0.20 M NH_3 and 0.10 M NH4Cl is added to 25 ml of $1.0 \cdot 10^{-3}$ M $Mg(NO_3)_2$?

Task 2. At what minimum concentration (g/l) of Ni^{2+} ions in a solution with a pH of 8.0 will the formation of a $Ni(OH)_2$ precipitate occur?

Task 3. Is a $Ni(OH)_2$ precipitate formed if an ammonia buffer solution is added to the $Ni(NO_3)_2$ solution so that the total concentration of Ni(II) in the resulting mixture is equal to $1.0 \cdot 10^{-4}$ mol/l, the equilibrium concentration NH_3 - 0.10 mol/l, and pH - 10.0? The formation constants of Ni(II) ammonia complexes are equal to $\beta_1 = 4{,}68 \cdot 10^2$, $\beta 2 = 6{,}17 \cdot 10^4$, $\beta_3 = 2{,}51 \cdot 10^6$, $\beta_4 = 2{,}95 \cdot 10^7$

Task 4. Will a precipitate of calcium fluoride fall out if 2 drops (0.1 ml) of a solution with a mass fraction of NaF of 1% are added to 1 ml of a solution with a mass fraction of Ca(NO3)2 of 0.1%?

Task 5. Will a precipitate form when mixing equal volumes of 0.15 M silver nitrate solution and 0.2 M sodium chloride solution?

Task 6. Establish the conditions for the beginning of the formation of a silver chloride precipitate under the action of 0.0001 n. silver nitrate solution (SP(AgC1) = $1.78 \cdot 10^{-10}$).

3. Test tasks for self-control:

1. A precipitate of poorly soluble electrolyte falls out if:

A. The stoichiometric product of the molar concentrations of ions is less than the solubility constant;

B. *the stoichiometric product of the molar concentrations of ions is greater than the solubility constant;

C. the solubility constant is equal to the product of the molar concentrations of ions;

D. there is no correct answer.

2. If the molar concentration of copper(I) ions is $1 \cdot 10^{-6}$ M and iodide ions is $1 \cdot 10^{-6}$ M in one liter of aqueous solution, then KS(CuI) is equal to:

A. $1 \cdot 10^{-10}$;

B. $1 \cdot 10^{-9}$;

C. *$1 \cdot 10^{-12}$;

D. $1 \cdot 10^{-6}$

3. 1 liter of water contains 10^{-5} mol of silver ions and 10^{-5} mol of chloride ions. The solubility constant of silver chloride is equal to:

A. $1 \cdot 10^{-5}$;

B. $1 \cdot 10^{-8}$;

C. $1 \cdot 10^{-9}$;

D. *$1 \cdot 10^{-10}$

4. The solubility constant of AgSCN is equal to $1\ 10^{-12}$. At what value of the product of the molar concentrations of ions does a precipitate fall out?

A. *$1 \cdot 10^{-10}$;

B. $1 \cdot 10^{-13}$;

C. $1 \cdot 10^{-14}$;

D. $1 \cdot 10^{-15}$

5. The solubility constant of barium sulfate is 1·10 -10. Dissolution of the precipitate will occur at the following value of the stoichiometric product of the molar concentrations of ions:

A. $1 \cdot 10^{-4}$;

B. $1 \cdot 10^{-8}$;

C. $1 \cdot 10^{-10}$;

D. *$1 \cdot 10^{-12}$

6. Of the proposed sediments, the most soluble in water (thermodynamic solubility constants KS are indicated in parentheses) is:

a. barium carbonate ($4\ 10^{-10}$);

b. barium oxalate ($1.1\ 10^{-7}$);

c. barium chromate ($1.2\ 10^{-10}$);

d. * barium sulfite ($8 \cdot 10^{-7}$)

7. The solubility constant for silver chromate corresponds to the expression:

A. $Ks=[Ag^+]\cdot[CrO_4^{2-}]$;

B. *$Ks=[Ag^+]^2 [CrO_4^{2-}]$;

C. $Ks=[Ag^+] [CrO_4^{2-}]^2$;

D. $Ks=[Ag^+]^2 [CrO_4^{2-}]^2$

8. The solubility constant for calcium phosphate corresponds to the expression:

A. $Ks=[Ca^{2+}]^2 [PO_4^{3-}]^3$;

B. $Ks=[Ca^{2+}] [PO_4^{3-}]^3$;

C. $Ks=[Ca^{2+}]^2 [PO_4^{3-}]$;

D. *$Ks=[Ca^{2+}]^3 [PO_4^{3-}]^2$

4. Individual tasks for students of higher education on the topic:

1) Heterogeneous systems. Reactions at the boundary of the phase distribution.
2) Heterogeneous catalysis.

5. **References:**

General:

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.

Independent work No. 6

Topic: Systematic analysis of the mixture of cations of I-III analytical groups.

Goal: Summarize knowledge on the use of analytical reactions for cations of the I-III analytical group.

Basic concepts:cation, analytical reactions, analytical groups, reaction sensitivity, detection limit, specific reagent, group reagent.

Plan

1. **Theoretical questions:**

1) Action of group reagent on cations of analytical group I.
2) Reactions of cations of analytical group I.
3) Systematic analysis of cations of analytical group I.

4) The action of the group reagent on the cations of the II analytical group.
5) Reactions of cations of the II analytical group.
6) Systematic course of analysis of cations of the II analytical group.
7) The action of the group reagent on the cations of the III analytical group.
8) Reactions of cations of the III analytical group.
9) Systematic course of analysis of cations of the III analytical group.
10) Systematic course of analysis of the mixture of cations of the I-III analytical group.

Questions for self-control:

1) Analytical reactions of anions of analytical group I
2) Systematic analysis of cations of analytical group I.
3) The action of the group reagent on the cations of the II analytical group. How can the formed chloride precipitates be separated?
4) Reactions of cations of the II analytical group. Solubility of the obtained precipitates.
5) Systematic course of analysis of cations of the II analytical group.
6) The action of the group reagent on the cations of the III analytical group. Solubility of the obtained precipitates. How are transplants carried out?
7) Reactions of cations of the III analytical group. Solubility of the obtained precipitates.
8) Systematic course of analysis of cations of the III analytical group.

Approximate tasks for processing the theoretical material:

- Compile a dictionary of basic concepts on the topic.

2. Practical works (tasks) to be performed:

Task 1.The solution contains NH_4^+, Pb^{2+} i Ba^{2+} ions. 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.

Task 2.The solution contains Na^+, Hg_2^{2+}, Ba^{2+}. ions. Suggest how to detect these ions by following a systematic course of analysis. Write the equations of the corresponding reactions.

Task 3. The solution contains Na^+, Hg_2^{2+}, Sr^{2+} i Ba^{2+}+ ions. 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

Task 4. K^+, Hg_2^{2+}, Ag^+ i 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. Test tasks for self-control:

1. 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.

2. A mixture of $PbSO_4$ and $BaSO_4$ can be separated using an aqueous solution:

A. $(NH_4)_2CO_3$;
B. Na_2SO_4;
C. *NaOH;
D. HCl.

3. Lead(II) sulfate can be dissolved in a solution:

A. * sodium hydroxide;
B. ammonia;
C. nitric acid;
D. acetic acid

4. Lead (II) chromate can be dissolved in:

A. sodium acetate solution;
B. ammonia solution;
C. *Sodium hydroxide solutions;
D. acetic acid.

5. Group reagent for group I cations from the acid-base classification (Na^+, K^+, NH_4^+):

A. 2n. excess ammonia solution

B. 2n. alkali solution

C. 2n. sulfuric acid solution

D. *there is no group reagent

6. Group reagent for group III cations from the acid-base classification (Ba^{2+}, Ca^{2+}, Sr^{2+}):

A. * sulfuric acid solution

B. hydrochloric acid solution

C. ammonia solution in excess

D. lye in excess

7. When analyzing a mixture of cations of the I and II groups, first of all, is it carried out?

A. deposition of the II group from the I group

B. *detection of NH_4^+ cations

C. detection of group II cations

D. separation of the I group from the II group

8. The precipitate contains lead chloride and mercury(I) chloride. Indicate which reagent must be used to separate lead and mercury(I) cations:

A. treat with a solution of ammonium sulfate;

B. * process with hot water;

C. treat with acetic acid;

D. treat with an excess of hydrochloric acid;

E. treat with ammonium oxalate solution

4. Individual tasks for students of higher education on the topic:

1) Medicinal preparations containing cations of the I-III analytical group. Application, mechanism of action, analysis.
2) Biological role of cations of analytical group I.

3) Biological role of cations of the II analytical group.
4) Biological role of cations of the III analytical group.

5. References:

General:

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.

Independent work No. 7

Topic: Chemical-analytical properties of cations of the IV analytical group, qualitative reactions for their determination.

Goal: Generalize knowledge about the qualitative analysis of cations of the IV analytical groups, familiarize yourself with the systematic course of analysis of the cations of these groups.

Basic concepts:cation, analytical reactions, analytical groups, reaction sensitivity, detection limit, specific reagent, group reagent.

Plan

1. Theoretical questions:

1) The action of the group reagent on the cations of the IV analytical group.
2) Properties of hydroxocomplexes of cations IVanalytical group.
3) Individual reactions of cationsIVanalytical group.
4) Systematic course of analysis of cationsIVanalytical group.

Approximate tasks for processing the theoretical material:

- Compile a dictionary of basic concepts on the topic.

2. Practical works (tasks) to be performed:

Task 1. 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.

Task 2. An excess of alkali was added to the solution containing the IV cation of the analytical group (acid-base classification) and boiled. A green precipitate fell out. Give an explanation. Write the equations of the corresponding reactions.

Task 3. Zn^{2+} and Al^{3+} 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.

Task 4. A solution of $HgC1_2$ was added to the solution containing the IV cation of the analytical group (acid-base classification). A white precipitate is observed, which quickly blackens over time. What cation does this analytical effect indicate? Write the equations of the corresponding reactions.

Task 5. Zn^{2+} and Sn^{2+} 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.

Task 6. 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. Test tasks for self-control:

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 the group reagent NaOH acts on aluminum ions, the following is formed:
   A. Aluminum hydroxide
   B. Sodium metaaluminate
   C. Sodium hexahydroxoaluminate
   D. Basic aluminum salts
   E. Aluminum oxide
3. An excess of 6M sodium hydroxide solution and 3% hydrogen peroxide solution were added to the studied 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. A qualitative reaction for determining Cr (VI) compounds is the formation of chromium oxide-diperoxide (perchromic acid), which colors the ether layer blue. Enter the formula of this chromium compound:
   A. H_2CrO_6 | CrO_5
   B. CrO_3

C. Cr_2O_3

D. CrO

E. $NaCrO_2$

5. 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 $Co(NO_3)_2$

D. An excess of 6M sodium hydroxide in the presence of hydrogen peroxide

E. Sulfuric acid solution

6. 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+}

7. 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

8. 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]

9. 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. Individual tasks for students of higher education on the topic:

1) Medicinal preparations containing cations of the IV analytical group. Application, mechanism of action, analysis.
2) Biological role of cations of analytical group IV.

5. References:

General:

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.

Independent work No. 8

Topic: Study of chemical-analytical properties of cations of V-VI analytical groups and qualitative reactions of their determination

Goal: Generalize knowledge about the qualitative analysis of cations of V and VI analytical groups, familiarize yourself with the systematic course of analysis of cations of these groups.

Basic concepts: cation, analytical reactions, analytical groups, reaction sensitivity, detection limit, limiting dilution, specific reagent, group reagent.

Plan

1. Theoretical questions:

1) The effect of the group reagent on the cations of the analytical group V.
2) Reactions of the Mg^{2+} cation
3) Reactions of the Mn^{2+} cation
4) Reactions of the Bi^{3+} cation
5) Reactions of Sb(III) and Sb(V) cations
6) Reactions of Fe^{2+} and Fe^{3+} cations
7) The action of the group reagent on the cations of the VI analytical group.
8) Reactions of Cu^{2+} cation
9) Reactions of the Hg^{2+} cation

Questions for self-control:

1) The effect of the group reagent on the cations of the analytical group V. Solubility of formed precipitates.
2) Qualitative reactions to the Mg^{2+} cation. Which of the listed reactions are pharmacopoeial?

3) Reactions of the Mn^{2+} cation. Make a redox balance of the proposed reactions.
4) Reactions of Bi^{3+}, Sb(III) and Sb(V) cations. Hydrolysis of salts.
5) Qualitative reactions of Fe^{2+} and Fe^{3+} cations. Dependence of the color of the solution with sulfosalicylic acid on pH.
6) The action of the group reagent on the cations of the VI analytical group. What happens when an excess of a group reagent is added
7) How to separate V analytical group from VI analytical group of cations?
8) Qualitative reactions to the Cu^{2+} cation. What color are copper(II) compounds colored?
9) Qualitative reactions of the Hg^{2+} cation.

Approximate tasks for processing the theoretical material:

- Compile a dictionary of basic concepts on the topic.

2. Practical works (tasks) to be performed:

Task 1. Properties of cations of analytical group V (acid-base classification) and conditions for their precipitation by 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.

Task 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.

Task 3. Explain the different ratio of cations of VI and VI analytical groups (acid-base classification) to an aqueous solution of ammonia. Write the equation for the separation and detection of magnesium, mercury (II), copper and nickel cations when they are present together.

Task 4. Group reagent for cations of analytical group VI (acid-base classification). Conditions of their use. Write the reaction equation for the interaction of $Cu2^{+}$ 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. Test tasks for self-control:

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 $(NH_4)_2S_2O_8$ in the presence of $AgNO_3$, the solution acquires a crimson color?

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

6. 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

7. 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

8. 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)

9. 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

10. 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

4. Individual tasks for students of higher education on the topic:

1. The use in medicine of preparations containing cations of the V analytical group.
2. The use in medicine of drugs containing cations of analytical group VI.

5. References:

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.

Independent work No. 9

Topic: Acid-base equilibria. Calculation of pH in solutions of strong and weak acids and bases, buffer systems. Protolytic equilibrium in nonaqueous solvents.

Goal: Get acquainted with the main provisions of the protolithic theory. Learn how to solve problems on the pH meter. Summarize knowledge about protolytic equilibrium in non-aqueous solvents.

Basic concepts:acids, bases, hydrolysis, hydrogen index, ionic product of water, buffer mixture, buffer capacity, autoprotolysis, autoprotolysis constant.

Plan

1. Theoretical questions:

1) Brønsted-Lowry theory.
2) Ionic product of water.
3) Values of pH, pH for strong and complex acids and bases
4) Buffer solutions

Questions for self-control:

1) Define the concepts of "acid" and "base (alkali)" according to the theory of Arrhenius, Brønsted-Lowry, Lewis.
2) What is a hydrogen indicator? Its relationship with the ionic product of water.
3) pH calculations for strong/weak acids/bases, salts, buffer systems

Approximate tasks for processing the theoretical material:

- Compile a dictionary of basic concepts on the topic.

2. Practical works (tasks) to be performed:

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

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

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

Task 4. How will the pH change in a 10^{-5} M solution of sodium hydroxide if potassium hydroxide with a substance mass of 0.056 g is added to 1 dm3 of it?

3. Test tasks for self-control:

1. What is a hydrogen indicator?

A. *negative decimal logarithm of the molar concentration of hydrogen ions;
B. concentration of hydrogen ions;
C. logarithm of hydrogen ion concentration;
D. the sum of the concentrations of hydrogen ions and hydroxide ions.

2. The pH of a 0.1 M solution of hydrochloric acid is equal to:

A. 4;
B. 3;
C. 2;
D. *1.

3. The pH value of a 0.01 M solution of hydrochloric acid is equal to:

A. 4;

B. 3;

C. *2;

D. 1

4. The pH value of a $1 \cdot 10^{-3}$ M nitric acid solution is equal to:

A. 4;

B. *3;

C. 2;

D. 1

5. The concentration of hydrogen ions when the pH of the solution is 5.0 is:

   A. $1 \cdot 10^{-3}$ M;

   B. $1 \cdot 10^{-4}$ M;

   C. *$1 \cdot 10^{-5}$ M;

   D. $1 \cdot 10^{-6}$ M

6. The indicator of the acidity constant of formic acid is 3.75. Why will the pH of a buffer solution consisting of equal volumes of 1.0 M formic acid (HCOOH) and 1.0 M sodium formate (HCOONa) be equal?

A. *3.75;

B. 2.75;

C. 1.75;

D. 0.75

7. The indicator of the acidity constant of formic acid is 3.75. Why will the hydrogen indicator (pH) of a buffer solution consisting of equal volumes of 0.10 M formic acid solution (HCOOH) and 1.0 M sodium formate solution (HCOONa) be equal:

A.*4.75;

B.3.75;

C.2.75;

D.5.00

8. Of the listed acids, the strongest acid is:

A. formic acid (pKa = 3.8);
B. acetic acid (pKa = 4.76);
C. hydrocyanic acid (pKa = 9.3);
D. *hydrofluoric acid (pKa = 3.2).

9. If the hydrogen indicator (pH) of the acetate buffer solution is 4.76, and the indicator of the acidity constant of acetic acid (pKa) is 4.76, the ratio of the concentration of acetic acid and sodium acetate is:

A. *1:1;
B. 1:2;
C. 1:3;
D. 1:1.5.

10. Specify the formula by which you can calculate the hydrogen index (pH) of a weak acid:

A. pH = lgC(HA);
B. pH=0,5lgC(HA);
C. *pH = 0,5·(pКa-lgc (HA));
D. pH = pКa-lgC(HA).

11. Specify acid-base buffer solutions:

A. *acetic acid and sodium acetate solution;
B. a solution of acetic and formic acids;
C. a solution of acetic and hydrochloric acids;
D. sodium acetate and potassium acetate solution.

4. Individual tasks for students of higher education on the topic:

1. Buffer solutions in chemistry, pharmacy, medicine
2. Theory of Brønsted-Lowry, Usanovich, Pearson, Lewis

5. References:

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.

Independent work No. 10

Topic: Analysis of a mixture of cations of IV-VI analytical groups. Test tasks.

Goal: Summarize knowledge about the qualitative analysis of cations of I-VI analytical groups, familiarize yourself with the systematic course of analysis of cations of IV-VI groups.

Basic concepts:cation, analytical reactions, analytical groups, reaction sensitivity, detection limit, limiting dilution, specific reagent, group reagent.

Plan

1. Theoretical questions:

1) General characteristics, systematic and fractional analysis of cations of the IV analytical group

2) General characteristics, systematic and fractional analysis of cations of analytical group V

3) General characteristics, systematic and fractional analysis of cations of the VI analytical group

Questions for self-control:

1) What cations are absent in a solution of a mixture of IV-VI group cations if the solution is not colored?
2) What is the difference in the chemical properties of SbOCl, SbO_2Cl, BiOCl used to separate Sb^{3+}, Bi^{3+}, Sb(V)?
3) What is masking? Give examples of the use of complexation reactions, ROR, or changes in pH to mask cations.

Approximate tasks for processing the theoretical material:

- Draw up a scheme of systematic analysis of a mixture of cationsIV-VI.

2. Practical works (tasks) to be performed:

Task 1.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.

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

Problem 3. 3.propose the course of analysis of a solution containing cations: Na^{+},Cu^{2+}, Zn^{2+}, Bi^{3+} (acid-base classification).

Task 4. 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 Hg2+ 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. Test tasks for self-control:

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

A. Lye solution

B. Hydrogen peroxide in an acidic environment

C. Argentum nitrate solution

D. Hydrogen peroxide in an ammonia medium

E. Chloric acid solution

2. When excess ammonia was added to the solution being analyzed, it turned bright blue. This indicates the presence of ions in the solution:

A. Cuprum

B. Argentum

C. Plumbum

D. Bismuth

E. Mercury (II)

3. Ferrum (III) and copper (II) cations are present in the studied mixture. By which group reagent can the named cations be separated:

A. Concentrated ammonia solution

B. A solution of sodium hydroxide and hydrogen peroxide

C. Concentrated solution of hydrochloric acid

D. Sodium hydroxide solution

E. Concentrated solution of sulfuric acid

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

A. Lye solution

B. A solution of hydrogen peroxide in an acidic environment

C. Silver nitrate solution

D. Ammonia solution

E. Chloric acid solution

5. The studied mixture contains cationsMg^{2+}, Ni^{2+}, Co^{2+}. Which reagent can be used to detect cationsNo^{2+}in this mixture?

A. Dimethylglyoxime

B. Ammonia

C. 1-nitroso-2-naphthol

D. Magneson-1

E. Alizarin

6. What reagent can be used to separate magnesium cations from other cations of analytical group V in a systematic analysis?
   A. A saturated solution of ammonium chloride
   B. Excess concentrated ammonia solution
   C. Hydrogen peroxide
   D. Nitric acid
   E. Alkali solution

4. Individual tasks for students of higher education on the topic:

1. Types of reactions used in qualitative analysis of anions.
2. Disguise. Possibilities of its application in chemical analysis.

5. References:

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.

Independent work No. 11

Topic: Classification of anions according to their various properties, qualitative reactions for the determination of anions of I-II analytical groups.

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

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

Plan

1. **Theoretical questions:**

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) Determination of oxidizing anions and reducing anions
3) And analytical group of anions. List the anions, indicate the group reactant.
4) II analytical group of anions. List the anions, indicate the group reactant

Questions for self-control:

1) Qualitative reactions to sulfate, sulfite, and thiosulfate anions. Analytical effects, performance conditions.
2) Qualitative reactions to carbonate and bicarbonate anions. Analytical effects, performance conditions. What reactions allow you to distinguish between these anions?
3) Qualitative reactions to arsenate and arsenite anions. Analytical effects, performance conditions. What reactions allow you to distinguish between these anions?
4) Qualitative reactions to phosphate anions. Analytical effects, performance conditions. What is magnesium mixture?
5) Qualitative reactions to oxalate ions. Analytical effects, performance conditions.

6) Qualitative reactions of borate, tetraborate, chromate, dichromate anions. Analytical effects, performance conditions.
7) Qualitative reactions to silicates and fluorides. Analytical effects, performance conditions.
8) Qualitative reactions to chloride, iodide, bromide and sulfide ions.

Approximate tasks for processing the theoretical material:

- Compile a dictionary of basic concepts on the topic.

2. Practical works (tasks) to be performed:

Task 1.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.

Task 2.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.

Task 3. A solution of silver nitrate was added to a solution containing anions of the 2nd and 3rd groups (classification is based on the solubility of barium and silver salts). A black precipitate fell out. The sediment was treated with a solution of ammonium carbonate. The sediment is partially dissolved. The remaining precipitate was centrifuged. The centrifuge was divided into two parts. A few drops of nitric acid were added to one. Turbidity is observed. The second part was treated with barium chloride, and then, after separation of the formed precipitate, a solution of iron (III) chloride was added to the filtrate. The formation of a red-brown precipitate is observed. What anions were present in the solution? Write the equations of the corresponding reactions.

3. Test tasks for self-control:

1. 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

2.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

3.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

4. 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

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

A. barium

B. lead

C. ammonium

D. bismuth

E. mercury

6. The pharmacopoeial reaction to phosphate ions is the effect of a magnesium mixture. As a result, a white crystalline precipitate of $MgNH_4PO_4$ is formed. The composition of the magnesium mixture is as follows:

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

B. $MgCl_2$, NaOH , NaCl

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

D. $MgCl_2$, $MnSO_4$, NH_4Cl

E. $MgCl_2$, NH_4Cl

7.Chloroform and chlorine water were added dropwise 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

8.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

9. 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

10. 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

4. Individual tasks for students of higher education on the topic:

1. Medicines containing inorganic anions.
2. Express methods of detecting anions

5. References:

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.

Independent work No. 12

Topic: Redox equilibria 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, electromotive force

Plan

1. Theoretical questions:

1) Redox reactions. General concepts. The main types of redox reactions (OR)

2) The Nernst equation, its application in practice.

3) Electromotive force. The direction and completeness of the OVR course.

Questions for self-control:

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?

Approximate tasks for processing the theoretical material:

- Compile a dictionary of basic concepts on the topic.

2. Practical works (tasks) to be performed:

Task 1. Calculate the potential of the hydrogen electrode (in volts), which is in a 0.05 M solution of potassium hydroxide.

Task 2. Calculate the potential of a silver electrode in a saturated AgCl solution (SP(AgCl) = 1.8·10-10).

Task 3. 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/dm3, and [Cr^{3+}] =0.1 mol /dm3, at pH=2 and t=25C°.

Task 4. Calculate the electrode potential of the system at pH = 0.1:

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

Problem 5. Write the reaction equation: $AsH_3 + Ag^+ + H_2O \rightarrow H_3AsO_3 + Ag + \dots$

In what direction will the corresponding chemical reaction go. Justify the answer.

3. Test tasks for self-control:

1. The value of the oxidation-reduction potential of the $S_2O_3^{2-}/S_4O_6^{2-}$ pair is influenced by the following factors:

A. presence of electrolyte;
B. addition of NaF (with (NaF) = 0.001 M);
C. reducing agent concentration;
D. not affected by any factor.

2. Specify the reductant with which the reaction with ions will occur spontaneously Fe^{3+} (E = 0.77V):

A. I_2 (E =+0.54 V);
B. Br_2 (E =+1.09 V);
C. Cl_2 (E = +1.36 V);
D. Mn^{2+}(E =+1.51 V).

3. What is the EMF reaction?

A. value of the electrode potential of the oxidizer;

B. value of the electrode potential of the reducing agent;

C. the difference in the electrode potentials of the oxidizer and reducer;

D. potential of the hydrogen electrode.

4. At what value of EMF will not spontaneously flow a straight line reaction:

A. emf = 0;

B. EMF>0;

C. EMF<0;

D. EMF = +0.5.

5. How will the value of the electrode potential of the iron(III) – iron(II) pair change if phosphoric acid is added to the solution?

A. will decrease;

B. will increase;

C. will not change;

D. will first decrease, then increase.

6. Redox reactions are:

A. reactions that occur with a change in the degree of oxidation of elements;

B. complex formation reactions;

C. neutralization reactions;

D. there is no correct answer.

4. Individual tasks for students of higher education on the topic:

1. Application of redox reactions in chemical analysis.
2. The influence of various factors on the course of redox reactions.
3. Redox reactions in the body. Enzymes.

5. References:

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.

Independent work No. 13

Topic: Analysis 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

Plan

3. Theoretical questions:

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) Determination of oxidizing anions and reducing anions
3) III analytical group of anions. List the anions, indicate the group reactant

Questions for self-control:

1) Qualitative reactions to nitrate and nitrite anions. What reactions will give the same analytical effect?

2) What reactions can be used to distinguish a nitrate ion from a nitrite ion

3) Qualitative reactions to acetate anion.

Approximate tasks for processing the theoretical material:

- Make a table.

Ion	Reagent	Product	Analytical effect	Reaction conditions
1	2	3	4	5

4. Practical works (tasks) to be performed:

Task 1.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.

Task 2. A solution of silver nitrate was added to a solution containing anions of the 2nd and 3rd groups (classification is based on the solubility of barium and silver salts). A black precipitate fell out. The sediment was treated with a solution of ammonium carbonate. The sediment is partially dissolved. The remaining precipitate was centrifuged. The centrifuge was divided into two parts. A few drops of nitric acid were added to one. Turbidity is observed. The second part was treated with barium chloride, and then, after separation of the formed precipitate, a solution of iron (III) chloride was added to the filtrate. The formation of a red-brown precipitate is observed. What anions were present in the solution? Write the equations of the corresponding reactions.

3. Test tasks for self-control:

1. 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

2. To determine nitrate anions, diphenylamine was added to the studied solution. At the same time, it is observed:

A. The formation of a blue solution
B. The formation of a yellow precipitate
C. The formation of a blue precipitate
D. Release of brown gas
E. The appearance of a characteristic smell

3. When anions were detected in the solution by the fractional method, a reaction with 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

4. 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

5.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

6. 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

7. To a solution of $FeSO_4$ 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

8. 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

9. 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

11. What ion is contained in the solution if a blue color is observed when diphenylamine acts on it in the presence of concentrated sulfuric acid?

A. nitrate

B. phosphate

C. sulfate

D. sulfide

E. acetate

4. Individual tasks for students of higher education on the topic:

1. Medicines containing inorganic anions.
2. Express methods of detecting anions

5. References:

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.

Independent work No. 14

Topic: Equilibrium in solutions of complex compounds. Chelates. Application of organic reagents in analytical chemistry.

Goal: Generalize knowledge about the structure of complexes and their dissociation. Familiarize yourself with the concepts of stability and instability constants. Familiarize yourself with the concept of functional-analytical and analytical-active groups in organic reagents.

Basic concepts:complex compound, complexing agent, ligand, coordination number, stability constant, instability constant,functional analytical group, auxochromes, tautomers

Plan

1. Theoretical questions:

1) Complex compounds. Composition, spatial structure, quantitative characteristics.
2) Organic reagents in analytical chemistry.
3) Use of complex compounds and organic reagents in analytical chemistry.

Questions for self-control:

1) Coordination compounds. Characterize the composition, spatial structure, isomerism
2) Dissociation of coordination compounds. Stability constant and instability constant, indicate their relationship.
3) Organic reagents in chemistry. Define the term "functional analytical group".

Approximate tasks for processing the theoretical material:

- Compile a dictionary of basic concepts on the topic.

2. Practical works (tasks) to be performed:

Task 1.Calculate [Cu^{2+}] and [HH_3] in a 1 M solution of [$Cy(HH_3)_4$]SO_4.

Task 2.Calculate [Co^{2+}] and [NH_3] in a 1 M solution of [$Co(NH_3)_6$]SO_4.

Task 3.In the solution of which of the following complex compounds of the same molar concentration, the molar concentration of silver ions is greater? Justify the answer.

1) diaminosilver nitrate, Kns=$7.2 \cdot 10^{-8}$;
2) potassium dicyanoargentate, Kns=$7.2 \cdot 10^{-21}$.

Task 4.Calculate the concentration of zinc ions in a 1 M solution of a complex salt of tetraaminozinc chloride (II), if the instability constant of the complex ion is Kns= $2 \cdot 10^{-9}$.

3. Test tasks for self-control:

1. Tetraamminecuprum(II) has a charge:

A. 1+;
B. *2+;
C. 3+;
D. 4+

2. The charge of the complex ion in hexacyanoferrate(III) is equal to:

A. 1-;
B. 2-;
C. *3-;
D. 4-.

3. Which of the listed metal ions are more prone to the formation of complex compounds:

A. * iron (III) ion;
B. sodium ion (I);
C. potassium ion (I);
D. barium(II) ion

4. The coordination number and degree of oxidation of the central atom of diquatetrahydroxoaluminum are equal:

A. 4 and +2;
B. *6 and +3;
C. 6 and +2;

D. 5 and +3

5. The formation constant of the complex is equal to 50. What is the instability constant of this complex?

A. 0.01;
B. *0.02;
C. 0.03;
D. 0.04

6. The instability constant of the complex is equal to 10-5. What is the formation constant of this complex?

A. 102;
B. 103;
C. 104;
D. 105

7. Which of the listed complex particles is the most stable, if the decimal logarithm of the total complex formation constant is equal to:

A. cobalt(II) ammonia – 5.07;
B. *copper(II) ammonia – 12.03;
C. nickel(II) ammonia – 4.47;
D. cadmium ammonia (II) - 6.36.

8. A polydentate ligand is:

A. ammonia;
B. chloride ion;
C. thiocyanate ion;
D. EDTA.

9. When forming chelates, the most stable structures are:

A. three-membered cycles;
B. *five-membered cycles;
C. four-membered cycles;
D. eight-membered cycles.

10. Specify the formula by which you can calculate the hydrogen index (pH) of a weak acid:

E. pH = lgC(NA);
F. pH=0.5lgC(NA);
G. pH = 0.5·(pKa-lgc (NA));
H. pH = pKa-lgC(NA).

4. Individual tasks for students of higher education on the topic:

1. Basic ideas about the structure of complex compounds. Werner's theory.
2. The use of complex compounds in medical practice.
3. Organic reagents in chemical analysis.

5. References:

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.

Independent work No. 15

Topic: Analysis of a mixture of anions of groups I-III.

Goal: Familiarize yourself with group reagents used in the analysis of anions. Summarize information about anions of the I-III analytical group and analytical reactions, the possibility of using a systematic course of analysis when analyzing a mixture of anions.

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

Plan

1. Theoretical questions:

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) Determination of oxidizing anions and reducing anions
3) And analytical group of anions. List the anions, indicate the group reactant.
4) II analytical group of anions. List the anions, indicate the group reactant
5) III analytical group of anions. List the anions, indicate the group reactant

Questions for self-control:

1) Suggest a scheme for the analysis of a mixture containing sulfate, sulfide, thiosulfate, and sulfite anions.
2) Suggest a scheme for the analysis of a mixture containing iodide, bromide, and chloride anions.

Approximate tasks for processing the theoretical material:

- Compile a dictionary of basic concepts on the topic.

2. Practical works (tasks) to be performed:

Task 1. To a solution containing anions of the 2nd and 3rd groups (classification is based on the solubility of barium and silver salts), add 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.

Task 2. Propose 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.

Task 3. Propose a diagram of the course of the analysis and write the reaction equations for the opening of the following anions: SO_4^{2-}, PO_4^{3-}, SO_3^{2-} (classification is based on the solubility of barium and silver salts).

Task 4. Propose a diagram of the course of the analysis and write equations for the reactions of opening the following anions: SO_4^{2-}, PO_4^{3-}, SO_3^{2-} (classification is based on the solubility of barium and silver salts).

Task 5. Propose a flow diagram of the analysis and write equations for the reactions of opening the following anions: $S_2O_3^{2-}$, CO_3^{2-}, SO_3^{2-} (classification is based on the solubility of barium and silver salts).

3. Test tasks for self-control:

1. Sodium arsenate solution can be distinguished from arsenite solution using the following reagent:

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

2. 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

3. 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. AgNO3 solution in an acidic environment
D. mineral acid solution
E. alkali solution

4. The pharmacopoeial reaction to phosphate ions is the effect of a magnesium mixture. As a result, a white crystalline precipitate of $MgNH_4PO_4$ is formed. The composition of the magnesium mixture is as follows:

A. $MgCl_2$, $NH_3 \bullet H_2O$, NH_4Cl
B. $MgCl_2$, NaOH , NaCl
C. $MnCl_2$, $NH_3 \bullet H_2O$, NaCl
D. $MgCl_2$, $MnSO_4$, NH_4Cl
E. $MgCl_2$, NH_4Cl

5. 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

6.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

7.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.

8. 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

9. 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

10. 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

4. **Individual tasks for students of higher education on the topic:**

3. Medicines containing inorganic anions.
4. Express methods of detecting anions

5. **References:**

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.

Independent work No. 16

Topic: Introduction to quantitative analysis. Gravimetric analysis. Application of gravimetry for the analysis of medicinal substances.

Goal: Get acquainted with methods of quantitative analysis, their classification. Get acquainted with the basics of gravimetric analysis, its main methods.

Basic concepts:gravimetry, sedimentation method, distillation method, precipitator, gravimetric factor.

Plan

1. **Theoretical questions:**

1) Classification of quantitative methods of analysis.
2) Gravimetric method of analysis.
3) Distillation method.
4) Deposition method
5) Selection method

Questions for self-control:

1) Classification of quantitative methods of analysis: physical, chemical, physico-chemical.
2) Volumetric and weight analysis.
3) The essence of the gravimetric method of analysis. Value of gravimetric analysis methods for medicine, pharmacy and industry.
4) Classification of gravimetric analysis methods.
5) Conditions for obtaining crystalline and amorphous sediments.
6) Precipitated form. Requirement to the precipitated form.
7) Gravimetric form. Requirements for gravimetric form.
8) Weighing technique on analytical balances.
9) The formula for calculating the gravimetric (analytical) factor.
10) Assessment of accuracy of results, absolute and relative error. Expression of measurement results in significant numbers.

Approximate tasks for processing the theoretical material:

- Compile a dictionary of basic concepts on the topic.

2. Practical works (tasks) to be performed:

Task 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.

Task 2.What volume of 15% Na_2CO_3 solution should be taken for almost complete precipitation of Sr from a weight of the analyzed substance of 0.6057 g of SrCl2?.

Task 3. Calculate the mass fraction (%) of Al in limestone, if a weight of 4.9600 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, 0.0180 g of the gravimetric form of Al_2O_3 was obtained

3. Test tasks for self-control:

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:

$(NH_4)_2C_2O_4$
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. Individual tasks for students of higher education on the topic:

1. Thermogravimetry. Thermograms. Possibilities of using thermogravimetric methods for drug analysis.
2. Electrogravimetry.Possibilities of using the method

5. References:

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.

Independent work No. 17

Topic: Titrimetric analysis. Basic concepts. Classification of methods. Titrants, their preparation and standardization. Calculations in titrimetric analysis. Titration errors

Goal: Familiarize yourself with the basic concepts of titrimetric analysis and learn 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

Plan

1. **Theoretical questions:**

1) The essence of the titrimetric method of analysis.
2) Classification of titrimetric analysis methods.
3) Requirements for reactions used in titrimetry.
4) Standard substances and requirements for them.
5) Rules for choosing an indicator based on reaction products and titration curves.

Questions for self-control:

1) What are the methods of making standard solutions?
2) Write how to prepare standard solutions of borax, hydrochloric acid, sodium hydroxide and how to store them?
3) What are fixanals, standard samples (normal) and what are they used for?
4) What is the normality and correction factor of standard solutions?
5) What are the ways of expressing the concentration of solutions?
6) What are correction curves for burettes and how to construct them? How to use them?

Approximate tasks for processing the theoretical material:

- Compile a dictionary of basic concepts on the topic.

2. **Practical works (tasks) to be performed:**

Task 1.Calculate the mass of sodium hydroxide containing 5% impurities of sodium hydrogen carbonate, which is required to make 100 ml of a 0.2 N solution.

Task 2.A solution of 2.5500 g of Na_2CO_3 was prepared in a volumetric flask with a capacity of 250.0 ml. Calculate for its solution: a) molar concentration, b) normal concentration, c) titer, d) titer by HCl.

Task 3. To what volume should 100 ml of 2.15 N HCl solution be diluted to obtain a 1.0000 N solution of this acid?

3. Test tasks for self-control:

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. In the control and analytical laboratory, the chemist needs to standardize the sodium hydroxide solution. What primary standard solution can he use for this:

A. oxalic acid
B. acetic acid
C. hydrochloric acid
D. sodium tetraborate
E. sodium chloride

3. The titrant of the permanganatometry method is a 0.1 M solution of potassium permanganate, which is prepared as a secondary standard solution. It is standardized by:

A. arsenic (III) oxide
B. potassium dichromate
C. sodium chloride
D. sodium carbonate
E. calcium oxide

4. 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

5. During the reverse titration of an aqueous solution of acetic acid, the following is used as an indicator:

A. phenolphthalein
B. diphenylamine
C. diphenylcarbazone
D. eriochrome black T
E. murexide

6. The titrant of the nitritometry method is a 0.1 M solution of sodium nitrite, which is prepared as a secondary standard solution. The exact concentration of sodium nitrite is set according to:

A. sulfanilic acid
B. hydrochloric acid
C. acetic acid
D. oxalic acid
E. sulfuric acid

7. For the quantitative determination of medicinal substances, the method of alkalimetry is used, in which the titrant is a 0.1 M solution of sodium hydroxide. The exact concentration of sodium hydroxide is set according to:

A. oxalic acid
B. sodium tetraborate
C. potassium dichromate
D. sodium thiosulfate

E. ammonium hydroxide

8. 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

9. Specify the value of the equivalence factor of Na_2CO_3 when quantified 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

10. 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

4. Individual tasks for students of higher education on the topic:

1. Development of quantitative methods of analysis.
2. Calculations in the methods of Kielski analysis.
3. Use of titrimetric methods of analysis in pharmaceutical chemistry.

5. References:

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.

Independent work No. 18

Topic: Acid-base titration. Primary and secondary standards. Titration of strong acids and strong bases. Fixing EPT. pH indicators. Selection of pH indicators.

Goal: Get acquainted with the basic concepts of acid-base titrimetric analysis and learn 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

Plan

1. Theoretical questions:

1) The essence of the titrimetric method of analysis.

2) Classification of titrimetric analysis methods.
3) Method of neutralization.
4) Acidimetry. General characteristics of the method.
5) Alkalimetry. General characteristics of the method.
6) Rules for choosing an indicator based on reaction products and titration curves.

Questions for self-control:

1) Describe the main concepts: "titrimetry", "titrant", "indicator", "primary standard", "secondary standard", "titration curve".
2) Write how to prepare standard solutions of borax, hydrochloric acid, sodium hydroxide and how to store them?
3) What are fixanals, standard samples (normal) and what are they used for?
4) What is the normality and correction factor of standard solutions?
5) What titrants are used in acidimetry and alkalimetry methods? How are they standardized?
6) Indicators of the acid-base method. Give examples, the mechanism of work.
7) What are correction curves for burettes and how to construct them? How to use them?

Approximate tasks for processing the theoretical material:

- Compile a dictionary of basic concepts on the topic.

2. Practical works (tasks) to be performed:

Task 1. Calculate the mass fraction of Na_2CO_3 in technical salt, when 0.2110 g of soda was dissolved in 25 ml of 0.2022H HCl, the excess of which was titrated with 5.50 ml of NaOH solution, the titer of which is 0.004018 g/ml.

Problem 2. A weight of 0.3580 g of a mixture of Na_2CO_3 and NaOH is dissolved in a volumetric flask with a capacity of 100.0 ml. For the titration of an aliquot part of the solution (25.00 ml) in the presence of phenolphthalein, 19.85 ml was used, and with the indicator methyl orange 20.95 ml 0.1030 n. NSI solution. Calculate the mass fraction of Na_2CO_3 in the studied sample.

Task 3. How many grams of sulfuric acid are in the solution, if 24.17 ml of NaOH solution with a titer of 0.004085 g/ml were used to titrate 25.00 ml?

Task 4. How many ml of water should be added to 1000 ml of 0.2 n. sulfuric acid solution so that the titer of the obtained acid solution according to Na_2CO_3 is equal to 0.007534 g/ml?

3. Test tasks for self-control:

1. 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

2. 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

3. In the control and analytical laboratory, the chemist needs to standardize the sodium hydroxide solution. What primary standard solution can he use for this:

A. oxalic acid
B. acetic acid
C. hydrochloric acid
D. sodium tetraborate
E. sodium chloride

4. 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

5. During the reverse titration of an aqueous solution of acetic acid, the following is used as an indicator:

A. phenolphthalein
B. diphenylamine
C. diphenylcarbazone
D. eriochrome black T
E. murexide

6. For the quantitative determination of medicinal substances, the method of alkalimetry is used, in which the titrant is a 0.1 M solution of sodium hydroxide. The exact concentration of sodium hydroxide is set according to:

A. oxalic acid
B. sodium tetraborate
C. potassium dichromate
D. sodium thiosulfate
E. ammonium hydroxide

7. 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

8. Specify the value of the equivalence factor of Na_2CO_3 when quantified 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

9. 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

10. What method of titrimetric analysis can be used to quantitatively determine sulfuric acid with a potassium hydroxide solution?

A. alkalimetry

B. acidimetry

C. oxidation-reduction

D. sedimentation

E. complex formation

4. Individual tasks for students of higher education on the topic:

1. Development of quantitative methods of analysis.
2. Use of acid-base titration in pharmaceutical analysis.

5. References:

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.

Independent work No. 19

Topic: Acid-base titration. Titration of weak acids with alkalis and weak bases with strong acids.

Goal: Get acquainted with the basic concepts of acid-base titrimetric analysis and learn 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

Plan

1. **Theoretical questions:**
   1) The essence of the titrimetric method of analysis.
   2) Classification of titrimetric analysis methods.
   3) Method of neutralization.
   4) Acidimetry. General characteristics of the method.
   5) Alkalimetry. General characteristics of the method.

6) Rules for choosing an indicator based on reaction products and titration curves.

Questions for self-control:

1) Describe the main concepts: "titrimetry", "titrant", "indicator", "primary standard", "secondary standard", "titration curve".
2) Write how to prepare standard solutions of borax, hydrochloric acid, sodium hydroxide and how to store them?
3) What titrants are used in acidimetry and alkalimetry methods? How are they standardized?
4) Indicators of the acid-base method. Give examples, the mechanism of work.
5) What do the titration curves of a weak base with a strong acid and a weak acid with an alkali look like?

Approximate tasks for processing the theoretical material:

- Compile a dictionary of basic concepts on the topic.

2. Practical works (tasks) to be performed:

Task 1. Calculate the titration indicator error of 0.1 n. solution of CH_3COOH 0.1 n. NaOH solution with litmus indicator (pT = 7).

Task 2.Calculate and plot a titration curve of 0.1 n. benzoic acid solution 0.1 n. hydroxide solution sodium pK (C_6H_5COOH = 4.20).

Task 3. Calculate the pH of the medium when titrating 10.00 ml 0.1 n. solution of HCOOH with the addition of such volumes (ml) of 0.1 n. NaOH solution: a) 5.00; b) 9.99; c) 10.00; d) 10.01.

Task 4.In the device for determining ammonium salts by distillation, the $(NH_4)_2SO_4$ solution was treated with a concentrated solutionNaOH. Ammonia was driven off in 50.00 ml of H_2SO_4 solution with a concentration of ($1/2H_2SO_4$ = 0.2000 mol/dm^3). Then the resulting solution was titrated with 22.50 ml of alkali. How many grams of ammonium sulfate are contained in the tested solution?

3. Test tasks for self-control:

1. To determine the mass-volume fraction of ammonia in the solution, use the following solution:

A. hydrochloric acid
B. sulfuric acid
C. potassium permanganate
D. iodine
E. sodium hydroxide

2. 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

3What is the titer of the solution?

A. The mass of the substance in grams, which is contained in 1 ml of solution
B. The mass of the substance in grams, which is contained in 1 liter of solution
C. The number of equivalents of the substance contained in 1 liter of solution
D. The mass of the substance in grams, which is contained in 1 ml of the solvent
E. The mass of a substance in grams, which is contained in 100 ml of water

4.When determining the content of acetic acid, it is best to use:

A. by back titration with phenolphthalein
B. by back titration with methyl orange
C. by direct titration with phenolphthalein
D. by direct titration with methyl red
E. indirect acid-base titration

5. During the reverse titration of an aqueous solution of acetic acid, the following is used as an indicator:

A. phenolphthalein

B. diphenylamine

C. diphenylcarbazone

D. eriochrome black T

E. murexide

6. The ammonia content in ammonia can be determined:

A. by back titration of excess sulfuric acid with sodium hydroxide solution with methyl red

B. by direct titration with hydrochloric acid in the presence of phenolphthalein

C. by direct titration with hydrochloric acid in the presence of methyl red

D. by the method of indirect acid-base titration

E. by back titration with phenolphthalein

7. 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

8.In the reverse titration of an aqueous solution of acetic acid, the following is used as an indicator:

A. phenolphthalein

B. diphenylamine

C. diphenylcarbazone

D. eriochrome black T

E. murexide

9. 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

10.Indicators are added to the reaction system during titrimetric determination of a substance. An indicator titration error occurs when:

A. the indicator of the ionization constant of the reaction product does not coincide with the indicator titration indicator
B. the indicator of the ionization constant of the titrant does not coincide with the indicator titration indicator
C. the titration jump is greater than the transition interval of the indicator
D. the equivalence point does not coincide with the end point of the titration
E. the equivalence point does not coincide with the transition interval of the indicator

4. Individual tasks for students of higher education on the topic:

1. Use of weak acids and weak bases in pharmaceutical practice
2. Use of acid-base titration in pharmaceutical analysis.

5. References:

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.

Independent work No. 20

Topic: Acid-base titration. Titration of polybasic acids, bases, mixtures of acids, bases. Non-aqueous titration. Application of acid-base titration.

Goal: Get acquainted with the basic concepts of acid-base titrimetric analysis and learn 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

Plan

1. Theoretical questions:

1) The essence of the titrimetric method of analysis.
2) Classification of titrimetric analysis methods.
3) Method of neutralization.
4) Titration of ampholytes.
5) Titration errors.
6) Non-aqueous titration.

Questions for self-control:

1) Describe the main concepts: "titrimetry", "titrant", "indicator", "primary standard", "secondary standard", "titration curve".
2) Write how to prepare standard solutions of borax, hydrochloric acid, sodium hydroxide, perchloric acid, sodium ethanoate and how to store them?
3) What titrants are used in non-aqueous acidimetry and alkalimetry methods? How are they standardized?
4) What solvents are used in the non-aqueous acid-base titration method?

5) Indicators of the acid-base method. Give examples, the mechanism of work.
6) Titration errors. Classification of indicator errors, causes of their occurrence.

Approximate tasks for processing the theoretical material:

- Compile a dictionary of basic concepts on the topic.

2. Practical works (tasks) to be performed:

Task 1. Calculate the titration indicator error of 0.1 N. solution of CH_3COOH 0.1 n. NaOH solution with litmus indicator (pT = 7).

Task 2. Calculate the indicator error of the titration of 0.01 n with a 0.01 n solution of NaOH. formic acid solution with methyl orange litmus indicator.

Task 3. Calculate the error of titration of sodium acetate with a solution of hydrochloric acid with methyl orange indicator (pT=4, KHA = $1.8 \cdot 10^{-5}$).

Task 4. Describe the method of separate determination of carbonate and hydroxide ions in a mixture by acid-base titration.

3. Test tasks for self-control:

1.What conditions are suitable when choosing an indicator in an acid-base titration:

A. the transition interval should be equal to the value of the titration jump;
B. indicator titration indicator (pT) should be as close as possible to the pH value at the equivalence point;
C. it is necessary that the pH of the indicator coincides with the pH value at the equivalence point;
D. only those indicators can be used for titration, the transition interval of which is fully or partially included in the titration jump.

2.What characteristic is calculated by the formula pH = pK ± 1?

A. indicator value;
B. indicator transition interval;
C. titration index;
D. hydrogen indicator.

3.What is the name of the range of pH values within which the color of the indicator changes?

A. indicator value
B. titration index
C. end point of the titration
D. transition interval

4.What does the transition interval of the indicator depend on?

A. From the ionization constant of Ind
B. From the acidity of the environment
C. From the concentration of the solution
D. From a titration jump
E. From the presence of a catalyst

5.When choosing pH indicators, the most important thing is:

A. pH of the medium at the equivalence point
B. the nature of the titrant
C. properties of reaction products
D. the nature of the investigated substances
E. change in the pH of the medium during the titration process

6. To increase the ionization power of aniline when titrating it in a non-aqueous environment, use:

A. acetic acid
B. ethanol
C. sulfuric acid
D. potassium dichromate solution
E. sodium hydroxide solution

7.What solution is used in non-aqueous acidimetry as a titrant?

A. Hydrochloric acid
B. Chloric acid
S. Sodium ethanoate
D. Sulfate acid

E. Sodium hydroxide

8. What indicators are most often used in non-aqueous titration?

A. Crystal violet
B. Methylornage
C. Phenolphthalein
D. Murexid
E. Potassium chromate

9. 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

10.Indicators are added to the reaction system during titrimetric determination of a substance. An indicator titration error occurs when:

A. the indicator of the ionization constant of the reaction product does not coincide with the indicator titration indicator
B. the indicator of the ionization constant of the titrant does not coincide with the indicator titration indicator
C. the titration jump is greater than the transition interval of the indicator
D. the equivalence point does not coincide with the end point of the titration
E. the equivalence point does not coincide with the transition interval of the indicator

4. Individual tasks for students of higher education on the topic:

1. Use of non-aqueous acid-base titration in pharmaceutical analysis.
2. Indicators of the neutralization method. Mechanism of work. Indicator errors, ways to avoid them.

5. References:

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.

Independent work No. 21

Topic: Redox titration. Terms. Classification. Cerimetry. Iodine chlorometry. Iodometry.

Goal: Familiarize yourself with the basic concepts of redox titrimetric analysis and learn the methods of calculations and preparation of working solutions (titrants). Get acquainted with the methods of cerimetry, iodochlormetry and iodatometry.

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, redox potential

Plan

1. Theoretical questions:

1) The essence of the titrimetric method of analysis.

2) Classification of titrimetric analysis methods.
3) Cerimetry
4) Iodometry
5) Iodochlormetry.

Questions for self-control:

1) Describe the main concepts: "titrimetry", "titrant", "indicator", "primary standard", "secondary standard", "titration curve".
2) Iodometry. The essence of the method.
3) Iodometry titrant, its preparation and standardization, titration conditions.
4) Fixation of the end point of titration in cerimetry. Possibilities of the method.
5) Titrant of the method of iodochlorometry, its preparation and properties.
6) Determination of the end point of titration in iodometry.
7) Fixation of the end point of titration in cerimetry. Possibilities of the method.

Approximate tasks for processing the theoretical material:

- Compile a dictionary of basic concepts on the topic.

2. Practical works (tasks) to be performed:

Task 1 Calculate the weight of potassium iodate, which is necessary for the preparation of 0.25 dm3 of 0.05 n. its solution.

Task 2. Complete the reaction equation: $KI + KIO_3 + H_2SO_4 \rightarrow \ldots$
Select the coefficients by the half-reaction method.

Task 3. Calculate the normal concentration and titer of the solution of cerium(IV) sulfate obtained by dissolving a weight of cerium(IV) sulfate of 0.4517 g in 500 ml of water.

Task 4. The solution was prepared in a 2.0 dm^3 volumetric flask from fixanal, which contains 0.1 mol equivalent of the KIO_3 substance ($f_{eq.}$ = 1/6). Calculate the titer of the obtained solution.

3. Test tasks for self-control:

1.The pharmacist-analyst performs the quantitative determination of "paracetamol" by the cerimetry method. Specify which indicator the DF of Ukraine recommends using for the specified method?

A. ferroin
B. potassium chromate
C. phenolphthalein
D. tropeolin 00
E. methyl orange

2. Specify the method of quantitative determination of medicinal substances, which is related to redox titration methods:

A. cerimetry
B. argentometry according to Mohr
C. argentometry according to Fayance
D. mercurimetry
E. Rhodanometry

3. The cerimetry method is used for the quantitative determination of ferrum(II) in ferrum(II) sulfate or gluconate. The drug is dissolved in a mixture of sulfuric and phosphoric acids and titrated with a solution of cerium sulfate. What half-reaction occurs in this case?

A. $Ce^{4+} + e \rightarrow Ce^{3+}$
B. $Ce^{4+} + 2e \rightarrow Ce^{2+}$
C. $Ce^{3+} - e \rightarrow Ce^{4+}$
D. $Ce^{3+} + 2e \rightarrow Ce^{+}$
E. $Ce^{4+} + 3e \rightarrow Ce^{+}$

4. In cerimetry, the titrant solution is prepared as a secondary standard solution. What substance is used to standardize the titrant solution?

A. by sodium thiosulfate solution
B. by a solution of hydrochloric acid
C. by potassium permanganate solution

D. by sodium oxalate solution

E. by a solution of ascorbic acid

5.Determination of the mass fraction of ascorbic acid by cerimetry is carried out in the presence of a redox indicator

A. ferroin, 0.025M solution

B. methyl red, 0.1% solution

C. starch, 1% solution

D. ammonium ferrum(III) sulfate, saturated solution

E. methyl orange, 0.1% solution

6. Some redox reactions are accompanied by the course of side (induced) reactions, in which one reaction proceeds independently, and the other only during the course of the first. What is the name of the substance that participates in both reactions?

A. Actor

B. Inductor

C. Acceptor

D. Catalyst

E. Indicator

7. What is used to characterize redox processes?

A. Values of redox potentials

B. Electronegativity values of elements

C. The number of accepted or given electrons

D. The value of the oxidation state of the metal

E. The number of hydrogen ions involved in the reaction

8. During titrimetric analysis by oxidation-reduction titration methods, indicators are added to the reaction mixture that react to the change:

A. Redox potential of the system.

B. Concentration of hydroxyl ions.

C. Ionic strength of the solution.

D. Degrees of ionization of the analyzed substance.

E. Concentration of hydrogen ions.

9.The change in color of redox indicators is associated with:

A. by setting a certain potential value in the system and the corresponding redox balance for the indicator

B. by the dominance of the corresponding oxidized or reduced form of the indicator

C. by changing the acidity of solutions and the dominance of acidic or basic forms of the indicator

D. by changing the concentration of ions of certain metals in the solution

E. by establishing the balance of the oxidized and reduced forms of the indicator

10. A reaction occurs during titration $n_T X_{Red} + n_x T_{Ox} \rightarrow n_T X_{Ox} + n_x T_{Red}$. The calculation of the potential to the equivalence point is carried out according to the following formula:

A. $E = \frac{n_x E^{0'}(X_{Ox}/X_{Red}) + n_T E^0(T_{Ox}/T_{Red})}{n_X + n_T}$;

B. $E = E^0(X_{Ox}/X_{Red}) + \frac{0,0592}{n_X} \lg \frac{a(X_{Ox})}{a(X_{Red})}$;

C. $E = E^0(T_{Ox}/T_{Red}) + \frac{0,0592}{n_T} \lg \frac{a(T_{Ox})}{a(T_{Red})}$.

4. Individual tasks for students of higher education on the topic:

1. Use of redox titration in pharmaceutical analysis.
2. Indicators of the redox method. Mechanism of work. Indicator errors, ways to avoid them.
3. Using the cerimetry method in pharmaceutical analysis.
4. Use of the iodochlormetry method in pharmaceutical analysis.
5. Use of the method of iodometry in pharmaceutical analysis.

5. References:

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.

Independent work No. 22

Topic: Permanganatometric titration. General characteristics of the method. Possibilities of application.

Goal: Familiarize yourself with the basic concepts of redox titrimetric analysis and learn the methods of calculations and preparation of working solutions (titrants). Familiarize yourself with the method of permanganatometry.

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, redox potential

Plan

1. Theoretical questions:

1) The essence of the titrimetric method of analysis.
2) Classification of titrimetric analysis methods.
3) Redox titration. General characteristics. Classification.
4) The Nernst equation.
5) Permanganatometry.

Questions for self-control:

1) Describe the main concepts: "titrimetry", "titrant", "indicator", "primary

standard", "secondary standard", "titration curve".

2) What groups are redox titration methods divided into by the type of titrant?
3) Redox titration curves. In what coordinates are they being built?
4) Indicators of the redox method. Give examples, methods of selecting indicators.
5) Permanganatometry. How to make, store and standardizemethod titrant.
6) Peculiarities of titrant standardization of the permanganatometry method.
7) Conditions and possibilities of using permanganatometry.

Approximate tasks for processing the theoretical material:

- Compile a dictionary of basic concepts on the topic.

2. Practical works (tasks) to be performed:

Task 1.Set the direction of the reaction

2Hg + Ag+ ↔ 2Hg22+ + Ag

at ion concentration (mol/dm3): a) $[Ag^+] = 10^{-4}$, $[Hg_2^{2+}] = 10^{-1}$; b) $[Ag^+] = 10^{-1}$, $[Hg_2^{2+}] = 10^{-4}$.

Task 2. What is the weight of the technical preparationKMnO4it is necessary to take 3 dm3 of a solution with a concentration ($1/5KMnO_4$) = 0.02 mol/dm3. The drug contains 98.3% of potassium permanganate.

Task 3. Calculate the indicator error of the titration of the HNO2 solution with the $KMnO_4$ solution in the presencephenylanthranilic acid; pH = 0; E^0_{ind}= +1.08 V.

Task 4.A solution of hydrogen peroxide with a volume of 2.50 *ml* (with a density of 1.08 g/*ml*) transferred to a volumetric flask with a capacity of 200.0 *ml*, led to the mark with water 30.05 ml of potassium permanganate solution with$T(KMnO_4/O)$= 0.000450*g/ml*.Calculate the mass fraction of active oxygen in the initial H2O2 solution.

3. Test tasks for self-control:

1.Specify which value is used to characterize the oxidation-reduction capacity of a substance:

A. The magnitude of redox potentials
B. The value of electronegativity of elements
C. The number of accepted or given electrons
D. The value of the degree of oxidation
E. The number of hydrogen ions involved in the reaction

2. Specify the standard solution (titrant) used in the permanganatometry method:

A. Potassium permanganate solution
B. Solution of iron(II) sulfate
C. Sodium oxalate solution
D. Manganese(II) sulfate solution
E. Potassium manganate solution

3. What substance is used to standardize the $KMnO_4$ solution?

A. Oxalic acid.
B. Sodium tetraborate.
C. Potassium dichromate.
D. Sodium nitrite.
E. Potassium iodide.

4.Indicate how the end point of the titration is determined in the permanganatometry method:

A. When the color of the solution appears from an excess drop of titrant
B. By the formation of a complex connection of the indicator with the titrant
C. By the formation of a poorly soluble compound of the indicator with the titrant
D. By the formation of a poorly soluble compound of the indicator with the specified substance
E. For the destruction of the complex connection of the titrant with the determinative

5. The quantitative content of oxalic acid is determined by the method of permanganatometry. How is the equivalence point established in this method?

A. with a change in the color of the titrated solution when an excess drop of titrant is added
B. using the redox indicator diphenylamine
C. using a pH indicator
D. using a specific indicator
E. using an adsorption indicator

6. Some redox reactions are accompanied by the course of side (induced) reactions, in which one reaction proceeds independently, and the other only during the course of the first. What is the name of the substance that participates in both reactions?

F. Actor
G. Inductor
H. Acceptor
I. Catalyst
J. Indicator

7. $KMnO_4$ is used as a titrant in permanganatometry. What is the equivalence factor of this substance if the titration is carried out in an acidic medium?

A. 1/5
B. 1/4
C. 1/2
D. 1/3
E. 1

8. During titrimetric analysis by oxidation-reduction titration methods, indicators are added to the reaction mixture that react to the change:

A. Redox potential of the system.
B. Concentration of hydroxyl ions.
C. Ionic strength of the solution.
D. Degrees of ionization of the analyzed substance.
E. Concentration of hydrogen ions.

9.Name a pair of substances that can be used to standardize a 0.1 M solution of $KMnO_4$:

A. $Na_2C_2O_4$, $H_2C_2O_4$

B. K_2CO_3, CH_3COOH

C. CH_3COOK, $H_2C_2O_4$

D. KHC_2O_4, HCOOH

E. $Na_2C_2O_4$, CH_3COOH

10. A reaction occurs during titrationnTXRed+nxTOx → nTXOx+nxTRed.. The calculation of the potential to the equivalence point is carried out according to the following formula:

A. $E = \frac{n_x E^{0'}(X_{Ox}/X_{Red}) + n_T E^0(T_{Ox}/T_{Red})}{n_X + n_T}$;

B. $E = E^0(X_{Ox}/X_{Red}) + \frac{0{,}0592}{n_X} \lg \frac{a(X_{Ox})}{a(X_{Red})}$;

C. $E = E^0(T_{Ox}/T_{Red}) + \frac{0{,}0592}{n_T} \lg \frac{a(T_{Ox})}{a(T_{Red})}$.

4. Individual tasks for students of higher education on the topic:

1. Use of redox titration in pharmaceutical analysis.
2. Indicators of the redox method. Mechanism of work. Indicator errors, ways to avoid them.
3. Use of the permanganatometer method in pharmaceutical analysis.

5. References:

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.

Independent work No. 23

Topic: Iodine and iodometric titration. General characteristics of the method. Possibilities of application.

Goal: Familiarize yourself with the basic concepts of redox titrimetric analysis and learn the methods of calculations and preparation of working solutions (titrants). Get acquainted with the method andaudio and iodometric titration.

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, redox potential

Plan

1. Theoretical questions:

1) The essence of the titrimetric method of analysis.
2) Classification of titrimetric analysis methods.
3) Iodometry. Titrants of the method.
4) Direct, reverse and surrogate iodometry
5) Fixing the shooting end point.

Questions for self-control:

1) Describe the main concepts: "titrimetry", "titrant", "indicator", "primary standard", "secondary standard", "titration curve".
2) What groups are redox titration methods divided into by the type of

titrant?

3) Redox titration curves. In what coordinates are they being built?
4) Give the storage conditions for iodometry braces. How are they standardized?
5) In what ways is it possible to fix the end point of the titration in the iodometry method?
6) Terms and possibilities of using iodometry.

Approximate tasks for processing the theoretical material:

- Compile a dictionary of basic concepts on the topic.

2. Practical works (tasks) to be performed:

Task 1.How many ml of hydrogen peroxide solution, obtained by diluting a 3% solution 10 times, must be taken so that 25.00 ml of 0.1500 N was spent on its titration after adding sulfuric acid and potassium iodide. sodium thiosulfate solution?

Task 2. What volume of water should be added to 25.0 ml of solution I_2 with a concentration of $c(1/2I_2) = 0.0250$ mol/dm^3 to obtain a solution with a concentration of $c(1/2I_2) = 0.0200$ mol/dm3?

Task 3.Calculate the normality, the titer of the sodium thiosulfate solution, if for the titration of the iodine released when added to the weight 0.1200 g $K_2Cr_2O_7$ (dissolved in water, acidic medium) excess of KI was spent on 24.00 ml of sodium thiosulfate solution.

Task 4.Calculate the redox potential (in relation to the hydrogen electrode) in the solution, if 0.2 n. to 50 ml. solution $Na_2S_2O_3$ added 20 ml of 0.2 n. solutionI2. $E^0(S_4O_6^{2-}/S_2O_3^{2-}) = +0{,}09\ V$; $E^0(J_2/2J^-) = +0{,}54\ V$.

3. Test tasks for self-control:

1.Indicate the type of reaction that occurs during the determination of ascorbic acid in the preparation by the iodometric method:

A. Oxidation-reduction

B. Acylation

C. Neutralization

D. Sedimentation

E. Complex formation

2.Specify the standard solution for iodometric determination of diluents (direct titration)?

A. Solution I_2

B. Solution $KMnO_4$

C. Solution $Na_2S_2O_3$

D. Solution $K_2Cr_2O_7$

E. Solution KI

3.The content of potassium dichromate in the solution was determined by the iodometric method. Specify the titrant of the iodometry method when determining oxidants:

A. Sodium thiosulfate

B. Sodium hydroxide

C. Potassium iodide

D. Potassium permanganate

E. Potassium bromate

4. Specify the standard solutions used in iodometry for direct and reverse titration of diluents:

A. $I_2, Na_2S_2O_3$

B. $K_2Cr_2O_7, Na_2S_2O_3$

C. I_2, KI

D. $KMnO_4, KI$

E. $K_2Cr_2O_7, I_2$

5.Back titration is used for iodimetric determination of formaldehyde in formalin. Excess iodine is titrated with a standard solution:

A. Sodium thiosulfate

B. Sodium nitrate

C. Sodium sulfate

D. Sodium carbonate

E. Sodium phosphate

6. Some redox reactions are accompanied by the course of side (induced) reactions, in which one reaction proceeds independently, and the other only during the course of the first. What is the name of the substance that participates in both reactions?

A. Actor

B. Inductor

C. Acceptor

D. Catalyst

E. Indicator

7.Determination of the end point of titration in redox methods is carried out: by the indicator-free method, with the help of specific indicators and redox indicators. How is the end point of titration determined in iodometry?

A. With the help of a specific starch indicator

B. By the indicatorless method

C. With the help of a specific indicator of ferrum rhodanide

D. Using the redox indicator of diphenylamine

E. Using methyl red

8.The method of iodometric titration was used to determine the content of copper (II) sulfate. The titrant of the method is:

A. Sodium thiosulfate solution

B. Potassium hydroxide solution

C. Iodine solution in potassium iodide solution

D. Periodate potassium solution

E. Potassium permanganate solution

9. Indicate the type of reaction that occurs during the determination of ascorbic acid in the preparation by the iodometric method:

A. Oxidation-reduction

B. Acylation

C. Neutralization

D. Sedimentation

E. Complex formation

10. A reaction occurs during titration $n_T X_{Red} + n_x T_{Ox} \rightarrow n_T X_{Ox} + n_x T_{Red}$ The calculation of the potential to the equivalence point is carried out according to the following formula:

A. $E = \frac{n_x E^{0'}(X_{Ox}/X_{Red}) + n_T E^0(T_{Ox}/T_{Red})}{n_X + n_T}$;

B. $E = E^0(X_{Ox}/X_{Red}) + \frac{0{,}0592}{n_X} \lg \frac{a(X_{Ox})}{a(X_{Red})}$;

C. $E = E^0(T_{Ox}/T_{Red}) + \frac{0{,}0592}{n_T} \lg \frac{a(T_{Ox})}{a(T_{Red})}$.

4. Individual tasks for students of higher education on the topic:

1. Use of redox titration in pharmaceutical analysis.
2. Indicators of the redox method. Mechanism of work. Indicator errors, ways to avoid them.
3. Use of the iodometry method in pharmaceutical analysis.

5. References:

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.

Independent work No. 24

Topic: Dichromatometric titration. General characteristics of the method. Possibilities of application.

Goal: Familiarize yourself with the basic concepts of redox titrimetric analysis and learn the methods of calculations and preparation of working solutions (titrants). Familiarize yourself with the dichromatometric methodtitration.

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, redox potential

Plan

1. **Theoretical questions:**

1) The essence of the titrimetric method of analysis.
2) Classification of titrimetric analysis methods.
3) Dichromatometry. Titrants of the method.
4) Fixing the shooting end point.
5) Possibilities of the dichromatometry method.

Questions for self-control:

1) Describe the oxidation-reduction potential of the Cr2O72– /2Cr3+ pair.
2) How can you prepare a working solution of dipotassium dichromate? What substance is the primary standard in dichromatometry?
3) In what environment is dichromatometric titration carried out?
4) What are the advantages of dichromatometry compared to permanganatometry? What are the disadvantages of dichromatometry?
5) In what ways is the equivalence point fixed in dichromatometry?

6) What redox indicators can be used in dichromatometric titration?
7) What factors affect the width of the titration jump in the dichromatometric determination of Fe2+ ions?
8) For what purpose is phosphoric(V) acid added to the solution being titrated during the dichromatometric titration of Fe2+ ions with the indicator diphenylamine?
9) Give examples of the determination of reducing agents by the method of dichromatometry by direct and reverse titration.
10) What titration methods are used in the determination of oxidants by dichromatometry? Make a scheme for determining nitrate(V) ions.

Approximate tasks for processing the theoretical material:

- Compile a dictionary of basic concepts on the topic.

2. Practical works (tasks) to be performed:

Task 1.Visit the titration curve of 100 ml 0.1 n. of Cu_2SO_4 solution (E^0 = 0.153 V) 0.1 n. potassium dichromate solution (E^0 = 0.133 V).

Task 2. Calculate the normal concentration and titer of a solution of potassium dichromate obtained by dissolving a portion of potassium dichromate 2.4515 g in 500 ml of water.

Task 3. Calculate the indicator error of $FeSO_4$ titration with $K_2Cr_2O_7$ solution with diphenylamine indicator: a) in the presence of H3PO4; b) in the absence of H_3PO_4.

Task 4. 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 (1/6 $K_2Cr_2O_7$) = 0.10 mol/dm3. The drug contains 98.3% of potassium dichromate.

3. Test tasks for self-control:

1.Suggest a redox method for the quantitative determination of iron (II) salts in a solution containing hydrochloric acid:

1) Dichromatometry
2) Iodometry

3) Permanganatometry
4) Nitritometry
5) Ascorbinometry

2.What working solution is used in the method called "dichromatometry"?

1) Potassium dichromate
2) Chromium (III) nitrate
3) Chromium (III) sulfate
4) Chromium (III) chloride
5) Chromium (III) bromide

3.The content of potassium dichromate in the solution was determined by the iodometric method. Specify the titrant of the iodometry method when determining oxidants:

A. Sodium thiosulfate
B. Sodium hydroxide
C. Potassium iodide
D. Potassium permanganate
E. Potassium bromate

4.Substances from which primary standard solutions of titrants can be prepared include:

A. $K_2Cr_2O_7$
B. NaOH
C. I_2
D. $KMnO_4$
E. HCl

5.Indicate the number of numbers corresponding to the number of electrons that are attached to 1 mole of oxidizing titrant and the degree of oxidation of the atom of the element in its reduced form in dichromatometry.

A. 6, +3
B. 6, +6
C. 3, +3

D. 3, +2

E. 3, +1

6. Some redox reactions are accompanied by the course of side (induced) reactions, in which one reaction proceeds independently, and the other only during the course of the first. What is the name of the substance that participates in both reactions?

F. Actor

G. Inductor

H. Acceptor

I. Catalyst

J. Indicator

7.A reaction occurs during titration $n_TX_{Red}+n_xT_{Ox} \rightarrow n_TX_{Ox}+n_xT_{Red}$ The calculation of the potential to the equivalence point is carried out according to the following formula:

A. $E = \frac{n_x E^{0'}(X_{Ox}/X_{Red}) + n_T E^0(T_{Ox}/T_{Red})}{n_X + n_T}$;

B. $E = E^0(X_{Ox}/X_{Red}) + \frac{0{,}0592}{n_X} \lg \frac{a(X_{Ox})}{a(X_{Red})}$;

C. $E = E^0(T_{Ox}/T_{Red}) + \frac{0{,}0592}{n_T} \lg \frac{a(T_{Ox})}{a(T_{Red})}$.

4. Individual tasks for students of higher education on the topic:

1. Use of redox titration in pharmaceutical analysis.
2. Indicators of the redox method. Mechanism of work. Indicator errors, ways to avoid them.
3. Use of the dichromatometry method in pharmaceutical analysis.

5. References:

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.

Independent work No. 25

Topic: Redox titration. Bromatometry. Nitritometry.

Goal: Familiarize yourself with the basic concepts of redox titrimetric analysis and learn the methods of calculations and preparation of working solutions (titrants). Familiarize yourself with bromatometric and nitritometric methodstitration.

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, redox potential

Plan

1. Theoretical questions:

1) The essence of the titrimetric method of analysis.
2) Classification of titrimetric analysis methods.
3) Nitritometry. Titrants of the method.
4) Fixing the shooting end point.
5) Possibilities of the nitritometry method.
6) Bromato- and bromometry. Titrants of the method.
7) Fixing the shooting end point.
8) Possibilities of the bromatometry method.

Questions for self-control:

1) Oxidizing properties of bromate ions in an acidic environment.
2) Secondary standard solution of potassium bromate, its preparation, standardization, storage.
3) What are the conditions for bromatometric determinations?
4) In what ways is the equivalence point fixed in bromatometry?
5) How is the end point of the titration fixed in the nitritometry method?
6) Reactions taking place in the nitritometry method?
7) What drugs are determined by nitritometry and bromatometry?

Approximate tasks for processing the theoretical material:

- Compile a dictionary of basic concepts on the topic.

2. Practical works (tasks) to be performed:

Task 1. The redox indicator diphenylamine turns blue when the potential of the system becomes equal to 0.77 V. What will be the error of titration of ferrous iron with potassium dichromate solution if this indicator is used to set the end point of the titration?

Task 2.To what volume should 10 ml 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/ml

Task 3.For the bromatometric determination of As2O3 in the preparation, 60 ml of the solution was prepared, in which the weight of the preparation by mass was dissolved0.1014 g. For the titration of 20.00 ml of this solution, 6.80 ml of a standard solution of potassium bromate with a titer according to As2O3 of 0.004946 g/ml was used. Calculate the mass fraction of As2O3 in the dosage of the drug.

Task 4.Mixed 400 ml of a 0.0405 mol/dm3 solution of potassium bromate and 250 ml of a solution of potassium bromate with a molar concentration equivalent to KBrO3 of 0.222 mol/dm3. The volume of the mixture is diluted with water to 1000 ml. Calculate the molar concentration of the equivalent of the resulting solution.

3. Test tasks for self-control:

1.Which of the titrimetric methods of analysis use external and internal indicators:

A. Nitritometry
B. Alkalimetry
C. Complexonometry
D. Permanganatometry
E. Argentometry

2. The titrant of the nitritometry method is a 0.1 M solution of sodium nitrite, which is prepared as a secondary standard solution. The exact concentration of sodium nitrite is set according to:

A. sulfanilic acid
B. hydrochloric acid
C. acetic acid
D. oxalic acid
E. sulfuric acid

3. Sulfanilamide drugs have a primary aromatic amino group in their structure. Specify the method of quantitative determination of these compounds:

A. nitritometry
B. iodometry
C. dichromatometry
D. permanganatometry
E. cerimetry

4. In the bromatometric determination of streptocide (primary aromatic amine), direct titration with a standard solution of potassium bromate is used. As an indicator of this titration, the following is used:

A. methyl orange
B. phenolphthalein
C. eriochrome black T

D. iron (III) thiocyanate

E. murexide

5. Sulfanilamides contain a primary aromatic amino group in their structure. Specify the method of quantitative determination of these compounds:

A. nitritometry

B. iodometry

C. dichromatometry

D. permanganatometry

E. cerimetry

6.It is necessary to determine the amount of sodium salicylate in the solution. What method of titrimetric analysis can be used to quantify aromatic compounds?

A. bromometry

B. mercurometry

C. cerimetry

D. argentometry

E. complexonometry

7. Select the appropriate indicators for fixing the end point of the titration in the nitritometry method:

A. tropeolin 00 + methylene blue

B. methylene blue

C. methyl orange

D. starch solution

E. diphenylamine

1. What titrant is used in bromatometric titration?

A. $KBrO_3$

B. KBr

C. Br_2

D. $KBrO_4$ + KCl

E. $KBrO_4$

2. How is the equivalent in oxidation-reduction reactions calculated?

A. The molar mass is divided by the number of electrons involved in the reaction
B. The molar mass is divided by the number of hydrogen ions involved in the reaction
C. The molar mass is divided by the number of hydroxyl ions involved in the reaction
D. The molar mass is divided by the product of the metal's oxidation state and the number of metal atoms
E. The molar mass is divided by the valence of the metal

3. When determining streptocide (aromatic amine) by the nitritometry method, a catalyst is added to accelerate the diazotization reaction. Name the substance that acts as a catalyst.

A. Potassium bromide
B. Hydrochloric acid
C. Potassium sulfate
D. Sulfuric acid
E. Sodium chloride

4. Individual tasks for students of higher education on the topic:

1. Use of redox titration in pharmaceutical analysis.
2. Indicators of the redox method. Mechanism of work. Indicator errors, ways to avoid them.
3. Use of the nitritometry method in pharmaceutical analysis.
4. Use of the bromatometry method in pharmaceutical analysis.

5. References:

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.

Independent work No. 26

Topic: Argent Precipitation titration. General characteristics. Mercurometry.

Goal: Familiarize yourself with the basic concepts of precipitation titrimetric analysis and learn the methods of calculations and preparation of working solutions (titrants). Familiarize yourself with the mercurimetry method.

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, solubility product.

Plan

1. Theoretical questions:

1) The essence of the titrimetric method of analysis.
2) Classification of titrimetric analysis methods.
3) The method of mercurimetry

Questions for self-control:

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 PR?
5) What titration reactions are based on the formation of a precipitate?
6) How is the equivalence point fixed in the argentometric determination of chlorides?
7) What impurities contain salts of mercury (I)? What conditions for titrant production should be followed in this regard?
8) Why should a control experiment be conducted when using $[Fe(NCS)_3]$ as a mercurimetry indicator?

Approximate tasks for processing the theoretical material:

- Compile a dictionary of basic concepts on the topic.

2. Practical works (tasks) to be performed:

Task 1.Calculate the molar concentration of the $Hg_2(NO_3)_2$ solution, if 18.06 ml of titrant is used for the titration of 0.1315 g of KCl.

Task 2. Determine the mass fraction in percent of NaCl in the solution, if 20.56 ml of a 0.1004 mol/ml solution is spent on the titration of a weight weighing 0.1635 g$Hg_2(NO_3)$2.

Task 3. Determine the normal concentration of the potassium rhodanide solution and its titer against silver, if 20.00 ml of 0.1014 N is used for the titration of 25.00 ml. $AgNO_3$ solution.

3. Test tasks for self-control:

1.For the quantitative determination of potassium chloride in the preparation, the method of mercurometry was used. The following was used as an indicator:

A. diphenylcarbazone

B. methyl red

C. phenolphthalein

D. fluorescein

E. ferroin

2.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. Permanganatometry

3. 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

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. A standard substance is used to standardize a solution of argentum nitrate:

A. sodium chloride

B. potassium hydroxide

C. bismuth nitrate

D. potassium chromate

E. potassium permanganate

7.To determine the mass fraction of argentum nitrate in the drug, the method of direct titration according to the Folgard method is used. Titration is carried out in the presence of an indicator:

A. ammonium ferrum(III) sulfate, saturated solution

B. potassium chromate solution (w=5%)

C. fluorescein solution (w=0.5%)

D. alcohol solution of diphenylcarbazone (w=1-2%)

E. sodium eosinate solution (0.1M)

8.What analytical effect is observed when fixing the equivalence point by Mohr's method?

A. Precipitation is brick-red in color

B. The color of the solution is red

C. The color of the solution is yellow

D. A crimson precipitate is formed

E. A yellow precipitate is formed

9.The studied mixture contains Cl–, Br– and I– ions in equimolar amounts. The sequence of sediment formation during argentometric titration will be determined:

A. by the solubility product of the formed argentum halides

B. constant of hydrolysis of argentum nitrate

C. by choosing a titration method - direct or reverse

D. indicator concentration

E. ionic strength of the solution

4. **Individual tasks for students of higher education on the topic:**
   1. Use of mercurometric titration in pharmaceutical analysis.
   2. Adsorption indicators. Mechanism of work. Indicator errors, ways to avoid them.

5. **References:**

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.

Independent work No. 27

Topic: Argentometry. Mohr's method. Fayans-Khodakov method.

Goal: Familiarize yourself with the basic concepts of precipitation titrimetric analysis and learn the methods of calculations and preparation of working solutions (titrants). Familiarize yourself with the methods of Mohr and Fayans-Khodakov.

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, solubility product.

Plan

1. **Theoretical questions:**

1) The essence of the titrimetric method of analysis.
2) Classification of titrimetric analysis methods.
3) Mohr's method
4) Fayans-Khodakov method

Questions for self-control:

1) Describe the main concepts: "titrimetry", "titrant", "indicator", "primary standard", "secondary standard", "titration curve".
2) What methods of titrant preparation are used in argentometry? Justify the answer.
3) Provide a comparative description of the Mohr and Fayans-Khodakov methods.
4) Give a comparative description of Mohr and Folgard methods.
5) Determination of chlorides according to Mohr. What anions and cations interfere with the determination of chloride ions by Mohr's method and why?

Approximate tasks for processing the theoretical material:

- Compile a dictionary of basic concepts on the topic.

2. **Practical works (tasks) to be performed:**

Task 1.Determine the percentage content of potassium iodide in the studied concentrate, if 5 ml of the concentrate were taken to prepare 100 ml of dilution, and 9.8 ml of silver nitrate solution with a molar concentration equivalent to 0.02 mol/l and a correction factor of 1 were used to titrate 5 ml of the resulting solution 1.00 (M m CI = 166.01 g/mol, ρ CI 20% = 1.1478 g/ml)

Task 2. Calculate pBr and pAg when titrating 100 ml 0.1N.of KBr solution 0.1 n. $AgNO_3$ solution if: a) 99 ml, b) 100 ml, c) 110 ml of titrant are added. PR(AgBr) = 7.7·10-13.

Task 3.Determine the normal concentration of the potassium rhodanide solution and its titer against silver, if 20.00 ml of 0.1014 N is used for the titration of 25.00 ml. $AgNO_3$ solution.

Task 4.Calculate the indicator error of the titration of 25.0 ml of a 0.010 mol/dm3 NaCl solution with an AgNO3 solution of the same concentration in the presence of 2.0 ml of a K_2CrO_4 solution with a concentration of c(1/2 K_2CrO_4) = 0.050 mol/dm3.

3. Test tasks for self-control:

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. Permanganatometry

3. 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

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. The following was used as an indicator:

A. diphenylcarbazone
B. methyl red
C. phenolphthalein
D. fluorescein
E. ferroin

7.A standard substance is used to standardize a solution of argentum nitrate:

A. sodium chloride
B. potassium hydroxide
C. bismuth nitrate
D. potassium chromate
E. potassium permanganate

8.To determine the mass fraction of argentum nitrate in the drug, the method of direct titration according to the Folgard method is used. Titration is carried out in the presence of an indicator:

A. ammonium ferrum(III) sulfate, saturated solution
B. potassium chromate solution (w=5%)
C. fluorescein solution (w=0.5%)

D. alcohol solution of diphenylcarbazone (w=1-2%)
E. sodium eosinate solution (0.1M)

9.What analytical effect is observed when fixing the equivalence point by Mohr's method?

A. Precipitation is brick-red in color
B. The color of the solution is red
C. The color of the solution is yellow
D. A crimson precipitate is formed
E. A yellow precipitate is formed

10.The studied mixture contains Cl–, Br– and I– ions in equimolar amounts. The sequence of sediment formation during argentometric titration will be determined:

A. by the solubility product of the formed argentum halides
B. constant of hydrolysis of argentum nitrate
C. by choosing a titration method - direct or reverse
D. indicator concentration
E. ionic strength of the solution

4. Individual tasks for students of higher education on the topic:

1. Adsorption indicators. Mechanism of work. Indicator errors, ways to avoid them.
2. Use of precipitation titration in pharmaceutical analysis.

5. References:

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.

Independent work No. 28

Topic: Thiocyanometry. Folgard's method.

Goal: Familiarize yourself with the basic concepts of precipitation titrimetric analysis and learn the methods of calculations and preparation of working solutions (titrants). Familiarize yourself with the Folgard method.

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, solubility product.

Plan

1. Theoretical questions:

1) The essence of the titrimetric method of analysis.
2) Classification of titrimetric analysis methods.
3) Folgard's method: titrant, indicator, titrant standardization, titration conditions.
4) Direct and reverse titration according to Folgard

Questions for self-control:

1) Describe the main concepts: "titrimetry", "titrant", "indicator", "primary standard", "secondary standard", "titration curve".
2) What methods of titrant preparation are used in argentometry? Justify the answer.
3) Give a comparative description of Mohr and Folgard methods.

4) Give a comparative description of Folgard and Fayans-Khodakov methods.

Approximate tasks for processing the theoretical material:

- Compile a dictionary of basic concepts on the topic.

2. Practical works (tasks) to be performed:

Task 1.To determine Cl- in water, 100 ml of water was taken and titrated to 0.1012 n. A $AgNO_3$ solution, which required 18.20 ml for titration. How many grams of Cl- were in the water?

Task 2. Calculate pBr and pAg when titrating 100 ml 0.1N of KBr solution 0.1 n. $AgNO_3$ solution if: a) 99 ml, b) 100 ml, c) 110 ml of titrant are added. SP (AgBr) = 7.7·10-13.

Task 3.Determine the normal concentration of the potassium rhodanide solution and its titer against silver, if 20.00 ml of 0.1014 N is used for the titration of 25.00 ml $AgNO_3$ solution.

Task 4.Calculate the indicator error of the titration of 25.0 ml of a 0.010 mol/dm3 NaCl solution with an AgNO3 solution of the same concentration in the presence of 2.0 ml of a K_2CrO_4 solution with a concentration of c(1/2 $K_2CrO_4$4) = 0.050 mol/dm^3.

3. Test tasks for self-control:

1.For the quantitative determination of argentum(I) in the pharmaceutical preparation, the Folgard method was used. An indicator is used to fix the end point of the titration:

A. iron-ammonium alum

B. sodium eosinate

C. potassium chromate

D. starch

E. diphenylcarbazone

2.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. Permanganatometry

3. 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

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. The following was used as an indicator:

A. diphenylcarbazone
B. methyl red
C. phenolphthalein
D. fluorescein
E. ferroin

7.A standard substance is used to standardize a solution of argentum nitrate:

A. sodium chloride
B. potassium hydroxide
C. bismuth nitrate
D. potassium chromate
E. potassium permanganate

8.To determine the mass fraction of argentum nitrate in the drug, the method of direct titration according to the Folgard method is used. Titration is carried out in the presence of an indicator:

A. ammonium ferrum(III) sulfate, saturated solution
B. potassium chromate solution (w=5%)
C. fluorescein solution (w=0.5%)
D. alcohol solution of diphenylcarbazone (w=1-2%)
E. sodium eosinate solution (0.1M)

9.The studied mixture contains Cl–, Br– and I– ions in equimolar amounts. The sequence of sediment formation during argentometric titration will be determined:

A. by the solubility product of the formed argentum halides
B. constant of hydrolysis of argentum nitrate
C. by choosing a titration method - direct or reverse
D. indicator concentration
E. ionic strength of the solution

4. Individual tasks for students of higher education on the topic:

1. Use of precipitation titration in pharmaceutical analysis.
2. Adsorption indicators. Mechanism of work. Indicator errors, ways to avoid them.
3. Use of precipitation titration in pharmaceutical analysis.

5. References:

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.

Independent work No. 29

Topic: Complex symmetric titration. Complexonometry.

Goal: Get acquainted with the basic concepts of compleximetric titrimetric analysis and learn the methods of calculations and preparation of working solutions (titrants). Familiarize yourself with the complexometry method.

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, complex compound, chelate.

Plan

1. Theoretical questions:

1) The essence of the titrimetric method of analysis.
2) Classification of titrimetric analysis methods.
3) Complexonometry method

Questions for self-control:

1) Describe the main concepts: "titrimetry", "titrant", "indicator", "primary standard", "secondary standard", "titration curve".
2) General characteristics of complex formation methods.
3) Complexometric titration. General assessment of the method.
4) Chelatometric titration.Application of complexes.
5) The method of preparing a standard solution of trilon-B (0.05 M)
6) Methods of fixing the end point of titration in complexometry.
7) Metallochromic indicators of the complexometric titration method.
8) How are indicators selected in compleximetric titration?

Approximate tasks for processing the theoretical material:

- Compile a dictionary of basic concepts on the topic.

2. Practical works (tasks) to be performed:

Task 1.To determine the total content of Ca^{2+} and Mg^{2+} in the solution, 6.0 ml of 0.1120 n were used for the titration of 10.00 ml of this solution in the presence of the eriochrome black T indicator. solution of Trilon B. To determine Ca^{2+}, 9.50 ml of 0.1120 N was added to 10.00 ml of the same solution. of trilon B solution, and its excess was titrated to 6.09 ml 0.10 n. solutionCaCl2 in the presencemurexide indicator. Calculate the mass fraction of Ca^{2+} and Mg^{2+} in 100.0 ml of the studied solution.

Task 2.Calculate the concentration of mmol/dm^3 of magnesium in water, if 24.20 ml of 0.1009 n went to the blue color when titrating 100.00 ml of water with trilon B with a black chromogen. Trilon B solution.

Task 3. Determine the content of $Na_2SO_4•10H_2O$ (g/dm^3), if an aliquot of 10.00 ml was taken for the analysis and 50.00 ml was added0.1000 Mof $Pb(NO_3)_2$ solution. Excess $Pb(NO_3)_2$ was titrated with 10.00 ml 0.09000 M trilon B solution.

Task 4. Calculate the hardness of water if 2.20 ml of 0.0480 N was spent on the titration of 25 ml of a water sample. Trilon B solution.

3. Test tasks for self-control:

1.The titrant of the complexonometry method is a trilon B solution, which forms complex compounds with metal cations, regardless of their valence, in the ratio:

A. 1:1

B. 1 : 3

C. 1 : 2

D. 2 : 1

E. 3 : 1

2. The quantitative content of calcium chloride is determined by the method of direct complexometric titration. Select the indicator for fixing the end point of the titration:

A. Eriochrome black T

B. Phenolphthalein

C. Methyl red

D. Eosin

E. Starch

3. A 0.05 M solution of Trilon B was prepared. Specify the standard substance for the standardization of this solution:

A. Zinc metal

B. Sodium tetraborate

C. Sodium hydroxide

D. Oxalic acid

E. Potassium dichromate

4.What compound is added when determining calcium cations with the murexide indicator to create pH>12?

A. Sodium hydroxide
B. Acetate buffer
C. Urotropin
D. Ammonia buffer
E. Ammonium hydroxide

5. When determining the total hardness of water, the laboratory technician uses the eriochrome black T indicator. Indicate by which method the determination was made:

A. Complexonometry
B. Argentometry
C. Permanganatometry
D. Bromatometry
E. Chromatometry

6. A solution of zinc sulfate was taken for analysis. Suggest a titrimetric method for quantitative determination$Z\ nSO_4$ in solution:

A. Complexonometry
B. Permanganatometry
C. Iodometry
D. Argentometry
E. Mercurometry

7.The content of magnesium sulfate in the medicinal product is determined by the complexometric titration method. Suggest an indicator for fixing the end point of the titration:

A. Chromogen is black
B. Phenolphthalein
C. Methyl orange
D. Eosin

E. -

8. A solution containing calcium and magnesium cations is titrated with a trilon B solution. In which medium is the complexometric titration of these cations carried out?

A. In the medium of ammonium buffer solution

B. In the medium of a formate buffer solution

C. In a neutral solution

D. In an acidic solution

E. In the medium of acetate buffer solution

9.Trilonometric titration is used to determine medicinal products containing magnesium and calcium cations. What type of chemical reaction occurs in this case?

A.Complex formation

B. Oxidation-reduction

C. Electrophilic substitution

D. Alkylation

E. Sedimentation

10. 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

4. Individual tasks for students of higher education on the topic:

1. Use of complexometric titration in pharmaceutical analysis.
2. Metallochromic indicators. Mechanism of work. Indicator errors, ways to avoid them.

5. References:

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.

Independent work No. 30

Topic: Optical methods of analysis. Photo and spectrophotometry. Refractometry.

Goal: Familiarize yourself with the basic concepts of physical and chemical analysis and learn the methods of making calculations, building graphs, and determining the content of substances by methods of optical analysis. Get acquainted with the methods of photocolorimetry and spectrophotometry.

Basic concepts: analysis, quantitative analysis, physical and chemical analysis, molar light absorption coefficient, optical density

Plan

1. **Theoretical questions:**

1) Classification of optical methods of analysis. Atomic and molecular emission and absorption spectra.
2) Dependence of the color of substances on their structure. Chromophoric and auxochromic groups.

3) Methods based on measuring the optical properties of substances. Absorption methods of analysis.
4) Bouguer-Lambert law- Takes. The physical content of the quantities included in it.
5) Spectrophotometry. The essence of the method. Advantages over photocolorimetry.
6) Spectra of substances in the ultraviolet, visible and infrared regions of the spectrum.
7) Colorimetry. Visual methods.

Questions for self-control:

1) Chromophoric and auxochromic groups.
2) Bouguer-Lambert law- Takes. The physical content of the quantities included in it.
3) Reasons for deviation from the basic law of light absorption
4) Molar absorption coefficient. Sensitivity of colorimetric reactions.
5) Spectra of substances in the ultraviolet, visible and infrared regions of the spectrum.
6) Methods of measuring color intensity in visual colorimetric measurements: scale method (standard series); breeding method; method of colorimetric titration (duplication).

Approximate tasks for processing the theoretical material:

- Compile a dictionary of basic concepts on the topic.

2. Practical works (tasks) to be performed:

Task 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 ml of water. From the resulting solution, 10 colored solutions containing from 1.00 to 10.00 ml of a standard solution in 20.00 ml of water were obtained by adding ammonia. Then0.750 g the studied compound was dissolved in 250 ml of water. After the interaction of 10.00 ml of this solution with ammonia and dilution to 20.00 ml, 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.

Task 2. To determine the chromium in the sample, a standard solution containing 0.750 g K_2CrO_4 in 250 ml of water. The concentration of the studied compound 0.500 g dissolved in acid, oxidized to chromate, the solution was made up to 200 ml with water. The resulting solution was compared with the standard, while for the color equation, 6.80 ml of the standard solution was diluted with water to 25.00 ml. Calculate the mass fraction of chromium in the studied sample

Task 3.To determine copper from the weight 0.325 g_after dissolution and treatment with ammonia, 250 ml of a colored solution was obtained, the optical density of which in the cuvette is the thickness of the layer 2 cm was 0.254. Determine the copper content if the molar absorption coefficient of copper ammonia is 423.

Task 4.Calculate the molar refraction of carbon tetrachloride CCl_4 if the refractive index ${}_n{}^{20}D$ = 1.4603 and the density $d^{20}{}_4$ = 1.604. Compare the found refraction with the one calculated from the tables of atomic refractions and bond refractions (R_C = 2.418; R_{Cl} = 5.567).

3. Test tasks for self-control:

1.Physico-chemical methods are used for quantitative determination of medicinal substances. Which of the following methods is based on the determination of the optical density of the solution?

A. Spectrophotometry
B. Polarography
C. Potentiometry
D. Coulometry
E. Electrogravimetry

2. For the quantitative photocolorimetric determination of Ferrum (III) ions, the specialist conducts a reaction with sulfosalicylic acid and measures the following indicator:

A. Optical density

B. Specific rotation

C. Refractive index

D. Wavelength

E. Half-wave potential

3. In the quantitative determination of glucose by the polarimetric method, the following are measured:

A. The angle of rotation of the plane of the polarized light beam

B. Coefficient of refraction of light

C. Degree of absorption of a polarized light beam by a solution

D. Dispersion of a light beam by a solution

E. The optical density of the solution

4. Photoelectrocolorimetric analysis.

A. requires the use of monochromatic radiation;

B. based on the ability of substances to be oxidized or reduced under the influence of visible radiation;

C. requires obtaining colored forms of analyzed compounds;

D. allows you to determine the concentration of cloudy and dark-colored solutions.

5. Specify the range of wavelengths (nm) in which the method of photocolorimetry can be applied.

A. 200-400;

B. 400 - 1000;

C. 200 - 760;

D. 100-540.

6. Compliance with the basic law is not affected by light absorption

A. dissociation of the substance to be determined;

B. low stability of the analyzed compound;

C. the thickness of the light-absorbing layer;

D. insufficient monochromaticity of absorbing light;

7.The molar light absorption coefficient depends on

A. the thickness of the light-absorbing layer;

B. substance concentration;

C. device sensitivity;

D. the nature of the substance

8. The minimum stipulated concentration of the substance depends on

A. the thickness of the light-absorbing layer;

B. the nature of the solvent;

C. pH of the solution

D. molar light absorption coefficient

9.Analysis methods based on the interaction of electromagnetic radiation with matter are called:

A. chromatographic;

B. spectroscopic;

C. electrochemical;

D. mass spectrometric.

10. The absorption spectrum of a substance is a graphical dependence:

A. radiation intensity of the solution from the wavelength of the emitted light;

B. the optical density of the solution from the wavelength of the incident light;

C. permeability of the solution depending on the concentration of the substance in the solution;

D. optical density from the concentration of the substance in the solution.

4. Individual tasks for students of higher education on the topic:

1. Use of optical methods of analysis in pharmaceutical practice
2. Spectrophotometry. Basics of the method. Spectrophotometry in the UV region in pharmaceutical analysis
3. Accuracy of visual test analysis depending on the method of constructing the color scale
4. Concept of refractometry and its application

5. References:

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.

Independent work No. 31

Topic: Electrochemical methods of analysis. Potentiometric analysis. Chromatographic methods.

Goal: Familiarize yourself with the basic concepts of physical and chemical analysis and learn the methods of making calculations, building graphs, and determining the content of substances using electrochemical analysis methods. Get acquainted with the methods of potentiometry, coulometry and polarography.

Basic concepts:analysis, quantitative analysis, physical and chemical analysis, polarimetry, potentiometry, electrode of the first kind, electrode of the second kind. Ion-selective electrode

Plan

1. **Theoretical questions:**

1) Classification of electrochemical methods of analysis.
2) Electrogravimetric analysis..

3) Classification of coulometry methods by reaction type
4) Coulometric titration.
5) Physico-chemical foundations of the conductometric method of analysis. Conductometric titration.
6) Potentiometric analysis, its types. The Nernst equation. Apparatus, analytical application
7) Polarographic analysis. Theoretical foundations of the method. Analytical application.

Questions for self-control:

1) Electrolysis at a constant cathode potential, electrolysis at a constant current
2) Conductometric analysis. Apparatus. Analytical application.
3) Determination of equivalence point on conductometric titration curves. Conductometric titration curves.
4) High-frequency conductometric titration. Advantages of high-frequency titration over low-frequency and indicator titration.
5) What types of chemical reactions are used in conductometric titration? Give examples of definitions.
6) Types of electrodes used in the potentiometry method. Indicator electrodes, comparison electrodes.
7) Potentiometric titration curves, determination of equivalence points by potentiometric titration curves
8) Ion-selective electrodes, their characteristics. Application in analytical chemistry.
9) Qualitative polarographic analysis.
10) Quantitative polarographic analysis.
11) Polarographic wave, its characteristics. Factors affecting the half-wave potential.

Approximate tasks for processing the theoretical material:

- Compile a dictionary of basic concepts on the topic.

2. Practical works (tasks) to be performed:

Task 1. The polarographic method of standard solutions was used to determine the kellin content. At the concentration of the standard solution C_{st} = 0.0001 g/ml, the height of the polarographic wave is equal to H_{st} =56 mm. The height of the polarographic wave of the investigated solution, prepared by dissolving the sample by mass0.0494 g in a volumetric flask with a capacity of 500.00 ml, is equal to 54 mm. Calculate the mass fraction of kellin in the sample.

Task 2. 0.3937 g powder of crushed paracetamol tablets (Mol.m. = 151.17 g/mol) was transferred to a flask, acidified with a solution of HC1, and titrated 0.1008 Msodium nitrite solution potentiometrically using platinum and saturated silver chloride electrodes. The obtained data are shown in the table:

V(NaNO2), ml	15.00	20.00	21.00	21.10	21,20	21.30	21.40
Well, mV	562	580	585	590	595	598	601

Construct the integral and differential titration curves and determine the end point of the titration. Calculate the mass fraction of paracetamol in the sample.

Task 3.Electromotive force of the chain: $Pt(H_2) \mid H^+ \parallel Cl^- \mid Hg_2C1_2, Hg$ at a temperature of 25°C EMF = 0.571 V, Electrode = 0.281 V. Calculate the concentration of hydrogen ions and the pH of the medium in the solution under study.

Task 4.Sample weight (0.2017), which contains NaCl and NaBr, was introduced into a volumetric flask with a capacity of 100.39 ml, an aliquot part with a volume of 20.00 ml was taken and titrated by the potentiometric method with a 0.0502 M solution of silver nitrate. Two potential jumps were observed on the potentiometric titration curve: at V1 = 3.42 ml and V2 = 4.76 ml. Calculate the mass fraction of NaCl and NaBr in the sample.

3. Test tasks for self-control:

1.For the quantitative determination of ferrum II sulfate by the method of potentiometric titration, as an indicator electrode, the following is used:

A. Platinum

B. Silver chloride

C. Hydronic

D. Surmyany

E. Glass

2. Choose an indicator electrode for the quantitative determination of acetic acid by the potentiometric titration method:

A. Glass

B. Silver chloride

C. Silver

D. Platinum

E. Calomel

3.Select a pair of electrodes for potentiometric determination *pH* solution:

A. Glass-silver chloride

B. Calomel-silver chloride

C. Hydronic-stibial

D. Mercuric-chloric silver sulfate

E. Glass-stibious

4. During conductometric titration of acid mixtures HCl and CH_3COOH 0.1M solution $NaOH$ measure:

A. Electrical conductivity of the solution

B. pH of the medium

C. Potential difference

D. Angle of rotation of the plane of polarized light

E. Refractive index

5. Which method is based on the functional dependence between the concentration of the studied component and the value of the electrode potential?

A. Potentiometry

B. Conductometry

C. Atomic absorption spectroscopy

D. Amperometry

E. Electrophoresis

6. What parameter is measured during conductometric titration of electrolyte solutions?

A. Electrical conductivity

B. Electromotive force

C. The viscosity of the solution

D. Acidity of the environment

E. Concentration of the solution

7. What type of electrodes does the silver chloride electrode belong to?

A. Second kind

B. First kind

C. Gas

D. Redox

E. Ion-selective

8.Select a pair of electrodes to define $FeSO_4$ by the potentiometric titration method:

A. Platinum and silver chloride

B. Copper and glass

C. Hydronic and zinc

D. Hydrogen and glass

E. Antimony and silver

9.The glass electrode is widely used for measuring pH in biological media, liquid medicinal forms, etc. What type is a glass electrode?

A. Ion selective electrode

B. Type I electrode

C. Redox electrode

D. Type II electrode

E. Gas electrode

10.In dichromatometric determination of the $FeSO_4$ content in a solution with potentiometric fixation of the equivalence point, the following electrode is used as an indicator:

A. Platinum

B. Glass

C. Hydronic

D. Silver

E. Silver chloride

4. Individual tasks for students of higher education on the topic:

1. Use of potentiometric titration in pharmaceutical analysis.
2. Voltammetry. Possibilities of the method

5. References:

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.