Odessa National Medical University

Department of Radiation Diagnostics, Therapy and Oncology

Discipline RADIOLOGY

The list of theoretical questions to the test

For 3th year medical students

Acting Pro-rector of science and education

Prof. Chmakova I.P.

DIRECTIONS: Each numbers questions or incomplete statement below contains letterd responses. Select the one best response

1. Which of the following is a factor that differs between x-rays and gamma rays?

(A) Electrical nature

(B) Particulate nature

(C) Speed in a vacuum

(D) Source of origin

2. A scattered photon with the greatest energy would be the one deflected from its original path at an angle of

(A) 20°

(B) 45°

(C) 60°

(D) 90°

S. Which unit of measurement would be most appropriate for stating the quantity of radiation exposure as measured by an ionization chamber?

THE CONTROL TEST

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(A) Roentgen

(B) Sievert

(C) Rad

(D) Curie

4. The unit of radiation measurement used to indicate dose *equivalent* is the

(A) rad
(B) rem

(C) gray
(D) roentgen

5. The monitoring and measuring of a person's exposure to radiation is termed

(A) densitometry

(B) dosimetry

(C) sensitometry

(D) ALARA

6.The *cardinal rules* of radiation protection recommend the use of

(A) maximum exposure time, distance, and shielding

(B) automatic exposure control, fast imaging systems, and maximum shielding

(C) minimum exposure time, maximum distance, and appropriate shielding

(D) maximum beam restriction, minimum exposure time, and maximum distance

7.What is the material used to express shielding equivalents?

(A) Copper

(B) Lead

(C) Aluminum

(D) Tungsten

8. Which of the following indicates *primary radiation?*

(A) Photons that have been scattered during x-ray/matter interactions

(B) The major source of operator radiation exposure

(C) Photons that do not undergo x-ray/matter interactions

(D) The major component of the exit beam

9. Any surface toward which the x-ray tube may be directed during operation is referred to as

(A) a primary barrier

(B) a secondary barrier

(C) a controlled area

(D)an uncontrolled area

10. The major contributor to natural background radiation is

(A) medical x-rays

(B) radon

(C) cosmic (extraterrestrial) rays

(D) consumer products

1 1 . Background radiation exposure includes:

1. Cosmic radiation
2. Medical x-rays
3. Fallout radiation
4. Ultrasonic waves

(A)1,2.&3

(B) 2 , 3 & 4

(C) 3&4

(D) 1 &2

12. For a given examination, dose to which anatomic structure will be the greatest?

(A) Gonads

(B) Skin

(C) Bone marrow

(D) All the above structures receive equal doses

13. lonization of matter occurs at the structural level of the

(A) atomic nucleus

(B) atomic shells

(C) molecule

(D) cell

14. Which type of ionizing radiation will have the LEAST biologic effect?

(A) Alpha particles

(B) Fast neutrons

(C) 25 MeV x-rays

(D) Diagnostic x-rays

15. *Direct effects* of irradiation are those that

(A) cause immediate cell death

(B) affect structures distant from the irradiated structures

(C) affect the site of irradiation

(D) cause the least biologic effect

16. Which of the following are considered types of *ionizing* radiation?

(A) X-rays, gamma rays, alpha particles

(B) Beta particles, gamma rays, light photons

(C) X-rays, light photons, beta particles

(D) Radio waves, alpha particles, beta particles

17. Radiolysis of water molecules creates

(A) increased radiosensitivity of the tissue involved

(B) decreased radiosensitivity of the tissue involved

(C) free radicals

(D) larger water molecules

18. What is the basic concept of the *target theory* in cell survival?

(A) The nucleus is the most radioresistant structure in the cell

(B) A key molecule determines cell survival

(C) Direct effects are more damaging than indirect effects

(D) Free radicals within a cell are most susceptible to irradiation

19. Which type of cell is most sensitive to irradiation?

(A) Red blood cells

(B) White blood cells

(C) Epithelial cells

(D) Muscle cells

20. Highly radiosensitive cells would have which of the following characteristics?

1. Immaturity
2. High specialization
3. High rate of proliferation

(A) 1 & 2

(B)2&3

(C) 1 & 3

(D) 1,2, &3

21 .Radiation effects that manifest themselves in the person exposed years after the exposure are considered to be:

1. Early effects
2. Late effects
3. Somatic effects
4. Genetic effects

(A) 1 & 3

(B) 1 &4

(C) 2 & 3

(D) 2&4

22. An example of an early somatic effect of irradiation would be

(A) leukemia

(B) lung cancer

(C) cataract formation

(D) skin erythema

23Which of the following are examples of possible late somatic effects?

(A) Cancer, skin erythema, congenital defects

(B) Destruction of the Gl tract, shortening of the life span, cataract formation

(C) Hemorrhage, cataract formation, convulsive seizures

(D) Cancer, congenital defects, shortening of the life
Span

24. The risk of congenital abnormalities is greatest if the embryo or fetus is irradiated during the

(A) first 2 weeks following fertilization

(B) first trimester after the first 2 weeks

(C) second trimester

(D) third trimester

25 Which of the following devices are used to protect the patient from unnecessary radiation exposure?

(A) Collimators, filters, grids

(B) Immobilization devices, filters, high-kVp techniques

(C) Shields, direct exposure systems, increased SID

(D) Short source-to-skin distance, fast screens, cones

26. Which of the following practices will reduce exposure to breast tissue during scoliosis imaging?

1. Use of breast shields
2. Use of AP rather than PA projection
3. Use, of a compensating filter

(A) 1 & 2

(B)2&3

(C) 1 & 3

(D) 1.2.&3

27. Each of the following is a true statement regarding the use of gonadal shielding EXCEPT

(A) shields should be used when gonads are in or near the field of exposure

(B) shields should be used in place of beam collimation

(C) shields should be used on all persons in their reproductive years

(D) shields should not be used when they are likely to obscure the structure of interest

28. Which of the following will function effectively as a gonadal shield?

1. Contact shield
2. Lead and plastic filter system
3. Shadow shield

(A) 1 & 2
(B) 2 & 3

(C) 1 & 3

(D) 1,2&3

29. AH the following are guidelines to be observed with regard to holding

a patient in position during radiographic exposure EXCEPT

(A) mechanical holding devices should be used whenever possible
(B) protective apparel must be worn by any person holding a patient
(C) persons under the age of 1 8 should not be used to hold a patient
(D) the same person should be routinely used to hold patients

30. The primary purpose for using personnel monitors is to

(A) protect the radiographer
(B) calculate the total amount of radiation a radiographer delivers
(C) monitor a radiographer's repeat rate
(D) indicate a radiographer's occupational exposure

31. Which area of radiation dose measurement is most frequently used when referring to a patient's dose?

(A) Skin dose
(B) Mean marrow dose
(C) Gonadal dose
(D) Mean glandular dose

32. Which radiation effect has a threshold between radiation dose and response?

(A) Cataracts
(B) Leukemia
(C) Skin cancer
(D) Shortening of life span

33. AII the following are recommended practices for radiation protection to reduce the chance of exposing a pregnant patient EXCEPT

(A) scheduling abdominal and pelvic radiographic examinations during the 10-day period following the onset of menstruation
(B) asking all female patients of child-bearing age if they could possibly be pregnant
(C) posting signs in waiting and radiographic rooms, in various languages, requesting patients to inform the technologist of the possibility of pregnancy
(D) requiring ail women of child-bearing age to have a pregnancy test performed

Questions 34-35

Classify each condition as a general type of radiation effect.

(A) Genetic effect
(B) Early somatic effect
(C) Late somatic effect
(D) Not associated with radiation exposure

34. Point mutations of chromosomes

35. Blood changes resulting in increased infections, anemia, or hemorrhage

Questions 36-39

Indicate whether the statements are properties of x-rays or not.

(A) True

(B) False

36. X-rays can be focused by a lens

37. X-rays carry a negative electrical charge

38. X-rays are polyenergetic

39. X-rays can ionize air molecules

Questions 40-42

Indicate which type of personnel monitor device is being described

(A) Thermoluminescent dosimeter (TLD)
(B) Film badge
(C) Pocket ion chambers

(D) Two of the-three types above

40. Must be charged prior to daily use

41. Is reusable

42. Detects x-radiation, gamma radiation, and high-energy beta particles

Questions 43-47

Who will primarily benefit from the following protection practices?

(A) Patient
(B) Radiographer
(C) General public

43. Increased filtration of the primary beam

44. Gonadal shielding

45. Protective barriers between radiography rooms and an uncontrolled area.

46. Protective curtain on the fluoroscopy carriage

47. Protective barrier between the radiographic unit and the control

panel

DIRECTIONS: Each numbered question or incomplete statement below contains lettered responses. Select the **one best** response.

48. Which of the following components would be considered part of the cathode assembly of an x-ray tube?

1. Filament
2. Target
3. Focusing cup

(A) 1 & 2
(B) 2 & 3
(C) 1 &3
(D) 1,2&3

49. The size of the focal spot is determined by the

(A) milliampere station selected
(B) kilovoltage level selected
(C) size of the target disk
(D) size of the filament coil

50. The material of choice for the construction of a long-lasting filament is

(A) molybdenum

(B) copper

(C) tungsten

(D) lead

51 The primary purpose of the target disk in the x-ray tube is to

(A) provide a source of electrons

(B) provide the site of energy conversion

(C) increase the heat loading capability of the tube

(D) maintain a finely focused stream of electrons

52.Which of the following describes the construction of the modern rotating target disk for a routine diagnostic x-ray tube?

(A) Tungsten-rhenium surface on a molybdenum base

(B) Tungsten disk imbedded in a copper block

(C) Molybdenum surface on a tungsten base

(D) Lead coating on a copper base

53. What units of measurement does the term *volt* indicate?

1. Number of electrons flowing per second
2. Electromotive force
3. Potential difference

(A) 1 & 2

(B) 2&3

(C) 1&3

(D) 1,2,&3

54. What is the direction of the flow of electrons in a circuit?

(A) Negative to positive

(B) Positive to negative

(C) Anode to cathode

(D) Low point to high point

55. The technique that allows for dynamic imaging of anatomic structures is

(A) tomography
(B) fluoroscopy
(C) stereoscopy
(D) subtraction

56. The image intensifier converts the exit beam to other forms of electromagnetic energy in which of the following orders?

(A) X-rays to electrons to light to x-rays
(B) X-rays to light to x-rays to electrons
(C) X-rays to light to electrons to light
(D) X-rays to light to x-rays to light

57. Which component can be evaluated by means of a visual check only?

(A) Grid alignment
(B) Table locks
(C) View box light intensity
(D) Film-screen contact

58. The condition of a lead apron is evaluated by

(A) visual inspection
(B) wearing a personal ion chamber under the apron during fluoroscopy and checking it for a reading

(C) scanning the apron with an ultraviolet light source for cracks
(D) fluoroscoping or radiographing the apron at high kilovoltage

59. On what type of imaging equipment would automatic exposure control be commonly available?

1. Diagnostic
2. Fluoroscopic
3. Mammographic

(A) 1 & 2
(B) 2&3
(C)1 &3
(D)1,2,&3

60. In which areas of specialty imaging is fluoroscopy commonly employed?

(A) Tomography and mammography
(B) Angiography and mammography
(C) Computed tomography and cardiac catheterization
(D) Angiography and cardiac catheterization

Questions 61-63

Indicate the minimum frequency for performing quality control testing on each of the components of radiographic imaging below.

(A) Daily
(B) Weekly
(C) Semiannually
(D) Annually

61. Quality of beam

62. Linearity of exposure

63. Darkroom fog

1 . **The answer is D.** *(Bushong, 5/e, p 64. Thompson, p 63.)* X-rays and gamma rays are virtually identical with the exception of their source of origin. X-rays are produced via the sudden deceleration of high-speed electrons in a device such as an x-ray tube. Gamma rays are a naturally occurring form of nuclear radiation arising from the nucleus of radioactive elements. Both types of radiation are nonparticulate (no mass), have a neutral electrical nature, are highly energetic, will travel at the speed of light in a vacuum, and will cause biologic and chemical effects on matter.

2. **The answer is** A. *(Bushong, 5/e, p 174. Carlton, pp 200-201. Curry, 41* e, *pp 65-68. Statkiewicz-Sherer, lie, pp 25-26. Thompson, pp 202-206.)* The amount of energy retained by the scattered photon is determined by the incident energy of the photon undergoing the Compton interaction and the angle of deflection of the incident photon with the electron to be ejected. The scattered photon will have less energy as the angle of deflection (from the original path of the incident photon) increases. Incident photons of lower energy tend to be deflected more during the scattering event than high-energy photons. Therefore, x-rays produced in the diagnostic range of energies will most likely be deflected in a forward direction and be recorded by the image receptor.
patient dose.

3. **The answer is A.** *(Bushong, 5/e, p 15. Statkiewicz-Sherer, 21e, pp 46, 50. Thompson, p 456.)* The roentgen is a unit of measurement of radiation "in air." It is more specifically defined as the quantity of radiation exposure to produce an electrical charge of 2.58 x $1O^4$ coulombs per kilogram of air (C/kg). The ionization chamber is a device that converts ionizing radiation to a corresponding electric charge (number of ion pairs created) and ultimately expresses the quantity of radiation exposure in terms of roentgens, While the other terms listed as answer options are units of radiation measurement, their use is more appropriate to other types of radiation effects, according to their various definitions.

4. **The answer** is **B.** *(Bushong, 5/e, p 16. Selman, 8/e, pp 504-505. Statkiewicz-Sherer, 2/e, p 52. Thompson, pp 457-458.)* Each form of ionizing radiation (nuclear or electromagnetic) has the ability to cause a biologic response. However, the response will vary with the type of radiation. Dose *equivalent* is used to account for the differences in biologic response. The standard unit of measure to express dose equivalent is the *rem,* and its SI counterpart is the *sievert.* Calculation of the dose equivalent is the product of absorbed dose and the quality factor (QF) for the type of radiation involved. According to NCRP Report No. 91, the QF for gamma, beta, and x-rays is the same: one (1). Particulate types of radiation have higher quality factors to correspond with their more reactive effect on biologic tissue; thermal neutrons have a QF of 5, and other neutrons, protons, and alpha particles have a QF of 20. These higher QF values demonstrate the increased biologic effect an equal dose of these forms of radiation will deliver compared with gamma or x-rays.

5. **The answer is B.** *(Bushong, 5/e, p 635. Thompson, p 459.)* The monitoring and measurement of radiation exposure is termed *dosimetry* (dose measurement). Occupational exposure is measured through the use of personnel dosimeters such as the film badge, thermoluminescent dosimeter (TLD), or personal ionization chambers. Patient dose may also be measured, most commonly with the placement of a TLD type of radiation monitor in the field of exposure. The
active component (lithium fluoride) of the TLD acts as a tissue equivalent for radiation exposure. *Densitometry* is the measurement of radiographic density on an exposed and processed film. *Sensitometry* is an indication of a film's response to exposure and processing.

ALARA is an acronym for the basic radiation philosophy introduced by the ICRP, which states that all radiation exposure should be kept as *low as reasonably achievable.*

6 The answer is C. *(Bushong, 5/e, p 599. Thompson, p 464.)* The cardinal rules of radiation protection are the basics and apply to the protection of both the patient and personnel. They include the use of the shortest exposure time, maximum distance between the source and the subject, and shielding of body parts not within the area of interest. Reducing exposure time refers to decreasing the amount of time the beam is on as well as minimizing the time personnel remain in a radiation area (i.e., fluoroscopy). Maximizing distance from the radiation source reduces exposure as defined in the inverse square law. Minimum source-to-skin distances are established for patient protection. Room design should allow personnel to stand back when not needed. Shielding of sensitive body parts is necessary for anyone in the radiographic room during a procedure, including patient, family, and personnel. Use of protective apparel as well as good collimation will satisfy this protection rule.

7. **The answer** is **B.** *(Bushong, 5/e, p 601. Statkiewicz-Sherer, 21 e, p 174.)* Lead is the material of choice for shielding purposes due to its high atomic number and dense molecular nature. By comparison with other materials, lead would be required in the least quantity to shield against radiation. When other materials are employed, sufficient quantities of these materials must be used to provide a level of shielding equivalent to that of lead. Aluminum is the material of choice for filters. Copper is occasionally used for filtration and tungsten is used in the construction of the tube filament and target disk.

8. **The answer is C.** *(Bushong, 5/e, p 632. Carroll, 5/e, pp 13-14. Statkiewicz-Sherer, 2/e, p 25.)* Primary radiation refers to those photons that do not participate in x-ray/matter interactions and therefore remain the same as when they originated. The three incorrect answer options all refer to scattered radiation, which is formed by Compton interactions. Scatter is the major source of exposure for the operator of radiographic equipment and is also the most prevalent component of the exit beam.

9. The answer is A. *(Bushong, 5/e, p 632. Statkiewicz-Sherer, 2/e, p 217.)* The *primary barrier* is any surface that receives primary radiation. Therefore, any wall or floor toward which the x-ray tube may be directed and energized is considered a primary barrier. This designation is important in order to properly construct the surface with sufficient thickness of building material to meet shielding requirements. The energy of the primary beam is greater than scattered or secondary radiation. *Secondary harriers* receive scattered exposure only and do not require as much shielding as the primary barriers. The terms *controlled* and *uncontrolled areas* are used to designate the occupancy status of various areas surrounding and containing radiation-producing equipment. The occupancy status must also be considered in determining shielding requirements for construction.

10. The answer is B. *(Bushong, 5/e, p 6. NCRP No. 93, pp 55-56. NCRP No, 105, p 6. Statkiewicz-Sherer, 2/e, pp 5-9.)* Background radiation is that radiation to which all persons are exposed during their lives. This radiation arises from natural and man-made sources. Natural radiation includes cosmic radiation, which originates in outer space and interacts with the earth's atmosphere, and terrestrial (earth) elements, which are unstable and emit radioactive particles and waves during their decay process. Radon is the major terrestrial radiation that contributes to our background exposure. Over half the background exposure received (natural and man-made) is due to radon exposure. Not only are we exposed to these types of radiation from outside our bodies, but radionuclides are found in the food chain, resulting in radiation exposure from within our bodies. Man-made radiation includes medical and dental x-rays, fallout from weapons testing and nuclear accidents, and radiation-emitting consumer products.

1 1 . **The answer** is A. *(Bushong, 5/e, p 6. NCRP No. 105, p 6. Statkiewicz-Sherer, 21e, pp 5-9.)* Alt the factors listed in the answer contribute to background exposure except ultrasonic waves. Only forms of ionizing radiation are included in the definition of background radiation. Ultrasonic waves are mechanical in nature. Although they may vibrate enough to cause some biologic reaction, such as tissue heating, ultrasonic waves are non ionizing,

12. **The answer is B.** *(Bushong, 5/e, p 651. Statkiewicz-Sherer, 21e, pp 15-17.)* For a given amount of radiation exposure to biologic tissue, the skin dose will be the greatest because it receives the entrance dose. As the radiation passes through the exposed medium, it is attenuated. The deeper structures will receive a reduced amount of exposure. Specifically, the dose to the gonads will further vary in regard to their position relative to the site of exposure. Also, for some examinations the gonadal dose for males will be much higher than for females and vice versa on other examinations. Again, this is due to the distance of the gonads from the area of exposure and the external versus internal location of the gonads, which offer a variation in the level of attenuation.

13. **The answer is B.** *(Bushong, 51e, p 523. Statkiewicz-Sherer,* 2/e, *pp 105-106.)* *lonization* results from the removal or addition of orbital electrons from or to the atom. Radiation ionizes by ejecting electrons from their orbits, resulting in the formation of an ion pair consisting of a freed electron (negative ion) and a pos itively charged atom (missing an electron). Photons or particles with the characteristics of high energy, short wavelength, and high penetration, are able to cause ionization events. When this does occur, at the atomic level, it can have effects on the structure of molecules that may be sufficient to disrupt cellular function.

14. **The answer is C.** *(Bushong, 5/e, p 534. Statkiewicz-Sherer, 2/e, p 107.)* The amount of biologic effect is dependent on the quantity of energy deposited in the irradiated matter and the radiosensitivity of the irradiated matter. Those types of radiation with high LET will also have a greater RJ3E. The LET values (stated in keV/micron of tissue traversed) for the types of radiation listed are alpha 100, fast neutrons 50, diagnostic x-rays 3, and 25-MeV x-rays 0.2. Therefore, the 25-MeV x-rays should produce the least biologic effect.

13. **The answer is C.** *(Bushing, 5/e, p 548. Statkiewicz-Sherer, 2/e, p 108.)* The effects of an irradiation assault may manifest themselves at the site of irradiation (direct effects) or at a point distant from the irradiation site (indirect effects), indirect effects generally occur as a result of the free radical by-products that arise from radiolysis of water molecules. Since the human body is 60 percent water, indirect effects from irradiation predominate over direct effects.

16. **The answer is** A. *(Bushong, 5/e, pp 52-53. Statkiewicz-Sherer, 2/e, p 105.)* ionizing radiation includes those types of radiant energies that have sufficient energy and short wavelengths to cause ionization of atoms (removal or addition of electrons) with which they interact. These include *paniculate* radiation and *electromagnetic* radiation. As the term implies, particulate types of radiation have mass and may be electrically charged. They include alpha, beta, and neutron particles. These types of radiant energy are emitted from unstable nuclei of radioactive elements during the disintegration process. They are highly energetic, but their mass limits their penetrability; thus they tend to give up their energy over a small area in the ionization process. Electromagnetic radiation has no mass and no electrical charge. However, not all electromagnetic photons are ionizing. Low-energy, long-wavelength types of electromagnetic energy are referred to as

nonionizing radiation and include radio and television waves and the visible light spectrum. Only x-rays and gamma rays have sufficient energy to cause ionization.

17. **The answer is C.** *(Bushong, 5/e, p 547. Statkiewicz-Sherer, 2/e, pp 111-114.)* Radiolysis (breakdown of a structure due to irradiation) of water molecules causes the formation of positive and negative water molecules. These ions can further dissociate into a hydroxyl (-) ion and hydrogen radical or a hydrogen (+) ion and hydroxyl radical. The free radicals are highly reactive and are able to move within the tissues and enter cells, disrupting their structure and function. They may also combine to form toxic agents within the cell, causing further damage.

18. **The answer is B.** *(Bushong, 5/e, pp 548-550. Statkiewicz-Sherer, 2/e, pp 116-117.)* The *target theory* of cell survival assumes that there is a key, or master, molecule whose irradiation would cause cell death. This theory is used to explain why some cells do not manifest injury following irradiation and others do. It is believed that if there is only one such master molecule to a cell, inactivation of this molecule would result in cell death. Since radiation interactions are random events, the master molecule would not always be directly affected. Based on these assumptions, it is believed that the DNA molecule is the master molecule for each cell. The DNA molecule is considered the control center for growth, reproduction, and function of each cell. Loss of the DNA molecule through direct or indirect irradiation would result in eel! death.

19. **The answer is B.** *(Bushong, 5/e,* pp 532-533. *Statkiewicz-Sherer, 2/e, pp 120-123.)* According to the law of Bergonie and Tribondeau, cellular radiosensitivity is directly related to the cell's proliferation and metabolic rates and indirectly related to its age and degree of specialization. This means that immature, nonspecialized cells that reproduce themselves frequently are more radiosensitive than mature, highly specialized cells with a low reproduction rate or none at all. Another factor in determining radiosensitivity is the abundance of a particular cell type (or macromolecule). Large quantities of a single type of cell (or macromolecule) mean that if some are lost, many others remain to continue their function and to repopulate the area. Therefore, radiosensitive cells include blood cells and gonadal cells. Of the blood cells, the erythrocytes are the most resistant because of their relatively large number (in the millions) and longer life cycle with a less frequent reproduction cycle as compared with white blood cells. The lymphocyte is the most radiosensitive cell in the body. This type numbers only in the thousands and has a life cycle of only about 24 h, requiring it to reproduce itself frequently. Epithelial cells are moderately sensitive to irradiation while mature muscle and nerve cells are the most resistant.

20. **The answer is C.** *(Bushong, 5/e, pp 532-533. Statkiewicz-Sherer, 2/e, pp 120-123.)* Highly radiosensitive cells would be immature (not fully developed) and not highly specialized (undifferentiated in their function) and would frequently reproduce. This describes such cells as blood and germ cells, especially when they are in their immature states. Muscle and nerve cells are highly specialized in their function and in their mature state do not reproduce, making them highly resistant to irradiation.

21. **The answer is C** (2, 3). *(Bushong, 5/e, p 577. Statkiewicz-Sherer, 2/e, pp 135-136.)* Irradiation may affect somatic or germ cells of the human body. Germ cells are found in the gonads and contain the genetic material of the being for purposes of reproduction. *Somatic* cells refer to all other cells of the body. Irradiation of germ cells can cause genetic effects, which may be passed on and manifest themselves

in future generations. *Somatic* effects are evident in the person exposed and may be either early or late. *Early effects* are the result of relatively high levels of radiation exposure and may occur within minutes, hours, days, or weeks following the exposure. The severity and time of onset is determined by the dose received and age of the person. Late *effects* are the result of low level radiation exposure and may show up months or years after exposure,

22. **The answer is D.** *(Bushong, 5/e, pp 562-566. Statkiewicz-Sherer, 2/e, pp 130, 135-136.)* Early somatic effects of irradiation may be evident following whole- or partial-body exposure to a relatively high dose. Whole-body exposures of 1 Gy (100 rads) or more may cause acute radiation syndrome, also known as radiation sickness. The severity of this condition and the likelihood of recovery are dose-dependent. Some signs and symptoms of acute radiation syndrome are nausea, vomiting, diarrhea, blood changes, and destruction of the gastrointestinal or central nervous systems. Limited exposure to localized areas of the body will result in the manifestation of radiation effects in the exposed area. The possible effects include skin erythema, anemia, hair loss, nausea, vomiting, and diarrhea. Cataract formation and cancers are examples of long-term somatic effects of irradiation.

23. **The answer is D,** *(Bushong, 5/e, pp 561-562, 577-582, 588-594. Statkiewicz-Sherer, lie, pp 133-146.) Late effects* are those that appear months or years after exposure to relatively low levels of radiation. *Somatic effects* are those which manifest in the exposed person's lifetime. The various types of late, somatic effects can be grouped into four categories: carcinogenic, cataractogenic, life span-shortening, and embryo-logic (of which congenital defects are one type). Many studies and observation of accidentally exposed persons have provided the data to support the understanding of the effects of low level radiation exposure.

The tragic nuclear accident in Chernobyl in 1986 has provided another group of people to follow and learn from regarding the long-term effects of radiation exposure.

24. **The answer is B.** *(Bushong, 5/e, pp 595-596. Statkiewicz-Sherer, lie, p 145.)* Various embryologic effects are possible following in utero exposure. During the first trimester of gestation, the fetus is the most susceptible because of the vast amount of change and organ development. The possible results include congenital abnormalities such as growth and mental retardation, structural deformity, and induction of childhood malignancy, specifically leukemia. If exposure occurs within the first 2 weeks following fertilization, the effect is considered to be "al! or none." That is, either a spontaneous abortion will occur or no damage will be caused. During the second and third trimesters, the fetus is less radiosensitive than it was in the first; however, it is still susceptible to damage and in utero exposure should always be kept as minimal as possible.

25. **The answer is B.** *(Bushong, 5/e, pp 665-668. Statkiewicz-Sherer, lie, pp 163-182, 184, 189.)* Patient exposure can be reduced through the implementation of various radiation protection practices. These practices include the following:

1. Reduction of the size of field of exposure through the use of a beam restrictor (collimator or cone). This action will limit the amount of tissue irradiated and the quantity of x-ray/matter interactions.
2. Increased beam quality through filtration to lower skin entrance dose.
3. The use of immobilization devices to reduce motion and need for repeat exposures.
4. The implementation of high-kV, low-mAs techniques to provide optimum penetration with the least possible quantity of exposure.

5. Contact or shadow shields to protect radiosensitive structures in or near the field of view.

6. Increased SID or source-to-skin distance according to the inverse square law, thereby reducing patient dose.

7. The use of fast intensifying screens where appropriate, to allow the least amount of exposure while obtaining satisfactory image density.

Direct exposure (non screen) imaging systems require excessive exposure and should not be used. Grids significantly improve image quality to warrant the increased dose necessary, but are not considered a radiation protection practice.

26. The answer is C. *(Bushong, 5/e, p 667. NCRP No. 102, p 8. Statkiewicz-Sherer, 2/e, pp 178-180.)* Imaging of the spine for a scoliosis survey is most commonly performed on young female patients whose breast tissue is in an active stage of development and thus radiosensitive. For this reason, precautions should be taken to reduce breast exposure during these procedures, which may require many radiographic examinations over the treatment period. The examination commonly requires the AP and lateral projection of the entire spine. Collimation should be employed as well as contact or shadow shielding of the breasts. It has been recommended that the PA projection be employed to drastically reduce exposure (exit dose rather than entrance dose) with a minimal amount of magnification of the spine, which may be accomplished by increasing the SID. Finally, a trough type of compensating filter may be employed to reduce the exposure intensity to the lateral aspects of the beam while maintaining sufficient exposure to the spine. Use of this device may be limited by the extent of the lateral curve of the spine.

27 The answer is B. *(Bushong, 5/e, p 669. NCRP No. 102, p 8. Statkiewicz-Sherer, 2/e, pp 173-174.)* The proper use of gonadal shields is important in reducing gonadal dose and the possibility of genetic effects due to irradiation. However, their use will vary with the type of examination being performed. The gonadal shielding is always employed in addition to proper collimation of the beam. Gonadal shielding should be utilized whenever the gonads are in or near the field of exposure, as long as the shield will not obscure the structures of interest. It is important to carefully place the shield so that it does not overlap the structures of interest and require a repeat image. They should also be used on ail patients who are within child-bearing age, young and old.

28. **The answer is D.** *{Bushong, 5/e, p 667. Statkiewicz-Sherer, 2/e, pp 173-174.)* Any of the shield types listed in this question may be used as gonadal shields as long as they are properly positioned so as not to obscure the structures of interest. Contact shields are placed directly on the patient over the gonads. Various sizes and shapes are available to accommodate males and females, children and adults. Shadow shields are mounted on the collimator and are positioned within the primary beam so as to cast a shadow over the area to be shielded. These can be just as effective as contact shields and may be better tolerated by some patients. The newest type of shield is incorporated with a filter system and is made of clear plastic impregnated with lead; it attaches to the bottom of the collimator. The clear plastic allows the localizing light of the collimator to project onto the patient while reducing exposure. Shielding is achieved through the use of accessory pieces that contain lead shapes and magnetically attach to the filter. This configuration resembles the shadow shield.

29. **The answer is D.** *(Bushong, 5/e, p 665. NCRP No. 102, p 9. Statkiewicz-Sherer, 2/e, pp 232-234.)* Occasionally, patients are unable to cooperate with maintaining a required position for radiography. Such cases require some external means of restraining the patient. Ideally, a mechanical device should be used whenever

possible. These devices would not require a person to remain in the examination room for unnecessary exposure. When such devices are not available or effective, someone must hold the patient in position. The best choice would be a relative of the patient who is older than 18 and not pregnant. When hospital personnel must be used, it should be someone other than radiology personnel. However, the same person should not be routinely called upon to hold patients. Protective apparel (aprons and gloves) must be provided to the holders and their position must be out of the primary beam as much as possible.

30. The answer is D. *(Bushong, 51e, p 659. NCRP No. 102, p 83. Statkiewicz-Sherer, 2/e, p 243.)* Personnel monitors are primarily issued to radiologists and radiologic technologists. The purpose of these devices is to indicate the amount of radiation exposure personnel receive as a result of the work they do. It further provides data on the effectiveness of a department's radiation protection policies and the work habits of the individual. Each type of personnel monitor has weak points of which the wearer must be aware. These devices do not directly act to protect the radiographer. Neither do they keep track of the level of exposure a radiographer delivers nor the repeat rate of the radiographer.

31. **The answer is** A. *(Bushong, 51e, pp 650-651.* Car/ton, *p 518. Statkiewicz-Sherer, 2/e. pp 194-195.)* When expressing a patient's dose from radiation exposure, the skin dose is most commonly used. This area receives the highest dose since no other tissue is present to attenuate the primary beam. As the beam traverses the patient to the specific area of interest, the body tissues attenuate the beam, reducing its intensity. Skin dose is also the only area in which radiation dose can be directly measured. This can be done by placing a TLD in the center of the field of exposure and then analyzing the dose recorded. The TLD responds to radiation in a similar manner as soft tissue would, thus making it a reliable means for measurement of patient dose. Since direct measurement of organ dose is not usually possible, it must be derived from the entrance skin dose according to the attenuation of the beam and the radiosensitivity of the specific organ.

32. **The answer is A.** *(Bushong, 51e, pp 579-580, 585, 590. Statkiewicz-Sherer, 21e, pp 136, 142, 144.)* Of the possible late somatic effects, most follow the linear, nonthreshold dose/response relationship. Only cataracts have been identified as having a threshold for safe exposure. Radiation-induced cataracts may occur following an exposure level of 2 Gy (200 rad) directly to the lens of the eye. Cataract formation also follows a nonlinear pattern of development. Eye shields may be recommended for high-dose radiologic examinations of the head and neck, such as multidirectional tomography examinations.

33. **The answer is D.** *(Bushong, 51e, pp 612-615. Statkiewicz-Sherer, 21e, pp 200-201.)* It is within the responsibility of the radiologic technologist to minimize the likelihood of inadvertent exposure of a pregnant patient. Before beginning the radiologic procedure, the radiographer should inquire as to the possibility of the patient's being pregnant. The answer to this query should be documented on the patient's requisition. There should also be signs regarding pregnancy posted around the department to encourage patients to inform the technologist of their possible pregnancy status. When possible, it is recommended that female patients have their abdominal and pelvic radiography examinations scheduled during the 10 days following the onset of their menstrual cycle. This practice is intended to limit their exposure to the time period during which women are least likely to be pregnant. If the patient indicates that pregnancy may be possible, the radiologist or referring physician or both should be consulted before proceeding

with the examination. They may decide to have the patient tested prior to continuing. However, requiring all female patients to have a pregnancy test is not recommended.

34-35. The answers are 34.A, , 35-B. *(Bushong, 51e, pp 559, 577, 596-597. Statkiewicz-Sherer, 21e, pp 130, 136, 147.)* The categories of radiation effects are defined according to the type of cells exposed and the time frame in which the effects are manifested. Two basic cell types exist in the human body: *somatic* and *germ* (or *genetic).* Germ cells contain the DNA for reproduction. These cells are contained within the male and female gonads. Exposure of the gonads can cause point mutations in the structure of the chromosomes, which are the genetic blueprints for the organism. These effects may be evident in future generations of the exposed person. All other cells in the body are of the somatic type. Exposure of these cells may produce effects that will manifest themselves within the lifetime of the exposed person. If these effects appear shortly after the exposure, they are termed *early effects.* Such effects are the result of large doses of radiation, delivered to a large volume of tissue over a short period of time. These conditions are met in the delivery of radiation for therapeutic purposes and frequently result in such effects as nausea and vomiting, diarrhea, and blood changes such as anemia, low white blood cell count, and hemorrhage. Such exposures are planned to be confined to the least amount of tissue in order to produce minimal effects. Exposure of the whole body, as may occur following a nuclear accident, would produce more damage and a reduced chance for recovery. Radiation effects that take months or years to manifest are termed *late effects.* This type may occur as the result of small exposures delivered over a long period of time as in diagnostic radiology. The potential effects include radiation-induced malignancies (cancer), formation of cataracts, nonspecific shortening of life span, and embryologic effects. Of these, radiation's carcinogenic and embryoiogic effects require most consideration. Numerous population groups have been studied to support the identification of radiation as a carcinogen. The effects include cancer of the skin, bone, lung, and breast, as well as leukemia. Embryologic effects are the result of in utero exposure and include such manifestations as spontaneous abortion, congenital abnormalities, and childhood leukemia.

36-39. The answers are 36-B, 37-B, 38-A, 39-A. *(Bushong, 5/e, pp 52, 63-64.* Car/ton, *pp* 39-40. *Carroll, 5/e, p 13. Thompson, p 63.)* X-rays are a form of electromagnetic (EM) energy, as are radio, television, and light rays. Some of the properties that differentiate x-rays from other forms of EM energy are as follows.

1. X-rays cannot be focused by a lens (as visible light can be). However, x-rays may be collimated.
2. X-rays have no electrical charge. They are not influenced by electrical or magnetic fields.
3. The x-ray beam is made up of photons, each with its own energy determined by the electron-matter interaction that produced it. Polyenergetic means "many energy values." The maximum energy an x-ray can have is determined by the peak kilovoltage set on the control panel. Therefore, an x-ray photon can have an energy value anywhere between 0 and the peak kiloelectron volt produced by electron acceleration in the x-ray tube.
4. As is true for all forms of EM radiation, the speed at which x-rays travel in a vacuum is a constant value. That speed is equivalent to the speed of light, which can be expressed as 186,000 miles/s, 3×10^8m/s, or 3 x 10 cm/s.
5. X-rays are able to ionize matter. The ability of x-rays to ionize air molecules is utilized in the design of instruments for the measurement of x-rays. The typical ionization chamber has a quantity of air (or gas) within it and contains two charged plates (one positive, one negative); alternatively, it may contain a single electrode that is positively charged while the walls of the chamber are negatively charged. Upon irradiation, the air is ionized, creating ion pairs. The freed electron is attracted to the positive terminal and the remaining

atom (positive ion) is attracted to the negative terminal. The result is a flow of current (electrons) along the positive electrode, which can be measured or used to discharge a capacitor. This device is commonly used in the construction of automatic exposure control devices, radiation detectors for CT equipment, and ion chambers for radiation detection and measurement.

40-42. The answers are 40-C, 41 -D, 42-D. *(Bushong, 5/e, pp 659-663. Statkiewicz-Sherer, 2/e, pp 258-259. Thompson, p 461.)* The luminescent material lithium fluo-ride is the active element of the thermoluminescent dosimeter (TLD). In response to radiation exposure, the valence electrons of the lithium fluoride are raised to the trapped band, where they will remain until heated and returned to their normal state. This movement back to the valence band produces the emission of light photons proportionate to the energy stored by the crystal. The TLD type of radiation monitor is the most durable as it is not affected by mechanical shock such as from dropping, as the pocket ion chamber is. Neither is it affected by heat or high humidity, as both the film badge and pocket ion chambers are. The heat required to stimulate the light emission of the lithium fluoride crystals is at least 190° C. The TLD is the only type of radiation monitor device that has a tissue-equivalent response to radiation exposure. For this reason, the TLD may be used to provide patient dose information for specific radiologic examinations. This may be done by placing the TLD on the patient's skin or in conjunction with a radiographic phantom.

The film badge is the only type of radiation monitor that provides a permanent record of the radiation exposure. This is achieved by storage of the processed piece of film once it has been analyzed. Should the need arise, the film can be retrieved and reread. Readings from the TLD and pocket ion chambers must be recorded immediately, as the reading process destroys the data. The dosimetry film used in the film badge must be replaced once it has been read. At the end of the monitoring period, the exposed film is processed and the density level indicates the exposure level. The film cannot be reused, but is filed for future reference. Both the ion chamber and TLD devices may be reused once they have been read and cleared of data (the ion chamber must also be recharged).

The film badge and TLDs are capable of detecting high-energy beta particles, as well as gamma rays and x-rays. Pocket ion chambers detect only gamma rays and x-rays.

The pocket ion chamber type of radiation monitor responds to radiation exposure as any ion chamber would; that is, as the air in the chamber is irradiated, ionization of the air molecules occurs, releasing electrons for movement. Prior to use, the pocket dosimeter is charged to cause a repulsion between the central electrode and the quartz fiber indicator. As ionization occurs, the charge within the chamber is neutralized, allowing the indicator to move towards the central electrode and providing a reading. The pocket ion chamber is also the only type of radiation monitor that can be read immediately following an exposure to radiation. Each exposure will proportionately discharge the charged chamber, and the exposure level will be indicated by viewing the calibrated scale through the eyepiece. Pocket ion chambers may be calibrated in units of roentgens or milliroentgens.

43-47. The answers are 43-A, 44-A, 45-C, 46-B, 47-B. *(Bushong, 5/e, pp 664-667, Statkiewicz-Scherer, 21 e, pp 171, 174, 215-217, 224-225, 232.)* Many radiation protection practices are beneficial to both the radiographer and the patient. Any practice that reduces the production of scattered radiation will decrease dose to both patient and radiographer. Such practices include minimizing field size, use of high kilo voltage techniques, use of high-speed imaging systems, and decreasing repeat exposures. Filtration in the beam and gonadal shields are for the protection of the patient. The protective curtain on the fluoroscopy carriage and the barrier that separates the control panel from the radiographic unit are in position to protect the radiographer. The general public should be protected from occasional or frequent exposure by the proper design and use of protective barriers between any source of radiation and any area classified as *uncontrolled occupancy.* Also, when a patient needs to be held during an exposure, it should not be done by a radiographer, but a member of the general public. This person should be over 18 years of age, not pregnant, and wear proper protective apparel such as lead aprons and gloves.

48. **The** answer is C (1, 3). *(Bushong, 5/e, pp 117-119. Curry, 41e, pp 11-12. Sefman, 8/e, p 205.)* The cathode assembly of the x-ray tube is the negative terminal of the diode and functions to provide the electrons for acceleration and bombardment, as needed in the production of x-rays. The specific components that serve this need are the filament, which is heated to the point of thermionic emission and releases a cloud of electrons, and the focusing cup, which acts to keep the electron cloud directed as a stream onto the focal spot of the target. The target itself is the site of electron bombardment and is a component of the anode assembly of the x-ray tube.

49. **The answer is D.** *(Bushong, 5/e, p 119, Curry, 41e, pp 12-13. Selman, 8/e, p 206.)* Focal spot size is chiefly determined by the size of the filament coil. Most modem x-ray tubes are duaf-focused, offering a large and small filament to produce, respectively, large or small electron streams to ultimately bombard the target disk. When a small filament is selected, less area on the target disk will be involved in the bombardment. In addition to the size of the filament, the angle of the target bevel and the design of the focusing cup are contributing factors to the effective focal spot size. The milliampere selection is of importance in selecting the appropriate focal spot size in terms of heat loading, but does not actually determine focal spot size. The kilo voltage selection plays no role in focal spot size.

50. **The answer is C.** *(Bushong, 5/e, p 118. Curry, 41 e, p 11. Selman, 8/e, p 205.)* Tungsten is the material of choice for construction of the filament chiefly because of its high melting point (3370° C). As part of the thermionic emission process, the filament will be heated to the point of incandescence by a high amperage current flowing through it. Repeated exposure of the filament to high heat loads may cause the filament to become thin owing to vaporization and eventually break, causing an incomplete circuit. Metals of lower melting points would not withstand this type of heat loading.

51. **The answer is B.** *(Bushong, 5/e, p 120. Curry, 41e, p 13.)* The role of the target disk within the anode assembly of the x-ray tube is to provide a surface for electron bombardment and the conversion of kinetic energy to electromagnetic energy (x-rays and heat). The filament and focusing cup within the cathode assembly act as the source of electrons and a means of maintaining a finely focused electron stream, respectively. Although the overall heat-loading capability is influenced by the size of the focal spot, which is the actual area of electron interaction, the target disk is the site of electron bombardment.

52.The answer is A. *(Bushong, 5/e, p 120. Cullinan, 2/e, pp 43-44. Curry, 41 e, p 17.Selman, 8/e, pp 210-211.)* Modem general purpose x-ray tubes are constructed with rotating disks made of molybdenum or graphite base to which a tungsten layer is added and then coated with rhenium. Tungsten is the desired material for the production of x-rays in the useful energy range for medical imaging. In order to reduce the overall weight of the disk, the tungsten is layered on a base of lighter weight material such as molybdenum or graphite. This reduction in weight will allow for greater speeds during rotation of the disk. The graphite is also a more effective conductor of heat and thereby improves a tube's heat-loading capability. The addition of the rhenium to the tungsten surface aids in providing a more durable surface and less pitting due to repeated electron bombardments. Early x-rays tubes, with stationary targets, were constructed of a small button of tungsten imbedded in a copper block. The copper was effective in conducting heat away from the target area. Molybdenum targets are commonly used in special purpose tubes such as for mammography in order to produce x-rays in the desired energy range.

53. **The answer is B** (2, 3). *(Bushong, 5/e, p 79. Carlton, pp 73-74. Curry, 4/e, p 37. Selman, 8/e, pp 69-70.)* The term *volt* is the unit of measure that indicates potential difference and electromotive force. Specifically, the *volt* is defined as the amount of electrical pressure that causes 1 ampere of current to flow in a circuit with a resistance of 1 ohm. This electrical pressure is the result of a difference in electrical potential: a point of excess electrons versus a point of electron deficiency within an electrical circuit. The greater this difference, the greater the force to drive the electrons (current) between the negative and positive terminals. This force has the ability to convert electric energy to mechanical energy. Therefore, the term *volt* may be applied to indicate potential difference or electromagnetic force (EMF). The number of electrons flowing per second in a circuit is termed *amperage.*

54. **The answer is** A. *(Carlton, pp 72-73. Selman, 8/e, pp 68-70, 75. Thompson, pp 91-92.)* The flow of electrons in a circuit is always from a point of excess electrons to a point deficient in electrons. The terminal with an excess of electrons has a large quantity of negative charges and is thus termed the *negative terminal.* The terminal deficient in electrons is termed the *positive terminal* because of its *lack* of negative charge. The electrons are the components of the atom that are "free" to move under certain conditions, and their nature is to repel like charges (each other) while being attracted to opposite charges (positive terminal). Therefore, the flow of electrons may be described as from negative to positive terminals, from a point of excess electrons to a point deficient in electrons, or from cathode to anode.

55. The answer is B. *(Bushong, 51e, p 352.)* Dynamic imaging provides a means for viewing anatomic structures in motion; that is, it shows how they function. Fluoroscopy allows the radiologist to indirectly observe physiologic motion within the gastrointestinal system or the flow of blood through arteries and veins. Such imaging is obtained through the use of a fluoroscope, which includes a fluorescent screen and an optics system for viewing the image. Continuous or pulsed irradiation of the patient provides a fairly continuous image of structures as they function. Fluoroscopy has changed greatly from the early days with tremendous improvement in the quality of the images and reduction of dose delivered to patient and personnel. Tomographic techniques are used to image the body in planes or sections in order to avoid looking through structures above or below the area of interest. Motion of the tube and image receptor are employed to obtain the images; however, the images are static, not dynamic. Stereoscopy is another technique employed to better visualize structures in regard to their relationship with other structures in the area of interest; however, it also yields static images. Subtraction techniques are used to photographically or electronically remove unwanted information from the image for better viewing of the desired structures. This technique may be employed with fluoroscopy, but the fluoroscope provides the means of dynamic imaging, not the subtraction techniques, which are used to enhance static images.

56. The answer is C. *(Bushong, 5/e, p 357.)* The image intensifier is employed in fluoroscopy for the primary purpose of increasing the light level of the image and thereby improving viewing conditions. N on in-ten sifted fluoroscopy produced a faint image on a fluoroscopic screen. The low light level of this image required complete darkness in order to enhance the use of the eye's scotopic viewing mechanism—the use of the rods of the eye. The result was poor visual acuity of the structures imaged. The incorporation of the image intensifier provides a method of amplifying the fluoroscopic image. This is achieved by converting the image to an electronic signal (electrons), which can be accelerated (acquiring large amounts of kinetic energy), and directing it into a very small fluoroscopic screen (output phosphor). The result of these two actions (flux gain and minification gain) is the transfer of a large quantity of energy onto a small area, producing many more tight photons than were previously available. The components of the image intensifier first convert the exit photons to light photons, then to electrons, and finally back to light photons. The use of the image intensifier provides a much brighter fluoroscopic image, which may be viewed in daylight conditions (photopic vision). This improves the level of visual acuity and decreases patient anxiety about being in the dark during fluoroscopic procedures.

57. The answer is B. *(Bushong, 5/e, pp 437-40. NCRP No. 99, pp 65-66.)* Visual checks of certain components of imaging and ancillary radiographic equipment are a form of quality control. For example, the locks on the table, tube, and upright bucky should be adjusted to their locked and unlocked positions to see if they work. Another example would be the checking and cleaning of cassettes and screens. The other answer options require a testing tool and procedure. A grid alignment tool is available to check the table ducky grid for alignment with the centered x-ray beam. A film is exposed with the tube centered and laterally off-center. When the film is processed, the density is evaluated for uniformity. The light intensity of a view box is measured with a light meter. Film-screen contact is evaluated with a wire mesh contact grid.

58. The answer is D. *(Bushong, 5/e, p 665. Thompson, p 410.)* AH protective apparel should be evaluated for loss of integrity that may cause unnecessary exposure to patients or personnel. This evaluation should be performed on an annual basis or whenever questions arise as to the quality of the aprons, gloves, or gonadal shields. This test method involves radiographing or fluoroscoping each piece of apparel with high kilo voltage (>100) to demonstrate areas of radiation leakage. When such areas are located, the surface should be marked to identify them; one must then consider whether the apparel should continue to be used. Visual inspection of aprons or gloves may suggest leaks, which then should be confirmed by radiation exposure. Scanning with an ultraviolet light may aid in the visual inspection. If there is concern regarding a piece of protective apparel, the apparel should not be used on patient or personnel until it has been evaluated.

59. The answer is D (1, 2, 3). *(Bushong, 5/e, pp 130-131, 337, 435.* Car/ton, *pp 544-545.)* The AEC device may be commonly found on just about all types of imaging equipment including diagnostic, fluoroscopic, mammography, dedicated chest radiography, and angiography. The inclusion of AEC for mobile radiography is available as an option to routine mobile imaging. For these units, the sensor chambers are part of a paddle that is positioned behind the cassette during the imaging procedure. All AEC devices must be properly used and calibrated in order to gain the benefits possible. Annual evaluation of the AEC should be performed to ensure optimum operation.

60. The answer is D. *(Adier, pp 6-8. Bushong, 5/e, pp 325, 336, 352, 364. NCRP No. 102, p 13.)* Fluoroscopy is used for dynamic imaging, that is, to visualize motion. This imaging option is commonly employed to examine the gastrointestinal tract and the circulatory system, the latter as performed in angiography and cardiac catheterization. Tomography, computed tomography, and mammography are all types of radiographic imaging that employ specific equipment. Each results in a static, or stationary, image. Static images are also possible with fluoroscopic equipment.

61-63. The answers are , 61-D, 62-D, 63-C. *(Bushong, 5/e, pp 430*31, 433, 439*43, 627.* Car/ton, pp *442, 444*46. NCRP No. 99, pp 46-55, 61-64, 69-73, 191-196.)* Quality control procedures should be performed on specific components of the radiographic imaging system on a schedule determined by (1) the significance each component has on image quality,'(2) the complexity of the test procedure, and (3) the likelihood of a variance to occur. Monitoring and maintenance of the film processor is the best example of the advantages to be achieved by a consistent quality control routine. Every image is subjected to the ups and downs of the processor. There are numerous systems within the processor that affect the final image. By ensuring optimum operation of the processor, it ceases to be a factor in poor image quality. For this reason, the processor should be monitored on a daily basis and adjusted to optimum operating levels before any images are processed. This will significantly reduce the number of repeat images and save on patient exposure and use of equipment and supplies. Once established, the daily monitoring process requires very little time and can avoid costly downtime. Evaluation of the collimator should be performed at least twice a year or whenever the x-ray tube or collimator has been serviced. Such items as the alignment of the x-ray to light fields or x-ray to image receptor, central ray perpendicularity, and accuracy of the PBL can be evaluated with this procedure. The light field, used for centering, is projected via a mirror mounted in the collimator, which can be misaligned by rough handling or jarring of the tube head. Problems with alignment of the x-ray and light field will be evidenced by "cone-cutting" of structures supposedly included in the light field. A simple means of evaluation is placing a cassette in the bucky, centering it to the beam, adjusting the light field to be smaller than the film size, and then placing a penny on each of the four comers of the light field and one in the center marking the central ray. The film is then exposed and processed. Evaluation of the image should demonstrate each of the pennies equidistant from the edges of the film and the exposed area of the film located in the center of the film. The acceptable limit for variation is ± 2 percent of the SID. This translates to 2 cm of variation for a 100-cm (40-inch) SID. The control of darkroom fog is necessary to prevent increased levels of base plus fog density on the unexposed film and to ensure a safe environment for the handling of all film. The primary sources of fog in the darkroom include improper "safelights" and white light leaks. Evaluation of the darkroom, particularly the safelights, should occur twice a year and whenever the safelights have been serviced. Safelights need to be checked for proper type of filter, correct wattage of light bulbs, and correct color for the types of film being handled in a particular darkroom. A simple method to determine the presence of safelight fog uses a piece of film that has received a minimum exposure to radiation in order to sensitize the film. Turn off all lights, including safelights, and place the exposed film on the work counter with half of it covered with a sheet of cardboard. This half of the film will remain covered during the rest of the test. A second piece of cardboard covers three-fourths of the uncovered side of the film. The safelights are turned on. After 1 min of safelight exposure, the second cardboard is lowered to uncover half of the test side of the film. This process is repeated twice more, for a total of four sections of the uncovered side of the film being exposed to the safelights for 4, 3, 2, and 1 min. The safelight-exposed half of the film is then compared with the unexposed half. Density levels should not be greater than 0.05 for the section representing 1 min of safelight exposure and preferably for the section exposed 2 min. Evaluation of the kilovoltage peak stations should be conducted on an annual basis or any time the x-ray generator has been serviced. This is to ensure that the kilovoltage being selected is what is being applied between the terminals within the x-ray tube. Changes in kilovoltage peak affect the quality of the beam produced, which in turn influences patient dose and image contrast. A technologist may perform a noninvasive evaluation of various kilovoltage stations with a kilovoltage peak test cassette, such as the Wisconsin or Ardran-Crooks test cassettes. Diagnostic equipment should be calibrated to provide actual kilovoltage peak levels with ± 4 kilovoltage peak of the selected kitovoltage station. The evaluation of beam quality provides information regarding the filtration levels of the x-ray tube, assuming the kilovoltage is properly calibrated. Filtration is an important factor to monitor because of its influence on patient dose. Insufficient levels of filtration will increase a patient's skin dose. A minimal-to-moderate increase in filtration will decrease patient dose without influencing image quality. Filtration is evaluated by determining the HVL at one or more kilovoltage stations and this should be performed at least annually and whenever the x-ray tube or collimator has been serviced. HVL is found by recording output levels in milliroentgens while introducing increasing amounts of aluminum sheets into the x-ray beam. By charting these values, one can determine the amount of filter material (aluminum) required to reduce the beam intensity to half its original value. For diagnostic tubes able to operate at 70 kV or higher, the minimum HVL should be 2.3 mm of repeated twice more, for a total of four sections of the uncovered side of the film being exposed to the safelights for 4, 3, 2, and 1 min. The safelight-exposed half of the film is then compared with the unexposed half. Density levels should not be greater than 0.05 for the section representing 1 min of safelight exposure and preferably for the section exposed 2 min. Evaluation of the kilovóltage peak stations should be conducted on an annual basis or any time the x-ray generator has been serviced. This is to ensure that the kilovoltage being selected is what is being applied between the terminals within the x-ray tube. Changes in kilovoltage peak affect the quality of the beam produced, which in turn influences patient dose and image contrast. A technologist may perform a noninvasive evaluation of various kilovoltage stations with a kilovoltage peak test cassette, such as the Wisconsin or Ardran-Crooks test cassettes. Diagnostic equipment should be calibrated to provide actual kilovoltage peak levels with ± 4 kilovoltage peak of the selected kitovoltage station. The evaluation of beam quality provides information regarding the filtration levels of the x-ray tube, assuming the kilovoltage is properly calibrated. Filtration is an important factor to monitor because of its influence on patient dose. Insufficient levels of filtration will increase a patient's skin dose. A minimal-to-moderate increase in filtration will decrease patient dose without influencing image quality. Filtration is evaluated by determining the HVL at one or more kilovoltage stations and this should be performed at least annually and whenever the x-ray tube or collimator has been serviced. HVL is found by recording output levels in milliroentgens while introducing increasing amounts of aluminum sheets into the x-ray beam. By charting these values, one can determine the amount of filter material (aluminum) required to reduce the beam intensity to half its original value. For diagnostic tubes able to operate at 70 kV or higher, the minimum HVL should be 2.3 mm of aluminum when using the 80 kV station. Specific HVLs for other kilovoltage stations are available for a more thorough evaluation of the tube's filtration. Exposure linearity is the ability to produce the same level of output in milliroentgens (within ± 10 percent) for a specific milliampere-second value using various milliamperage and time stations. The noninvasive method of evaluation requires using a dosimeter and recording the output values (in milliroentgens) for exposures made at the various milliamperage stations. These data can provide information regarding the calibration of the milliamperage stations, assuming the exposure times are accurate. If the time stations are not accurate, linearity may stilt be determined by keeping the same time stop, varying the milliamperage (yielding different milliampere-second values), and then finding the milliroentgen per milliampere-second value for analysis of linearity. For either method, the acceptable limit for variation is ± 10 percent for consecutive milliamperage stations. Evaluation of linearity should be performed at least annually and whenever the x-ray generator or control panel has been serviced. When possible, more frequent monitoring of radiographic components will alert personnel to important changes at an earlier point than will adhering to the minimum frequency schedule.

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