White: Oral Radiology, 6th Edition

Chapter 1: Radiation Physics

Test Bank

Multiple Choice

1) According to the Standard Model:

A. fundamental particles have an inner structure and can be divided.
B. quarks exist only as solitary particles.
C. electrons are made of quarks.
D. all visible matter in the universe is made of up quarks, down quarks, or electrons.

ANS: D

According to the Standard Model, all visible matter in the universe is made of up quarks, down quarks, or electrons. Fundamental particles have no inner structure and cannot be divided. Quarks only exist in association with other quarks, never as solitary particles. Leptons exist only as solitary particles. Neutrons and protons are made of quarks. Electrons and neutrinos are stable leptons.

REF: Page 2

2) When antimatter particles interact with matter, they:

A. form leptons.
B. form quarks.
C. mutually annihilate into pure energy.
D. create an antiparticle.

ANS: C

When antimatter particles interact with matter, they mutually annihilate into pure energy. Electrons and neutrinos are stable leptons. The universe is made of 24% matter and 76% dark energy. Only 5% of the matter is in the form of atoms and neutrinos. The nature of the rest of the matter, and of dark energy, is unknown.

REF: Page 2

3) Which of the following types of force carrier particles mediates the strong nuclear force that binds nuclei together?

A. Photons
B. Bosons

C. Gluons
D. Gravitons

ANS: C
Gluons mediate the strong nuclear force that binds nuclei together. Photons mediate the electromagnetic force, bosons mediate the weak nuclear force associated with β decay, and gravity is speculated to be mediated by gravitons.

REF: Page 2

4) Which of the following statements is true of electron orbitals in an atom?

A. “S” represents the principal quantum number describing the size of the orbital.
B. The p-type orbital consists of four lobes arranged around the nucleus.
C. No known atom has more than 19 orbitals.
D. Only two electrons may occupy an orbital.

ANS: D

Only two electrons may occupy an orbital. The principal quantum number is *n,* which describes the size of the orbital. The p-type orbitals are bilobed and centered on the nucleus. D-type orbitals consist of four lobes arranged around the nucleus or are bilobed with a ring. No known atom has more than seven orbitals.

REF: Page 2

5) In order for an electron to move from an outer orbital shell to one closer to the nucleus:

A. energy is lost and given up in the form of electromagnetic radiation.
B. energy is lost and given up in the form of particulate radiation.
C. energy must be supplied in an amount equal to the difference in binding energies between the two orbitals.
D. energy must be supplied in an amount equal to the binding energy of the inner orbital.

ANS: A

When an electron moves from an outer orbital shell to one closer to the nucleus, energy is lost and given up in the form of electromagnetic radiation. In order for an electron to move from a specific orbital to another orbital farther from the nucleus, energy must be supplied in an amount equal to the difference in binding energies between the two orbitals.

REF: Page 3

6) β Particles most closely resemble a(n):

A. boson.

B. neutron.
C. proton.
D. electron.

ANS: D

β Particles most closely resemble an electron. When a neutron in a radioactive nucleus decays, it produces a proton, a β particle and a neutrino. β Particles are otherwise identical to electrons.

REF: Page 4

7) The _____ of a particle, the greater is its linear energy transfer (LET).

A. greater the mass
B. greater the velocity
C. lesser the physical size
D. lesser the charge

ANS: A
The greater a particle's mass and charge, the lower is its velocity. The rate of loss of energy from a particle as it moves through matter, because of ionization of the surrounding matter, is its LET.

REF: Page 4

8) Which of the following forms of electromagnetic radiation has greater energy than x rays?

A. Infrared radiation
B. Gamma (γ) rays
C. Microwaves
D. Radio waves

ANS: B
γ Rays have greater energy than x rays. γ Rays originate in the nuclei of radioactive atoms.

REF: Page 4
9) The quantum theory of radiation has been successful in correlating experimental data on:

A. diffraction.
B. the production of x rays.
C. polarization.
D. refraction.

ANS: B
The quantum theory of radiation has been successful in correlating experimental data on the interaction of radiation with atoms, the photoelectric effect, and the production of x rays. Wave theory is more useful for considering radiation in bulk when millions of quanta are being

examined, as in experiments dealing with refraction, reflection, diffraction, interference, and polarization.

REF: Pages 4-5

10) High-energy photons such as x rays and γ rays are typically characterized by their:

A. energy.
B. wavelength.
C. frequency.
D. magnitude.

ANS: A
High-energy photons such as x rays and γ rays are typically characterized by their energy (electron volts). Medium-energy photons (e.g., visible light and ultraviolet waves) are characterized by their wavelength (nanometers), and low-energy photons (e.g., AM and FM radio waves) by their frequency (KHz and MHz).

REF: Page 5

11) Within the x-ray tube:

A. electrons stream from a filament in the anode to a target in the cathode.
B. electrons stream from a filament in the cathode to a target in the anode.
C. photons stream from a filament in the anode to a target in the cathode.
D. photons stream from a filament in the cathode to a target in the anode.

ANS: B
Within the x-ray tube, electrons stream from a filament in the cathode to a target in the anode.

REF: Page 5

12) When x rays are being produced, the focusing cup:

A. is made of tungsten.
B. is positively charged
C. is a convex reflector.
D. contains the filament.

ANS: D
The focusing cup contains the filament. It is a negatively charged, concave reflector made of molybdenum. The shape of the focusing cup electrostatically focuses the electrons emitted by the filament into a narrow beam directed at the focal spot on the anode.

REF: Pages 5-6

13) More than __% of the kinetic energy of electrons produced at the filament is converted to heat at the target.

A. 10
B. 50
C. 90
D. 99

ANS: D
More than 99% of the kinetic energy of electrons produced at the filament is converted to heat at the target. The conversion of the kinetic energy of the electrons into x-ray photons is an inefficient process.

REF: Page 6

14) The apparent size of the focal spot seen from a position perpendicular to the electron beam is smaller than the actual focal spot size because the:

A. anode has many moving parts.
B. target is placed at an angle to the electron beam.
C. speed of the electrons is degraded by air in the x-ray tube.
D. focusing cup focuses the electrons into a narrow beam.

ANS: B
The apparent size of the focal spot seen from a position perpendicular to the electron beam is smaller than the actual focal spot size because the target is placed at an angle to the electron beam.

REF: Page 6

15) The primary function(s) of the power supply of an x-ray machine is to:

A. provide a high-voltage current to heat the x-ray tube filament.
B. generate a low potential difference between the anode and the cathode.
C. provide a low-voltage current to heat the x-ray tube filament and generate a low potential difference between the anode and the cathode.
D. provide a low-voltage current to heat the x-ray tube filament and generate a high potential difference between the anode and the cathode.

ANS: D
The primary functions of the power supply of an x-ray machine are to provide a low-voltage current to heat the x-ray tube filament and to generate a high potential difference between the anode and the cathode. The low-voltage current also powers the light on the panel that indicates that the machine is turned on.

REF: Page 7

16) When an x-ray machine is set to 70 kVp, the peak energy of electrons passing through the x-ray tube is:

A. boosted by the high-voltage transformer to 70 volts.
B. boosted by the high-voltage transformer to up to 70,000 volts.
C. reduced by the filament transformer to 70 volts.
D. reduced by the filament transformer to 70 milliamps.

ANS: B
The peak energy of electrons passing through the x-ray tube is boosted by the high-voltage transformer to up to 90,000 volts. This high voltage is required to give electrons sufficient energy to generate x rays. The kVp dial is used to select the peak operating kilovoltage between the anode and the cathode.

REF: Page 8

17) Current flows through the tube when the target anode is _____ and the filament is _____.

A. positive; positive
B. negative; negative
C. positive; negative
D. negative; positive

ANS: C
Current flows through the tube when the target anode is positive and the filament is negative. The voltage potential between the anode and the cathode varies continuously as the polarity of the line current alternates at 60 cycles per second.

REF: Page 8

18) Which of the following statements is true regarding the generation of x-ray pulses within an alternating current (AC) x-ray tube?

A. During the inverse voltage or reverse bias portion of each cycle, the filament becomes negative and the target becomes positive.
B. When an x-ray tube is powered with 60-cycle AC, 120 x rays are generated each second.
C. No x rays are generated during the inverse-voltage portion of the voltage cycle.
D. When photons produced by the filament strike the focal spot of the target, some of their energy converts to electrons.

ANS: C
No x rays are generated during the inverse voltage or reverse bias portion of each cycle. When an x-ray tube is powered with 60-cycle AC, 60 pulses of x rays are generated each second, each having a duration of 1/120 second. When AC is applied across the x-ray tube, x-ray production is

limited to half the AC cycle. When electrons produced by the filament strike the focal spot of the target, some of their energy converts to x-ray photons.

REF: Page 8

19) For a full-wave rectified, high-frequency power x-ray machine:

A. the mean energy of the x-ray beam is lower than that from a conventional half-wave rectified machine operated at the same voltage.
B. the images for a given voltage setting and radiographic density will have a shorter contrast scale compared with conventional x-ray machines.
C. at a given voltage setting and radiographic density, the patient receives a lower dose compared with conventional x-ray machines.
D. X rays will not be generated during the inverse voltage portion of the voltage cycle.

ANS: C
For a full-wave rectified, high-frequency power x-ray machine, at a given voltage setting and radiographic density, the patient receives a lower dose compared with conventional x-ray machines.

REF: Page 9

20) A 15-impulse exposure is equivalent to _____ second for a conventional 60-cycle AC, half-wave rectified x-ray machine.

A. 1
B. 0.5
C. 0.25
D. 0.125

ANS: C
A 15-impulse exposure is equivalent to 0.25 or ¼ second. Because conventional line current alternates at 60 cycles per second, 60 impulses would equal a 1-second exposure.

REF: Page 9

21) The duty cycle of a dental x-ray machine:

A. is the lifetime of the machine in years permitted by law before it must be replaced.
B. is the number of x-ray exposures permitted by law before it must be replaced.
C. reflects the frequency with which successive exposures can be made.
D. describes the longest exposure time the tube can be energized for a range of voltages and tube current values with risk of damage to the target from overheating.

ANS: C

The duty cycle of a dental x-ray machine reflects the frequency with which successive exposures can be made. The tube rating describes the longest exposure time the tube can be energized for a range of voltages and tube current values with risk of damage to the target from overheating.

REF: Page 9

22) The primary source of radiation from an x-ray tube is caused by:

A. bremsstrahlung radiation.
B. characteristic radiation.
C. electrons from the filament directly hitting the nucleus of atoms in the target.
D. electrons from the filament directly hitting electrons in the target.

ANS: A
The primary source of radiation from an x-ray tube is caused by bremsstrahlung radiation. It occurs when the electron is attracted toward a positively charged nucleus, its path is altered toward the nucleus because of the difference in electrical charges, and it loses some of its velocity. Characteristic radiation only contributes a small fraction of the photons in an x-ray beam. It occurs when an electron ejects an inner electron from the tungsten target.

REF: Page 9

23) The shape of the x-ray beam may be modified by altering the:

A. exposure duration.
B. exposure rate.
C. collimation.
D. intensity.

ANS: C
The shape of the x-ray beam may be modified by altering the collimation. The beam exposure duration is altered by the timer, the exposure rate by the milliamperage, the energy by the kVp and filtration, and the intensity by the target-patient distance.

REF: Page 10

24) When exposure time is doubled, the number of photons generated at all energies in the x-ray emission spectrum is:

A. the same, and the range of photon energies is unchanged.
B. the same, but the range of photon energies doubles.
C. doubled, but the range of photon energies is unchanged.
D. doubled, and the range of photon energies doubles as well.

ANS: C

When the exposure time is doubled, the number of photons generated at all energies in the x-ray emission spectrum is doubled, but the range of photon energies is unchanged.

REF: Page 10

25) A machine operating at 15 mA for 2 seconds produces the same quantity of radiation when operated at 10 mA for __ second(s).

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

ANS: C
A machine operating at 15 mA for 2 seconds produces the same quantity of radiation when operated at 10 mA for 3 seconds. Both produce 30 mA.

REF: Page 10

26) Increasing the kVp will:

A. increase the number of photons generated, but neither their mean energy nor their maximal energy.
B. increase the number of photons generated and their mean energy, but not their maximal energy.
C. increase the number of photons generated, their mean energy, and their maximal energy.
D. decrease the number of photons generated, but will increase their mean energy and their maximal energy.

ANS: C
Increasing the kVp will increase the number of photons generated, their mean energy, and their maximal energy.

REF: Page 10

27) Dental x-ray beams are usually collimated to a circle ____ in diameter.

A. 1.0 mm
B. 2.5 mm
C. 2.75 inches
D. 8 inches

ANS: C
Dental x-ray beams are usually collimated to a circle 2.75 inches in diameter. Rectangular collimators further limit the size of the beam to just larger than the x-ray film. The focal spot of the tungsten target in the x-ray tube is about 1.0 × 3.0 mm. A short x-ray tube is 8 inches long.

REF: Page 12

28) The patient exposure resulting from a 1.0-second exposure using a 16-inch cone would be equivalent to a __-second exposure with an 8-inch cone if the kVp and mA are kept constant.

A. 0.25
B. 0.5
C. 1.0
D. 2.0

ANS: A
The patient exposure resulting from a 1.0-second exposure using a 16-inch cone would be equivalent to a 0.25-second exposure with an 8-inch cone if the kVp and mA are kept constant. The inverse square law states that the intensity of an x-ray beam depends on the distance of the measuring device from the focal spot. The intensity is inversely proportional to the square of the distance from the source.

REF: Page 12

29) The primary means of dental x-ray beam attenuation is caused by:

A. coherent scattering.
B. photoelectric absorption.
C. Compton scattering.
D. pass-through with no interaction.

ANS: C
The primary means of dental x-ray beam attenuation is caused by Compton scattering. About 49% of the interactions in a dental x-ray beam exposure involve Compton scattering.

REF: Page 14

30) Photoelectric absorption occurs when a(n) _____ of the absorbing medium.

A. low-energy incident photon passes near the outer electron of an atom
B. photon interacts with an outer orbital electron
C. incident photon interacts with an electron in an inner orbital of an atom
D. photon interacts with the nucleus

ANS: C
Photoelectric absorption occurs when an incident photon interacts with an electron in an inner orbital of an atom of the absorbing medium. The photon ejects the electron from its orbital, and it becomes a recoil electron. The incident photon ceases to exist. The kinetic energy imparted to the recoil electron is equal to the energy of the incident photon minus the binding energy of the

electron. Most photoelectric interactions occur in the 1s orbital because the density of the electron cloud is greatest in this region and there is a higher probability of interaction.

REF: Pages 13-14

31) _____ will result in the loss of an electron and ionization of the absorbing atom.

A. Coherent scattering, photoelectric absorption, and Compton scattering
B. Coherent scattering and photoelectric absorption, but not Compton scattering
C. Coherent scattering, but neither photoelectric absorption nor Compton scattering
D. Photoelectric absorption and Compton scattering, but not coherent scattering

ANS: D
Photoelectric absorption and Compton scattering, but not coherent scattering, will result in the loss of an electron and ionization of the absorbing atom. Scattered photons will continue on new paths, causing further ionizations. The recoil electrons also give up their energy by ionizing other atoms.

REF: Page 14

32) As an x-ray beam passes through matter, the intensity of the beam _____ and the mean energy of the residual beam _____ by preferential removal of low-energy photons.

A. increases; decreases
B. decreases; increases
C. decreases; decreases
D. increases; increases

ANS: B
As an x-ray beam passes through matter, the intensity of the beam decreases and the mean energy of the residual beam increases by preferential removal of low-energy photons. This occurs because there is a wide range of photon energies in an x-ray beam. Low-energy photons are much more likely to be absorbed than high-energy photons.

REF: Page 14

33) When the energy of the incident photon is raised to match the binding energy of the 1s orbital electrons of the absorber, the probability of photoelectric absorption _____ and the number of transmitted photons _____.

A. increases; increases
B. increases; decreases
C. decreases; increases
D. decreases; decreases

ANS: B

When the energy of the incident photon is raised to match the binding energy of the 1s orbital electrons of the absorber, the probability of photoelectric absorption increases and the number of transmitted photons decreases. This is called K-edge absorption. Rare earth elements are sometimes used as filters because their 1s orbital binding energies greatly increase the absorption of high-energy photons. These high-energy photons are not as likely to contribute to a radiographic image as mid-energy photons.

REF: Page 15

34) The SI unit of exposure is the:

A. Gray.
B. Sievert.
C. air kerma.
D. Becquerel.

ANS: C
The SI unit of exposure is air kerma. Kerma is an acronym for "kinetic energy released in matter." It measures the kinetic energy transferred from photons to electrons. The SI measure of absorbed dose is the Gray, and the rad is the traditional unit. The equivalent dose and the effective dose are both measured in Sieverts according to the SI. Becquerel is the SI unit of measurement for radioactivity.

REF: Page 16