BioE 1330 - Review Chapter 4 2/24/2010

Instructions: On the Answer Sheet, enter your 2-digit ID number (with a leading 0 if needed) in the boxes of the ID section. *Fill in the corresponding numbered circles.* Answer each of the numbered questions by filling in the corresponding circles in the numbered question section. Print your name in the space at the bottom of the answer sheet. Sign here stating that you have neither given nor received help.

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your signature

1. Which of the following statements is true about Bremsstrahlung and Characteristic Radiation?

A. Bremsstrahlung and Characteristic Radiation are both due to the photoelectric effect.

B. Bremsstrahlung and Characteristic Radiation are both generated by incoming x-rays.

C. X-rays from Bremsstrahlung is polyenergetic while that from Characteristic Radiation is monoenergetic.

D. Bremsstrahlung is evident in the spectrum produced by a typical x-ray machine, while Characteristic Radiation is not.

E. Bremsstrahlung is due to Compton Scattering but Characteristic Radiation is not.

2. Which of the following statements is false?

A. If radiation transfers energy to an orbiting electron that is greater than the electron's binding energy, the result is ionization.

B. If radiation transfers energy to an orbiting electron that is less than the electron's binding energy, the electron may be raised to a higher energy state (a more outer orbit), but is not ejected.

C. If radiation transfers energy to an orbiting electron that is less than the electron's binding energy, the result is excitation.

D. If radiation transfers energy to an orbiting electron that is greater than the electron's binding energy, the electron is ejected from the atom.

E. After both ionization and excitation, a "hole" is formed in the electron shell, which is filled via a process that does not involve characteristic radiation.

3. Which of the following statements is *false*?

A. X-rays were first discovered in 1895, by a German physicist, Wilhelm Roentgen.

B. The target anode may spin to avoid heat buildup due to a tightly focused electron beam required for a high resolution x-ray image.

C. Both Bremsstrahlung and characteristic radiation are produced by the x-ray tube and form components of a polyenergetic x-ray source.

D. Lower frequency x-rays, which are not as useful for imaging purposes due to their poor penetration, are filtered out by metal in the tube itself.

E. In an x-ray tube, magnetic fields are used to accelerate electron from the cathode to the anode, where x-rays are produced upon collision with the dense metal anode.

4. Bremsstrahlung describes a process in which

A. high energy photons are used to create photoelectrons.

B. high energy photons interact with outer shell electrons.

C. an electron beam is used to create high energy photons.

D. electrons created in the x-ray tube interact directly with atoms in the patient.

E. energy is released through nuclear decay.

5. The following are true about x-rays *except*

A. They may reflect off the tiles on the walls of the room in which the scan is taking place.

B. They are produced in an x-ray tube by Bremsstrahlung over a continuous band of frequencies and by Characteristic Radiation at specific frequencies.

C. The cause damage to the body because they can produce ions.

D. They can be thought of as particles or waves.

E. They penetrate the body better than visible light because they have a *longer* wavelength than visible light.

6. Which one of the following statements is *false*?

A. The electron beam in an x-ray tube transfers energy to the target via collisional transfer (generating heat) and radiative transfer (generating characteristic radiation and bremsstrahlung radiation).

B. Compton scattering, which changes the path of photons in the body rendering them useless in image formation, is particularly a problem at low x-ray energies.

C. A "K-edge" occurs in the energy spectrum of photons at the binding energies of inner shell electrons, because above these energies many electrons become available and the probability of the photoelectric effect rises sharply.

D. Ionization is the ejection of an orbiting electron from an atom; ionizing radiation has sufficient energy to produce ionization.

E. The probability of the photoelectric effect increases non-linearly with increasing effective atomic number of the material through which the radiation passes.

7. Characteristic radiation peaks

A. have too much energy to be useful for imaging.

B. result from electrons moving from one orbit to another of greater binding energy.

C. don't have enough energy to be useful for imaging.

D. are filtered out before reaching the patient.

E. are different from Bremsstrahlung radiation in that they are not harmful to the patient.

8. All of the following statements describe limitations of imaging using X-rays, *except*

A. Iodine and barium are commonly used as contrast agents because of their high atomic number.

B. Only tissues with different attenuation coefficients can be distinguished.

C. The risk of cancer increases with each scan.

D. Radiation sources remain active within the patient after the scan.

E. Projection and tomographic images are both obtainable.

9. Which of the following statements is *false*?

A. Lower frequency x-rays, which are not as useful for imaging purposes due to their poor penetration, are filtered out by metal in the tube itself.

B. Both Bremsstrahlung and characteristic radiation are produced by the x-ray tube and form components of a polyenergetic x-ray source.

C. X-rays were first discovered in 1895, by a German physicist, Wilhelm Roentgen.

D. X-rays and gamma rays represent distinct and non-overlapping regions of the electromagnetic spectrum.

E. The target anode may spin to avoid heat buildup due to a tightly focused electron beam required for a high resolution x-ray image.

10. Why do barium and iodine (contrast agents) appear white on x-ray?

A. They produce less Compton interaction at higher energies.

B. They equally reflect all wavelengths of visible light.

C. They have a high atomic number and have K edges in the diagnostic x-ray range.

D. They allow more x-rays to pass.

E. They form ions in the normal environment of the body.

11. Ultraviolet light has a wavelength in the range of 4-400 nanometers, what is the frequency range? (speed of light $= 3 \times 10^8$ m/s)

A. 7.5×10^{14} Hz to 7.5×10^{16} Hz.

B. 1.33×10^{-15} Hz to 1.33×10^{-17} Hz

C. 1.2 GHz to 120 GHz

D. 1.2 Hz to 120 Hz

E. 7.5 Hz to 7.5 MHz

12. The following is *not true* about Characteristic Radiation

A. It is a form of radiative transfer.

B. It is caused by the interaction of an electron with a nucleus of an atom.

C. The incoming electron collides with a K-shell electron.

D. The intensity spectrum exhibits discrete narrow bands.

E. A K-shell hole is created prior to the emission of the characteristic x-ray.

13. Which of the following photons constitutes ionizing radiation?

A. All of the above.

B. Ultraviolet light with energy of 4.1 eV

C. X-ray with energy of 45 KeV.

D. Infrared radiation with energy of 1.24 eV.

E. Radio Waves with energy of 120×10^{-6} eV.

14. Which of the following is (are) true? In the atom, the binding energy for an electron

I - is specific to a given element, shell, and quantum state.
II - generally decreases with increasing shell number (further from nucleus) .
III - increases with lower atomic number (less positive charge in nucleus).

A. I, II, and III

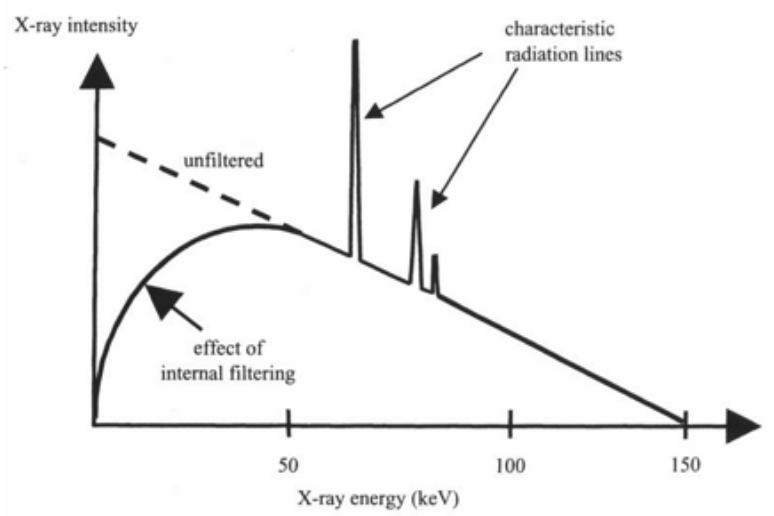
B. I and III

C. II and III

D. I

E. I and II

15. In the histogram below, why does the source have internal filtering at low energies?



A. The filtered X-rays would not get through the patient to the detector, so they are worthless from an imaging standpoint.

B. None of the other choices

C. The filtered X-rays have alpha-particles which must be stopped from reaching the patient.

D. The filtered X-rays are part of the correction for beam-hardening.

E. The filtered X-rays would provide useful imaging information, but would cause too much damage in the patient.

16. With reference (where appropriate) to the histogram above, decreasing the accelerating voltage (kVp) would cause all of the following EXCEPT:

A. Decreased effective X-ray energy of the beam

B. Increased radiation dose to the patient

C. None of the other choices

D. Reduced number of high-energy photons

E. Decreased or absent characteristic radiation lines

17. With reference (where appropriate) to the histogram above, decreasing the tube current (Amperes) would cause which of the following?

A. None of the other choices

B. Decreased effective X-ray energy of the beam

C. Absence of high-energy photons

D. Increased radiation dose to the patient

E. Absence of characteristic radiation lines

18. Characteristic radiation peaks:

A. Have too much energy to be useful for imaging

B. Make up 10-30% of the X-ray beam's intensity spectrum

C. Are filtered out before reaching the patient

D. Are different from Bremsstrahlung radiation in that they are not harmful to the patient

E. Don't have enough energy to be useful for imaging

19. All of the following statements about Compton scattering of X-rays are true, *except*:

A. Compton-scattered X-rays provide the most contrast between different tissues.

B. The probability of an X-ray photon undergoing Compton scattering is essentially independent of the effective atomic number of the tissue.

C. Compton scattering reduces the signal-to-noise of x-ray images.

D. Compton scattering is the most common interaction for a high energy X-ray.

E. Most Compton-scattered X-rays are hopefully absorbed by the lead septa of an antiscatter grid

20. All of the following statements about the photoelectric effect are true, EXCEPT:

A. The photoelectric effect provides the most image contrast between different tissues.

B. The net result of a photoelectric interaction is that the incident X-ray does NOT reach the detector.

C. The photoelectric effect is the most common interaction for a low energy X-ray.

D. The photoelectric effect is the interaction that allows us to make high-quality x-ray images.

E. The probability of an X-ray photon undergoing a photoelectric interaction is essentially independent of the effective atomic number of the tissue.

21. All of the following statements describe limitations of planar X-ray imaging, /it except:

A. Only 2-D information is available

B. Radiation dose can remain in the patient for days after the scan

C. The risk of cancer increases with each scan

D. Both iodine and barium are commonly used as contrast agents.

E. Only tissues with different attenuation coefficients can be distinguished

22. The linear attenuation coefficient of a gadolinium-based phosphor used for the attenuation of X-rays is $\mu = 560$ cm^{-1} at an X-ray energy of 150 keV. What percentage of these X-rays is detected by a phosphor layer of thickness 10 μm?

A. About 57%

B. About 43%

C. About 83%

D. Less than 1%

E. Greater than 99%

23. The half-value layer (HVL) of a tissue is dependent upon the type of tissue attenuating the X-ray as well as the energy of the incident X-ray. If the linear attenuation coefficient μ for bone is 10 cm^{-1} at the effective X-ray energy of 68 keV, what is the half-value layer (HVL) of the bone for that effective energy?

A. 0.1 cm^{-1}

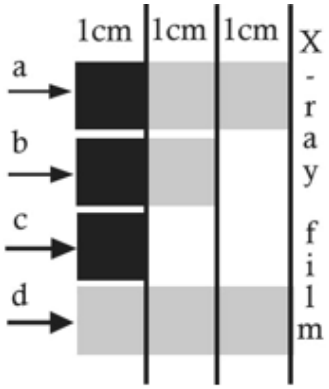
B. $\frac{\ln 2}{10 cm^{-1}}$

C. 0.1 cm

D. $\frac{10 cm^{-1}}{\ln 2}$

E. 10 cm

24. Four X-ray beams, each with intensity I_0, are incident upon the object below, in which black represents bone, gray represents muscle, and white represents fat. Which of the four beams will appear the darkest on a typical X-ray image? Assume that the linear attenuation coefficients at the effective X-ray energy of 68 keV are 10 cm^{-1}, 2 cm^{-1}, and 1 cm^{-1}, for bone, muscle, and fat, respectively.



A. Beam b

B. Beam d

C. Beam a

D. Beam c

E. The beams will have the same transmitted intensity

25. By convention, radiation with energy greater than or equal to 13.6 eV is considered *ionizing radiation.* What range of wavelengths contain the cutoff wavelength below which UV light is ionizing? $c = 2.998 \times 10^8$ meters per second, $h = 6.626 \times 10^{-34}$ Joule-sec, and 1 eV $= 1.6 \times 10^{-19}$ Joule.

A. 10 nm - 100 nm

B. 1 nm - 10 nm

C. 1 μm - 10 μm

D. 0.1 nm - 1 nm

E. 100 nm - 1 μm

26. You are designing an x-ray detector system and wish to eliminate all photons that have been scattered more than 20 degrees in an attempt to improve the resulting image quality. You are using a monoenergetic x-ray source that emits photons having wavelength $\lambda = 8.9 \times 10^{-2}$ angstroms (1 angstrom $= 10^{-10}$ meters). If your detector is capable of discriminating the energy of incoming photons, which of the following photon energies will be accepted by the system? Recall that the energy of a scattered photon is given by:

$hv^* = \frac{hv}{1+\frac{hv}{m_0c^2}(1-\cos\theta)}$

with $m_0c^2 = 511$ KeV.

A. 140 KeV

B. 134 KeV

C. 136 KeV

D. 138 KeV

E. 142 KeV

27. Place the following tissues or materials in ranked order, in terms of greatest to least X-ray absorption:

I - item fat
II - item muscle
III - air
IV - lead
V - bone

A. V - IV - II - I - III

B. III - I - II - V - IV

C. III - II - I - IV - V

D. IV - V - II - I - III

E. IV - V - III - II - I

28. The inverse square law has very practical use in radiography. Suppose an acceptable chest radiography was taken using 67.5 mAs at 80 kVp from 1.5 m. Suppose that it was now requested that be taken at 1 m at 80kVp. What mAs setting should be used to yield the same exposure?

A. 20 mAs

B. 45 mAs

C. 60 mAs

D. 30 mAs

E. 37.5 mAs

29. Ultraviolet light is defined as electromagnetic waves having wavelengths in the range of

A. 400 nm - 10 nm

B. 3 km - 0.01 m

C. 700 nm - 400 nm

D. 10 pm - 1 pm

E. 100 pm - 10 pm

30. Which one of the following statements is true?

A. Particulate ionizing radiation transfers energy via collisional transfer and radiative transfer.

B. All of them

C. The probability of radiative transfer increases with increasing effective atomic number of the material through which the particulate radiation passes.

D. Electromagnetic ionizing radiation transfers energy in medical imaging applications via the photoelectric effect.

E. Ionization is the ejection of an orbiting electron from an atom; ionization radiation has sufficient energy to produce ionization.

31. What determines the highest energy of x-ray photons emitted from an x-ray tube?

A. The integral of the bremsstrahlung x-ray spectrum.

B. The elements of the atoms in the anode of the x-ray tube

C. The sum of characteristic x-ray spectra

D. None of the other answers.

E. The peak x-ray tube voltage

32. For a point source of radiation, the exposure at a distance d from the source follows an inverse square law. If the exposure at $d = 3$ cm from point source is 36 R, what is the exposure at $d = 18$ cm from the source?

A. 6 R

B. 3 R

C. 1 R

D. 1.5 R

E. 4 R

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Answer Sheet - Correct answer is A for all questions

1. Which of the following statements is true about Bremsstrahlung and Characteristic Radiation?

A. X-rays from Bremsstrahlung is polyenergetic while that from Characteristic Radiation is monoenergetic.

B. Bremsstrahlung is due to Compton Scattering but Characteristic Radiation is not.

C. Bremsstrahlung and Characteristic Radiation are both due to the photoelectric effect.

D. Bremsstrahlung and Characteristic Radiation are both generated by incoming x-rays.

E. Bremsstrahlung is evident in the spectrum produced by a typical x-ray machine, while Characteristic Radiation is not.

Explanation: Bremsstrahlung is the "breaking radiation" produced in an x-ray tube by a stream of electrons hitting a metal target, and is polyenergetic. Characteristic Radiation is also produced there, and is monoenergetic, resulting from displaced electrons being replaced from higher shells.
[*imaging0036.mcq*]

2. Which of the following statements is false?

A. After both ionization and excitation, a "hole" is formed in the electron shell, which is filled via a process that does not involve characteristic radiation.

B. If radiation transfers energy to an orbiting electron that is greater than the electron's binding energy, the electron is ejected from the atom.

C. If radiation transfers energy to an orbiting electron that is less than the electron's binding energy, the electron may be raised to a higher energy state (a more outer orbit), but is not ejected.

D. If radiation transfers energy to an orbiting electron that is greater than the electron's binding energy, the result is ionization.

E. If radiation transfers energy to an orbiting electron that is less than the electron's binding energy, the result is excitation.

Explanation: "Holes" in electron shells are in fact filled via a process that comprises a source of secondary radiation known as characteristic radiation. (See Prince, Chapter 4, section 4.2.3.) The other statements are all true.
[*imaging0038.mcq*]

3. Which of the following statements is *false*?

A. In an x-ray tube, magnetic fields are used to accelerate electron from the cathode to the anode, where x-rays are produced upon collision with the dense metal anode.

B. Lower frequency x-rays, which are not as useful for imaging purposes due to their poor penetration, are filtered out by metal in the tube itself.

C. Both Bremsstrahlung and characteristic radiation are produced by the x-ray tube and form components of a polyenergetic x-ray source.

D. The target anode may spin to avoid heat buildup due to a tightly focused electron beam required for a high resolution x-ray image.

E. X-rays were first discovered in 1895, by a German physicist, Wilhelm Roentgen.

Explanation: Electrostatic fields, not magnetic fields, are used to accelerate the eletrons. Magnetic fields can only exert forces on moving electrons. The other statements are all true.
[*imaging0039.mcq*]

4. Bremsstrahlung describes a process in which

A. an electron beam is used to create high energy photons.

B. high energy photons are used to create photoelectrons.

C. high energy photons interact with outer shell electrons.

D. energy is released through nuclear decay.

E. electrons created in the x-ray tube interact directly with atoms in the patient.

Explanation: Electrons are accelerated in the x-ray tube to hit a target in the tube, creating x-ray photons that interact with atoms in the patient.
[*imaging0093.mcq*]

5. The following are true about x-rays *except*

A. They penetrate the body better than visible light because they have a *longer* wavelength than visible light.

B. They can be thought of as particles or waves.

C. They may reflect off the tiles on the walls of the room in which the scan is taking place.

D. They are produced in an x-ray tube by Bremsstrahlung over a continuous band of frequencies and by Characteristic Radiation at specific frequencies.

E. The cause damage to the body because they can produce ions.

Explanation: They penetrate the body better than visible light because they have a *shorter* wavelength than visible light.
[*imaging0098.mcq*]

6. Which one of the following statements is *false*?

A. Compton scattering, which changes the path of photons in the body rendering them useless in image formation, is particularly a problem at low x-ray energies.

B. The probability of the photoelectric effect increases non-linearly with increasing effective atomic number of the material through which the radiation passes.

C. Ionization is the ejection of an orbiting electron from an atom; ionizing radiation has sufficient energy to produce ionization.

D. A "K-edge" occurs in the energy spectrum of photons at the binding energies of inner shell electrons, because above these energies many electrons become available and the probability of the photoelectric effect rises sharply.

E. The electron beam in an x-ray tube transfers energy to the target via collisional transfer (generating heat) and radiative transfer (generating characteristic radiation and bremsstrahlung radiation).

Explanation: Compton scattering is particularly a problem at *high* x-ray energies.
[*imaging0102.mcq*]

7. Characteristic radiation peaks

A. result from electrons moving from one orbit to another of greater binding energy.

B. don't have enough energy to be useful for imaging.

C. are filtered out before reaching the patient.

D. have too much energy to be useful for imaging.

E. are different from Bremsstrahlung radiation in that they are not harmful to the patient.

Explanation: Characteristic radiation is extremely important in medical image formation. It is ionizing just like Bremsstrahlung and thus is potentially harmful to patients. They have characteristic energies, being the difference between the binding energy of one orbit vs. another.
[*imaging0104.mcq*]

8. All of the following statements describe limitations of imaging using X-rays, *except*

A. Radiation sources remain active within the patient after the scan.

B. Projection and tomographic images are both obtainable.

C. Only tissues with different attenuation coefficients can be distinguished.

D. The risk of cancer increases with each scan.

E. Iodine and barium are commonly used as contrast agents because of their high atomic number.

Explanation: Radiation doses may remain active within the patient after the scan with nuclear medicine, but X-rays are gone immediately.
[*imaging0105.mcq*]

9. Which of the following statements is *false*?

A. X-rays and gamma rays represent distinct and non-overlapping regions of the electromagnetic spectrum.

B. Lower frequency x-rays, which are not as useful for imaging purposes due to their poor penetration, are filtered out by metal in the tube itself.

C. Both Bremsstrahlung and characteristic radiation are produced by the x-ray tube and form components of a polyenergetic x-ray source.

D. The target anode may spin to avoid heat buildup due to a tightly focused electron beam required for a high resolution x-ray image.

E. X-rays were first discovered in 1895, by a German physicist, Wilhelm Roentgen.

Explanation: X-rays and gamma rays overlap in the the electromagnetic spectrum, differing fundamentally only in their source, x-rays coming from Bremsstrahlung and gamma rays from nuclear reactions.
[*imaging0108.mcq*]

10. Why do barium and iodine (contrast agents) appear white on x-ray?

A. They have a high atomic number and have K edges in the diagnostic x-ray range.

B. They equally reflect all wavelengths of visible light.

C. They allow more x-rays to pass.

D. They produce less Compton interaction at higher energies.

E. They form ions in the normal environment of the body.

Explanation: Barium and iodine both have a relatively high atomic number and have K edges in the useful range of photon energies.
[*imaging0109.mcq*]

11. Ultraviolet light has a wavelength in the range of 4-400 nanometers, what is the frequency range? (speed of light $= 3 \times 10^8$ m/s)

A. 7.5×10^{14} Hz to 7.5×10^{16} Hz.

B. 1.33×10^{-15} Hz to 1.33×10^{-17} Hz

C. 1.2 Hz to 120 Hz

D. 7.5 Hz to 7.5 MHz

E. 1.2 GHz to 120 GHz

Explanation: Frequency = velocity/wavelength.
[*imaging0110.mcq*]

12. The following is *not true* about Characteristic Radiation

A. It is caused by the interaction of an electron with a nucleus of an atom.

B. The intensity spectrum exhibits discrete narrow bands.

C. It is a form of radiative transfer.

D. A K-shell hole is created prior to the emission of the characteristic x-ray.

E. The incoming electron collides with a K-shell electron.

Explanation: The incoming electron interacts with a K-shell electron, not with the nucleus.
[*imaging0111.mcq*]

13. Which of the following photons constitutes ionizing radiation?

A. X-ray with energy of 45 KeV.

B. Ultraviolet light with energy of 4.1 eV

C. Infrared radiation with energy of 1.24 eV.

D. Radio Waves with energy of 120×10^{-6} eV.

E. All of the above.

Explanation: Radiation with energy greater than 13.6 eV is considered ionizing.
[*imaging0112.mcq*]

14. Which of the following is (are) true? In the atom, the binding energy for an electron

I - is specific to a given element, shell, and quantum state.
II - generally decreases with increasing shell number (further from nucleus) .
III - increases with lower atomic number (less positive charge in nucleus).

A. I and II

B. II and III

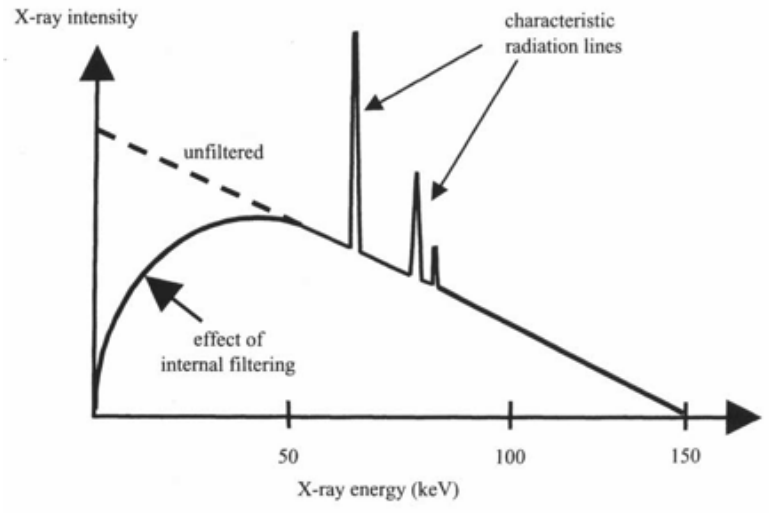
C. I and III

D. I, II, and III

E. I

Explanation: Binding energy *decreases* with lower atomic number (less positive charge in nucleus) because it takes less energy to remove them from the atom.
[*imaging0117.mcq*]

15. In the histogram below, why does the source have internal filtering at low energies?



A. The filtered X-rays would not get through the patient to the detector, so they are worthless from an imaging standpoint.

B. The filtered X-rays would provide useful imaging information, but would cause too much damage in the patient.

C. The filtered X-rays have alpha-particles which must be stopped from reaching the patient.

D. The filtered X-rays are part of the correction for beam-hardening.

E. None of the other choices

Explanation: Low-energy x-rays do not penetrate far enough to form images, and therefore a filter is built to remove them from the X-ray beam profile, preventing unnecessary exposure.
[*imaging0159.mcq*]

16. With reference (where appropriate) to the histogram above, decreasing the accelerating voltage (kVp) would cause all of the following EXCEPT:

A. Increased radiation dose to the patient

B. Decreased or absent characteristic radiation lines

C. Reduced number of high-energy photons

D. Decreased effective X-ray energy of the beam

E. None of the other choices

Explanation: Recall the relationship that X-ray intensity is proportional to the square of the accelerating voltage times the tube current. Decreasing the kVp of the X-ray machine would do all of these things except increase the radiation dose (it would decrease the radiation dose).
[*imaging0160.mcq*]

17. With reference (where appropriate) to the histogram above, decreasing the tube current (Amperes) would cause which of the following?

A. None of the other choices

B. Absence of characteristic radiation lines

C. Absence of high-energy photons

D. Decreased effective X-ray energy of the beam

E. Increased radiation dose to the patient

Explanation: Recall the relationship that X-ray intensity is proportional to the square of the accelerating voltage times the tube current. Decreasing the tube current of the X-ray machine would do none of these things – it simply means that more photons are coming per second.
[*imaging0161.mcq*]

18. Characteristic radiation peaks:

A. Make up 10-30% of the X-ray beam's intensity spectrum

B. Don't have enough energy to be useful for imaging

C. Are filtered out before reaching the patient

D. Have too much energy to be useful for imaging

E. Are different from Bremsstrahlung radiation in that they are not harmful to the patient

Explanation: Characteristic radiation is extremely important in medical image formation. It is ionizing just like Bremsstrahlung and thus is potentially harmful to patients.
[*imaging0162.mcq*]

19. All of the following statements about Compton scattering of X-rays are true, *except*:

A. Compton-scattered X-rays provide the most contrast between different tissues.

B. Most Compton-scattered X-rays are hopefully absorbed by the lead septa of an antiscatter grid

C. Compton scattering is the most common interaction for a high energy X-ray.

D. The probability of an X-ray photon undergoing Compton scattering is essentially independent of the effective atomic number of the tissue.

E. Compton scattering reduces the signal-to-noise of x-ray images.

Explanation: The photoelectric effect provides the most contrast between tissues. Compton scattering is generally bad for imaging and thus we seek to reduce its effect on the image via antiscatter grids.
[*imaging0163.mcq*]

20. All of the following statements about the photoelectric effect are true, EXCEPT:

A. The probability of an X-ray photon undergoing a photoelectric interaction is essentially independent of the effective atomic number of the tissue.

B. The net result of a photoelectric interaction is that the incident X-ray does NOT reach the detector.

C. The photoelectric effect is the most common interaction for a low energy X-ray.

D. The photoelectric effect provides the most image contrast between different tissues.

E. The photoelectric effect is the interaction that allows us to make high-quality x-ray images.

Explanation: PE effect is dependent on the cube of the effective atomic number of the tissue. That's why bones appear so white (high calcium) while air appears so black (mostly nitrogen and oxygen).
[*imaging0164.mcq*]

21. All of the following statements describe limitations of planar X-ray imaging, /it except:

A. Radiation dose can remain in the patient for days after the scan

B. Only 2-D information is available

C. Only tissues with different attenuation coefficients can be distinguished

D. The risk of cancer increases with each scan

E. Both iodine and barium are commonly used as contrast agents.

Explanation: Radiation doses stay in patients for days with nuclear medicine, not with X-rays.
[*imaging0165.mcq*]

22. The linear attenuation coefficient of a gadolinium-based phosphor used for the attenuation of X-rays is $\mu = 560$ cm^{-1} at an X-ray energy of 150 keV. What percentage of these X-rays is detected by a phosphor layer of thickness 10 μm?

A. About 43%

B. About 57%

C. Less than 1%

D. Greater than 99%

E. About 83%

Explanation: Use the Beer-Lambert equation $\frac{I}{I_0} = \exp(-\mu\Delta x)$ to find that 57% penetrates the phosphor layer, leaving 43% to be deposited.
[*imaging0166.mcq*]

23. The half-value layer (HVL) of a tissue is dependent upon the type of tissue attenuating the X-ray as well as the energy of the incident X-ray. If the linear attenuation coefficient μ for bone is 10 cm^{-1} at the effective X-ray energy of 68 keV, what is the half-value layer (HVL) of the bone for that effective energy?

A. $\frac{\ln 2}{10cm^{-1}}$

B. $\frac{10cm^{-1}}{\ln 2}$

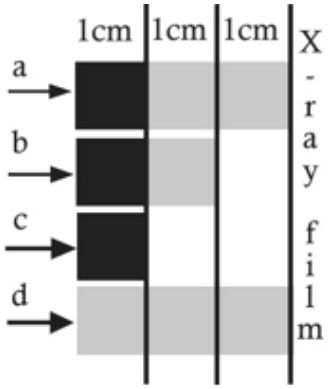
C. 0.1 cm

D. 10 cm

E. 0.1 cm^{-1}

Explanation: HVL = $\frac{\ln 2}{\mu}$
[*imaging0168.mcq*]

24. Four X-ray beams, each with intensity I_0, are incident upon the object below, in which black represents bone, gray represents muscle, and white represents fat. Which of the four beams will appear the darkest on a typical X-ray image? Assume that the linear attenuation coefficients at the effective X-ray energy of 68 keV are 10 cm^{-1}, 2 cm^{-1}, and 1 cm^{-1}, for bone, muscle, and fat, respectively.



A. Beam d

B. Beam c

C. Beam b

D. Beam a

E. The beams will have the same transmitted intensity

Explanation: Use Beer-Lambert equation again, with three $\mu\Delta x$ terms summed in the argument of the exponent.
[*imaging0169.mcq*]

25. By convention, radiation with energy greater than or equal to 13.6 eV is considered *ionizing radiation.* What range of wavelengths contain the cutoff wavelength below which UV light is ionizing? $c = 2.998 \times 10^8$ meters per second, $h = 6.626 \times 10^{-34}$ Joule-sec, and 1 eV $= 1.6 \times 10^{-19}$ Joule.

A. 10 nm - 100 nm

B. 1 nm - 10 nm

C. 0.1 nm - 1 nm

D. 100 nm - 1 μm

E. 1 μm - 10 μm

Explanation: Using $E = h\nu$, we solve for the frequency of the UV light as $\nu = 3.284 \times 10^{15}$ Hz. Then we use $c = \lambda\nu$ to solve for $\lambda = 91.4$ nm, below which UV light is ionizing.
[*imaging0170.mcq*]

26. You are designing an x-ray detector system and wish to eliminate all photons that have been scattered more than 20 degrees in an attempt to improve the resulting image quality. You are using a monoenergetic x-ray source that emits photons having wavelength $\lambda = 8.9 \times 10^{-2}$ angstroms (1 angstrom $= 10^{-10}$ meters). If your detector is capable of discriminating the energy of incoming photons, which of the following photon energies will be accepted by the system? Recall that the energy of a scattered photon is given by:

$hv^* = \frac{hv}{1+\frac{hv}{m_0c^2}(1-\cos\theta)}$

with $m_0c^2 = 511$ KeV.

A. 138 KeV

B. 134 KeV

C. 136 KeV

D. 140 KeV

E. 142 KeV

Explanation: See homework problem 4.11. Calculate the energies of an unscattered photon ($\theta = 0$) and one maximally scattered by $\theta = 20$, using the given equation. The range is between 137.2 KeV and 139.4 KeV, making the answer 138 KeV the only energy within that range.
[*imaging0171.mcq*]

27. Place the following tissues or materials in ranked order, in terms of greatest to least X-ray absorption:

I - item fat
II - item muscle
III - air
IV - lead
V - bone

A. IV - V - II - I - III

B. V - IV - II - I - III

C. III - II - I - IV - V

D. III - I - II - V - IV

E. IV - V - III - II - I

Explanation: Lead has the highest attenuation coefficient (which is why it is used to protect people from unnecessary radiation exposure). Bone is next. Air has the smallest attenuation coefficient. Muscle is slightly more absorptive than fat, but the key is knowing that lead is more absorptive than bone while air is much less absorptive than the others.
[*imaging0193.mcq*]

28. The inverse square law has very practical use in radiography. Suppose an acceptable chest radiography was taken using 67.5 mAs at 80 kVp from 1.5 m. Suppose that it was now requested that be taken at 1 m at 80kVp. What mAs setting should be used to yield the same exposure?

A. 30 mAs

B. 37.5 mAs

C. 60 mAs

D. 45 mAs

E. 20 mAs

Explanation: For explanation look at example 5.2
[*imaging0196.mcq*]

29. Ultraviolet light is defined as electromagnetic waves having wavelengths in the range of

A. 400 nm - 10 nm

B. 700 nm - 400 nm

C. 100 pm - 10 pm

D. 3 km - 0.01 m

E. 10 pm - 1 pm

Explanation: 10-400 nanometers. Ultraviolet is just shorter than visible, which is 700 nm - 400 nm.
[*imaging0199.mcq*]

30. Which one of the following statements is true?

A. All of them

B. The probability of radiative transfer increases with increasing effective atomic number of the material through which the particulate radiation passes.

C. Ionization is the ejection of an orbiting electron from an atom; ionization radiation has sufficient energy to produce ionization.

D. Electromagnetic ionizing radiation transfers energy in medical imaging applications via the photoelectric effect.

E. Particulate ionizing radiation transfers energy via collisional transfer and radiative transfer.

Explanation: All of the statements are true.

Errata: This question has a number of ambiguities and should not be used.
[*imaging0201.mcq*]

31. What determines the highest energy of x-ray photons emitted from an x-ray tube?

A. The peak x-ray tube voltage

B. The sum of characteristic x-ray spectra

C. The integral of the bremsstrahlung x-ray spectrum.

D. The elements of the atoms in the anode of the x-ray tube

E. None of the other answers.

Explanation: The peak x-ray tube voltage determines how fast the electrons hit the anode, and thus the maximum x-ray photon energy produced.
[*imaging0202.mcq*]

32. For a point source of radiation, the exposure at a distance d from the source follows an inverse square law. If the exposure at $d = 3$ cm from point source is 36 R, what is the exposure at $d = 18$ cm from the source?

A. 1 R

B. 6 R

C. 3 R

D. 4 R

E. 1.5 R

Explanation: The exposure at d = 3 cm is 36 (1/36) times that at d = 18 cm. So the exposure at d = 18 cm is R.
[*imaging0205.mcq*]