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1 - Therapy-Atomic & Nuclear Structure

1.1. Which of the following statements is **<u>TRUE</u>** about electrons:
a. They are found within the nucleus
b. The electron rest mass is equal to that of the neutron
c. The electron charge is equal to that of the proton
d. **The electron charge is equal in magnitude and opposite in sign to that of the proton**
e. Free electrons are unstable and decay into gamma rays

1.2. The electron volt is a unit of:
a. Charge
b. Mass
c. **Energy**
d. Wavelength
e. Electric current

1.3. The numerical value of one electron volt is:
a. 1.602 X 10^{-13} Joules
b. 1.602 X 10^{-16} Joules
c. **1.602 X 10^{-19} Joules**
d. 1.602 X 10^{-22} Joules
e. 1.602 X 10^{-25} Joules

1.4. Protons and neutron have:
a. **Approximately equal rest mass**
b. Equal charge
c. Equal charge and rest mass
d. Both unstable and decay into each other
e. Both can be accelerated using a particle accelerator

1.5. One atomic mass unit (amu) is equal to:
a. 1 KeV
b. 0.511 MeV
c. 1 MeV
d. 1.022 MeV
e. **931 MeV**

1.6. The energy associated with a rest mass of 1 kg is:
a. 5.62 X 10^{26} meV
b. 5.62 X 10^{26} eV
c. 5.62 X 10^{26} KeV
d. 5.62 X 10^{26} MeV
e. **5.62 X 10^{26} GeV**

1.7. Avogadro's number refers to:
   a. Number of electrons per gram
   b. **Number of atoms per gram**
   c. Number of grams per atom
   d. Number of nuclei per gram
   e. Number of gram per nucleus

1.8. The binding energy of an electron is defined as:
   a. The rest energy of the electron
   b. **The energy that keeps the electron in its atomic orbit**
   c. The energy required to raise the electron from one atomic shell to another
   d. The energy associated with electron capture by the nucleus
   e. The energy associated with beta decay

1.9. The nuclear force keeps the protons and neutrons bound in the nucleus, its strength is:
   a. The same as the electromagnetic force
   b. Significantly less than the electromagnetic force
   c. Somewhat less than the electromagnetic force
   d. **Significantly stronger than the electromagnetic force**
   e. Somewhat stronger than the electromagnetic force

1.10. In the neutral atom, the number of protons in the nucleus is equal to:
   a. **The number of electrons in the atomic orbitals**
   b. The number of neutrons in the nucleus
   c. The number of neutrons in the nucleus plus the number of electrons in the atomic orbitals
   d. The number of neutrons in the nucleus minus the number of electrons in the atomic orbitals
   e. The atomic weight of the nucleus

1.11. The atomic weight of an element is equal to:
   a. The number of protons in the nucleus
   b. The number of neutrons in the nucleus
   c. **The number of protons plus the number of neutrons in the nucleus**
   d. The number of protons plus the number of neutrons in the nucleus plus the number of electrons in the atomic orbitals
   e. The difference between the number of protons and the number of neutrons

1.12. The ratio of atomic diameter to the nuclear diameter is approximately:
   a. 10
   b. 100
   c. 1000
   d. **10,000**
   e. 100,000

1.13. Characteristic x-rays are emitted when:
   a. **Electrons from higher atomic shells fill a vacancy created in an inner shell**
   b. A radioactive nucleus undergoes gamma decay
   c. An outer shell electron is ejected from the atom
   d. A radioactive nucleus undergoes beta decay
   e. Two orbital electrons exchange positions

1.14. As the frequency of electromagnetic radiation increases:
   a. **The wavelength decreases, and the energy increases**
   b. Both the wavelength and energy decrease
   c. The wavelength increases and the energy decreases
   d. Both the wavelength and energy increase
   e. Both the wavelength and energy remain constant

1.15. The following is **TRUE** about infra-red radiation:
   a. It has shorter wavelength than ultraviolet rays
   b. It has higher frequency than x-rays
   c. **It has longer wavelength than visible light**
   d. It has longer wavelength than microwaves
   e. It is used in ultrasound imaging

1.16. The following is **TRUE** about the radioactive decay process:
   a. **It is a statistical process**
   b. It is a deterministic process
   c. It is either deterministic or statistical depending on the decaying nucleus
   d. It is statistical only in the case of beta decay
   e. It is deterministic only in the case of alpha decay

1.17. The SI unit of activity is:
   a. disintegrations per second (dps)
   b. Curie (Ci)
   c. Milli-Curie (mCi)
   d. **Becquerel (Bq)**
   e. Milligram Radium Equivalent (mgRaEq)

1.18. One pico-Curie (pCi) is:
   a. 3.7×10^{-5} Bq
   b. 3.7×10^{7} Bq
   c. 3.7×10^{4} Bq
   d. 3.7×10^{2} Bq
   e. **3.7×10^{-2} Bq**

1.19. The activity of a radioactive sample decays, with time:
  a. In direct proportionality
  b. Inversely
  c. **Exponentially**
  d. Logarithmically
  e. Parabolically

1.20. The decay constant (λ) of a radioactive substance is related to the half-life ($T_{1/2}$) as follows:
  a. $\lambda \sim T_{1/2}$
  b. **$\lambda \sim 1/T_{1/2}$**
  c. $\lambda \sim (T_{1/2})^2$
  d. $\lambda \sim (T_{1/2})^{1/2}$
  e. $\lambda \sim 1/(T_{1/2})^2$

1.21. The mean life of a radioactive substance (T_a) is related to the half life($T_{1/2}$) as follows:
  a. $T_a = T_{1/2}$
  b. $T_a = 1/T_{1/2}$
  c. $T_a = 0.693 \text{ X } T_{1/2}$
  d. $T_a = 0.693/T_{1/2}$
  e. **$T_a = 1.44 * T_{1/2}$**

1.22. A radioactive nucleus decays by alpha decay. Upon such a decay, its atomic number (Z) and atomic weight change as follows:
  a. Z decreases by 2 and A increases by 1
  b. Z decreases by 2 and A decreases by 2
  c. Z decreases by 4 and A increases 4
  d. **Z decreases by 2 and A decreases by 4**
  e. Z decreases by 4 and A increases by 2

1.23. In beta decay, the following is emitted:
  a. **Electrons with a range of energies**
  b. Electrons with a well defined energy
  c. Positrons with a range of energies
  d. Positrons with a well-defined energy
  e. Both, electrons and positrons with a well defined energy

1.24. Nuclei with the same atomic number and atomic weight, but different energy states, are called:
  a. Isotopes
  b. **Isomers**
  c. Isotones
  d. Isobars
  e. No special term is needed since they are the same nucleus

1.25. Nuclear fission, normally, refers to the process of:
a. Collision of heavy nuclei with each other in a cyclotron resulting in even heavier nuclei
b. Collision of relatively light nuclei in a cyclotron resulting in heavy nuclei.
c. Disintegration of a relatively light nucleus
d. **Disintegration of a relatively heavy nucleus**
e. All of the above.

1.26. A nucleus A, is bombarded by a particle a, resulting in nucleus B and particle b. The reaction is represented as follows:
a. A(a,B)b
b. a(A,b)B
c. B(a,b)A
d. a(A,B)b
e. **A(a,b)B**

1.27. Secular equilibrium refers to the situation where:
a. **The parent nucleus has a considerably longer half life than the daughter product**
b. The parent nucleus has a similar half life to that of the daughter product
c. The parent nucleus has a somewhat shorter half life than that of the daughter product
d. The parent nucleus has a considerably shorter half life than that of the daughter product
e. The parent nucleus has a half life that is exactly the same as that of the daughter nucleus.

1.28. Transient equilibrium refers to the situation where:
a. The daughter nucleus has a considerably longer half life than the parent nucleus
b. The daughter nucleus has a similar half life to that of the parent nucleus
c. **The daughter nucleus has a somewhat shorter half life than that of the parent nucleus**
d. The daughter nucleus has a considerably shorter half life than that of the parent nucleus
e. The daughter nucleus has a half life that is exactly the same as that of the parent nucleus

1.29. Positron emission is most likely to occur in nuclei which have:
a. More neutrons than protons
b. Equal number of neutrons and protons
c. Less electrons than protons
d. **More protons than neutrons**
e. Less electrons than neutrons

1.30. Most radioactive isotopes used in radiation oncology are produced in a nuclear reactor from parent nuclei that are bombarded with neutrons. Because of this, the primary decay process of these radioactive isotopes is
a. alpha decay
b. **beta decay**
c. positron emission
d. electron capture

1.31. When a K-shell electron is ejected from an atom, all of the following occur except
a. an Auger electron is emitted
b. a characteristic x-ray is emitted
c. an outer shell electron drops into the K-shell vacancy
d. **a positron is emitted**

1.32. The mass of a ^{12}C nucleus is 12.00000 amu, while the combined masses of the 6 protons and 6 neutrons that make up the nucleus is 12.09558 amu. Account for the discrepancy in masses.
a. The excess mass appears in the form of neutrinos.
b. **The excess mass is converted into binding energy of the nucleus.**
c. The excess mass is emitted in the form of gamma rays.
d. The excess mass is used to eject an inner-shell electron from the nucleus.

1.33. ^{125}I and ^{131}I are
a. isobars
b. isomers
c. isotones
d. **isotopes**

1.34. The energy of the therapeutic photon produced by the radioactive decay of 125I is significantly lower than the photon energies from other brachytherapy sources. This is because 125I decays via
a. alpha decay
b. beta decay
c. positron emission
d. **electron capture**

2 - Therapy-Production of Photons & Electrons

2.1. Which of the following is TRUE about the Bremsstrahlung process:
a. It involves a collision of a proton and a neutron
b. It refers to radiation emission accompanying electron-positron pair creation
c. It refers to radiation emission accompanying electron-positron pair annihilation
d. **It is the result of radiative interaction between a high speed electron and a nucleus**

2.2. Which of the following is **TRUE** about Bremsstrahlung process:
a. **A continuous spectrum of x-rays is emitted**
b. Monoenergetic x-rays are emitted
c. A continuous spectrum of γ-rays is emitted
d. Monoenergetic γ –rays are emitted
e. The process is 99% efficient

2.3. Emission of characteristic x-rays is associated with:
a. **Atomic transitions**
b. Nuclear reactions
c. Normally happens in a nuclear reactor
d. Neutron-proton collision
e. Pair production

2.4. Which of the following is **TRUE** about characteristic x-rays:
a. A continuous spectrum of x-rays is emitted
b. **Monoenergetic x-rays are emitted**
c. A continuous spectrum of γ-rays is emitted
d. Monoenergetic γ –rays are emitted
e. It occurs when an electron in an outer shell is ejected from its orbital.

2.5. Characteristic x-rays are mostly used in:
a. Radiation therapy
b. Diagnostic imaging excluding mammography
c. Both, radiation therapy and diagnostic imaging
d. **They are not useful in either application**
e. They are only useful sometimes

2.6. The most likely element used as a target material in a diagnostic x-ray tube is:
a. Copper
b. Stainless steel
c. **Tungsten**
d. Gold
e. Lead

2.7. A typical dimension for the apparent focal spot size in a diagnostic x-ray tube is:

a. 0.1 mm
b. **1 mm**
c. 5 mm
d. 10 mm
e. 20 mm

2.8. The purpose of added filtration is to:
a. **Remove low energy x-rays**
b. Remove characteristic x-rays
c. Remove high energy x-rays
d. Reduce the x-ray output of the machine
e. Reduce scatter

2.9. The Thoraeus filter is made out of:
a. Lead + Copper + Tin
b. Copper + Aluminum + Lead
c. Tin + Copper + Lead
d. **Aluminum + Copper + Tin**
e. Tin + Aluminum + Lead

2.10. Cs-137 is generally **NOT** suitable for external beam radiation therapy because:
a. It has low specific activity
b. Its half-life is not long enough
c. **The emitted gamma ray energy is too low**
d. Its exposure rate constant is too low
e. It emits toxic fumes

2.11. Co-60 is produced using the following method:
a. Bombardment of ^{60}Ni with a beam of gamma rays in a ^{60}Ni(γ,p)^{60}Co reaction
b. Electron capture reaction by bombardment of ^{60}Ni with a beam of electrons in an electron linear accelerator beam
c. It is a naturally occurring isotope of cobalt which is mined and purified from the ore by chemical methods
d. It is a by-product of the enriched uranium fission process in a nuclear reactor
e. **Bombardment of naturally occurring ^{59}Co with neutrons in a nuclear reactor through the 59Co(n,γ) ^{60}Co reaction**

2.12. The ^{60}Co isotope decays to the following:
a. **An excited state of ^{60}Ni by beta decay**
b. An excited state of ^{60}Ni by gamma decay
c. Ground state of ^{60}Ni by beta decay
d. Ground state of ^{60}Ni by gamma decay
e. Ground state of ^{60}Ni by electron capture

2.13. A ^{60}Co source employed in a teletherapy machine emits:
a. a gamma ray of energy 1.25 MeV

b. Two gamma rays of average energy 1.25 MeV
c. A gamma ray of energy 1.17 MeV
d. A gamma ray of energy 1.33 MeV
e. **Two gamma rays of 1.2 MeV and 1.3 MeV**

2.14. The half life of ^{60}Co is:
a. 5 years
b. 5.3 years
c. 5.2 years
d. **5.26 years**
e. 5.21 years

2.15. The source of electrons in a linear accelerator is:
a. The wave guide
b. **The electron gun**
c. The klystron
d. The bending magnet
e. The Thyratron

2.16. To obtain a high x-ray yield, the x-ray target material in a linear accelerator is made out of:
a. A metallic alloy
b. Stainless steel
c. Low Z metal
d. Intermediate Z metal
e. **High Z metal**

2.17. In a linear accelerator, x-rays are generated primarily via the following process:
a. Characteristic x-ray emission
b. **Bremsstrahlung**
c. Compton effect
d. Photoelectric effect
e. Pair production

2.18. Which statement is **NOT** true about magnetrons:
a. It produces microwaves
b. It is a high power oscillator
c. It has a central cathode and an outer cylindrical anode
d. **It generates pulses of several seconds duration**
e. Magnetrons operate at 2–5 MW peak power

2.19. Which of the following statements is **<u>TRUE</u>** about klystrons:

a. **It is not a microwave generator**
b. It is used as the power source in most low energy linear accelerators
c. It is less expensive than a magnetron
d. It needs to be changed annually as part of the annual preventative maintenance on the linear accelerator
e. It is one of the components of the beam transport system of a linear accelerator

2.20. As the energy of the electron beam in the waveguide is increased, the magnetic field of the bending magnet required to bend the electron beam needs to be:

a. Decreased
b. **Increased**
c. Kept at a constant value
d. Depends on the type of linear accelerator
e. None of the above

3 - Therapy-Radiation Interactions Questions

3.1. Photon beam intensity follows the inverse square law because

a. the force is inversely proportional to the square of the distance from the source.
b. the further away from the source the lower the beam intensity.
c. the number of photons attenuated is directly proportional to the number of photons incident on the absorber.
d. **the total number of photons passing through a sphere at any distance from the source must remain constant.**

3.2. Beam hardening occurs for beams from a linear accelerator because

a. Compton scatter is the predominant interaction in the megavoltage therapy energy range.
b. **low-energy photons are attenuated more than high-energy photons.**
c. photon scatter decreases the degree of attenuation.
d. the flattening filter decreases the average energy of the x-ray beam.

3.3. All the following explain why image quality for portal images is so much poorer than image quality for simulator images <u>except</u>

a. attenuation of the therapeutic photon beam is related to the density of the absorber while attenuation of the simulator photon beam is related to the atomic number of the absorber.
b. **more scattered photons are produced when the therapeutic photon beam interacts with the absorber than when the simulator photon beam interacts with the absorber.**
c. patient motion has a greater effect on the portal image because of the longer exposure times.
d. the radiation source on the therapy machine is larger than the radiation source on the simulator.

3.4. Compton scatter is the principal interaction in soft tissue in the range of energies from

a. 1 keV to 100 keV
b. **30 keV to 30 MeV**
c. 3 MeV to 300 MeV
d. 10 MeV to 1000 MeV

3.5. Photodisintegration is an important process in radiation oncology because

a. ejected nuclear fragments can damage sensitive dosimetry equipment.
b. many side effects of radiation are caused by the production of neutrons.
c. most interactions of photon with patients are via photodisintegration.
d. **neutrons may be produced in the head of a linear accelerator operating at energies greater than 10 MeV.**

4 - Therapy-Treatment Machines and Generators; Simulators

4.1. How many curies of cobalt-60 are in a typical teletherapy unit?

a. 6 Curies
b. **6 kiloCuries**
c. 6 MegaCuries
d. 1 kiloCurie

4.2. Cobalt-60 is preferred over radium-226 as a teletherapy source because it:

a. has a shorter half-life
b. has a higher average energy
c. **has a higher specific activity**
d. is easier to shield

4.3. Which of the following statements about a racetrack microtron is not true?
a. it uses the same magnetron as a linac
b. it has a smaller energy spread than a linac
c. it has a shorter length than a linac
d. **it requires larger bending magnets than a linac**

4.4. Quality assurance procedures for conventional simulators should be done:
a. less often than for linear accelerators
b. **the same as for linear accelerators**
c. more often than for linear accelerators
d. the same as a CT scanner

4.5. Both traveling wave and standing wave accelerators are used in clinical linear accelerators. More standing wave accelerators are used currently because:
a. the energy spread is smaller
b. the power requirements are less
c. **the length is shorter**
d. they are more reliable

4.6. The collimator jaw readouts should be calibrated by:
a. rotating the collimator assembly through its range of motion and verifying that the shadow of the cross-hairs remain fixed.
b. comparing with the light field profile projected onto a piece of graph paper or ruler
c. **comparing with the x ray dose profile measured with an ion chamber in a water tank**
d. producing a star shot using x ray sensitive film

4.7. The leakage through a standard linac jaw as measured in the isocenter plane is mandated by most states as being:
a. less than 0.01% of the open field dose
b. **less than 0.1% of the open field dose**
c. less than 1% of the open field dose
d. less than 2% of the open field dose

4.8. The x ray number spectrum produced from a typical megavoltage linear accelerator:
a. has a relatively constant number of photons for all energies up to the electron energy.
b. is peaked near the electron energy.
c. is peaked at half the electron energy.
d. **is weighted towards lower photon energies.**

5 - Therapy-Radiation Beam Quality and Dose

5.1. Air Kerma strength is expressed in:
a. C/kg
b. J/kg
c. **U**
d. Roentgen
e. R-cm2/mCi-hr

5.2. Kerma is expressed in ___
a. C/kg
b. **J/kg**
c. Gy
d. Sv
e. Rad
f. Roentgen

5.3. Dose Equivalent is expressed in the SI unit of ____
a. C/kg
b. Gy
c. **Sv**
d. Rad
e. Rem

5.4. Absorbed Dose is expressed in the SI unit of ____
a. C/kg
b. J/kg
c. **Gy**
d. Sv
e. Rad
f. Roentgen

5.5. The exposure rate constant is expressed in _____
a. C/kg
b. J/kg
c. U
d. Roentgen
e. **R-cm2/mCi-hr**

6 - Therapy- Radiation Measurement and Calibration

6.1. According to TG 51 AAPM calibration protocol a cobalt teletherapy machine should be calibrated_________?

a. in air
b. in plastic
c. in water at d_{max}
d. **in water at 5 cm deep.**

6.2. The most common device used to measure the absolute dose from a linear accelerator is_______.

6.3. **Ionization chamber**
6.4. Extrapolation chamber
6.5. TLD
6.6. Proportional counter

7 - Therapy-Photons

7.1. As the distance from the surface of the patient to the source increases, the tissue-air ratio

a. increases
b. decreases
c. **remains the same**

7.2. Which of the following best describes the dose distribution of a 10 x 10 cm 6 MV photon beam?

a. **surface dose near 30%; d_{max} near 1.5 cm; dose at 10 cm around 67%**
b. surface dose near 30%; d_{max} near 3.0 cm; dose at 10 cm around 77%
c. surface dose near 90%; d_{max} near 0.5 cm; dose at 10 cm around 55%
d. surface dose near 90%; d_{max} near 1.5 cm; dose at 10 cm around 77%

7.3. All the following are applications of full field wedges <u>except:</u>

a. a pair of fields with a 90° hinge angle
b. combining an AP field with two lateral fields
c. compensating for oblique incidence
d. **matching a field junction between two adjacent PA fields**

7.4. If a 6 MV beam is calibrated to deliver 1 cGy/MU at d_{max} at an SSD of 100 cm, the dose rate at isocenter is

a. 0.942 cGy/MU
b. 0.971 cGy/MU
c. **1.030 cGy/MU**
d. 1.061 cGy/MU

7.5. Which dose calculation algorithm is likely to be the most accurate in calculating dose in the lung near the chest wall?
   a. Bentley-Milan
   b. **Convolution/superposition**
   c. Effective SAR
   d. Scatter summation

8 - Therapy-Electrons

8.1. The percent depth dose at 10 cm for an 18 MeV electron beam is approximately
   a. **5%**
   b. 55%
   c. 67%
   d. 77%

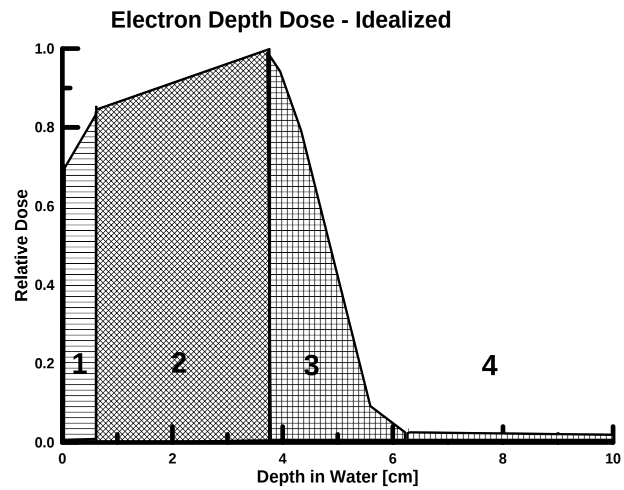
8.2. An advantage of using electrons over photons is that electrons
   a. are more easily produced than photons.
   b. deliver a lower dose to the skin surface than photons.
   c. **deposit a uniform dose to a finite depth.**
   d. penetrate more deeply than photons.

8.3. According to TG-25, electron dose prescriptions should not be based on dose to the point on central axis where the dose is maximum because
   a. electron depth doses are highly dependent on the size and shape of the radiation field
   b. **surface irregularities can cause this point to be in a region of high dose gradient**
   c. the electron output of a linear accelerator can fluctuate from treatment to treatment
   d. there is wide variety in the energy spectrum of an electron beam among various linear accelerators

8.4. A chest wall reaches a maximum depth of 3 cm. What electron energy would be the best to irradiate this chest wall?
   a. 2 MeV
   b. 6 MeV
   c. **10 MeV**
   d. 18 MeV
   e. 25 MeV

8.5. You are treating a superficial facial tumor with 6 MeV electrons and you wish to design a lead shield to protect the region outside the treatment field. What would be a reasonable thickness of lead shielding to use?
a. 1 mm
b. **5 mm**
c. 1 cm
d. 3 cm
e. 5 cm

The graph to the right is an idealized depth dose curve for a clinical electron beam. Use this curve to answer the following questions.



8.6. Region 2 of the idealized electron beam depth dose curve is primarily due to what process?
a. buildup of secondary electron fluence
b. buildup of secondary photon fluence
c. electron range straggling
d. **increasing obliquity of primary electrons**

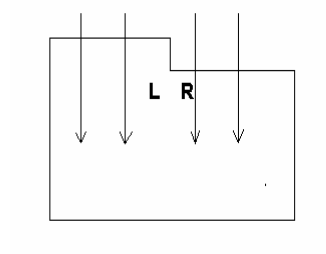
8.7. As the field size increases, region 2 of the idealized electron beam depth dose curve:
a. remains the same
b. **increases in height**
c. decreases in height
d. disappears

8.8. If 80% of the prescribed dose is to be delivered to the distal side of a tumor at a depth of 5 cm with a field size of 11 cm x 11 cm, what energy should be prescribed?
a. 5 MeV
b. 10 MeV
c. **15 MeV**
d. 25 MeV

8.9. Which of the following is not an advantage of a scanned electron beam?
a. lower skin dose
b. lower x ray contamination
c. greater 90-10% distal gradient
d. **faster dosimetry measurements**

8.10. Lead shielding for electrons is typically ordered from a vendor in inches rather than millimeters. What thickness of lead is just sufficient to stop 13 MeV electrons?
a. 1/8"
b. 3/16"
c. **1/4"**
d. 3/8"

8.11. Below the edge of a stepped phantom with an incident electron beam there will be a:
a. uniform profile but increased penetration on the right side
b. increased penumbra at the edges of the beam
c. local overdose on the left side and local underdose on the right side
d. **local underdose on the left side and local overdose on the right side**



9 - Therapy- External Beam Quality Assurance

9.1. The objective of quality assurance is to
a. Ensure dose delivery to within 5% of the prescribed dose
b. Ensure dose delivery exactly as the prescribed dose delivery
c. Ensure dose delivery to within 10% of the prescribed dose
d. Ensure dose delivery to within 1% of the prescribed dose.

9.2. AAPM Task group 21 is
a. Protocol for Performing patient setup
b. Protocol to measure dose in electron beam
c. Protocol to measure dose in photon beam
d. Protocol to measure dose in Proton beam

9.3. Machine output and laser accuracy should be checked
a. Weekly /Daily
b. Yearly
c. Every six months
d. Only when the machine breaks down

9.4. A qualified Medical Physicist should
a. Develop requirements and specifications for the purchase of appropriate equipment
b. Plan the facilities to house the accelerator
c. Commission the machine for clinical use
d. Implement and monitor a quality assurance program for patient safety and accuracy of dose delivery
e. Establish procedure for monitor unit calculations for the accelerator
f. All of the above
g. None of the above

9.5. The purpose of an acceptance procedure is to:
a. Just sign off the delivery of the equipment
b. Verify the specifications set in the tender document by measurements
c. Should be performed after commissioning the Linac
d. Acceptance procedure is performed at the factory

9.6. Radiation isocenter of gantry should be contained within a
a. 3 mm diameter sphere
b. 1 cm diameter sphere
c. 5 mm diameter sphere
d. 2 mm diameter sphere

9.7. Build up dose measurements for photon beams are performed with a
a. Diode
b. 0.6 cc calibrated farmer chamber
c. Diamond detector
d. Parallel plate chamber

9.8. The major difference between TG51 and TG 21 protocol is
a. Measured at 22°C as against 25°C
b. Absorbed dose as against exposure calibration
c. Solid water phantom as against water phantom
d. Measured with parallel plate chamber as against Farmer chamber

9.9. The light radiation field coincidence should be within $\pm$_____ .
a. 2 mm
b. 0.1 mm
c. 5 mm
d. 0 mm

9.10. Electron beam energy is specified in terms of
  a. Central axis dose at the depth of 10 cm for a 10x10 Field
  b. TPR ratio between 10 and 20 cm depths
  c. 80% and 50% depth ionization distal to d_{max} for 10x10 field
  d. d_{max} depth

9.11. Photon beam energy is specified in terms of
  a. Percent dose at depth of 10 cm or depth of d_{max} for 10 x 10 field
  b. Dose at the surface for 10 x10 cm field
  c. TPR at 20 cm depth for 10x10 field
  d. TPR ratio between 5 and 10 cm depths

9.12. Typical transmission through block for a 6MV photon beam is
  a. ~ 3.5 %
  b. ~10 %
  c. ~0.1 %
  d. ~1 %

9.13. Typical block tray distance from isocenter is
  a. 50 cm
  b. 70 cm
  c. 25 cm
  d. 10 cm

9.14. Typical wedge factor for 45 degree wedge in a 6 MV photon for a 10 x 10 field is
  a. 0.5
  b. 0.2
  c. 0.8
  d. 0.15

9.15. The tolerance for daily output constancy check of the Linac QA is
  a. 1%
  b. 3%
  c. 5%
  d. 10%

10 - Therapy- Radiation Protection and Shielding

10.1. After a patient who has received a permanent seed implant is removed from an operating room, it is discovered that one or more ^{125}I seeds are missing. Which of the following is the first course of action to be taken?
  a. Scan the room using a calibrated ion-chamber survey meter.
  b. Report the missing seeds to the regulatory agency.
  c. **Secure the room and hold all items in the room.**
  d. Check the CT scans of the patient.

10.2. Which type of instrument and method would be optimal for locating any missing seeds in the operating room?
   a. Perform a wide scan of the room using a Geiger-Muller probe and then specifically locate seeds using a scintillation probe.
   b. Perform a wide scan using a calibrated ion-chamber survey meter and then locate the seeds using a Geiger-Muller probe.
   c. Perform a wide scan of the room using a Geiger-Muller probe and then take readings with a calibrated ion-chamber survey meter.
   d. **Perform a wide scan of the room using a scintillation probe and then specifically locate seeds using a Geiger-Muller probe.**

10.3. A patient treated with a prostate implant of ^{103}Pd seeds is to be discharged. Which of the following does NOT need to be discussed with the patient?
   a. Possibility of loss of seeds within first 48 hours.
   b. **Presence of pregnant family members in the same room.**
   c. Sleeping arrangements.
   d. Holding children.

10.4. You receive a report from the personnel monitoring service that the EDE reading for the waist badge of an interventional radiologist is 700 mrem. The EDE reading for the collar badge is 40 mrem. What is the most probable explanation for this difference?
   a. The supplier has applied the wrong algorithm.
   b. **The badges have been worn in the wrong locations.**
   c. The monitors have been accidentally exposed.
   d. The waist monitor was dropped in the x-ray room.

11 - Therapy-Imaging for Radiation Oncology

11.1. Which of the following ready-pack films has the maximal dose response range?
   a. PPT
   b. XTL
   c. XV2
   d. **EDR2**

11.2. Which of the following film-based imaging systems is not typically used in the radiation oncology department?
   a. Lanex regular cassette/simulation film
   b. **Min-R 2000 film/screen system**
   c. X-Omat V film/cassette system
   d. EC-L film and cassette system

11.3. When gold seeds are implanted in the prostate, treatment localization for the prostate could be better-achieved using ________
  a. An electronic portal imager
  b. Ultrasound imaging
  c. **MRI imaging**
  d. Infrared cameras

11.4. Ultrasound could be used to image
  a. Brain
  b. Lung
  c. **Prostate**
  d. Vertebral body

11.5. Which type of following images is the best for defining the CTV of GBM brain tumor?
  a. CT
  b. Ultrasound images
  c. Angiograms
  d. **T1-weighted MR images**
  e. T2-weighted MR images

11.6. Why is image fusion of CT and MRI commonly used?
  a. Automated imaging fusion method is available
  b. **CT provides better geometric information and MRI provides better tumor information**
  c. MRI provides better geometric information and CT provides better tumor information
  d. Tumors in CT and MRI have the same radiographic appearances

11.7. What kind of contrast agent is typically used in MRI imaging?
  a. **Gadolinium**
  b. Iodine
  c. Carbon dioxide
  d. Barium

11.8. What physics property influences CT imaging contrast the most?
  a. **Atomic number**
  b. Activity
  c. Velocity
  d. Proton density
  e. Physical density

11.9. What is the most suitable word to describe principle of PET imaging?
- a. **Annihilation**
- b. Relaxation
- c. Attenuation
- d. Emission

11.10. What of the following imaging devices may not be used for monitoring internal organ motion in the radiation treatment room?
- a. Electronic portal imager
- b. KV x-ray tube
- c. Infrared cameras
- d. Ultrasound
- e. **MRI**
- f. PET/SPECT

12 - Therapy-3D CRT

12.1. The volume that contains microscopic, as well as demonstrable, disease is the
- a. Gross tumor volume
- b. **Clinical target volume**
- c. Internal target volume
- d. Planning target volume

12.2. In designing a treatment portal around a clinical target volume of a lung tumor, you must account for all of the following except:
- a. Beam penumbra
- b. **Microscopic disease**
- c. Respiratory motion
- d. Setup uncertainty

12.3. Which of the following would be most useful in evaluation of a treatment plan?
- a. **DVH**
- b. ICRU
- c. PRV
- d. TG-51

12.4. What is an MLC most likely used to replace?
- a. Alpha cradle
- b. **Customized blocks**
- c. EPID
- d. stereotactic frame

12.5. Which component of the treatment planning process is least likely to be improved by higher-speed processors?
a. Beam weight optimization
b. Contour delineation
c. Dose calculation
d. DRR generation

13 - Therapy-Assessment of Patient Setup and Treatment

13.1. Stereotactic radiosurgery treatment requires positional accuracy of
a. ~ 1mm
b. ~ 5 mm
c. ~ 10 mm
d. positional accuracy is not required

13.2. The objective of immobilization is
a. To prevent motion after localization and during treatment.
b. To visualize the critical structure better in the CT imaging
c. To ensure fast patient setup
d. To achieve skin sparing

13.3. What is the most accurate method of patient setup verification
a. Laser + tattoo marks
b. Orthogonal portal imaging compared with DRR images
c. Measuring tabletop heights and SSD measurements.
d. Implanted fiducial markers verified in orthogonal portal images

13.4. What is the common method of immobilizing the patient in treating Head and Neck cancer
a. Stereotactic frames bolted on to the skull
b. Custom molded masks
c. Byte bloc frame
d. Vac-Loc bag

13.5. Cone-beam CT is
a. CT, whose shape looks like cone hence the name cone-beam CT
b. CT which has a conical detector
c. A number of radiographic projections in 0-360° used to reconstruct the CT
d. A fast image acquisition CT capable imaging in real time

13.6. Ultrasound guided patient set up is popularly used in
   a. Head and neck region
   b. Thoracic region
   c. Pelvic region
   d. Cardiac gated radiotherapy

13.7. On-line correction of setup errors has a potential
   a. To improve patient setup accuracy
   b. To perform fast and efficient patient setup
   c. Eliminate need for immobilization
   d. Can visualize internal structures better

13.8. Cone-beam CT image reconstruction
   a. requires very large radiation doses
   b. has better spatial resolution than 2 dimension reconstruction
   c. is commonly used for virtual simulation
   d. Can be used for real time tracking of organ motion

13.9. Adaptive planning concept is to:
   a. Modify the plan based on patient setup
   b. Treat primary target and secondary target volume simultaneously to reduce the number of fractions
   c. Treatment plan based on ONLY MR images
   d. Produce one single standardized plan applicable to a large number of patients

13.10. Electronic portal imaging is commonly used to
   a. Perform routine quality assurance of linear accelerator
   b. To perform linear accelerator output calibration
   c. Radiographic images of the patient in the treatment position
   d. Used for treatment planning when CT scan is not used

13.11. The patient setup accuracy that can be commonly achieved using lasers and tattoos is
   a. 0.5 mm
   b. 5 mm
   c. 1 mm
   d. 3 cm

13.12. The setup errors comprised of
   a. Patient motion
   b. Random errors
   c. Systematic errors
   d. All of the above

13.13. The custom mold VACLOC bag
 a. Reduces skin dose
 b. Increases penetration of the photon beam
 c. Reduces skin sparing
 d. Produces high quality images

13.14. The position of prostate can be evaluated better by using
 a. Implanted gold seeds + Portal Imaging
 b. Cone beam CT with bony anatomy matching
 c. Optical guidance system
 d. Orthogonal images using amorphous silicon imager

13.15. The optical patient positioning device is based on
 a. Surface anatomy
 b. Internal anatomy
 c. Laser system
 d. Bony land marks

14 - Therapy-IMRT

14.1. IMRT treatment can be delivered by
 a. Custom molded 3D compensator
 b. Using MLC leaves
 c. Using tomotherapy
 d. All of the above
 e. None of the above

14.2. In dynamic MLC delivery, the intensity modulation is achieved by
 a. Varying the dose rate and MLC gap width
 b. Varying the MLC speed
 c. Changing dose per pulse and MLC gap width
 d. Varying MLC gap and MLC speed

14.3. Helical Tomotherapy is
 a. an IMRT system
 b. Fan beam is continuously rotated around the patient
 c. The patient couch is translated through the bore of the gantry with simultaneous radiation delivery
 d. The Linac is placed in to the ring gantry of the CT scanner
 e. All of the above

14.4. Serial Tomotherapy is
  a. a high resolution CT scanner
  b. Image guided treatment delivery system
  c. Radiation treatment is delivered one slice at a time
  d. The radiation is continuously delivery, while the couch is simultaneously translated

14.5. The radiation beam intensity can be modulated by
  a. using blocks
  b. using wedges
  c. using MLC
  d. using Attenuators
  e. all of the above

14.6. Primary difference between IMRT and conformal treatment is
  a. IMRT uses more number of beams
  b. Modulate intensity
  c. IMRT conforms radiation delivery to the target while conformably avoiding critical structures
  d. IMRT requires planning system

14.7. Segmented MLC or step and shoot technique is
  a. Delivery of multiple static segments to modulate the intensity in a given field
  b. Use jaws to define segments
  c. Delivery of multiple static segments with simultaneous gantry rotation
  d. Requires MLC leaf width of 5mm or less

14.8. Tongue and groove effect in IMRT can result
  a. in significant difference between measured and delivered dose
  b. may occur under the region of overlap between two leaves of a multileaf collimator (MLC)
  c. usually not modelled well by inverse planning system
  d. all of the above

14.9. In order to deliver an IMRT accurately it is necessary to have
  a. good immobilization
  b. special imaging techniques
  c. always requires virtual simulation
  d. Special couch mounts

14.10. To plan an IMRT, generally requires to
  a. delineate more structures than normal conformal techniques
  b. delineate only critical structures
  c. delineate only targets to be treated
  d. Always requires MR to delineate the targets

14.11. Current inverse planning systems
- **a. require detailed constraints to achieve a good plan**
- b. does not require to input the constraints to achieve good plan
- c. requires detailed constraints for the targets to achieve good plan
- d. required extensive library of constraints to achieve good plan

14.12. Generally the IMRT plan can be verified by performing
- a. manual Monitor Unit calculation
- b. by point dose measurements of the treatment field in the phantom
- c. by using external software to calculate the monitor units
- d. **using b or c**
- e. using a and b and c

14.13. The general tolerance for IMRT plan verification by measurements is
- a. ± 1mm isodose and ± 1% dose
- b. ± 10mm isodose and 10% dose
- **c. ± 5mm isodose and ± 5% dose**
- d. ± 0.1 mm isodose and 1% dose

14.14. which MLC QA is not required for an IMRT enabled machine
- a. fence test
- b. speed test
- **c. leaf position test at extended SSD**
- d. leaf transmission

15 - Therapy-Special Procedures

15.1. Robotic linac is
- **a. A miniature linac uses image guidance system to deliver the radiation dose to the target**
- b. A mobile linac which produces high resolution MR images to track the target and deliver the radiation dose
- c. A miniature linac uses real time functional images to map the clinical extent of the target and adjusts the radiation dose using robotic arm
- d. All of the above

16 - Therapy-Brachytherapy

16.1. Simulation films are taken isocentrically at 100cm on a brachytherapy implant patient. The Cesium line sources are spaced 2 cm apart. The magnification factor is 1.45. How far apart do the line sources measure on the film?
   a. 1 cm
   b. 1.45 cm
   c. 2 cm
   d. **2.9 cm**
   e. 3 cm.

16.2. A radiation oncologist wishes to treat a prostate cancer patient using a radioactive implant. Which isotope is most likely to be used?
   a. **I-125**
   b. Cs-137
   c. Rn-222
   d. P-32

17 - Therapy-Hyperthermia

17.1. Hyperthermia is used in conjunction with radiation therapy in patients with large tumor masses that have large necrotic centers because:
   a. The periphery of the tumor is relative radioresistant and the center is thermosensitive.
   b. **The center of the tumor is relative radioresistant and the periphery is thermosensitive.**
   c. The periphery of the tumor is relative radioresistant and the whole tumor is thermosensitive.
   d. The whole tumor is relative radioresistant and the center is thermosensitive.

18 - Therapy-Particle Therapy

18.1. Which of the following is not used to accelerate protons to therapeutic energies?
   a. cyclotron
   b. synchrotron
   c. **betatron**
   d. linear accelerator

18.2. Which of the following is not used for range modulation with light ion beams?
   a. ridge filter
   b. propeller
   c. energy stacking
   d. **bolus**

18.3. Which particle has the highest LET at the Bragg peak?
a. hydrogen ion
b. helium ion
c. carbon ion
d. **neon ion**

18.4. Which particle has the largest differential RBE between the entrance and Bragg peak regions?
a. hydrogen ion
b. helium ion
c. **carbon ion**
d. neon ion

18.5. For most tumors, the accepted RBE for a low dose rate treatment with fast neutrons from a californium-252 brachytherapy source is:
a. 1.1
b. 3
c. **6**
d. 20

18.6. For most normal tissues, the accepted RBE for high dose rate treatment with high energy fast neutron beams is:
a. 1.1
b. **3**
c. 6
d. 20

18.7. The reason that thermal neutrons are preferred to fast neutrons for neutron capture with boron-10 is:
a. the range of the secondary helium and lithium ions is less keeping the dose confined to the tumor.
b. **the probability of capturing the neutron is higher.**
c. residual radioactivity adds to the tumor dose.
d. there is synergy between the radiation and heating effects.

19 - Therapy-Radiobiology

19.1. The indirect action of ionizing radiation is the
a. **creation of free radicals.**
b. production of scattered radiation.
c. excitation of a molecule by an electron.
d. systematic production of secondary electrons.
e. creation of different relative biological effects.

19.2. **Which statement is NOT TRUE regarding the photon irradiation of pure water**

a. **The H_2O group is most effective in causing biological damage.**
b. The principal products are · OH, H ·, e_{aq}, H_2 and H_2O_2.
c. Two prominent products are e_{aq} and · OH groups.
d. Excited water breaks into hydrogen radical, H · and hydroxyl radical, · OH.
e. Cell damage through radiolysis of water is considered an indirect action.

19.3. For the same incident energy, arrange the radiation type in order of increasing LET.

1-photon
2-electron
3-proton
4-alpha

a. **2, 1, 3, 4**
b. 1, 2, 4, 3
c. 2, 1, 4, 3
d. none of the above.

19.4. The "Law of Bergonie and Tribondeau" relates the radiosensitivity of tissue to

a. the oxygen content in cells.
b. **the cell differentiation.**
c. the fractionation dosage.
d. the types of radiation.
e. the radiosensitizers.

19.5. The sequence of the stages of mitosis is

a. telophase → anaphase → metaphase → prophase.
b. anaphase → telophase → metaphase → prophase.
c. metaphase → telophase → anaphase → prophase.
d. **prophase → metaphase → anaphase → telophase.**
e. prophase → anaphase → metaphase → telophase.

19.6. Interference of radiation with DNA synthesis may create the following effects EXCEPT

a. failure to commence DNA synthesis due to damage in the G_1 period.
b. interference with DNA synthesis in progress.
c. failure to initiate DNA synthesis due to blocking of preceding mitosis.
d. **causing cells to bypass selective phases of the cell cycle.**
e. none of the above.

19.7. Which statement is NOT true regarding cell-survival curves?
  a. The multi-target single-hit survival equation is derived from the Poisson distribution.
  b. α is the linear while β is the quadratic component of cell killing.
  c. D_o is the reciprocal of the slope of the cell-survival curve.
  d. **A shouldered survival curve is seen with high LET radiation.**
  e. β is zero for high LET radiation.

19.8. If the α/β ratio is 10 Gy and one delivers a dose of 2 Gy, most of the damage would be
  a. **lethal and irreparable.**
  b. lethal and reparable.
  c. sublethal and irreparable.
  d. sublethal and reparable.
  e. nonlethal.

19.9. Which statement is FALSE regarding survival time following single dose whole body irradiation?
  a. Between 2-10 Gy, it is dependent on the dose.
  b. It varies with the type of death.
  c. It varies widely from species to species.
  d. It is shorter for CNS death compared to bone marrow death.
  e. **It is independent of dose.**

19.10. Which statement is CORRECT regarding genetic mutations?
  a. **Spontaneous mutations occur with fixed frequencies.**
  b. The spontaneous mutation rate is the same for all genes.
  c. Mutations due to radiation are different from spontaneous mutations.
  d. Mutation rate may decrease with low doses of radiation.
  e. Radiation induced genetic effects were seen in atomic bomb survivors.

19.11. The risk of leukemia and other malignancies in children irradiated in utero with low exposure has been estimated to be
  a. the same as non-irradiated population.
  b. **1.5 times the non-irradiated population.**
  c. 3 times the non-irradiated population.
  d. 6 times the non-irradiated population.
  e. 9 times the non-irradiated population.

19.12. Regarding the cell cycle,
  a. **chromosome aberrations are the probable mechanism of reproductive death.**
  b. the most resistant phase of the cell-cycle is the late S-phase.
  c. the OER is dependent on the cell cycle.
  d. the cell cycle variation is greater for low LET than high LET radiation.
  e. the phases of the cell cycle after mitosis are G_1, S, and G_2.

19.13. Which of the following oxygen enhancement ratio statements is not true?

a. The OER for X-rays is approximately 2.5.
b. The OER for neutrons is approximately 1.5.
c. Oxygen is a dose modifying sensitizer.
d. **The oxygen diffusion distance in tissue is approximately 300 μm.**

19.14. During radiotherapy, a FALSE statement is

a. that fractionation improves differential tumor to normal tissue cell killing.
b. that the late effects are independent of overall treatment time.
c. that it would be advantageous to deliver total dose in a shorter overall time.
d. that it would be disadvantageous to deliver total dose in a longer overall time.
e. **that misonidazole serves as a radioprotector.**

19.15. Regarding oxygenation, which statement is NOT true?

a. Reoxygenation would make a hypoxic cell sensitizer seem less effective during fractionated radiotherapy.
b. Reoxygenation would make neutron fractionation seem less effective compared to X-rays.
c. **To take advantage of reoxygenation, one should use many small fractions in a short overall time.**
d. Hypoxia and reoxygenation are not important factors in understanding the response of normal tissues to fractionated radiotherapy.
e. Misonidazole has limited success because a sufficient dose cannot be infused into the patient.

19.16. The percent of surviving cells in an "average" experimental tumor that is radiobiologically hypoxic immediately after exposure to a dose of 10 Gy would be close to

a. 1%
b. 33%
c. 50%
d. 80%
e. **100%**