BME4500-INTRODUCTION TO NUCLEAR MEDICINE MIDTERM QUESTIONS

1. Explain the Alpha Scattering experiment.

Answer: Rutherford designed the Alpha Scattering experiment to find how electrons are designed in an atom. In the experiment alpha particles were bombarded on a metallic thin gold foil. These particles interacted with the gold foil. Experiment results:

- Most of the alpha particles undeflected through the gold foil and went straight.
- Some of the alpha particles deflected through a small angle.
- Some of the alpha particles deflected at a large angle.
- Very few alpha particles returned back. (back scattered)
- Since most alpha particles passed through the gold foil without any deflection, most of the space inside an atom is empty.

2. What are the properties of Alpha particles? Explain.

Answer:

- Alpha particles were the first nuclear radiation to be discovered
- Alpha particles are composite particles consisting of two protons and two neutrons tightly bound together.
- Alpha particles are relatively slow and heavy compared with other forms of nuclear radiation.
- The particles travel at 5 to 7 % of the speed of light and have a mass approximately equivalent to 4 protons.
- Alpha particles are highly ionising because of their double positive charge, large mass (compared to a beta particle) and they are relatively slow.
- Alpha particles, because they are highly ionising, are unable to penetrate very far through matter and are brought to rest by a few centimetres of air or less than a tenth of a millimetre of biological tissue.
- They can cause multiple ionisations within a very small distance. This gives them the potential to do much more biological damage for the same amount of deposited energy.

3. Alpha particles can go through paper.(T/**F**)

Answer: False

4. The unit of “equivalent dose” is Sievert. (**T**/F)

Answer: True

5. All the elements which their atomic numbers are greater than 84, are radioactive. (**T**/F)

Answer: True.

6. What is the difference between ionizing and non-ionizing radiation?

Answer: Ionizing radiation has more energy than non-ionizing radiation. Also ionizing radiation has the ability to penetrate matter and other types do not have this ability.

7. Radiation activity refers to the amount of radiation that a material is exposed to.(T/**F**)

Answer: False.

8. What does isotone mean? Give an example to the isotonic elements.

Answer: Elements with the same number of neutrons but different proton and mass numbers are called isotones. The physical and chemical properties of isotone elements are different from each other. Magnesium and sodium atoms are isotones of each other. The mass number of magnesium is 24 and it has a proton number 12. The mass number of sodium is 23 and it has a proton number 11. They both have neutron number 12. Therefore, magnesium and sodium are isotones of each other.

9. What is radiation? [Explanation]

Answer: Radiation is the release of energy in electromagnetic waves or particles. This energy can be low level or high level. Low-level energy is like microwaves and radiowaves. High-level energy is like X-rays or gamma rays. Radiation falls into two main categories. Ionizing and non-ionizing, depending on its energy and ability to penetrate matter.

10. What are unstable nuclei? Explain.

Answer: The balance of protons and neutrons in a nucleus that determines whether it is stable or unstable. The strong nuclear forces in unstable nuclei do not generate enough binding energy to keep the nucleus together permanently. Too many neutrons or protons disrupt this balance, causing the nucleus to become unstable by disrupting the binding energy from the strong nuclear forces. An unstable nucleus attempts to achieve a balanced state by emitting a neutron or proton through radioactive decay.

11. Elements which are rich in neutrons emit ...... [Gap-filling]

Answer: Beta minus (β^-)

12. Explain the formula for the Half Life using the Radiation Decay Law.

Answer: The law tells us that at any time t, $N_t = N_0 exp(-\lambda t)$ and the definition of half life tells us that, $N_t = \frac{N_0}{2}$ when $t = t_{\frac{1}{2}}$

We can therefore rewrite the Radioactive Decay Law by substituting by N_t and t as follows.

$$\frac{N_0}{2} = N_0 exp(-\lambda t_{\frac{1}{2}})$$

$$2^{-1} = exp(-\lambda t_{\frac{1}{2}})$$

$$ln2^{-1} = -\lambda t_{\frac{1}{2}}$$

$$ln2 = \lambda t_{\frac{1}{2}}$$

$$t_{\frac{1}{2}} = \frac{0.693}{\lambda}$$

$$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$$

Last two equations express the relationship between the Decay Constant and the Half Life. Therefore, the Half Life and the Radioactive Decay Law.

13. A radioactive isotope decayed to 17/32 of its original mass after 60 minutes. Find the half-life of this radioisotope. [Mathematical question]

Answer:

$$17/32 = 0.53125\ (this\ is\ the\ decimal\ amount\ that\ remains)$$

$$\left(\frac{1}{2}\right) n = 0.53125$$

$$nlog(0.5) = \log(0.53125)$$

$$n = 0.91254\ (this\ is\ how\ many\ half-lives\ have\ elapsed)$$

$$60\ min\ /\ 0.91254 = 65.75\ min$$

$$n = 66\ min\ (to\ two\ sig\ figs)$$

14. Write the effective dose formula.

Answer: Effective dose = Equivalent dose * tissue weighting factor

15. The unit of effective dose is the same as the unit of equivalent dose.(**T**/F)

Answer: True

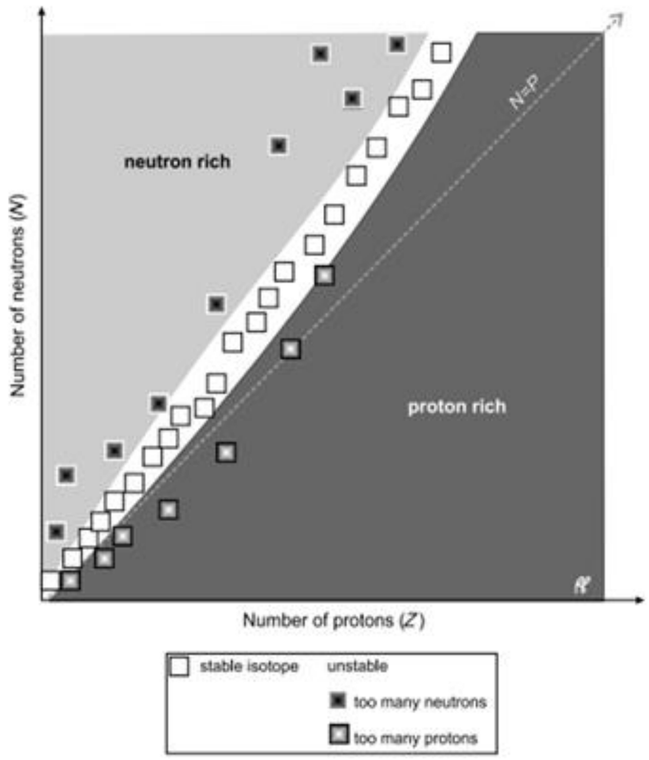
16. Write a short paragraph about the ISOTOPE nucleus. And mention one example.

Answer:

In nature, some nucleus have the same number of protons but different numbers of neutrons.These kinds of atoms are called isotopes.And for example : Hydrogen has three isotopes and they are called (hydrogen), (deuterium),and (tritium).All the three nucleus have one proton and (hydrogen has no neutron, deuterium has 1 neutron ,tritium has 2 neutrons)

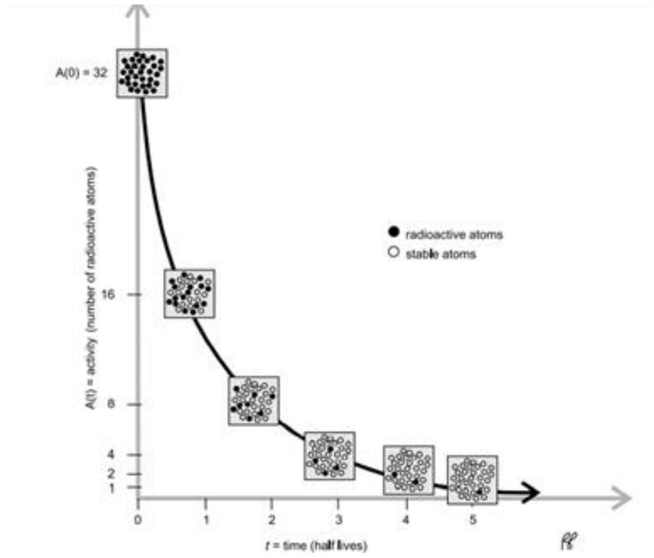
17. Draw the stability curve which shows the relation between the protons and neutron numbers. Label all of the proton rich, neutron rich and the stable area.

Answer:



18. Draw and explain the Decay Curve.

Answer: The decay curve shows the progressive replacement of the radioactive atoms by the stable atoms through the half-life time.



19. According to Bohr's atomic model, how do electrons revolve around the nucleus?

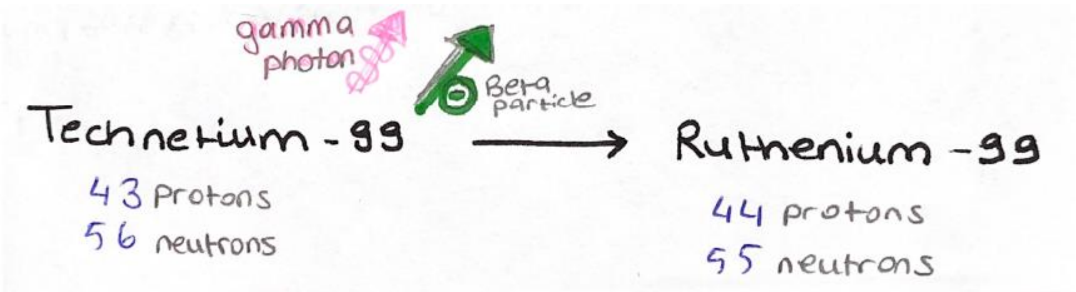
Answer: Electrons revolve around the nucleus regularly, not randomly. Electrons move in definite orbits around the nucleus like planets revolve around the sun.

20. What does Ionizing radiation mean?

Answer: Ionizing radiation is a type of electromagnetic radiation that has enough energy to remove bound electrons, cousin atoms to become ionized.

21. Draw the Technetium decay image.

Answer:



22. What is the mass number?

Answer: The mass number is the total number of neutrons and protons in the nucleus. The mass number is denoted as A.

A = protons + neutrons

23. Strong nuclear force only occurs between the protons. (T / **F**)

Answer: False

24. Draw the decay scheme according to the information given below:

This isotope can decay through three beta-minus processes.

- The first process occurs in 1.6% of disintegration, I-123 decays via beta- minus emission then, it decays via gamma-ray emission.
- The second process occurs in 6.9% disintegration, I-123 decays via beta- minus emission then, it decays via gamma-ray emission.
- The last opportunity occurs in 90.4% disintegration, I-123 decays via beta- minus emission then, it decays via gamma-ray emission.

Answer:

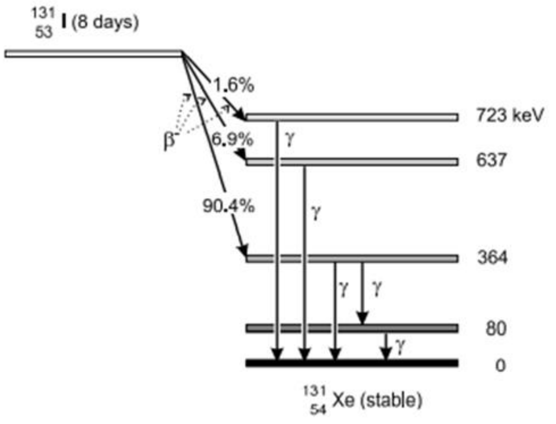


Figure 1-24 Decay schemes showing principal transitions for technetium-99m, indium-111, iodine-131. Energy levels are rounded to three significant figures.

25. Gray x Radiation Weighting Factor = rem (T / **F)**

Answer: False

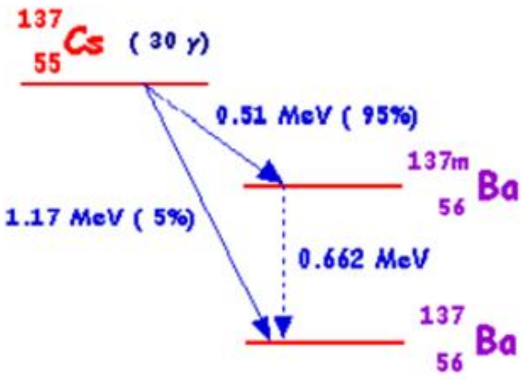
26. What is nucleon?

Answer: Protons and neutrons both are called nucleons.

27. What is the strong nuclear force? Explain.

Answer: The Strong Nuclear Force is an attractive force between protons and neutrons that keep the nucleus together. To hold positively charged protons together in the very small volume of a nucleus requires very strong attractive forces because the positively charged protons repel one another strongly at such short distances. The force of attraction that holds the nucleus together is the strong nuclear force. This force acts between protons, between neutrons, and between protons and neutrons. This force is attractive over short distances.

28. Answer given true-false sentences in a and b according to the given figure.



28a. The cesium isotope shown in the figure decays by emitting 1.17MeV beta-minus with a 5% probability. (**T**/F) Answer: True

28b. The cesium isotope shown in the figure becomes stable by emitting 0.662 MeV gamma radiation after making beta-minus of 0.51MeV with a 95% probability.(**T**/F) Answer: True

29. The radiation weighting factor of electrons and positrons is equal to one. (**T**/F)

Answer: True

30. What is the key difference between x-ray and gamma-ray?

Answer: The key difference between gamma rays and X-rays is how they are produced. Gamma radiation is produced in the nucleus. X-rays are produced outside of the nucleus by electrons. In addition, the energies of gamma-rays are generally higher than the energies of x-rays.

31. Write the β^{-}decay equation and give an example.

Answer:

$$ {}^{2n+2}_{n}X_{n+2} --\rightarrow {}^{2n+2}_{n+2}Y_{n+1} + B^{-} $$

$$ {}^{32}_{15}P_{17} --\rightarrow {}^{32}_{17}S_{16} + B^{-} $$

32. In nuclear medicine, Becquerel level radiation is used. (T/**F**)

Answer: False, Because Becquerel level is very small. It will be insufficient.

33. What are the types of ionizing particles?

Answer: Alpha particles, Beta particles, Gamma rays and X-ray.

34. Only atoms with atomic number 84 or more are radioactive. (T/**F**)

Answer: False, for example we have the element Carbon-14 (^{14}C) it has an atomic number 14 which is less than 84 and its radioactive.

35. What are the unit measures for radiation activity?

Answer: There are 2 different units of radiation activity, one of them is Curie, the traditional unit and the other is Becquerel, the unit in the international system.

36. What does Isobar mean? Give an example to Isobar atoms.

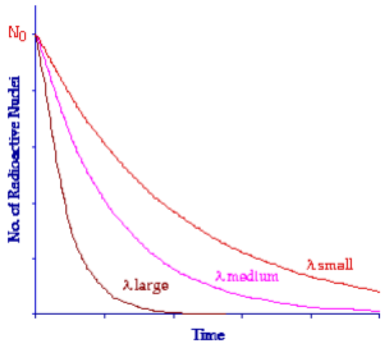
Answer: Isobars are the atoms of different elements having the same mass number A, but different atomic number Z. Isobars are the atoms of different chemical elements which have the same number of nucleon. 40-S, 40-Cl, Ar-40, K-40 and Ca-40 have the same mass number and different atomic number. Isobars are chemically different elements.

37. What is Stable Nuclei?

Answer: Stable nuclides are nuclides that are not radioactive and so (unlike radionuclides) do not spontaneously undergo radioactive decay. Many nuclei in nature are very stable, most of the nuclei formed at the creation of the universe or after supernovae explosions many millions of years ago are still in existence now. The graph is a plot of neutron number against proton number. It is used as a rule to determine which nuclei are stable or unstable. Nuclei which lie on the stability line are stable nuclei.

38. How does the decay curve change when the decay constant increases or decreases?

Answer: When the Decay Constant has a low value the curve decreases relatively slowly and when the Decay Constant is large the curve decreases very quickly.



39. The effective dose is different in each organ because it is calculated by tissue weight factor. (**T**/F)

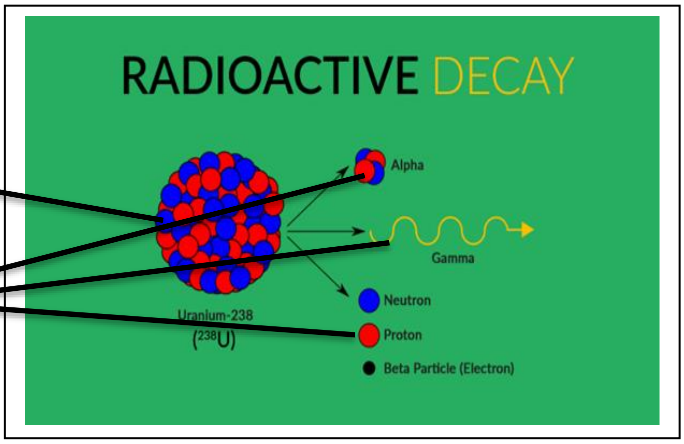
Answer: True

40. What is the difference between radioactivity and radiation? Explain via drawing.

Answer:

Radioactive materials are materials that emit radiation.

Radiation is the energy or particles that are released during radioactive decay



41. Write down the equation of Beta^{+} decay. Then, give an example.

Answer:

$$ {}^{A}_{Z}X \rightarrow {}_{Z-1}^{\ \ A}Y + e^{+} $$
$$ {}^{12}_{7}N \rightarrow {}^{12}_{6}C + e^{+} $$

42. Write down the units of absorbed dose. Indicate which one is old and the other one SI unit of it.

Answer: Rad is the old one. Gray is the SI unit.

43. Write the two most important postulates of Bohr?

Answer:

- Electrons revolve about the nucleus in well-defined allowed orbits.
- While in orbit the electron doesn’t lose any energy.

44. Radioactivity was discovered by Becquerel. (**T**/F)

Answer: True

45. In which devices is Beta used in nuclear medicine?

Answer: Positron Emission Tomography

46. Absorbed dose has nothing to do with biological structure.(**T**/F)

Answer: True

47. What are the types of nuclear radiation?

Answer: Alpha particles, Beta + and Beta- particles, Gamma particles.

48. What are the types of particle radiations?

Answer: Alpha particles, Beta + and Beta- particles, neutrons and protons

49. Write the equation of alpha decay and give one example.

Answer: Alpha Decay Equation:

$$^{A}_{Z}X \rightarrow \, ^{A-4}_{Z-2}Y + \, ^{4}_{2}He$$

Example:

$$^{238}_{92}U \rightarrow \, ^{234}_{90}Th + \, ^{4}_{2}He$$

$$^{226}_{88}Ra \rightarrow \, ^{222}_{86}Rn + \, ^{4}_{2}He$$

50. Radiations are used on Curie level in nuclear medicine. (T/**F)**

Answer: False, Radiations are used on microCurie or milliCurie level in nuclear medicine.

51. Radiations are used on Becquerel level in nuclear medicine. (T/**F)**

Answer: False, Radiations are used on MegaBecquerel or GigaBecquerel level in nuclear medicine.

52. What are the properties of Gamma Rays?

Answer: They penetrate matter very easily. They are harmful to living beings as it penetrates deeply into tissue. They are the most energetic photons in the electromagnetic spectrum.

53. Write the gamma decay equation. Give an example.

Answer:

The gamma decay equation:

$$^{A}_{Z}X^{*} \rightarrow \, ^{A}_{Z}X + \gamma$$

Example:

$$^{12}_{5}B \rightarrow \, ^{12}_{6}C^{*} + e^{-} + \bar{\nu}$$

$$^{12}_{6}C^{*} \rightarrow \, ^{12}_{6}C + \gamma$$

54. Write the units of the absorbed dose, specifying whether it is new or old.

Answer: Gray and Rad. Gray is new and Rad is old.

55. Write down ionized electromagnetic waves.

Answer: X-ray and gamma

56. Gamma rays usually occur after an alpha or beta.(**T**/F)

Answer: True

57. At time t=0 the radioactive sample contains 5.60 microgram of pure ^{3}H which has a half-life of 36.8 , determining the number N0 of nuclei in the sample at t=0.

Answer:

$Molar\ mass\ 3.0$

$$n = \frac{m}{M_a}$$

$$n = 1{,}87\ x\ 10 - 6$$

$$N_0 = (1{,}87\ x\ 10 - 6mol)\left(6{,}02\ x\ 1023\,\frac{nuclei}{mol}\right) = 1.12574e + 18\,nuclei$$

58. Write the electromagnetic radiations in order.

Answer: Radio waves, microwave, infrared, visible light, ultraviolet, X-ray and Gamma ray.

59. Elements which are rich in protons emit ...... [Gap-filling]

Answer: Alpha/ β+/ Electron capture

60. There are two same radioactive substances with different energies in a class and we have to stay in the class. One of them has a large λ and stays in the left corner of the class and the other one has a small λ and stays in the right corner. They are on the same side. Where do we have to stand to suffer the least damage?

Answer: First, we have to stand at the opposite corner of the substance with a small λ, then when the decay of the larger λ will run out, we have to go to the opposite side.

61. What are the two situations that Rutherford couldn't explain?

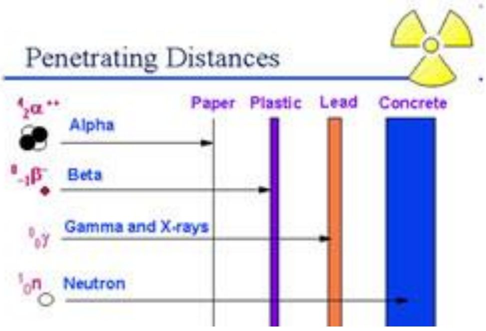
Answer: Rutherford couldn’t explain why negatively charged electrons remain in orbit when they should instantly fall into the positively charged nucleus.

62. What is the traditional unit of equivalent dose?

Answer: Traditional unit of equivalent dose is rem

63. Show alpha, beta and gamma penetration powers

Answer:



64. The discovery of alpha radiation precedes the discovery of the nucleus.(**T**/F)

Answer: True

65. What are the names of two previously unknown elements that Marie Curie discovered?

Answer: Curie discovered of two previously unknown elements named polonium and radium.

66. What is the relationship between absorbed dose and equivalent dose?

Answer: Equivalent dose, H (Sv) = absorbed dose (Gy) * wR