Chapter

27 Nuclei

TYPE A : MULTIPLE CHOICE QUESTIONS

1. In the nuclear reaction, there is a conservation of:

(a) momentum (b) mass ***[1997]***

(c) energy (d) all of these

2. If the radioactive decay constant of radium is 1.07×10^{-4} per year. Then its half life period approximately is equal to : ***[1998]***

(a) 5000 years (b) 6500 years

(c) 7000 years (d) 8900 years

3. In $_{88}Ra^{226}$ nucleus there are : ***[1998]***

(a) 226 protons and 88 electrons

(b) 138 protons and 88 neutrons

(c) 226 neutrons and 138 electrons

(d) 138 neutrons and 88 protons

4. The activity of radioactive sample is measured as 9750 counts per minute at t = 0 and as 975 counts per minute at t = 5 minutes, the decay constant is approximately : ***[1998]***

(a) 0.922 per minute (b) 0.270 per minute

(c) 0.461 per minute (d) 0.39 per minute

5. The activity of a radioactive sample is 1.6 curie and its half life is 2.5 days. Then activity after 10 days will be : ***[1999]***

(a) 0.16 curie (b) 0.8 curie

(c) 0.1 curie (d) 0.4 curie

6. Which one of the following is used as a moderator in nuclear reaction ? ***[1999]***

(a) Uranium (b) Heavy water

(c) Cadmium (d) Plutonium

7. The reaction responsible for the production of light energy from the sun will be: ***[1999]***

(a) fission (b) fusion

(c) nuclear (d) none of these

8. Half life of a substance is 20 minutes, then the time between 33 % decay and 67 % decay will be

(a) 20 minute (b) 40 minute ***[2000]***

(c) 50 minute (d) 10 minute

9. Consider the following nuclear reaction

$X^{200} \rightarrow A^{110} + B^{90} + \text{Energy}$

If the binding energy per nucleon for X, A and B are 7.4 MeV, and 8.2 MeV and 8.2 MeV respectively, the energy released will be :***[2000]***

(a) 90 MeV (b) 110 MeV

(c) 200 MeV (d) 160 MeV

10. In each fission of $_{92}U^{235}$ releases 200 MeV, how many fissions must occur per second to produce power of 1 kW ? ***[2000]***

(a) 1.25×10^{18} (b) 3.125×10^{13}

(c) 3.2×10^{18} (d) 1.25×10^{13}

11. The function of heavy water in a nuclear reactor to

(a) slow down the neutrons ***[2001]***

(b) increase the neutrons

(c) stop the electrons

(d) none of these

12. Which one of the following has the highest neutrons ratio ? ***[2001]***

(a) $_{92}U^{235}$ (b) $_{8}O^{16}$

(c) $_{2}He^{4}$ (d) $_{26}Fe^{56}$

13. When radioactive substance emits an α-particle, then its position in the periodic table is lowered by ***[2001]***

(a) two places (b) three places

(c) five places (c) one place

14. In an atom bomb, the energy is released because of the : ***[2001]***

(a) chain reaction of neutrons and $_{92}U^{238}$

(b) chain reaction of neutrons and $_{92}U^{235}$

(c) chain reaction of neutrons and $_{92}U^{236}$

(d) chain reaction of neutrons and $_{92}U^{240}$

15. A radioactive substance decays to $1/16^{th}$ of its initial activity in 40 days. The half-life of the radioactive substance expressed in days is

(a) 2.5 (b) 5 ***[2003]***

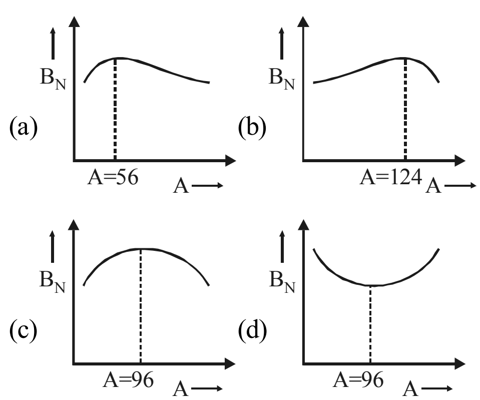
(c) 10 (d) 20

16. Nuclear fusion is possible ***[2003]***
(a) only between light nuclei
(b) only between heavy nuclei
(c) between both light and heavy nuclei
(d) only between nuclei which are stable against β-decay

17. Radioactive nuclei that are injected into a potient collected at certain sites within its body, undergoing radioactive decay and emitting electromagnetic radiation. These radiations can then be recorded by a detector. This procedure provides an important diagnostic tools called
(a) Gamma camera ***[2003]***
(b) CAT can
(c) Radiotracer technique
(d) Gamma ray spectroscopy

18. In a material medium, when a positron meets an electron both the particles annihilate leading to the emission of two gamma ray photons. This process forms the basis of an important diagnostic procedure called ***[2003]***
(a) MRI (b) PET
(c) CAT (d) SPECT

19. The dependence of binding energy per nucleon, B_N, on the mass number A, is represented by ***[2004]***



20. Carbon dating is best suited for determining the age of fossils if their age in years is of the order of ***[2004]***
(a) 10^3 (b) 10^4
(c) 10^5 (d) 10^6

21. In nucleus of mass number A, originally at rest, emits an a-particle with speed v. The daughter nucleus recoils with a speed : ***[2004]***
(a) $\frac{2v}{A+4}$ (b) $\frac{4v}{A+4}$
(c) $\frac{4v}{A-4}$ (d) $\frac{2v}{A-4}$

22. When an electron-positron pair annihilates, the energy released is about ***[2004]***
(a) 0.8×10^{-13} J (b) 1.6×10^{-13} J
(c) 3.2×10^{-13} J (d) 4.8×10^{-13} J

23. A radioactive material has half-life of 10 days. What fraction of the material would remain after 30 days ? ***[2005]***
(a) 0.5 (b) 0.25
(c) 0.125 (d) 0.33

24. The operation of a nuclear reactor is said to be critical, if the multiplication factor (K) has a value
(a) 1 (b) 1.5 ***[2006]***
(c) 2.1 (d) 2.5

25. ^{238}U has 92 protons and 238 nucleons. It decays by emitting an Alpha particle and becomes
(a) $^{234}_{92}\text{U}$ (b) $^{234}_{90}\text{Th}$ ***[2006]***
(c) $^{235}_{92}\text{U}$ (d) $^{237}_{93}\text{Np}$

26. The fossil bone has a ^{14}C: ^{12}C ratio, which is $\left(\frac{1}{16}\right)$ of that in a living animal bone. If the half-life time of ^{14}C is 5730 years, then the age of the fossil bone is ***[2006]***
(a) 11460 years (b) 17190 years
(c) 22920 years (d) 45840 years

27. Which one of the following is a possible nuclear reaction ***[2006]***
(a) $^{10}_{5}\text{B} + ^{4}_{2}\text{He} \longrightarrow ^{13}_{7}\text{N} + ^{1}_{1}\text{H}$
(b) $^{23}_{11}\text{Na} + ^{1}_{1}\text{H} \longrightarrow ^{20}_{10}\text{Ne} + ^{4}_{2}\text{He}$
(c) $^{239}_{11}\text{Np} \longrightarrow ^{239}_{94}\text{Pu} + \beta^- + \bar{v}$
(d) $^{11}_{7}\text{N} + ^{1}_{1}\text{H} \longrightarrow ^{12}_{6}\text{C} + \beta^- + v$

28. If Alpha, Beta and Gamma rays carry same momentum, which has the longest wavelength
(a) Alpha rays ***[2006]***
(b) Beta rays
(c) Gamma rays
(d) None, all have some wavelength

29. What is the amount of energy released by deuterium and tritium fusion? ***[2007]***
(a) 60.6 eV (b) 123.6 eV
(c) 17.6 eV (d) 28.3 eV

30. Calculate power output of $^{235}_{92}U$ reactor, if it takes 30 days to use up 2 kg of fuel, and if each fission gives 185 MeV of useable energy. Avogadro's number = 6×10^{23} /mol? ***[2007]***

(a) 56.3 MW (b) 60.3 MW
(c) 58.3 MW (d) 54.3 MW

31. Starting with a sample of pure ^{66}Cu, $\frac{7}{8}$ of it decays into Zn in 15 minutes. The corresponding half life is ***[2008]***

(a) 15 minutes (b) 10 minutes
(c) $7\frac{1}{2}$ minutes (d) 5 minutes

32. A radioactive material decays by simultaneous emission of two particles with respective half-lives 1620 and 810 years. The time, in years, after which one-fourth of the material reamins is

(a) 1080 (b) 2430 ***[2008]***
(c) 3240 (d) 4860

33. If the binding energy per nucleon of a nuclide is high then ***[2009]***

(a) It should be abundantly available in nature
(b) It will decay instantly
(c) It will have a large disintegration constant
(d) It will have a small half-life.

34. Activity of a radioactive sample decreases to $(1/3)^{rd}$ of its original value in 3 days. Then, in 9 days its activity will become ***[2009]***

(a) (1/27) of the original value
(b) (1/9) of the original value
(c) (1/18) of the original value
(d) (1/3) of the original value

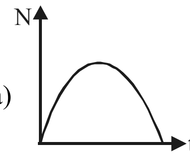
35. The half life of a radioactive substance against α -decay is 1.2×10^7 s. What is the decay rate for 4.0×10^{15} atoms of the substance ***[2010]***

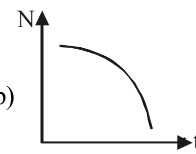
(a) 4.6×10^{12} atoms/s
(b) 2.3×10^{11} atoms/s
(c) 4.6×10^{10} atoms/s
(d) 2.3×10^{8} atoms/s

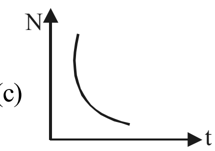
36. Actinium 231, $^{231}Ac_{89}$, emit in succession two β-particles, four alphas, one β and one alpha plus several γ rays. What is the resultant isotope:

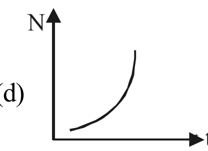
(a) $^{221}Au_{79}$ (b) $^{211}Au_{79}$ ***[2011]***
(c) $^{221}Pb_{82}$ (d) $^{211}Pb_{82}$

37. Radioactive element decays to form a stable nuclide, then the rate of decay of reactant is ***[2012]***

(a) 

(b) 

(c) 

(d) 

38. A nuclear reaction is given by ***[2012]***

${}_{Z}X^{A} \rightarrow {}_{Z+1}Y^{A} + {}_{-1}e^{0} + \bar{v}$, represents

(a) fission (b) β-decay
(c) σ -decay (d) fusion

39. An archaeologist analyses the wood in a prehistoric structure and finds that C^{14} (Half life = 5700 years) to C^{12} is only one-fourth of that found in the cells of buried plants. The age of the wood is about ***[2013]***

(a) 5700 years (b) 2850 years
(c) 11,400 years (d) 22,800 years

40. A radioactive nuclide is produced at the constant rate of n per second (say, by bombarding a target with neutrons). The expected number N of nuclei in existence t seconds after the number is N_0 is given by ***[2014]***

(a) $N = N_0 e^{-\lambda t}$

(b) $N = \frac{n}{\lambda} + N_0 e^{-\lambda t}$

(c) $N = \frac{n}{\lambda} + \left(N_0 - \frac{n}{\lambda}\right)e^{-\lambda t}$

(d) $N = \frac{n}{\lambda} + \left(N_0 + \frac{n}{\lambda}\right)e^{-\lambda t}$

Where λ is the decay constant of the sample

41. The fossil bone has a $^{14}C : {}^{12}C$ ratio, which is $\left[\frac{1}{16}\right]$ of that in a living animal bone. If the half-life of ^{14}C is 5730 years, then the age of the fossil bone is ***[2015]***

(a) 11460 years (b) 17190 years
(c) 22920 years (d) 45840 years

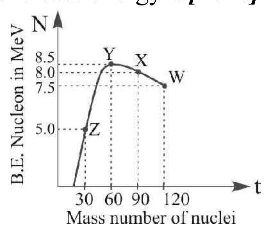
42. Binding energy per nucleon versus mass number curve for nuclei is shown in the figure. W, X, Y and Z are four nuclei indicated on the curve. The process that would release energy is ***[2016]***

(a) $Y \rightarrow 2Z$

(b) $W \rightarrow X + Z$

(c) $W \rightarrow 2Y$

(d) $X \rightarrow Y + Z$



43. The activity of a radioactive sample is measured as N_0 counts per minute at $t = 0$ and N_0/e counts per minute at $t = 5$ minutes. The time (in minutes) at which the activity reduces to half its value is ***[2017]***

(a) $\log_e 2/5$ (b) $\frac{5}{\log_e 2}$

(c) $5 \log_{10} 2$ (d) $5 \log_e 2$

TYPE B : ASSERTION REASON QUESTIONS

Directions for (Qs. 44-55) : These questions consist of two statements, each printed as Assertion and Reason. While answering these questions, you are required to choose any one of the following five responses.

(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.

(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.

(c) If the Assertion is correct but Reason is incorrect.

(d) If both the Assertion and Reason are incorrect.

(e) If the Assertion is incorrect but the Reason is correct.

44. **Assertion :** Isobars are the elements having same mass number but different atomic number.

Reason : Neutrons and protons are present inside nucleus. ***[1997]***

45. **Assertion :** If the half life of a radioactive substance is 40 days then 25% substance decay in 20 days. ***[1998]***

Reason : $N = N_0\left(\frac{1}{2}\right)^n$

where, $n = \frac{\text{time elapsed}}{\text{half life period}}$

46. **Assertion:** Separation of isotope is possible because of the difference in electron numbers of isotope.

Reason: Isotope of an element can be separated by using a mass spectrometer. ***[1999]***

47. **Assertion:** ${}_ZX^A$ undergoes 2α-decays, 2β-decays and 2γ-decays and the daughter product is ${}_{Z-2}X^{A-8}$.

Reason : In α-decays the mass number decreases by 4 and atomic number decreases by 2. In 2β-decays the mass number remains unchanged, but atomic number increases by 1 only. ***[2001]***

48. **Assertion :** Radioactive nuclei emit β^- particles.

Reason : Electrons exist inside the nucleus. ***[2003]***

49. **Assertion :** Neutrons penetrate mater more readily as compared to protons.

Reason : Neutrons are slightly more massive than protons. ***[2003]***

50. **Assertion :** ${}^{90}Sr$ from the radioactive fall out from a nuclear bomb ends up in the bones of human beings through the milk consumed by them. It causes impairment of the production of red blood cells.

Reason : The energetic β-particles emitted in the decay of ${}^{90}Sr$ damage the bone marrow. ***[2004]***

51. **Assertion :** Energy is released in nuclear fission.

Reason : Total binding energy of the fission fragments is larger than the total binding energy of the parent nucleus. ***[2004]***

52. **Assertion :** It is not possible to use ${}^{35}Cl$ as the fuel for fusion energy.

Reason : The binding energy of ${}^{35}Cl$ is too small. ***[2005]***

53. **Assertion :** The binding energy per nucleon, for nuclei with atomic mass number A > 100, decreases with A.

Reason : The nuclear forces are weak for heavier nuclei. ***[2006, 2013]***

54. **Assertion :** Cobalt-60 is useful in cancer therapy.

Reason : Cobalt-60 is a source of γ-radiations capable of killing cancerous cells. ***[2006]***

55. **Assertion :** Heavy water is a better moderator than normal water.

Reason : Heavy water absorbs neutrons more efficiently than normal water. ***[2007]***

Directions for (Qs. 56-61) : Each of these questions contains an Assertion followed by Reason. Read them carefully and answer the question on the basis of following options. You have to select the one that best describes the two statements.

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.
(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.
(c) If Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.

56. **Assertion :** In a decay process of a nucleus, the mass of products is less than that of the parent.

Reason : The rest mass energy of the products must be less than that of the parent. ***[2012]***

57. **Assertion :** Binding energy (or mass defect) of hydrogen nucleus is zero.

Reason : Hydrogen nucleus contain only one nucleon. ***[2012]***

58. **Assertion :** The ionising power of β-particle is less compared to α-particles but their penetrating power is more.

Reason : The mass of β-particle is less than the mass of α-particle. ***[2014]***

59. **Assertion :** Energy is released when heavy nuclei undergo fission or light nuclei undergo fusion and

Reason : For heavy nuclei, binding energy per nucleon increases with increasing Z while for light nuclei it decreases with increasing Z. ***[2015]***

60. **Assertion :** Energy is released when heavy nuclei undergo fission or light nuclei undergo fusion and

Reason : For heavy nuclei, binding energy per nucleon increases with increasing Z while for light nuclei it decreases with increasing Z. ***[2017]***

61. **Assertion :** Between any two given energy levels, the number of absorption transitions is always less than the number of emission transitions.

Reason : Absorption transitions start from the lowest energy level only and may end at any higher energy level. But emission transitions may start from any higher energy level and end at any energy level below it. ***[2017]***

HINTS & SOLUTIONS

Type A : Multiple Choice Questions

1. **(a)** In a nuclear reaction, there may be conversion of some mass into energy. So, both mass and energy are not conserved. It is the momentum which is conserved.

2. **(b)** $\lambda = 1.07 \times 10^{-4}$

$$T_{1/2} = \frac{0.693}{1.07 \times 10^{-4}} = 6500 \text{ years}$$

3. **(d)** $_{88}Ra^{226}$

Number of protons = 88

Number of neutrons = 226 – 88 = 138

4. **(c)** We know that

$$\frac{dN}{dt} = \lambda N$$

Now, $\frac{dN_0}{dt} = \lambda N_0$; $\frac{dN_t}{dt} = \lambda N_t$

$9750 = \lambda N_0$; $975 = \lambda N_t$

$$\frac{N_0}{N_t} = \frac{9750}{975} = \frac{10}{1} \Rightarrow N_0 = 10N_t$$

We know that

$N_t = N_0 e^{-\lambda t}$

$$\frac{N_t}{N_0} = e^{-\lambda t} \Rightarrow \frac{1}{10} = e^{-\lambda .5}$$

$10^{-1} = e^{-5\lambda}$

Taking log on both sides,

$$-1 = -5\lambda \times \frac{1}{2.303}$$

$$\lambda = \frac{1}{5} \times 2.303 = 0.461 \text{ per minute.}$$

5. **(c)** After every 2.5 days its activity reduces to half the value,

$$10\text{days} = \frac{10}{2.5} = 4 \text{ half lives}$$

$$\text{Reduced activity} = 1.6 \times \left(\frac{1}{2}\right)^4$$

$$= 1.6 \times \frac{1}{16} = 0.1 \text{ curie}$$

6. **(b)** Heavy water (D_2O) is used as a moderator in nuclear reaction.

7. **(b)** Fusion is the reaction responsible for the production of light energy from the Sun. In it two hydrogen molecules fuse to form helium.

$_1H^1 + {_1H^1} \longrightarrow {_2He^4} + \text{Energy}$

8. **(a)** When the body is already 33% decayed to be decayed to a further 33%, it will require a period equal to its half life. So achieve level of decay from 33% to 67% it takes time equal to half life or 20 minutes.

9. **(d)** Energy released = total binding energy of A and B less total binding energy of X.

$= (110 \times 8.2 + 90 \times 8.2)$

$\quad - (200 \times 7.4)\,(902 + 738) - 1480$

$= 160$ MeV

10. **(b)** Let n be number of fission per second

$n \times 200 \times 10^6$ eV is produced in one second

$= n \times 200 \times 10^6 \times 1.6 \times 10^{-19}$ Joule per second

$$= \frac{n \times 200 \times 10^6 \times 1.6 \times 10^{-19}}{10^3} = 1(\text{given})$$

$$n = \frac{10^3}{2 \times 1.6 \times 10^{-11}} = \frac{10^{14}}{3.2}$$

$$= \frac{10}{3.2} \times 10^{13} = 3.125 \times 10^{13}$$

11. **(a)** In a nuclear reactor neutrons are needed for nuclear reactions. The product of nuclear reaction is also neutrons. But fast neutrons can not induce nuclear reactions. It requires to be slowed down. Fast neutrons cannot transfer its energy to the target atom effectively due to its high velocity. So, its velocity is reduced. For it we uses heavy water.

12. **(a)** Neutrons ratio that is $\frac{n}{p}$ determines the stability of nucleus. (Here, n is number of neutrons and p is number of protons).

Now, $n = 235 - 92 = 143$

$p = 92$

For $_{92}U^{235}$; Neutron ratio $= \frac{143}{92} = 1.55$

Which is the highest no. So, $_{92}U^{235}$ is most unstable.

13. (a) When radioactive substance emits an α-particle then the atomic number is reduced by 2. Naturally its position in periodic table will be reduced by 2 places.

14. (b) The nuclear reaction taking place in the atom is as follows

$$_{92}U^{235} + {}_0n^1 \longrightarrow {}_{36}Ba^{141} + {}_{56}Kr^{92} + 3\,{}_0n^1 + Q$$

Q = 200 MeV.

The three neutrons generated are capable of reacting with three atoms individually which leads to chain reaction.

15. (c) Let half life = T

$$40 \text{ days} = \frac{40}{T} \text{ Half life}$$

$$\text{Ratio of substance left} = \left(\frac{1}{2}\right)^{\frac{40}{T}}$$

$$\text{So, } \left(\frac{1}{2}\right)^{\frac{40}{T}} = \left(\frac{1}{2}\right)^4$$

$$\frac{40}{T} = 4 \Rightarrow T = \frac{40}{4} = 10 \text{ days}$$

16. (a) Nuclear fusion is possible only between light nuclei as they become more stable by acquiring greater atomic no.

17. (c) In radiotracer technique we trace the existence of an atom by detecting the radiation emitted by it if atom is a radioactive one. The case as stated in the question confirms to it so it is an example of radiotracer technique.

18. (b) Positron emission tomography (PET) is a nuclear medicine medical imaging technique which produces a three dimensional image are map of functional process in the body. The positron annihilates with an electron producing a pair of annihilation photons (gama rays) moving in opposite direction

19. (a) Binding energy per nucleon is maximum for atomic number (A) = 56, so figure (a) is correct alternative.

20. (b) Carbon dating is best suited for determining the age of fossils if their age in years is of the order of 10, 000 years. This is because fossil older than this are destroyed due to time factor. The tracks that are built by the rays are destroyed. For fossil earlier then this, the tracks are so small that it cannot be measured with accuracy.

21. (c) Applying law of conservation of momentum

$$MV = mv$$

Let mass of each proton = m

Mass of daughter nucleus = (Am – 4m)

Mass of α-particle = 4m

So, $(Am - 4m)\,V = 4m \times v$

$$V = \frac{4mv}{m(A-4)} = \frac{4v}{A-4}$$

22. (b) When electron-positron pair annihilates the energy released is due to conversion of mass into energy.

Total mass = $2 \times 9 \times 10^{-31}$ kg

Energy produced

$$= 2 \times 9 \times 10^{-31} \times (3 \times 10^8)^2$$

$$= 162 \times 10^{-15} = 1.62 \times 10^{-13} \text{ J}$$

23. (c) 30 days = 3 halflife

Fraction of material remained

$$= \left(\frac{1}{2}\right)^3 = \frac{1}{8} = 0.125$$

24. (a) The operation of a nuclear reactor is said to be critical if the multiplication factor is

$$k = \frac{\text{rate of production of neutrons}}{\text{rate of loss of neutrons}}$$

If k > 1 explosion occurs

If k < 1 the chain reaction comes to half.

25. (b) $_{92}U^{238} \longrightarrow {}_{90}Th^{234} + {}_2He^4$

26. (c) Let $\frac{p}{q}$ be the initial ratio of $^{14}C : {}^{12}C$. Let it is $\frac{1}{16}\frac{p}{q}$ in the fossil. As q remains constant, p must have reduced to $\frac{p}{16}$ during the period.

$$\frac{p}{q} = \frac{1}{16} = \frac{1}{(2)^4}$$

No. of half lives required = 4

Age of fossil = 4 × 5730 = 22920 years

27. (c)

28. **(d)** $\lambda = \dfrac{h}{mv}$

If they have same momentum (mv), they must have same wave length.

29. **(c)** ${}_1^2H + {}_1^3H \longrightarrow {}_2^4H + n + 17.59\,\text{MeV}$

(Controlled thermonuclear fission reaction)

30. **(c)** No. of ${}^{235}U$ atoms in 2 kg of fuel

$= \dfrac{6.023 \times 10^{23}}{235} \times 2000$

fission energy per atom = 185 MeV

$\therefore$ Energy for 2 kg of fuel

$= \dfrac{6.023 \times 10^{26} \times 2}{235} \times 185\,\text{MeV}$

$\text{Power} = \dfrac{\text{Energy released}}{\text{time}}$

$= \dfrac{6.023 \times 10^{26} \times 2 \times 185 \times 1.6 \times 10^{-13}\,\text{J}}{235 \times 30\,\text{days}}$

($\because$ 1 MeV = 1.6×10^{-13} J, 30 days = $30 \times 24 \times 60 \times 60$ sec)

$\therefore \text{Power} = \dfrac{6.023 \times 10^{26} \times 2 \times 185 \times 1.6 \times 10^{-13}}{235 \times 30 \times 24 \times 60 \times 60}$

$= \dfrac{3552 \times 10^{13}}{235 \times 3 \times 6 \times 6 \times 24 \times 10^{3}}\,\text{W}$

$= \dfrac{3552 \times 10^{10}}{235 \times 3 \times 6 \times 6 \times 24}$

$= \dfrac{3552 \times 10^{4}}{235 \times 18 \times 6 \times 24}\,\text{MW} = 58.3\,\text{MW}$

31. **(d)** $\dfrac{7}{8}$ days of Cu decays.

$\therefore$ Cu undecayed, $N = 1 - \dfrac{7}{8} = \dfrac{1}{8} = \left(\dfrac{1}{2}\right)^3$

$\therefore$ No. of half lifes = 3

$n = \dfrac{t}{T}$ or $3 = \dfrac{15}{T}$

$\Rightarrow$ half life period, $T = \dfrac{15}{3} = 5$ minutes

32. **(a)** $\dfrac{-dN}{dt} = \lambda_1 N + \lambda_2 N \Rightarrow \log_e \dfrac{N}{N_0} = -(\lambda_1 + \lambda_2)t$

where N_0 is initial no. of atom

Here $\lambda_1 = \dfrac{0.693}{1620}$ and $\lambda_2 = \dfrac{0.693}{810}$

$\dfrac{N}{N_0} = \dfrac{1}{4} \Rightarrow \log_e \dfrac{1}{4} = -\left(\dfrac{0.693}{1620} + \dfrac{0.693}{810}\right)t$

$\Rightarrow 2.303[-2 \times (.3010)]$

$= -0.693\left(\dfrac{0.693}{1620} + \dfrac{0.693}{810}\right)t$

$\Rightarrow \dfrac{2 \times 1620 \times 810}{2430} = t = 1080$ year.

33. **(a)** High binding energy per nucleon ensures very high life of the nuclide. Hence they should be abundant in nature.

34. **(a)** $R = R_0 e^{-\lambda t}$

$\Rightarrow \dfrac{1}{3} = e^{-\lambda \times 3} = e^{-3\lambda}$ ...(1)

Let activity in 9 days be R'. Then

$\dfrac{R'}{R_0} = e^{-\lambda \times 9} = e^{-9\lambda}\, e^{-\lambda \times 3} = (e^{-3\lambda})^3$

$= \left(\dfrac{1}{3}\right)^3$, from (1)

$= \dfrac{1}{27} \Rightarrow R' = \dfrac{R_0}{27}$.

35. **(d)** We have, $\dfrac{dN}{dt} = \lambda N$

$\lambda = \dfrac{0.693}{T} = \dfrac{0.693}{1.2 \times 10^7}$

$\dfrac{dN}{dt} = \dfrac{0.693}{1.2 \times 10^7} \times 4 \times 10^{15}$

$= 2.3 \times 10^8$ atom/s

36. **(d)** Five alpha and three beta particles results

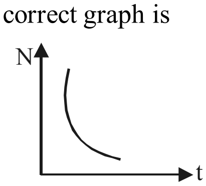
$${}^{231}AC_{89} \longrightarrow \underset{(89-5\times2+3\times1)=82}{\overset{231-5\times4=211}{Pb}}$$

37. **(c)** No. of nuclide at time t is given by $N = N_0 e^{-\lambda t}$

Where N_0 = initial nuclide

thus this equation is equivalent to $y = ae^{-kx}$

Thus correct graph is



38. (b) ${}_{-1}e^0$ is known as β^- particle & $\bar{\nu}$ is known as antineutrino. Since in this reaction $\bar{\nu}$ is emitted with ${}_{-1}e^0$ (β^- particle or electron), so it is known as β-decay.

39. (c) $\frac{C_{14}}{C_{12}} = \frac{1}{4} = \left(\frac{1}{2}\right)^{t/5700}$

$\Rightarrow \frac{t}{5700} = 2 \Rightarrow t = 11400$ years

40. (c) $\frac{dN}{dt} = n - \lambda N$

$dN = (n - \lambda N)dt$

$$\int_{N_0}^{N} \frac{dN}{n-\lambda N} = \int_0^t dt \Rightarrow -\frac{1}{\lambda}\int_{N_0}^{N}\frac{-\lambda dN}{n-\lambda N} = t$$

$$\Rightarrow -\frac{1}{\lambda}\left[\log_e(n-\lambda N)\right]_{N_0}^{N} = t$$

$$\Rightarrow -\frac{1}{\lambda}\left[\log_e\left(\frac{n-\lambda N}{n-\lambda N_0}\right)\right] = t$$

$$\Rightarrow \lambda t = \left[\log_e\left(\frac{n-\lambda N_0}{n-\lambda N}\right)\right]$$

$$e^{\lambda t} = \frac{n-\lambda N_0}{n-\lambda N}$$

$$n - \lambda N = (n - \lambda N_0)\, e^{-\lambda t}$$

$$\frac{n}{\lambda} - \left(\frac{n}{\lambda} - N_0\right)e^{-\lambda t} = N$$

41. (c) $\frac{{}^{14}C}{{}^{12}C} = \frac{1}{16} = \frac{N}{N_0}$

$\because \quad \frac{N}{N_0} = \left(\frac{1}{2}\right)^n$

$\Rightarrow \quad \frac{1}{16} = \left(\frac{1}{2}\right)^n \Rightarrow \left(\frac{1}{2}\right)^4 = \left(\frac{1}{2}\right)^n$

or, $n = 4$

or $\frac{t}{T} = 4$

or $t = 4 \times T = 4 \times 5730 = 22920$ years

42. (c) Energy is released in a process when total binding energy (BE) of products is more than the reactants. By calculations we can see that this happens in option (c).

Given $W = 2Y$

BE of reactants = 120 × 7.5 = 900 MeV

BE of products = 2 × (60 × 8.5) = 1020 MeV.

43. (d) $N = N_0 e^{-\lambda t}$

Here, $t = 5$ minutes

$$\frac{N_0}{e} = N_0 \cdot e^{-5\lambda}$$

$\Rightarrow \quad 5\lambda = 1$, or $\lambda = \frac{1}{5}$,

Now, $T_{1/2} = \frac{\ell n2}{\lambda} = 5\ \ell n2$

Type B : Assertion Reason Questions

44. (b) By definition, isobars are elements having same mass number but different atomic number. Presence of neutron and proton inside nucleus has nothing to do with this definition.

45. (e) Half life of radioactive substance is 40 days. It means 50% substance decays in 40 days. During this period rate of decay is on decrease. So, 25% decay must have taken place is less than 20 days.

$$N = N_0\left(\frac{1}{2}\right)^n, \text{ where } n = \frac{\text{time elapsed}}{\text{half life period}}$$

46. (e) Isotope of an element can be separated by using a mass spectrometer because isotopes have different atomic mass. Alternative (e) is correct.

47. (a) The reason given is true. If we test the authenticity of assertion,

$${}_ZX^A \xrightarrow{\alpha-\text{decay}} {}_{Z-2}X^{A-4} \xrightarrow{\alpha-\text{rays}}$$

$${}_{Z-4}X^{A-8} \xrightarrow{(2\beta-\text{rays})} {}_{Z-2}X^{A-8}$$

47. (c) Radioactive nuclei emit β-particles. This β-particle comes from the splitting of neutron into β-particle and proton.

48. (b) Neturon is penetrate more readily as compared to protons because neutrons do not carry any change so there is no repulsion between nucleus and neutrons. So assertion is true reason is also true as mass of neutron is more than proton but reason does not explain assertion.

49. (a) RBC of blood are produced in the bone marrow. The radiation from the radioactive substances destroys of bone marrow which result in hampered production of RBC.

50. (a) Total binding energy of fragment nucleus is more than total binding energy of parent nucleus. Since, binding energy results in decrease of total energy. Hence there is great decrease in energy fragment nucleus because energy is released in nuclear fission.

$$\underset{(\text{Parent})}{A} \longrightarrow \underset{(\text{Fragment})}{B} + \underset{(\text{Energy})}{E}$$

Energy of B is decrease but the binding energy of B is increased due to release of energy from it. So, reason supports the assertion.

51. (a)

52. (c) Since, ^{35}Cl is stable so binding energy is high. So it is not capable of disintegration.

53. (a) Binding energy per nucleon decreases with A for nuclei with atomic mass number A > 100 due to weak nuclear forces. It can be explain as :

At short distances, the nuclear force is stronger than the Coulomb force; it can overcome the Coulomb repulsion of protons inside the nucleus. At typical nucleon separation (1.3 fm) it is a very strong attractive force (104 newtons). Beyond about 1.3 fm separation, the force exponentially dies off to zero. However, the Coulomb force between protons has a much larger range and becomes the only significant force between protons when their separation exceeds about (2.5 fm, A > 100).

54. (a) Cobalt 60 is radioactive isotope of cobalt. γ-radiation emitted by it is used in radiation therapy is cancer as it destroys cancerous cells.

So, assertion and reason is true and reason explains assertion.

55. (c) Heavy water has better ability to slow down neutrons by elastic collision between their protons and neutrons hence they are better moderators. Heavy water does not absorb neutrons.

56. (a)

57. (a)

58. (b) β-particles, being emitted with very high speed compared to α-particles, pass for very little time near the atoms of the medium. So the probability of the atoms being ionised is comparatively less. But due to this reason, their loss of energy is very slow and they can penetrate the medium through a sufficient depth.

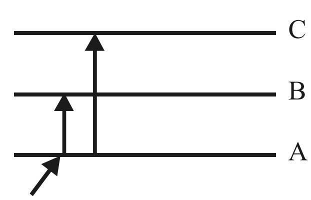
59. (c) We know that energy is released when heavy nuclei undergo fission or light nuclei undergo fusion. Therefore Assertion is correct.

The Reason is incorrect because for heavy nuclei the binding energy per nucleon decreases with increasing Z and for light nuclei, B.E/nucleon increases with increasing Z.

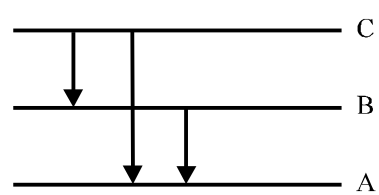
60. (d) We know that energy is released when heavy nuclei undergo fission or light nuclei undergo fusion. Therefore Assertion is correct.

The Reason is incorrect because for heavy nuclei the binding energy per nucleon decreases with increasing Z and for light nuclei, B.E/nucleon increases with increasing Z.

61. (a) Absorption transition



Two possibilities in absorption transition.



Three possibilities in emission transition.
Therefore, absorption transition < emission.