Blue Print (As per PU Board)

Topic	1 mark questions	2 marks questions	3 marks questions	5 marks questions	Total Marks
Nuclei	1	–	–	1	6

One mark questions

1. Write the nuclear reaction equations for (i) β decay of $_{15}P^{32}$ (ii) Positron decay of $_{11}Na^{22}$

Answer:

(i) $_{15}P^{32} \rightarrow_{16} S^{32} +_{-1}\beta + _0\nu^0$ (Neutrino)

(ii) $_{11}Na^{22} \rightarrow_{10} Ne^{22} + _{+1}\beta + _0\bar{\nu}^0$ (antineutrino)

2. What is the principle of (i) a nuclear reactor (ii) an atom bomb?

Answer:

(i) Principle of nuclear reactor: Controlled chain reaction

(ii) Principle of an atom bomb: Uncontrolled chain reaction

3. Which is the source of energy in stars?

Answer: Thermo nuclear reactions. Nuclear fusion reactions.

Two marks questions

4. Define one atomic mass unit (u) and express it in kg.

Answer: One atomic mass unit is defined as $\frac{1}{12}$ the mass of carbon -12 atom.

$1u = \frac{1}{12}$ (Mass of C^{12} atom) (1 mark)

6.023×10^{23} atoms of carbon weigh $12kg$

1 atom………... ?

$= \frac{12}{6.023\times10^{23}}$

$= \frac{12}{6.023}\times10^{-23}g$

$1u = \frac{1}{12}\left[\frac{12}{6.023}\times10^{-23}\right]g$

$= \frac{1}{6.023}\times10^{-23}g$

$= 0.166\times10^{-23}g$

$= 1.66\times10^{-27}kg$

$\therefore 1u = 1.66\times10^{-27}kg$ (1 mark)

5. What are isobars? Give an example.

Answer: Isobars are atoms of different elements having the mass number. (1 mark)

e.g. $_1H^3$ and $_2H_e^3$ (1 mark)

6. Show that the density of nucleus is independent of its mass number.

Answer: We know that the radius of nucleus with mass number A is given by

$R = R_o A^{\frac{1}{3}}$

$\Rightarrow R \propto A^{\frac{1}{3}}$ (1 mark)

Volume of the nucleus $= \frac{4}{3}\pi R^3$

Density of nucleus $= \frac{\text{Nuclear Mass}}{\text{Nuclear volume}}$

$\propto \left(\frac{\text{Nuclear Mass}}{\text{A}}\right)$ (1 mark)

Hence nuclear density is a constant and it is independent of mass number. It is a constant for all elements.

Three marks questions

7. **Mention the three types of decay. Explain with examples.**

Answer:

(i) $\alpha-$decay: In $\alpha-$decay, a radioactive nucleus emits an $\alpha-$particle. The mass of the nucleus is reduced by 4 and atomic number is reduced by 2. (1 mark)

(ii) $\beta-$decay: In $\beta-$decay, a radioactive nucleus emits a $\beta-$particle. The mass is not altered. Atomic number is increased by 1. (1 mark)

(iii) $\gamma-$decay When a radioactive nucleus emits a $\gamma-$particle. There is no change either in the mass number or atomic number. Energy is liberated. (1 mark)

8. **Mention three different ways in which uranium undergoes fission.**

Answer: ${}_{92}u^{235} + {}_0 n^1 \rightarrow {}_{56} Ba^{141} + {}_{36} Kr^{92} + 3{}_0 n^1$ (1 mark)

${}_{92}u^{235} + {}_0 n^1 \rightarrow {}_{38} Sr^{94} + {}_{54} Xe^{140} + 2{}_0 n^1$ (1 mark)

${}_{92}u^{235} + {}_0 n^1 \rightarrow {}_{51} So^{133} + {}_{41} No^{99} + 4{}_0 n^1$ (1 mark)

Five marks questions

9. **State the law of radioactive decay. Show that $N_t = N_o.e^{-\lambda t}$ where the symbols have their usual significance.**

Answer: **Law of Radioactive Decay**

" The rate of disintegration at any instant of time is directly proportional to the number of nuclei present at that instant of time". (1 mark)

If dN_t number of nuclei disintegrate in a small interval of time dt at the instant of time t, then the rate of disintegration is $\frac{dN_t}{dt}$. This is directly proportional to N_t.

$\frac{dN_t}{dt} \propto -N_t$

Disintegration Constant (or) Decay Constant

$\frac{dN_t}{dt} = -\lambda N_t$ (1 mark)

λ is a constant called the decay constant or disintegration constant. It is a constant for a given radioactive substance. The negative sign shows that the number of nuclei and the rate of decay goes on decreasing as time passes.

To derive the equation of Radioactive decay

We have $\frac{dN_t}{dt} = -\lambda N_t$

$dN_t = -\lambda N_t\, dt$

Integrating $\int dN_t = \int -\lambda N_t\, dt$

$\int \frac{dN_t}{N_t} = \int -\lambda\, dt$

$\log_e N_t = -\lambda t + C$ …………………. (1)

C is a constant the value of which is found as follows :- (1 mark)

Evaluation of the constant C

When t = 0 , i.e., the number of nuclei $N_t = N_o$

Substitute this in (1)

$log_e N_0 = -\lambda(0) + C$

$\Rightarrow C = log_e N_0$ (1 mark)

Substitute for C in (1)

$\log_e N_t = -\lambda t + \log_e N_0$

$\log_e N_t - \log_e N_0 = -\lambda t$

$\log_e\left(\frac{N_t}{N_o}\right) = -\lambda t \Rightarrow \left(\frac{N_t}{N_o}\right) = e^{-\lambda t} \Rightarrow \boldsymbol{N_t = N_o e^{-\lambda t}}$ (1 mark)

This is called the equation of radioactive decay.

10. Define half-life period of a radioactive substance. Assuming the expression for the number of nuclei present at any instant of time in a radioactive substance, derive an expression for the half-life period of a radioactive substance.

Answer:

The half-life period of a radioactive substance is defined as the time during which half the initial number of radioactive nuclei decay. At the end of the half-life period number of nuclei remaining $= \frac{N_0}{2}$ (1 mark)

$\boldsymbol{N_t = N_o e^{-\lambda t}}$ (1 mark)

When $t = t_{1/2}$, $N_t = \frac{N_0}{2}$ (1 mark)

$\frac{N_0}{2} = N_0 e^{-\lambda t_{1/2}} \Rightarrow \frac{1}{2} = e^{\lambda t_{1/2}}$

$\lambda t_{1/2} = log_e 2$; $e^{\lambda t_{1/2}} = 2$ (1 mark)

$\lambda t_{1/2} = log_e 2$

$t_{1/2} = \frac{log_e 2}{\lambda} = \frac{0.693}{\lambda}$ (1 mark)

11. Calculate the energy equivalent of one atomic mass unit. Express the answer in MeV .

Answer: $m = 1\text{u} = 1.6605\times10^{-27}\,\text{kg}$ (1 mark)

When this amount of matter is completely converted into energy,

$E = mc^2$; $\left(c = 2.9979\times10^8 ms^{-1}\right)$ (1 mark)

$= 1.6605\times10^{-27}\times\left(2.9979\times10^8\right)^2$

$= 1.4924\times10^{-10}\,\text{J}$ (1 mark)

To convert this into MeV , divide by 1.602×10^{-19} (1 mark)

$= \frac{1.4924\times10^{-10}}{1.602\times10^{-19}}$

$= 0.931\times10^9\,\text{eV}$

$= 931\times10^6\,\text{eV}$

$= 931\,\text{MeV}$. (1 mark)

12. Calculate the half-life and mean life of Ra^{226} of activity $1C_i$ if the mass of radium is $1\,g$ and $226\,g$ of R_a contains 6.023×10^{23} atoms.

Answer: Activity $= a_t = 1C_i = 3.7\times10^{10}$ disintegrations/s

Now $a_t = \lambda N_t$ …(1) (1 mark)

226 g of R_a contains 6.023×10^{23} atoms

1g of R_a contains ?

$$N_t = \frac{6.023\times10^{23}}{226}$$

$= 0.02665\times10^{23}$

$= 2.665\times10^{21}$ (1 mark)

$$\therefore \lambda = \frac{3.7\times10^{10}}{2.665\times10^{21}}$$

$\lambda = 1.38836\times10^{-11}\,s^{-1}$ (1 mark)

Now $t_{\frac{1}{2}} = \frac{0.693}{\lambda}$ (1 mark)

$$t_{\frac{1}{2}} = \frac{0.693}{1.38836\times10^{-11}}$$

$= 0.49915\times10^{10}\,s$

$t_{\frac{1}{2}} = 4.9915\times10^{10}\,s$

$= 0.00000015827\times10^{10}$ years

$t_{\frac{1}{2}} = 1582.7$ years (1 mark)