CBSE Test Paper-04

Class - 12 Physics (Nuclei)

1. In which of the following decays does the element not change?
   a. γ -decay
   b. β^{+} -decay.
   c. α –decay
   d. β^{-} -decay
2. Half life of a substance is 20 minutes. What is the time between 33$\%$ decay and 67 $\%$ decay?
   a. 25 minutes
   b. 20 minutes
   c. 30 minutes
   d. 40 minutes
3. What is the rest mass energy of an electron?
   a. 0.51 MeV
   b. 1 eV
   c. 931 MeV
   d. none of these
4. When a hydrogen bomb explodes, which of the following is used?
   a. fusion
   b. fission
   c. both
   d. neither of two
5. $_{79}^{197}Au$ Contains
   a. 79 protons and 197 neutrons
   b. 197 protons and 118 neutrons
   c. 79 neutrons and 118 protons
   d. 79 protons and 118 neutrons
6. Name the absorbing material used to control the reaction rate of neutrons in a nuclear reactor.

7. Why is it found experimentally difficult to detect neutrinos in nuclear β-decay?

8. A nucleus undergoes β^- decay. How does its
   i. mass number and
   ii. atomic number changes?

9. Which one of $_3^7X$ and $_3^4Y$ is likely to be more stable? Given reason.

10. Define decay constant.

11. A radioactive isotope X has a half life of 3 seconds. At t = 0 second, a given sample of this isotope X contains 8000 atoms. Calculate (a) its decay constant (b) the time t_1, when 1000 atoms of the isotope X remains in the sample and (c) the number of decays per second in the sample at $t = t_1$ second.

12. How long can an electric lamp of 100W be kept glowing by fusion of 2.0 kg of deuterium? Take the fusion reaction as: $_1^2H +_1^2 H \rightarrow_2^3 He + n + 3.2MeV$

13. i. A radioactive nucleus A undergoes a series of decays as given below:

    $$A \xrightarrow{\alpha} A_1 \xrightarrow{\beta} A_2 \xrightarrow{\alpha} A_3 \xrightarrow{\gamma} A_4$$

    The mass number and an atomic number of A_2 are 176 and 71, respectively.

    Determine the mass and atomic numbers of A_4 and A.

    ii. Write the basic nuclear processes underlying β^+ and β^- decays.

14. A source contains two phosphorous radio nuclides $_{15}^{33}P\left(T_{1/2} = 14.3d\right)$ and $_{15}^{32}P(T_{1/2} = 25.3d)$. Initially, 10% of the decays come from $_{15}^{33}P$. How long one must wait until 90% do so?

15. Calculate the mass of 1 curie of $R_aB(Pb^2)$ from its half life of 26.8 minutes.

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Answers

1. a. γ-decay

   Explanation: Because mass no and atomic no of product nuclei remains the same as parent nuclei after gamma decay.

2. b. 20 minutes

   Explanation: $\lambda = \frac{0.693}{20}$

   $T_{33\%} = \frac{2.303 \times 20}{0.093} \log\left[\frac{1}{0.33}\right]$

   $T_{67\%} = \frac{2.303 \times 20}{0.693} \log\left[\frac{1}{0.067}\right]$

   $T_{23\%}$ - $T_{67\%}$ = 20 minutes

3. a. 0.51 MeV

   Explanation: E = mc^2

   $= \frac{9.1 \times 10^{-31} \times 9 \times 10^{16}}{1.6 \times 10^{-19}}$

   = 0.51 MeV

4. c. both

   Explanation: Hydrogen bomb combines both nuclear fission and a different process known as nuclear fusion to produce a far, far more powerful blast. The first stage of a hydrogen bomb involves a fission explosion. The explosion, in turn, leads to a second stage - fusion.

5. d. 79 protons and 118 neutrons

   Explanation: Number of protons = Atomic number = 79

   Number of neutrons = Atomic mass number - atomic number = 197-79 = 118.

6. Heavy water

7. A neutrino is a subatomic particle that is very similar to an electron, but has no electrical charge and a very small mass, Because they have very little interaction with matter, however, they are incredibly difficult to detect.

8. During β- decay, neutron gets converted into proton, electron and anti neutrino as

following -

n $\rightarrow$ p + e + v

i. no change in mass number.
ii. atomic number increases by 1.

9. ^7_3X will be more stable than ^4_3Y, because the odd-even pair is more stable than odd-odd pair.

10. Decay constant of a radioactive element is the reciprocal of the time during which the number of atoms left in the sample reduces to $\frac{1}{e}$ times the original number of atoms in the sample.

11. a. $\lambda = \frac{0.6931}{T} = \frac{0.6931}{3} = 0.231s^{-1}$
b. $t = \frac{1}{\lambda}\log_e \frac{N_0}{N} = \frac{2.3026}{0.231}\log_{10} 8 = 9s$
c. $-\frac{dN}{dt} = \lambda N = 0.231 \times 1000 = 231s^{-1}$

12. When two nuclei of deuterium fuse together,

Energy released = 3.2 MeV

Number of deuterium atoms in 2 kg

$= \frac{6.023 \times 10^{23}}{2} \times 2000 = 6.023 \times 10^{26}$

When 6.023×10^{26} nuclei of deuterium fuse together, energy released

$= \frac{3.2}{2} \times 6.023 \times 10^{26} MeV$

$= \frac{3.2}{2} \times 6.023 \times 10^{26} \times 1.6 \times 10^{-13} J$

$= 1.54 \times 10^{14} J$ or Ws

Power of electric lamp = 100 W

If the lamp glows for time t, then the electrical energy consumed by the lamp is 100 t.

$\therefore 100t = 1.54 \times 10^{14}$ or $t = 1.54 \times 10^{12} s$

$= \frac{1.54 \times 10^{12}}{3.154 \times 10^{7}} years$

$= 4.88 \times 10^{4} years$

13. i. **Nuclear decay (Radioactive decay)** occurs when an unstable atom loses energy by emitting ionizing radiation. In α-decay, the atomic number is decreased by 2 units and the mass number decreases by 4 units. In β-decay, the atomic number increases by 1 unit but the mass number does not change. In γ -decay, there is no change in mass and atomic number.

Therefore, the mentioned radioactive decays will proceed as below.

${}^{176}_{71}A_2 +^{0}_{-1}\beta \rightarrow^{176}_{70} A_1 +^{4}_{2}He \rightarrow^{180}_{72} A$

So,A has mass number 180 and atomic number 72.

Also, ${}^{176}_{71}A_2 \overset{\alpha\ 172}{\rightarrow}_{69} A_3 \overset{\gamma\ 172}{\rightarrow}_{69} A_4$

So, A_4 has mass number 172 and atomic number 69.

ii. $\beta^- - decay$

$\underset{(neuron\ decay)}{n} \rightarrow \underset{(proton)}{p} + \beta^- + \overline{v}\ (anti - neutrino)$

e.g ${}^{32}_{15}P \rightarrow^{32}_{16} S + e^- + \overline{v}$

$\beta^+ - decay$

$\underset{(proton\ decay)}{p} \rightarrow \underset{(neuron)}{n} + \beta^+ + v\ (neutrino)$

e.g. ${}^{22}_{11}Na \longrightarrow^{22}_{10} Ne + e^+ + v$

14. We know that $-\frac{dN}{dt}\alpha N$.

So, clearly the initial ratio of the amounts of ${}^{33}_{15}P$ and ${}^{32}_{15}P$ is 1 : 9. We have to find the time after which the ratio is 9 : 1.

Initially, if the amount of ${}^{33}_{15}P$ is x, the amount of ${}^{32}_{15}P$ is 9x . Finally, if the amount of ${}^{33}_{15}P$ is 9 y, the amount of ${}^{32}_{15}P$ is y.

Using $N = \frac{N_0}{2^{t/T}}$

$9y = \frac{x}{2^{t/25.3}}$

$y = \frac{9x}{2^{t/143}}$

Dividing $9 = \frac{x}{2^{t/25.3}} \times \frac{2^{t/14.3}}{9x}$

or 81 = 2 $\frac{t}{14.3} - \frac{t}{25.3}$

or, 81 = 2 $\frac{11t}{361.79}$

or $\log_{10} 81 = \frac{11t}{361.79}\log_{10} 2 = \frac{11\times 0.3010t}{361.79}$

$= 9.15 \times 10^{-3}t$

$9.15 \times 10^{-3}t = 1.91$

or $t = \frac{1.91\times 1000}{9.15}d = 208.7d$

15. Activity of $R_aB = \frac{dN}{N} = 1$ curie $= 3.7 \times 10^{10}$ disintegrations

Half life of R_aB(T) = 26.8 minutes

If λ is the disintegration constant of R_aB , we have

$$\lambda = \frac{0.693}{T}$$
$$= \frac{0.693}{26.8 \times 60} s^{-1}$$

Let N be the number of atoms of R_aB having an activity of 1 curie. Then we have

$$\left| \frac{dN}{dt} \right| = \lambda N$$

or $N = \frac{\left| \frac{dN}{dt} \right|}{\lambda}$

$$\therefore N = \frac{3.7 \times 10^{10} \times 26.8 \times 60}{0.693}$$

Further we know that 6.02×10^{23} atoms = 1 gram atom = 214 g. Therefore, the mass of R_aB having an activity of 1 curie.

$$= \frac{214 \times 3.7 \times 10^{10} \times 26.8 \times 60}{6.02 \times 10^{23} \times 0.693}$$
$$= 30.52 \times 10^{-9} g$$