

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. ${}^{197}_{79}\text{Au}$ 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 7_3X and 4_3Y 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: ${}^2_1H + {}^2_1H \rightarrow {}^3_2He + n + 3.2MeV$
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 ${}^{33}_{15}P$ ($T_{1/2} = 14.3d$) and ${}^{32}_{15}P$ ($T_{1/2} = 25.3d$). Initially, 10% of the decays come from ${}^{33}_{15}P$. How long one must wait until 90% do so?
15. Calculate the mass of 1 curie of $RaB(Pb^{212})$ from its half life of 26.8 minutes.

CBSE Test Paper-04
Class - 12 Physics (Nuclei)
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: $\lambda = \frac{0.693}{20}$

$$T_{33\%} = \frac{2.303 \times 20}{0.693} \log \left[\frac{1}{0.33} \right]$$

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

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

3. a. 0.51 MeV

Explanation: $E = mc^2$

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

$$= 0.51 \text{ MeV}$$

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

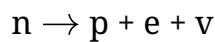
Number of neutrons = Atomic mass number - atomic number = 197-79 = 118.

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 -



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

$$\begin{aligned} &= \frac{3.2}{2} \times 6.023 \times 10^{26} \text{ MeV} \\ &= \frac{3.2}{2} \times 6.023 \times 10^{26} \times 1.6 \times 10^{-13} \text{ J} \\ &= 1.54 \times 10^{14} \text{ J or Ws} \end{aligned}$$

Power of electric lamp = 100 W

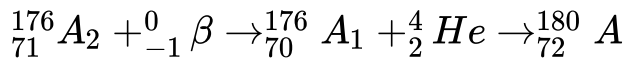
If the lamp glows for time t, then the electrical energy consumed by the lamp is 100 t.

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

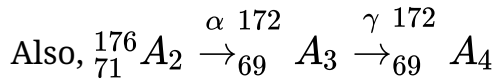
$$\begin{aligned} &= \frac{1.54 \times 10^{12}}{3.154 \times 10^7} \text{ years} \\ &= 4.88 \times 10^4 \text{ years} \end{aligned}$$

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.

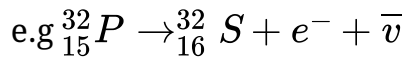
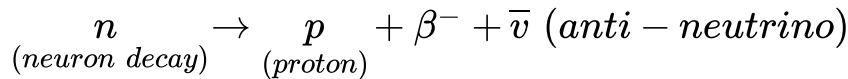


So, A has mass number 180 and atomic number 72.

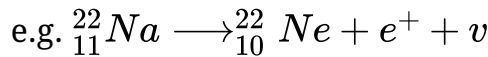
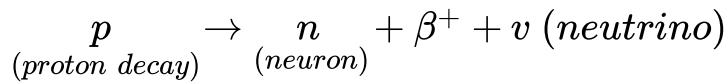


So, A₄ has mass number 172 and atomic number 69.

ii. β^- – decay



β^+ – decay



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

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

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

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

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

$$y = \frac{9x}{2^{t/14.3}}$$

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

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

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

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

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

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

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

15. Activity of $R_a B = \frac{dN}{dt} = 1 \text{ curie} = 3.7 \times 10^{10} \text{ disintegrations}$

Half life of $R_a B(T) = 26.8 \text{ minutes}$

If λ is the disintegration constant of $R_a B$, we have

$$\lambda = \frac{0.693}{T}$$

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

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

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

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

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

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.

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

$$= 30.52 \times 10^{-9} \text{ g}$$