Chapter Thirteen NUCLEI

MCQ I

- **13.1** Suppose we consider a large number of containers each containing initially 10000 atoms of a radioactive material with a half life of 1 year. After 1 year,
 - (a) all the containers will have 5000 atoms of the material.
 - (b) all the containers will contain the same number of atoms of the material but that number will only be approximately 5000.
 - (c) the containers will in general have different numbers of the atoms of the material but their average will be close to 5000.
 - (d) none of the containers can have more than 5000 atoms.
- **13.2** The gravitational force between a H-atom and another particle of mass *m* will be given by Newton's law:

$$F = G \frac{M.m}{r^2}$$
, where *r* is in km and

(a)
$$M = m_{\text{proton}} + m_{\text{electron}}$$
.

• •

(b)
$$M = m_{\text{proton}} + m_{\text{electron}} - \frac{B}{c^2}$$
 (B = 13.6 eV).

Get More Learning Materials Here :

🕀 www.studentbro.in

- (c) *M* is not related to the mass of the hydrogen atom.
- (d) $M = m_{\text{proton}} + m_{\text{electron}} \frac{|V|}{c^2}$ (|V| = magnitude of the potential energy of electron in the H-atom).
- **13.3** When a nucleus in an atom undergoes a radioactive decay, the electronic energy levels of the atom
 - (a) do not change for any type of radioactivity.
 - (b) change for α and β radioactivity but not for γ -radioactivity.
 - (c) change for α -radioactivity but not for others.
 - (d) change for β -radioactivity but not for others.
- **13.4** M_x and M_y denote the atomic masses of the parent and the daughter nuclei respectively in a radioactive decay. The *Q*-value for a β^- decay is Q_1 and that for a β^+ decay is Q_2 . If m_e denotes the mass of an electron, then which of the following statements is correct?
 - (a) $Q_1 = (M_x M_y) c^2$ and $Q_2 = (M_x M_y 2m_z)c^2$
 - (b) $Q_1 = (M_x M_y) c^2$ and $Q_2 = (M_x M_y) c^2$
 - (c) $Q_1 = (M_x M_y 2m_e) c^2$ and $Q_2 = (M_x M_y + 2m_e)c^2$
 - (d) $Q_1 = (M_x M_y + 2m_e) c^2$ and $Q_2 = (M_x M_y + 2m_e)c^2$
- **13.5** Tritium is an isotope of hydrogen whose nucleus Triton contains 2 neutrons and 1 proton. Free neutrons decay into $p + \overline{e} + \overline{v}$. If one of the neutrons in Triton decays, it would transform into He³ nucleus. This does not happen. This is because
 - (a) Triton energy is less than that of a He^3 nucleus.
 - (b) the electron created in the beta decay process cannot remain in the nucleus.
 - (c) both the neutrons in triton have to decay simultaneously resulting in a nucleus with 3 protons, which is not a He³ nucleus.
 - (d) because free neutrons decay due to external perturbations which is absent in a triton nucleus.
- **13.6.** Heavy stable nucle have more neutrons than protons. This is because of the fact that
 - (a) neutrons are heavier than protons.

CLICK HERE

- (b) electrostatic force between protons are repulsive.
- (c) neutrons decay into protons through beta decay.
- (d) nuclear forces between neutrons are weaker than that between protons.

🕀 www.studentbro.in

13.7 In a nuclear reactor, moderators slow down the neutrons which come out in a fission process. The moderator used have light nuclei. Heavy nuclei will not serve the purpose because

82

Get More Learning Materials Here : **_**

Nuclei

- (a) they will break up.
- (b) elastic collision of neutrons with heavy nuclei will not slow them down.
- (c) the net weight of the reactor would be unbearably high.
- (d) substances with heavy nuclei do not occur in liquid or gaseous state at room temperature.

MCQ II

- **13.8** Fusion processes, like combining two deuterons to form a He nucleus are impossible at ordinary temperatures and pressure. The reasons for this can be traced to the fact:
 - (a) nuclear forces have short range.
 - (b) nuclei are positively charged.
 - (c) the original nuclei must be completely ionized before fusion can take place.
 - (d) the original nuclei must first break up before combining with each other.
- **13.9** Samples of two radioactive nuclides A and B are taken. λ_A and λ_B are the disintegration constants of A and B respectively. In which of the following cases, the two samples can simultaneously have the same decay rate at any time?
 - (a) Initial rate of decay of A is twice the initial rate of decay of B and $\lambda_A = \lambda_B$.
 - (b) Initial rate of decay of A is twice the initial rate of decay of B and $\lambda_{_{\rm A}} > \lambda_{_{\rm B}}$.
 - (c) Initial rate of decay of B is twice the initial rate of decay of A and $\lambda_A > \lambda_B$.
 - (d) Initial rate of decay of B is same as the rate of decay of A at t = 2h and $\lambda_{\rm B} < \lambda_{\rm A}$.
- **13.10** The variation of decay rate of two radioactive samples A and B with time is shown in Fig. 13.1.

Which of the following statements are true?

- (a) Decay constant of A is greater than that of B, hence A always decays faster than B.
- (b) Decay constant of B is greater than that of A but its decay rate is always smaller than that of A.
- (c) Decay constant of A is greater than that of B but it does not always decay faster than B.
- (d) Decay constant of B is smaller than that of A but still its decay rate becomes equal to that of A at a later instant.

CLICK HERE



🕀 www.studentbro.in

Get More Learning Materials Here :

VSA



Fig. 13.2

- **13.11** He_2^3 and He_1^3 nuclei have the same mass number. Do they have the same binding energy?
- **13.12** Draw a graph showing the variation of decay rate with number of active nuclei.
- 13.13 Which sample, A or B shown in Fig. 13.2 has shorter mean-life?
- 13.14 Which one of the following cannot emit radiation and why?

Excited nucleus, excited electron.

13.15 In pair annihilation, an electron and a positron destroy each other to produce gamma radiation. How is the momentum conserved?

SA

- **13.16** Why do stable nuclei never have more protons than neutrons?
- **13.17** Consider a radioactive nucleus A which decays to a stable nucleus C through the following sequence:

 $A \rightarrow B \rightarrow C$

Here B is an intermediate nuclei which is also radioactive. Considering that there are N_o atoms of A initially, plot the graph showing the variation of number of atoms of A and B versus time.

- **13.18** A piece of wood from the ruins of an ancient building was found to have a ¹⁴C activity of 12 disintegrations per minute per gram of its carbon content. The ¹⁴C activity of the living wood is 16 disintegrations per minute per gram. How long ago did the tree, from which the wooden sample came, die? Given half-life of ¹⁴C is 5760 years.
- **13.19** Are the nucleons fundamental particles, or do they consist of still smaller parts? One way to find out is to probe a nucleon just as Rutherford probed an atom. What should be the kinetic energy of an electron for it to be able to probe a nucleon? Assume the diameter of a nucleon to be approximately 10⁻¹⁵ m.
- **13.20** A nuclide 1 is said to be the mirror isobar of nuclide 2 if $Z_1 = N_2$ and $Z_2 = N_1$. (a) What nuclide is a mirror isobar of ${}^{23}_{11}$ Na? (b) Which nuclide out of the two mirror isobars have greater binding energy and why?

🕀 www.studentbro.in

CLICK HERE

84

Get More Learning Materials Here : 📕

Nuclei

LA

13.21 Sometimes a radioactive nucleus decays into a nucleus which itself is radioactive. An example is :

³⁸Sulphur $\xrightarrow{\text{half-life}}_{=2.48\,\text{h}}$ ³⁸Cl $\xrightarrow{\text{half-life}}_{=0.62\text{h}}$ ³⁸Ar (stable)

Assume that we start with 1000 ³⁸S nuclei at time t = 0. The number of ³⁸Cl is of count zero at t = 0 and will again be zero at $t = \infty$. At what value of t, would the number of counts be a maximum?

- **13.22** Deuteron is a bound state of a neutron and a proton with a binding energy B = 2.2 MeV. A γ -ray of energy *E* is aimed at a deuteron nucleus to try to break it into a (neutron + proton) such that the *n* and *p* move in the direction of the incident γ -ray. If E = B, show that this cannot happen. Hence calculate how much bigger than *B* must *E* be for such a process to happen.
- **13.23** The deuteron is bound by nuclear forces just as H-atom is made up of p and e bound by electrostatic forces. If we consider the force between neutron and proton in deuteron as given in the form of a Coulomb potential but with an effective charge e':

$$F = \frac{1}{4\pi\varepsilon_0} \frac{e^{\prime 2}}{r}$$

estimate the value of (e'/e) given that the binding energy of a deuteron is 2.2 MeV.

13.24 Before the neutrino hypothesis, the beta decay process was throught to be the transition,

 $n \rightarrow p + \overline{e}$

If this was true, show that if the neutron was at rest, the proton and electron would emerge with fixed energies and calculate them.Experimentally, the electron energy was found to have a large range.

13.25 The activity R of an unknown radioactive nuclide is measured at hourly intervals. The results found are tabulated as follows:

<i>t</i> (h)	0	1	2	3	4
R (MBq)	100	35.36	12.51	4.42	1.56

85



- (i) Plot the graph of R versus t and calculate half-life from the graph.
- (ii) Plot the graph of $\ln\left(\frac{R}{R_0}\right)$ versus *t* and obtain the value of

half-life from the graph.

13.26 Nuclei with magic no. of proton Z = 2, 8, 20, 28, 50, 52 and magic no. of neutrons N = 2, 8, 20, 28, 50, 82 and 126 are found to be very stable. (i) Verify this by calculating the proton separation energy S_p for ¹²⁰Sn (Z = 50) and ¹²¹Sb = (Z = 51).

The proton separation energy for a nuclide is the minimum energy required to separate the least tightly bound proton from a nucleus of that nuclide. It is given by

$$S_p = (M_{Z-1}, N + M_H - M_{Z,N}) c^2$$

Given ${}^{119}In = 118.9058u$, ${}^{120}Sn = 119.902199u$, ${}^{121}Sb = 120.903824u$, ${}^{1}H = 1.0078252u$.

(ii) What does the existance of magic number indicate?

86

