Q. 3.4. The half life of $_{92}U^{238}$ is 4.51×10^9 years. What percentage of $_{92}U^{238}$ that existed 10^{10} years ago still survives. *(K.U. 1991)*

Ans. Radioactive constant of $_{92}U^{238} = \lambda = \dfrac{0.6931}{\text{Half life}} = \dfrac{0.6931}{4.51 \times 10^9}\ yr^{-1}$

If N_0 is the number of atoms of $_{92}U^{238}$ that existed 10^{10} years ago and N is the number now present, then

$$N = N_0 e^{-\lambda t} \text{ where } t = 10^{10} \text{ years.}$$

or $$\frac{N_0}{N} = e^{+\lambda t}.$$

or $$\log_e \frac{N_0}{N} = \lambda t.$$

or $$2.3026 \cdot \log_{10} \frac{N_0}{N} = \lambda t = \frac{0.6931 \times 10^{10}}{4.51 \times 10^9}$$

or $$\log_{10} \frac{N_0}{N} = \frac{0.6931 \times 10}{2.3026 \times 4.51} = 0.6673$$

$\therefore$ $$\frac{N_0}{N} = \text{Antilog } 0.6673 = 4.648$$

or $$\frac{N}{N_0} = \frac{1}{4.648} = 0.215$$

$\therefore$ % age of $_{92}U^{235}$ now present $= 0.215 \times 100 = 21.5\%$.

Q. 3.5. The half-value period of radium is 1590 years. In how many years will one gram of pure element

(*i*) lose one centigram and

(*ii*) be reduced to one centigram? ***(P.U. 1990)***

Ans. Half life period of radium $T = 1590$ years

$$\text{Radioactive constant } \lambda = \frac{0.6931}{T} = \frac{0.6931}{1590}\ yr^{-1}.$$

(*i*) Let t be the time in which one gram of radium loses one centigram (0.01 gram).

$\therefore$ Radium left behind

$$= 1 - 0.01 = 0.99 \text{ gm.}$$

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

or $$\log_e N = \log_e N_0 - \lambda t$$

or $$\lambda t = \log_e \left(\frac{N_0}{N}\right)$$

$\therefore$ $$t = \frac{1}{\lambda} \log_e \left(\frac{1}{0.99}\right)$$

$$= \frac{1590}{0.6931} \log_e \left(\frac{100}{99}\right) = \frac{1590 \times 2.3026}{0.6931} \log_{10} \left(\frac{1}{0.99}\right)$$

$$= \frac{1590 \times 2.3026 \times 0.0044}{0.6931} = 23.25 \text{ years.}$$

(*ii*) When it is reduced to one centigram

$$N = 0.01 \text{ gram}$$

$\therefore$ $$\lambda t = \log_e \frac{1}{0.01}$$

or $$t = \frac{1590 \times 2.3026}{0.6931} \times \log_{10}(100)$$

$$= \frac{1590 \times 2.3026 \times 2}{0.6931}$$

$$= 10560 \text{ years.}$$

Q. 3.6. The half-life of $_{11}Na^{24}$ is 15 hrs. How long does it take for 93.75 per cent of a sample of this isotope to decay? ***(P.U. 1997; G.N.D.U. 1997; Pbi. U. 1997)***

Ans. Half-life of $_{11}Na^{24}$, $T = 15$ hrs.

$\therefore$ Radioactive constant

$$\lambda = \frac{0.6931}{T} = \frac{0.9631}{15} \text{ hr}^{-1}$$

Let t be the time in which 93.75 per cent of the sample decays *i.e.*, $(100 - 93.75) = 6.25$ per cent of the sample remains behind, then

$$\frac{N}{N_0} = \frac{6.25}{100} = e^{-\lambda t}$$

or $$\frac{1}{16} = e^{-\lambda t}$$

$\therefore$ $$\log_e \left(\frac{1}{16}\right) = -\lambda t$$

or $$\log_e 16 = \lambda t$$

or $$t = \frac{\log_e 16}{\lambda}$$

$$= \frac{2.3026 \times \log_{10} 16 \times 15}{0.6931}$$

$$= 60 \text{ hrs.}$$

Q. 3.7. Calculate the half life time and mean life time of the radioactive substance whose decay constant is 4.28×10^{-4} per year. ***(H.P.U. 1995)***

Ans. Decay constant $\lambda = 4.28 \times 10^{-4}$ per year

Mean life $$T_a = \frac{1}{\lambda} = \frac{10^4}{4.28} = 2336 \text{ years.}$$

Half life $$T_{1/2} = \frac{0.6931}{\lambda} = \frac{0.6931 \times 10^4}{4.28} = 1619 \text{ years.}$$

Q. 3.8. The half life of a radioactive substance is 5 hrs. What will be its one third life time? ***(Luck. U. 1995)***

Ans. Half life $T_{1/2} = 5$ hrs.

Now half life $$T_{1/2} = \frac{0.6931}{\lambda}$$

$\therefore$ $$\lambda = \frac{0.6931}{5} = 0.1386 \text{ per hour}$$

Also $\frac{N}{N_0} = e^{-\lambda t}$. In this case $\frac{N}{N_0} = \frac{1}{3}$

$\therefore$ $$\frac{1}{3} = e^{-\lambda t} \quad \text{or} \quad 3 = e^{\lambda t}$$

Hence $$\log_e 3 = \lambda t \text{ or } t = \frac{2.3026 \log_{10} 3}{0.1386} = 7.93 \text{ hrs}$$

Q. 3.9. Half life of a radioactive element is 4 years. After what time the element present in a specimen will reduce to $\frac{1}{64}$ of its original mass. ***(Vid. S.U. 1992)***

Ans. Half life of the radioactive element $T = 4$ years.

$\therefore$ Radioactive constant $\lambda = \frac{0.6931}{T} = \frac{0.6931}{4} = 0.1733$ per year

Let N_0 be the number of radioactive atoms present in the beginning and N left after a time t, then

$$\frac{N}{N_0} = \frac{1}{64} = e^{-\lambda t} = e^{-0.1733t}$$

or

$$64 = e^{0.1733\,t} \quad \therefore\ t = \frac{\log_3 64}{0.1733}$$

$$= \frac{2.3026 \log_{10} 64}{0.1733} = \frac{2.3026 \times 1.80618}{0.1733}$$

$$= 24 \text{ years.}$$

Q. 3.10. The half lie of radon gas is 3.8 days. Is it true that it will vanish in 8 days? Discuss your answer. *(H.P.U. 1993)*

Ans. No, it is not true. Radon gas will not vanish in 8 days. We shall calculate the fraction of radon gas left after 8 days.

Half life of radon gas $T = 3.8$ days.

Now half life $T = \frac{0.6931}{\lambda}$

$$\therefore \quad \lambda = \frac{0.6931}{T} = \frac{0.6931}{3.8} = 0.1824$$

It N_0 is the number of atoms of radon to begin with, and N the number left-after 8 days, then

$$\frac{N}{N_0} = e^{-\lambda t} = e^{-0.1824 \times 8} = e^{-1.4592} = \frac{1}{e^{1.4592}}$$

or

$$\frac{N_0}{N} = e^{1.4592}$$

or

$$\log_e \frac{N_0}{N} = 1.4592$$

$$\therefore \quad \frac{N_0}{N} = 4.3 \quad \text{or} \quad \frac{N}{N_0} = 0.232$$

$\therefore$ $\frac{N}{N_0} = 23.2\ \%$ *i.e.*, After 8 days 23.2% of radon gas will still exist.

Q. 3.11. The activity of certain radio nuclide decreases to 15% of its original value in 10 days. Find its half life? *(G.N.D.U. 1997)*

Ans. Let N_0 be the original number of nuclei and N left behind after 10 days. If λ is the radio active constant, then

$$\frac{N}{N_0} = e^{-\lambda t} \quad \text{or} \quad \frac{15}{100} = e^{-\lambda 10}$$

or

$$\log_e \frac{100}{15} = 10\,\lambda$$

$$\therefore \quad \lambda = \frac{1}{10} \log_e \frac{100}{15} = \frac{1}{10} \times 2.3026 \log 10 \frac{100}{15} = 0.1897$$

$$\therefore \quad \text{Half life} = \frac{0.6931}{\lambda} = \frac{0.6931}{0.1897} = 3.65 \text{ days.}$$

Q. 3.12. The half life of a radioactive substance is 15 years. Calculate the period in which 2.5% of the initial quantity will be left over. *(Luck. U. 1996)*

Ans. Let N_0 be the initial number of nuclei and N left over after a time t, where $N = 2.5\%$.

$$\therefore \qquad \frac{N}{N_0} = \frac{2.5}{100} = \frac{1}{40}$$

Half life $\qquad T = 15$ year

$\therefore$ Radioactive constant $\lambda = \frac{0.6931}{\lambda} = \frac{0.6931}{15} = 0.0462$

Hence $\qquad \frac{N}{N_0} = e^{-\lambda t}$ or $\frac{1}{40} = e^{-0.462t}$

or $\qquad \log_e \frac{1}{40} = -0.0462\ t$ or $\log_e 40 = 0.0462\ t.$

$$\therefore \qquad t = \frac{\log_e 40}{0.0462} = \frac{2.3026 \log_{10} 40}{0.0462} = \frac{2.3026 \times 1.60206}{0.0462}$$

$$= 79.846 \text{ years.}$$

Q. 3.17. Given the half life of radioactive K^{40} is 18.3×10^8 years, calculate the number of β-particle emitted per second per kg. *(Bang. U. 1994)*

Ans. Given half life $T = 18.3 \times 10^8$ years $= 18.3 \times 10^8 \times 365 \times 24 \times 60 \times 60$

$= 5.77 \times 10^{16}$ sec.

Radioactive constant $\lambda = \dfrac{0.6931}{T} = \dfrac{0.6931}{5.77 \times 10^{16}} = 1.2 \times 10^{-17}$ sec^{-1}

If N_0 is the initial number of nuclei and N the number remaining after a time t, then Number of atoms decaying during this period

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

But λt being a very small quantity $e^{-\lambda t} = 1 - \lambda t$

$$\therefore \quad \Delta N = N_0 - N_0 (1 - \lambda t) = N_0 \lambda t$$

$$N_0 = \text{number of atoms in 1 kg of } K^{40} = \frac{6.023 \times 10^{26}}{40}$$

$$= 1.5 \times 10^{25}$$

$$\therefore \quad \Delta N = 1.5 \times 10^{25} \times 1.2 \times 10^{-17} = 1.8 \times 10^8$$

∴ Number of β-particles emitted per second $= 1.8 \times 10^8$.

Q. 3.18. Natural carbon is 18% of human body weight. The activity of ^{14}C in a person weighing 70 kg is 0.1 micro-curie. What fraction of carbon in the body is ^{14}C? Given one currie is 3.7×10^{10} nuclei disintegration per second and half life of ^{14}C = 5730 years.

Ans. Activity $R = \dfrac{dN}{dt} = -\lambda N$

Half life $T = \dfrac{0.6931}{\lambda} = 5730 \times 365 \times 24 \times 60 \times 60$ sec.

$$\therefore \quad \lambda = \frac{R}{N} = \frac{0.6931}{T} = \frac{0.6931}{5730 \times 365 \times 24 \times 60 \times 60} \text{ s}^{-1}$$

If the body contains m gm of ^{14}C, then

$$N = \frac{6.025 \times 10^{23}}{14} \times m$$

$$R = 0.1 \text{ micro curie}$$

$$= 0.1 \times 10^{-6} \times 3.7 \times 10^{10} = 3.7 \times 10^3 \text{ disint/sec}$$

$$\therefore \quad \frac{R}{N} = \frac{3.7 \times 10^3 \times 14}{6.025 \times 10^{23} \times m} = \frac{0.6931}{5730 \times 365 \times 24 \times 60 \times 60}$$

or $\quad m = 2.242 \times 10^{-8}$ gm

∴ Percentage of ^{14}C in natural carbon

$$= \frac{2.242 \times 10^{-8} \times 100}{70 \times 1000 \times \frac{18}{100}}$$

$$= 1.78 \times 10^{-10}\ \%$$

Q. 3.19. Calculate the mass of Pb^{214} (RaB) having a radioactivity of 1 curie. Half life of Pb^{214} = 26.8 minutes. *(P.U. 1992)*

Ans. One curie $= 3.7 \times 10^{10}$ disintegrations/sec.

Let a mass m gm of Pb^{214} (RaB) has an activity of one curie, then

No. of atoms in m gm of Pb^{214}

$$N = \frac{6.025 \times 10^{23} \times m}{214}$$

Since one gm atom (214 gm) of Pb^{214} have 6.025×10^{23} atoms (Avogadro's number)

Half-life of Pb^{214} $T = 26.8$ minutes $= 26.8 \times 60$ sec.

$\therefore$ Radioactive constant

$$\lambda = \frac{0.6931}{T} = \frac{0.6931}{26.8 \times 60}$$

Now activity $R = -\frac{dN}{dt} = \lambda N$

or $$3.7 \times 10^{10} = \frac{0.6931 \times 6.025 \times 10^{23} \times m}{26.8 \times 60 \times 214}$$

or $m = 3.048 \times 10^{-3}$ gm.

Q. 3.20. One gm of Ra^{226} has an activity of one curie. Calculate the mean life and half life of radium. *(P.U. 1996; Luck. U. 1995)*

Ans. Number of atoms of Ra^{226} breaking per second

$R = 1$ Curie $= 3.7 \times 10^{10}$ [1 Curie $= 3.7 \times 10^{10}$ disintegrations per second]

Number of atoms of Ra^{226} present in one gm

$$N = \frac{6.025 \times 10^{23}}{226}$$

as the number of atoms in one gram atom (226 gm) $= 6.025 \times 10^{23}$ (Avogadro's number)

Radioactive constant $\lambda = \frac{R}{N} = \frac{3.7 \times 10^{10} \times 226}{6.025 \times 10^{23}}$

$= 1.38 \times 10^{-11}$ sec^{-1}

Average life $= \frac{1}{\lambda} = \frac{1}{1.38 \times 10^{-11}} = 7.25 \times 10^{10}$ sec $= 2298$ years.

Half life $= \frac{0.6931}{\lambda} = \frac{0.6931}{1.38 \times 10^{-11}} = 5 \times 10^{10}$ sec $= 1585$ years.

Q. 3.21. Half life of radon is 3.8 days. After how many days will $\frac{1}{10}$th of a radon sample remain behind?

Ans. Half life of radon $T = 3.8$ days.

$\therefore$ Radioactive constant $\lambda = \frac{0.6931}{T} = \frac{0.6931}{3.8} = 0.1824$ days^{-1}

Let t be the time in which $\frac{1}{10}$ of the radon sample remains behind then

$$\frac{N}{N_0} = \frac{1}{10} = e^{-\lambda t}$$

or $$10 = e^{\lambda t}$$

or $\log_e 10 = \lambda t$ or $t = \frac{\log_e 10}{\lambda} = \frac{2.3026 \times \log_{10} 10}{0.1824}$

$= 12.62$ days.

Q. 3.22. Calculate the activity of 1 gm of Bi^{209} with a half life of 2.7×10^7 years, in curies. *(Luck. U. 1995)*

Ans. Half life of B^{209}, $T = 2.7 \times 10^7$ years

$= 2.7 \times 10^7 \times 365 \times 24 \times 60 \times 60 = 8.5 \times 10^{14}$ sec.

Radioactive constant $\lambda = \frac{0.6931}{T} = \frac{0.6931}{8.5 \times 10^{14}} = 8.15 \times 10^{-16}$ sec^{-1}

If N_0 is the original number of atoms and N remaining after a time t, then

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

But $\lambda = 8.15 \times 10^{-16}$ s^{-1} and $t = 1$ sec, therefore, λt is very small.

Hence $e^{-\lambda t} = 1 - \lambda t$

or $\Delta N = N_0 - N = N_0 - N_0 (1 - \lambda t) = N_0 \lambda t$

Now N_0 = number Bi^{209} atoms in 1 gm $= \frac{6.023 \times 10^{23}}{209} = 2.88 \times 10^{21}$ where 6.023×10^{23} is Faraday's number representing the number of atoms in one gram atom *i.e.,* 209 gm of Bi^{209}.

$\therefore$ $\Delta N = 2.88 \times 10^{21} \times 8.15 \times 10^{-16} \times 1 = 23.472 \times 10^5$

or Number of disintegrations per second $= 23.472 \times 10^5$

But one Curie $= 3.7 \times 10^{10}$ disintegrations per second

$\therefore$ Activity in Curies $= \frac{23.472 \times 10^5}{3.7 \times 10^{10}} = 63.6 \times 10^{-6}$

$= 63.6$ micro-curie.

Q. 3.23. Calculate the activity of K^{40} in 100 kg mass, assuming that 0.35% of the total weight is potassium. The abundance of K^{40} is 0.012%, its half life is 1.31×10^9 years. ***(Bang. U. 1994)***

Ans. Total mass of potassium in 100 kg mass $= 100 \times \frac{0.35}{100} = 0.35$ kg.

Mass of K^{40} in the total mass $= \frac{0.35 \times 0.012}{100} = 4.2 \times 10^{-5}$ kg.

Number of atoms in one kg. atom of a substance $= 6.023 \times 10^{26}$ atoms

$\therefore$ Total number of K^{40} atoms $N_0 = \frac{6.023 \times 10^{26}}{40} \times 4.2 \times 10^{-5}$

$= 6.32425 \times 10^{20}$

Half life of $K^{40} = 1.31 \times 10^9$ years $= 1.31 \times 10^9 \times 365 \times 24 \times 60 \times 60$

$= 4.13 \times 10^{16}$ sec.

$\therefore$ Radioactive constant $\lambda = \frac{0.6931}{4.13 \times 10^{16}} = 1.678 \times 10^{-17}$

If N_0 is the original number of atoms and N that remaining after a time t, then

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

As λ is a very small quantity $e^{-\lambda t} = 1 - \lambda t$

$\therefore$ $\Delta N = N_0 - N = N_0 - N_0 (1 - \lambda t) = N_0 \lambda t$

$= 6.32425 \times 10^{20} \times 1.678 \times 10^{-17} = 1.061 \times 10^4$ disintegrations/sec

$= \frac{1.061 \times 10^4}{3.7 \times 10^{10}} = 0.287 \times 10^{-6}$ curie $= 0.287$ micro-curie

Q. 3.26. A quantity of ore is found to contain 1 kg of uranium 238, the half-life of uranium 238 is 4.5×10^9 years and that of radium of atomic mass unit 226 is 1620 years. Find the mass of radium in the ore considering them in radioactive equilibrium.

Ans. The parent element uranium is very long lived as compared to the daughter element, radium. The two are, therefore, in secular equilibrium.

Let Avogadro's number be denoted by N.

$\therefore$ Number of atoms in 1 kg of uranium 238,

$$N_1 = \frac{1000}{238} N$$

If m is the mass of radium in equilibrium with 1 kg of uranium, then the number of atoms in m gm of radium 226,

$$N_2 = \frac{m}{226} N$$

If λ_1 and λ_2 are the radioactive constants of U 238 and Ra 226 respectively and T_1 and T_2 their corresponding half-life periods, then

$$\lambda_1 = \frac{0.6931}{T_1} = \frac{0.6931}{4.5 \times 10^9} \text{ yr}^{-1}$$

and

$$\lambda_2 = \frac{0.6931}{T_2} = \frac{0.6931}{1620} \text{ yr}^{-1}$$

Taking T_1 and T_2 in years.

In secular equilibrium

$$\lambda_1 N_1 = \lambda_2 N_2$$

or

$$\frac{0.6931}{4.5 \times 10^9} \times \frac{1000\,N}{238} = \frac{0.6931}{1620} \times \frac{mN}{226}.$$

or

$$m = \frac{1000 \times 1620 \times 226}{4.5 \times 10^9 \times 238}$$

$$= 3.418 \times 10^{-4} \text{ gm.}$$

Q. 3.27. The half life of radium (226) is 1600 years and that of radon (222) is 3.8 days. Calculate the mass of radon that will be in equilibrium with one gm of radium.

(Bang. U. 1995, 1992; Cal. U. 1992)

Ans. The parent element radium is very long lived as compared to the daughter element radon. The two are, therefore, in secular equilibrium. If N is Avogadro's number, then

Number of atoms in 1 gm of radium (226), $N_1 = \frac{N}{226}$. If m is the mass of radon (222) in equilibrium with 1 gm of radium, then the number of atoms in m gm of radon (222), $N_2 = \frac{mN}{222}$.

If λ_1 and λ_2 are the radioactive constants of Radium (226) and radon (222) respectively and T_1 and T_2 corresponding half life periods, then

$$\lambda_1 = \frac{0.6931}{T_1} = \frac{0.6931}{1600 \times 365} \text{ days}^{-1}$$

and

$$\lambda_2 = \frac{0.6931}{T_2} = \frac{0.6931}{3.8} \text{ days}^{-1}$$

taking T_1 and T_2 in days.

In secular equilibrium

$$\lambda_1 N_1 = \lambda_2 N_2$$

or

$$\frac{N_1}{226} \times \frac{0.6931}{1600 \times 365} = \frac{mN}{222} \times \frac{0.6931}{3.8}$$

or

$$m = \frac{222 \times 3.8}{226 \times 1600 \times 365} = \frac{843.6}{1.32 \times 10^8} = 6.39 \times 10^{-6} \text{ gm}$$

$$= 6.39 \text{ microgram.}$$

Q. 4.7. Calculate the Q-value for the formation of P^{30} in the ground state in the reaction Si^{29} (d, n) P^{30} from the following cycles of nuclear reactions.

$$P^{31} + \gamma \longrightarrow P^{30} + n - 12.37 \text{ MeV} \qquad ...(i)$$

$$P^{31} + p \longrightarrow Si^{28} + He^4 + 1.909 \text{ MeV} \qquad ...(ii)$$

$$Si^{28} + d \longrightarrow Si^{29} + p + 6.246 \text{ MeV} \qquad ...(iii)$$

$$2d = He^4 + 23.834 \text{ MeV} \qquad ...(iv)$$

(Cal. U. 1992)

Ans. Reaction (i) can be written as

$$P^{30} + n = P^{31} + \gamma + 12.37 \text{ MeV} \qquad ...(v)$$

Formation of P^{30} from Si^{29} is given by the reaction

$$Si^{29} + d \longrightarrow P^{30} + n + Q \qquad ...(vi)$$

Adding equations (ii), (iii), (iv), (v) and (vi) we get,

$$P^{31} + p + Si^{28} + d + 2d + P^{30} + n + Si^{29} + d$$

$$\longrightarrow Si^{28} + He^4 + 1.909 + Si^{29} + p + 6.246 + He^4 + 23.834$$

$$+ P^{31} + \gamma + 12.37 + P^{30} + n + Q$$

or $$4d = 2He^4 + Q + 44.359 \text{ MeV}$$

$$2He^4 + 47.668 \text{ MeV} = 2He^4 + Q + 44.359 \text{ MeV}$$

$\therefore$ $$Q = 47.668 - 44.359 = 3.309 \text{ MeV.}$$

Q. 4.8. Calculate the energy required to remove the least tightly bound neutron from Ca^{40}. Given mass of Ca^{40} = 39.962589 u, mass of Ca^{39} = 38.970691 u, mass of neutron = 1.008665 u. *(Bang. U. 1994)*

Ans. Removal of neutron from Ca^{40} can be represented by the equation

$$_{20}Ca^{40} \longrightarrow {}_{20}Ca^{39} + {}_0n^1$$

If Q is the energy required to remove the least tightly bound neutron and taking 1 atomic mass unit u = 931.5 MeV, we have

$$39.962589 \times 931.5 + Q = 38.970691 \times 931.5 + 1.008665 \times 931.5$$

or $$Q = (38.970691 + 1.008665 - 39.962589)\ 931.5 \text{ MeV}$$

$$= 15.6 \text{ MeV}$$

Q. 4.9. Calculate the threshold energy required to initiate the reaction $P^{31}(n, p) Si^{31}$. Given $m_p = 1.00814$, $m_n = 1.00898$, $M_P = 30.98356$ and $M_{Si} = 30.98515$.

(P.U. 1996)

Ans. The reaction $P^{31}(n, p) Si^{31}$ can be represented as

$$P^{31} + n \longrightarrow Si^{31} + p + Q$$

Substituting the values of masses given, we have

$$30.98356 + 1.00898 = 30.98515 + 1.00814 + Q$$

$$\therefore \quad Q = 31.99254 - 31.99329 = -0.00075 \text{ u} = -0.00075 \times 931.5 = -0.698 \text{ MeV}$$

Now threshold energy $= -Q\left[\dfrac{M_x + m_a}{M_x}\right]$

$$= 0.698\left[\frac{30.98356 + 1.00898}{30.98356}\right]$$

$$= 0.698 \times 1.03 = 0.719 \text{ MeV}.$$

Q. 4.10. When a nucleus of Li^7 is bombarded with a proton two α- particles are formed. Calculate the kinetic energy of the α- particle assuming the kinetic energy of the bombardin proton is negligible.

(Bang. U. 1992)

Ans. Given mass of $Li^7 = 7.016004$ u

mass of proton $= 1.007825$ u

mass of $He^4 = 4.002603$ u

The reaction takes place as under

$$Li^7 + H^1 \longrightarrow 2He^4$$

Mass of $Li^7 + H^1 = 7.016004 + 1.007825$

$= 8.023829$

Mass of $2\,He^4 = 2 \times 4.002603 = 8.005206$

Loss in mass $= 8.023829 - 8.005206 = 0.018623$ u

Energy released $= 0.018623 \times 931.5 = 17.34$ MeV

$\therefore$ Kinetic energy of each α- particle $= \dfrac{17.34}{2} = 8.67$ MeV

Q. 4.11. Calculate the energy realesed in the reaction

$${}_3Li^6 + {}_0n^1 \longrightarrow {}_2He^4 + {}_1H^3$$

(H.P.U. 1993)

Given **Mass of ${}_3Li^6$ = 6.015123 u**

Mass of ${}_1H^3$ = 3.016029 u

Mass of neutron = 1.008665 u

Mass of ${}_2He^4$ = 4.002603 u

Ans. Mass of ${}_3Li^6 + {}_0n^1 = (6.015123 + 1.008665)$ u

$= 7.023788$ u

Mass of ${}_2He^4 + {}_1H^3 = (4.002603 + 3.016029)$ u

$= 7.018632$ u

$\therefore$ Loss in mass $= (7.023788 - 7.018632)$ u

$= 0.005156$ u $= 0.005156 \times 931.5$

$= 4.8$ MeV

Q. 4.12. Compute the Q-value of the reaction $Be^9(d, n) B^{10}$.

(Luck.U. 1993)

Given: **Mass of Be^9 = 9.012182 u**

B^{10} = 10.012938 u

$$d = \mathbf{2.014102 \ u}$$
$$n = \mathbf{1.008665 \ u.}$$

Ans. The reaction can be represented as

$$Be^9 + H^2 \longrightarrow B^{10} + n^1$$

Mass of $Be^9 + H^2\,(d) = (9.012182 + 2.014102)$ u
$= 11.026284$ u

Mass of $B^{10} + n^1 = (10.012938 + 1.008665)$ u
$= 11.021603$ u

Loss of mass $= (11.026284 - 11.021603)$ u
$= 0.004681$ u

$\therefore$ Q value $= 0.004681 \times 931.5 = 4.36$ MeV.