$$= \frac{6.02 \times 10^{23}}{232}$$

$$= 2.5948 \times 10^{21} \text{ atoms}$$

(ii) To calculate the rate of disintegration

Formula used

$$\frac{dN}{dt} = \lambda \times N$$

Quantities given

$\lambda = 1.58 \times 10^{-18}$ sec^{-1} $\quad N = 2.5948 \times 10^{21}$ atoms

Substitution of values

$$\frac{dN}{dt} = 1.58 \times 10^{-18} \text{ sec}^{-1} \times 2.5948 \times 10^{21} \text{ atoms}$$

$$= \mathbf{4.099 \times 10^{3} \text{ dps}}$$

SOLVED PROBLEM 17. Calculate the mass defect, binding energy and the binding energy per nucleon of $_2He^4$ which has an isotopic mass of 4.0026 amu ($_1H^1 = 1.0081$ amu; $_0H^1 = 1.0089$ amu).

SOLUTION :

Mass of 2 protons + mass of 2 electron = 2 × mass of $_1H^1$

= 2 × 1.0081 amu

= 2.0162 amu

and mass of 2 neutrons =

= 2.0178 amu

mass of He atom = 2.0162 + 2.0178 amu

= 4.034 amu

But Actual mass of He atom = 4.0026 amu

Mass defect (*i.e.* loss of mass) = 4.034 amu – 4.0026 amu

= **0.0314 amu**

Binding Energy =

= 0.0314 × 931.5 MeV

= **29.249 MeV**

and Binding energy per nucleon =

= **7.3122 MeV**

SOLVED PROBLEM 18. In the nuclear reaction

$$_7N^{14} + {}_2He^4 \rightarrow {}_1H^1 + x$$

the x will be (i) $_8O^{17}$ (ii) $_8O^{18}$ (iii) $_9F^{18}$ (iv) $_5B^{10}$

SOLUTION :

The nuclear reaction is

$$_7N^{14} + {}_2He^4 \rightarrow {}_1H^1 + {}_ax^b$$

Comparing the mass numbers

$$14 + 4 = 1 + b$$

or $b = 17$

Comparing the atomic numbers

$$7 + 2 = 1 + a$$

or $a = 8$

$\therefore$ x will be $_8O^{17}$

SOLVED PROBLEM 19. The activity of a radioactive sample falls to 85% of the initial value in four years. What is the half life of the sample ? Calculate the time by which activity will fall by 85%.

SOLUTION :

(i) To calculate the disintegration constant

Formula used

$$\lambda = \frac{2.303}{t} \log \frac{a}{a-x}$$

Quantities given

$t = 4$ years $\quad a = 100 \quad a - x = 85$

Substitution of values

$$\lambda = \frac{2.303}{4 \text{ years}} \log \frac{100}{85}$$

$$= \frac{2.303}{4 \text{ years}} \log 1.1765$$

$$= \frac{2.303}{4 \text{ years}} \times 0.0705$$

$$= \mathbf{4.059 \quad 10^{-2} \ year^{-1}}$$

(ii) To calculate half life period

Formula used

$$t_{1/2} = \frac{0.693}{\lambda}$$

$$\therefore \quad \lambda = \frac{0.693}{4.059 \times 10^{-2} \text{ year}^{-1}}$$

$$= \mathbf{17.07 \text{ years}}$$

(iii) To calculate the time

Formula used

$$\lambda = \frac{2.303}{t} \log \frac{a}{a-x}$$

or

$$t = \frac{2.303}{\lambda} \log \frac{a}{a-x}$$

Quantities given

$\lambda = 4.059 \times 10^{-2}$ year^{-1} $\quad a = 100 \quad a - x = 15$

Substitution of values

$$t = \frac{2.303}{4.059 \times 10^{-2} \text{ year}^{-1}} \log \frac{100}{15}$$

$$= \frac{2.303}{4.059 \times 10^{-2} \text{ year}^{-1}} \times \log 6.66$$

$$= \mathbf{46.69 \text{ years}}$$

SOLVED PROBLEM 20. The mass number and atomic number of a radioactive element Actinium are 227 and 89 respectively. Calculate the number of α and β particles emitted, if the mass number and atomic number of the new element lead are 207 and 82 respectively.

SOLUTION :

Let the number of α and β particles emitted be x and y respectively.

Let the number of α and β particles emitted be x and y respectively.

$$_{89}Ac^{227} \rightarrow {}_{82}Pb^{207} + x\ {}_{2}He^{4} + y\ {}_{-1}e^{0}$$

Comparing the mass numbers, we have

$$227 = $$

or $4x = 20$

$x = 5$

Now comparing the atomic numbers, we have

$$89 = 82 + 2x + y(-1)$$

$$89 - 82 = 2x - y$$

or $7 = $ $(\because x = 5)$

or $y = 3$

SOLVED PROBLEM 21. Complete the following nuclear equations :

(i) ${}_{18}Ar^{40} + \ldots\ldots \rightarrow {}_{19}K^{40} + {}_{0}n^{1}$

(ii) $\ldots\ldots + {}_{1}H^{1} \rightarrow {}_{2}He^{4} + {}_{2}He^{4}$

(iii) ${}_{88}Ra^{236} \rightarrow \ldots\ldots + {}_{2}He^{4}$

(iv) ${}_{92}U^{238} \rightarrow {}_{56}Ba^{143} + \ldots\ldots + {}_{0}n^{1}$

SOLUTION :

Comparing mass numbers and atomic numbers we have

(i) ${}_{18}Ar^{40} + {}_{1}H^{1} \rightarrow {}_{19}K^{40} + {}_{0}n^{1}$

(ii) ${}_{3}Li^{7} + {}_{1}H^{1} \rightarrow {}_{2}He^{4} + {}_{2}He^{4}$

(iii) ${}_{88}Ra^{236} \rightarrow {}_{86}Rn^{232} + {}_{2}He^{4}$

(iv) ${}_{92}U^{238} \rightarrow {}_{56}Ba^{143} + {}_{36}Kr^{92} + 3\,{}_{0}n^{1}$

SOLVED PROBLEM 22. Calculate the age of the tooth in which C^{14} activity is 20% of the activity found at the present time (for C^{14} = 5580 years).

SOLUTION :

(i) To calculate the disintegration constant

Formula used

$$\lambda = \frac{0.693}{t_{1/2}}$$

Quantity given

$$t_{1/2} = 5580 \text{ years}$$

Substitution of values

$$\lambda = \frac{0.693}{5580 \text{ years}}$$

$$= 1.2419 \times 10^{-4} \text{ year}^{-1}$$

(ii) To calculate the time

Formula used

$$\lambda = \frac{2.303}{t} \log \frac{N^0}{N}$$

or $$t = \frac{2.303}{\lambda} \log \frac{N^0}{N}$$

Quantities given

$\lambda = 1.1785 \times 10^{-4}$ year^{-1} $N^0 = 100$ $N = 20$

Substitution of values

$$t = \frac{2.303}{1.2419 \times 10^{-4} \text{ year}^{-1}} \log \frac{100}{20}$$

$$= \frac{2.303}{1.2419 \times 10^{-4} \text{ year}^{-1}} \log 5$$

$$= \frac{2.303 \times 0.6990}{1.2419 \times 10^{-4} \text{ year}^{-1}}$$

$$= \mathbf{12962 \text{ years}}$$

SOLVED PROBLEM 23. An old wooden article shows 2.0 counts per minute per gram. A fresh sample of wood shows 15.2 counts per minute per gram. Calculate the age of the wooden article ($t_{1/2}$ for C^{14} = 5760 years)..

SOLUTION :

(i) To calculate the disintegration constant

Formula used

$$\lambda = \frac{0.693}{t_{1/2}}$$

Quantity given

$$t_{1/2} = 5760 \text{ years}$$

Substitution of values

$$\lambda = \frac{0.693}{5760 \text{ years}} = 1.203 \times 10^{-4} \text{ year}^{-1}$$

(ii) To calculate the age of the wooden article

Formula used

$$\lambda = \frac{2.303}{t} \log \frac{N^0}{N}$$

or

$$t = \frac{2.303}{\lambda} \log \frac{N^0}{N}$$

Quantities given

$\lambda = 1.203 \times 10^{-4}$ year^{-1} $\quad N^0 = 15.2$ Counts per min per g

$N = 2.0$ Counts per min per g

Substitution of values

$$t = \frac{2.303}{1.203 \times 10^{-4} \text{ year}^{-1}} \log \frac{15.2}{2}$$

$$= \frac{2.303}{1.203 \times 10^{-4} \text{ year}^{-1}} \log 7.6$$

$$= \frac{2.303}{1.203 \times 10^{-4} \text{ year}^{-1}} \times 0.8808$$

$$= 1.943 \times 10^{4} \text{ year} \times 0.8808$$

$$= \mathbf{16862 \text{ years}}$$

SOLVED PROBLEM 24. $_{92}U^{238}$ by successive radioactive decay changes to $_{82}Pb^{206}$. A sample of uranium ore was analyzed and found to contain 1 g of U^{238} and 0.1 g of Pb^{206}. Assuming that all Pb^{206} had accumulated due to decay of U^{238} find out age of the ore. (Half life of U^{238} = years).

SOLUTION :

(i) To calculate the disintegration constant

Formula used

$$\lambda = \frac{0.693}{t_{1/2}}$$

Quantity given

$$t_{1/2} = 4.5 \times 10^{9} \text{ years}$$

Substitution of values

$$\lambda = \frac{0.693}{4.5 \times 10^{9} \text{ years}}$$

$$= \mathbf{0.154 \quad 10^{9} \text{ year}^{1}}$$

(ii) To calculate the initial amount of U^{238}, N^0

Since the whole of Pb^{206} comes from U^{238}

Amount of U^{238} decayed = Amount of Pb^{206} formed

$\therefore$ Amount of U^{238} decayed $= \frac{0.1 \times 238}{206}$ g

$= 0.1155$ g

and the initial amount of U^{238} $= 1\text{ g} + 0.1155\text{ g}$

$N^0 = 1.1155$ g

(iii) To calculate the age of the ore

Formula used

$$\lambda = \frac{2.303}{t} \log \frac{N^0}{N}$$

or $$t = \frac{2.303}{\lambda} \log \frac{N^0}{N}$$

Quantities given

$\lambda = 0.154 \times 10^{-9}$ year^{-1} $N^0 = 1.1155$ g $N = 1$ g

Substitution of values

$$t = \frac{2.303}{0.154 \times 10^{-9}\text{ year}^{-1}} \log \frac{1.1155}{1}$$

$$= 14.95 \times 10^9\text{ year} \times 0.0474$$

$$= \mathbf{7.09 \times 10^8\ years}$$

SOLVED PROBLEM 25. Po^{210} decays with alpha to $_{82}Pb^{206}$ with a half life of 138.4 days. If 1.0 g of Po^{210} is placed in a sealed tube, how much helium will accumulate in 69.2 days ? Express the answer in cm^3 at STP.

SOLUTION :

The nuclear equation is

$$_{84}Po^{210} \rightarrow {}_{82}Pb^{206} + {}_{2}He^{4}$$

(i) To calculate the decay constant

Formula used

$$\lambda =$$

Quantity given

$t_{1/2} = 138.4$ days

Substitution of values

$$\lambda = \frac{0.693}{138.4\text{ days}}$$

$$= 5.0 \times 10^{-3}\text{ day}^{-1}$$

(ii) To calculate the amount of $_{84}Po^{210}$ left after 69.2 days

Formula used

$$\lambda = \frac{2.303}{t} \log \frac{N^0}{N}$$

Quantities given

$\lambda = 5.0 \times 10^{-3}$ day^{-1} $t = 69.2$ days

Substitution of values

$$5.0 \times 10^{-3}\text{ day}^{-1} = \frac{2.303}{69.2\text{ days}} \log \frac{N^0}{N}$$

or $$\log \frac{N^0}{N} = \frac{5.0 \times 10^{-3}\text{ day}^{-1} \times 69.2\text{ day}}{2.303}$$

$$\log \frac{N^0}{N} = 1.502 \times 10^{-1} = 0.1502$$

or $$\frac{N^0}{N} = \text{Antilog } 0.1502$$

$$= 1.413$$

or $$\frac{N}{N^0} = \frac{1}{1.413} = 0.707$$

or $$N = N^0 \times 0.707$$

$$= 1\,\text{g} \times 0.707 \qquad [\because N^0 = 1\ \text{g given}]$$

$$= 0.707\,\text{g}$$

Mass of $_{84}Po^{210}$ decomposed to $_{2}He^{4}$

$$= 1\,\text{g} - 0.707\,\text{g}$$

$$= 0.293\,\text{g}$$

(iii) To calculate the volume of $_{2}He^{4}$ accumulated at STP

$$_{84}Po^{210} = {}_{2}He^{4}$$

i.e. 210 g of $_{84}Po^{210} = 4$ g of $_{2}He^{4}$

$\therefore$ 0.293 g of $_{84}Po^{210} = 0.293$ g of $_{2}He^{4}$

$$= 5.580 \times 10^{-3}\,\text{g}$$

At STP 4 g of $_{2}He^{4} = 22400\,\text{cm}^3$

$\therefore$ 5.580×10^{-3} g of $_{2}He^{4} = \frac{22400}{4} \times 5.580 \times 10^{-3}\ \text{cm}^3$

$$= \mathbf{31.248\ cm^3}$$

$\frac{4}{210} \times$

SOLVED PROBLEM 26. In nature a decay chain series start with $_{90}Th^{232}$ and finally terminates at $_{82}Pb^{208}$. A thorium ore sample was found to contain 8×10^5ml of helium at STP and of Th^{232}. Find the age of the sample assuming the source of helium to be only due to the decay of Th^{232}. Also assume complete retention of helium within the ore. (Half life of $Th^{232} = 1.39 \times 10^{10}$ml).

SOLUTION :

(i) To calculate the decay constant

Formula used

$$\lambda = \frac{0.693}{t_{1/2}}$$

Quantity given

$$t_{1/2} = 1.39 \times 10^{10}\ \text{year}$$

Substitution of values

$$\lambda = \frac{0.693}{1.39 \times 10^{10}\ \text{year}}$$

$$= \mathbf{4.986 \times 10^{-11}\ year^{-1}}$$

(ii) To calculate the no. of Th^{232} used up and left

No. of helium atoms in 8×10^{-5} ml at STP $= \frac{8 \times 10^{-5} \times 6.02 \times 10^{23}}{22400}$

$[\because 22400\ \text{ml} = 6.02 \times 10^{23}\ \text{atoms}]$

$$= 2.15 \times 10^{15}\ \text{atoms}$$

No. of Th^{232} atoms used up $= \dfrac{2.15 \times 10^{15} \text{ atoms}}{6}$

$= 3.583 \times 10^{14}$ atoms

No. of Th^{232} atoms left (N) $= \dfrac{5 \times 10^{-7} \times 6.02 \times 10^{23}}{232}$

[∵ 232 g of Th = 6.02×10^{23} atoms]

$= 1.297 \times 10^{15}$ atoms

No. of Th^{232} atoms at the beginning (N^0)

$= 3.583 \times 10^{14} + 1.297 \times 10^{15}$ atoms

$= 16.553 \times 10^{14}$ atoms

(iii) To calculate the age of the sample

Formula used

$$\lambda = \frac{2.303}{t} \log \frac{N^0}{N}$$

or $$t = \frac{2.303}{\lambda} \log \frac{N^0}{N}$$

Quantities given

$\lambda = 4.985 \times 10^{-11}$ year^{-1} $N^0 = 16.553 \times 10^{14}$ atoms $N = 1.297 \times 10^{14}$ atoms

Substitution of values

$$t = \frac{2.303}{4.985 \times 10^{-11} \text{ year}^{-1}} \times \log \frac{16.553 \times 10^{14} \text{ atom}}{12.97 \times 10^{14} \text{ atom}}$$

$= 4.6199 \times 10^{10}$ year $\times 0.1059$

$= \mathbf{4.892 \times 10^{9}}$ **years**

SOLVED PROBLEM 27. A sample of U^{238} (half life = 4.5×10^9 years) ore is found to contain 23.8 g of U^{238} and 20.6 g of Pb^{206}. Calculate the age of the ore.

SOLUTION :

Formula used

$$\lambda = \frac{0.693}{t_{1/2}}$$

Quantity given

$t_{1/2} = 4.5 \times 10^9$ years

Substitution of values

$$\lambda = \frac{0.693}{4.5 \times 10^9 \text{ years}}$$

$= 0.154 \times 10^{-9}$ year^{-1}

$= 1.54 \times 10^{-10}$ year^{-1}

(ii) To calculate the number of moles of U^{238} disintegrated and left

Since $U^{238} = Pb^{206}$

and 20.6 g of $Pb^{206} = \dfrac{20.6 \text{ g}}{206 \text{ g mol}^{-1}} = 0.1$ mole

∴ no. of mole of U^{238} disintegrated = 0.1 mole

and the initial no. of moles of U^{238} = no. of moles of U^{238} left + no. of moles of U^{238} integrated

$= 0.1 + 0.1$ mol

$= 0.2$ mol

(iii) To calculate the age of the ore

Formula used

$$\lambda = \frac{2.303}{t} \log \frac{N^0}{N}$$

or

$$t = \frac{2.303}{\lambda} \log \frac{N^0}{N}$$

Quantities given

$\lambda = 1.54 \times 10^{-10}$ year^{-1} $\quad N^0 = 0.2$ mol $\quad N = 0.1$ mol

Substitution of values

$$t = \frac{2.303}{1.54 \times 10^{-10} \text{ year}^{-1}} \log \frac{0.2 \text{ mol}}{0.1 \text{ mol}}$$

$$= 1.4955 \times 10^{10} \text{ year} \times \log 2$$

$$= 1.4955 \times 10^{10} \times 0.3010 \text{ years}$$

$$= 0.450 \times 10^{10} \text{ years}$$

$$= \mathbf{4.50 \quad 10^9 \text{ years}}$$

SOLVED PROBLEM 28. An experiment requires minimum Beta activity produced at the rate of 346 Beta particles per minute. The half life of $_{42}Mo^{99}$, which is a Beta emitter is 66.6 hours. Find the minimum amount of $_{42}Mo^{99}$ required to carry out the experiment 6.909 hours.

SOLUTION :

(i) To calculate the disintegration constant

Formula used

$$\lambda = \frac{0.693}{t_{1/2}}$$

Quantity given

$t_{1/2} = 66.6$ hours $= 66.6 \times 60$ min $= 3996$ min

Substitution of values

$$\lambda = \frac{0.693}{3996 \text{ min}}$$

$$= 1.734 \times 10^{-4} \text{ min}^{-1}$$

(ii) To calculate the activity required

Time required for the completion of experiment

$$= 6.909 \text{ hours}$$

$$= 6.909 \times 60 \text{ min}$$

$$= 414.54 \text{ min}$$

Total activity required $= 346 \times 414.54$ Beta particles

$=$ Beta particles

(iii) To calculate the amount of $_{42}Mo^{99}$ required

Formula used

$$Activity = \lambda \times N$$

or

$$N = \frac{Activity}{\lambda}$$

Quantities given

$Activity = 1.4343 \times 10^5$ β particles $\quad \lambda = 1.734 \times 10^{-4}$ min^{-1}

Substitution of values

$$N = \frac{1.4343 \times 10^5 \text{ β particles}}{1.734 \times 10^{-4} \text{ min}^{-1}}$$

1.4343×10^5

$= 8.27 \times 10^{8}$ β particles

∴ No. of moles of $_{42}Mo^{99}$ required

$$= \frac{8.27 \times 10^{8}}{6.02 \times 10^{23}\ mol^{-1}}$$

$$= 1.37 \times 10^{-15}\ mol$$

and Amount of $_{42}Mo^{99}$ required $= 1.37 \times 10^{-15}$ mol $\times$ 99 g mol^{-1}

$$= \mathbf{135.63 \times 10^{-15}\ g}$$

SOLVED PROBLEM 29. The nucleidic ratio $_1H^3$ to $_1H^1$ in a sample of water is . Tritium undergoes decay with half life period of 12.3 years. How many tritium atoms would 10 g of such a sample contain 40 years after the original sample is collected.

SOLUTION :

(i) To calculate the disintegration constant

Formula used

$$\lambda = \frac{0.693}{t_{1/2}}$$

Quantity given

$$t_{1/2} = 12.3 \text{ years}$$

Substitution of values

$$\lambda = \frac{0.693}{12.3 \text{ years}}$$

$$= 5.634 \times 10^{-2}\ year^{-1}$$

(ii) To calculate the number of Tritium atoms

No. of moles of water in 10 g sample $= \frac{10}{18}$ mole

No. of moles of H atoms in 10 g sample $= \frac{2 \times 10}{18}$ mole

As $_1H^3 : {}_1H^1 = 8 \times 10^{-18} : 1$

∴ the no. of tritium atoms $= \frac{8 \times 10^{-18} \times 2 \times 10 \times 6.02 \times 10^{23}}{18}$

$$= 5.35 \times 10^{6} \text{ atoms}$$

(iii) To calculate the number of Tritium atoms left after 40 years

Formula used

$$\lambda = \frac{2.303}{t} \log \frac{N^0}{N}$$

Quantities given

$\lambda = 5.634 \times 10^{-2}\ year^{-1}$ $t = 40$ years $N^0 = 5.35 \times 10^{6}$ atoms

Substitution of values

$$5.634 \times 10^{-2}\ year^{-1} = \frac{2.303}{40 \text{ years}} \log \frac{N^0}{N}$$

or $$\log \frac{N^0}{N} = \frac{5.634 \times 10^{-2}\ year^{-1} \times 40 \text{ years}}{2.303}$$

$$= 0.9785$$

or $$\log \frac{N}{N^0} = 0.9785$$

or $\frac{N}{N^0} = \text{Antilog } (-0.9785)$

$= 0.1050$

or $N = N^0 \times 0.1050$

$= 5.35 \times 10^6 \times 0.1050$

$= \mathbf{5.6175 \times 10^5 \text{ atoms}}$

SOLVED PROBLEM 30. One of the hazards of nuclear explosion is the generation of Sr^{90} and its subsequent incorporation in bones. This nuclide has half life of 28.1 years. Suppose one microgram was absorbed by a new born child, how much Sr^{90} will remain in his bones after 20 years.

SOLUTION :

(i) To calculate the disintegration constant

Formula used

$$\lambda = \frac{0.693}{t_{1/2}}$$

Quantity given

$t_{1/2} = 28.1$ years

Substitution of values

$$\lambda = \frac{0.693}{28.1 \text{ years}} = 0.0246 \text{ year}^{-1}$$

(ii) To calculate the amount of Sr^{90} left after 20 years

Formula used

$$\lambda = \frac{2.303}{t} \log \frac{N^0}{N}$$

Quantities given

$\lambda = 0.0246 \text{ year}^{-1}$ $N^0 = 1$ g $t = 20$ years

Substitution of values

$$0.0246 \text{ year}^{-1} = \frac{2.303}{20 \text{ years}} \times \log \frac{N^0}{N}$$

or $\log \frac{N^0}{N} = \frac{0.0246 \text{ year}^{-1} \times 20 \text{ years}}{2.303}$

$= 0.2136$

or $\frac{N^0}{N} = \text{Antilog } 0.2136$

or $\frac{N^0}{N} = 1.635$

or $\frac{N}{N^0} = \frac{1}{1.635} = 0.61$

or $N = N^0 \times 0.61$

$= 1 \text{ µg} \times 0.61$

$= \mathbf{0.61 \text{ µg}}$

SOLVED PROBLEM 31. Ac^{227} has a half life of 21.8 years with respect to radioactive decay. The decay follows two parallel paths, one leading to Th^{227} and the other leading to Fr^{223}. The percentage yield of these two daughter nucleides are 1.2% and 98.8% respectively. What is the rate constant, in year^{-1}, for each of the separate path.

SOLUTION :

(i) To calculate the rate constant for Ac^{227} decay

Formula used

$$k = \lambda =$$

Quantity given

$$t_{1/2} = 21.8 \text{ years}$$

Substitution of values

$$k = \frac{0.693}{21.8 \text{ years}}$$

$$= 3.178 \times 10^{-2} \text{ year}^{-1}$$

(ii) To calculate the rate constants for Th^{227} and Fr^{223}.

For a first order parallel reaction, the overall rate constant is equal to the sum of rate constant for separate paths *i.e.*

$$K_{Ac} = k_{Th} + k_{Fr}$$

$$k_{Th} = \%\text{age yield} \times K_{Ac}$$

$$=$$

$$= \mathbf{3.814 \times 10^{2} \text{ year}^{1}}$$

and

$$k_{Fr} = \%\text{age yield} \times K_{Ac}$$

$$=$$

$$= \mathbf{3.139 \times 10^{2} \text{ year}^{1}}$$

ADDITIONAL PRACTICE PROBLEMS

1. Calculate the number of λ and β particles emitted in the conversion of Thorium, $_{90}Th^{232}$, to lead, $_{82}Pb^{206}$.
   Answer. 6 α, 4 β
2. The mass number and atomic number of a radioactive element Actinium are 227 and 89 respectively. Calculate the number of α and β particles emitted if the mass number and atomic number of the new element lead are 207 and 82 respectively.
   Answer. 5 α, 3 β
3. $_{92}U^{238}$ undergoes a series of change emitting α and β particles and finally $_{82}Pb^{206}$ is formed. Calculate the number of α and β particles which must have been ejected during the series.
   Answer. 8 α, 6 β
4. The half life of cobalt-60 is 5.26 years. Calculate the percentage activity after eight years.
   Answer. 34.87%

5. An old wooden article shows 2.0 counts per minute per gram. A fresh sample of wood shows 15.2 counts per minute per gram. Calculate the age of the wooden article. (of C^{14} = 5760 years)
Answer. 1686.6 years

6. Calculate the age of the tooth in which C^{14} activity is 20% of the activity found at the present time (for C^{14} = 5580 years)
Answer. 12961.4 years

7. Calculate the energy released in the fusion reaction per atom of helium produced.
$$_1H^2 + {}_1H^3 \rightarrow {}_2He^4 + {}_0n^1$$
Given the following atomic masses
$_1H^2 = 2.014$; $_1H^3 = 3.016$; $_2He^4 = 4.003$; $_0n^1 = 1.009$ amu and
1 amu = 1.51×10^{-10} J .
Answer. 2.72×10^{-12} J

8. Calculate the rate of disintegration of one gram of Th^{232} if its decay constant is 1.58×10^{-18} sec^{-1} .
Answer. 4.0998×10^3 dps

9. The activity of a radioactive sample falls to 85% of the initial value in four years. What is the half life of the sample ? Calculate the time by which activity will fall to 85%.
Answer. 17.05 years; 46.735 years

10. 2 g of a radioactive element degraded to 0.5 g in 60 hours. In what time will it be reduced to 10% of its original amount ?
Answer. 4.56 hours

11. Calculate the time required for a radioactive sample to lose one-third of the atoms of its parent Isotope. The half life is 33 min.
Answer. 19.31 min

12. A piece of wood recovered in excavation has 30% as much $_6C^{14}$ as a fresh wood today. Calculate the age of excavated piece assuming half life period of $_6C^{14}$ as 5700 years.
Answer. 9908 years

13. Radioisotope $_{15}P^{32}$ has a half life of 15 days. Calculate the time in which the radioactivity of its 1 mg quantity will fall to 10% of the initial value.
Answer. 49.84 days

14. A natural isotope of potassium has a half life of years. Out of 1 mole of this isotope, how many atoms will remain after 10^{11} years ?
Answer. 1.258×10^{23} atoms

15. In the fission of $_{92}U^{235}$ with thermal neutron, the products are Mo^{95}, La^{139} and two neutrons. Calculate the energy released in MeV in the fission of 1 g $_{92}U^{235}$. The atomic masses in amu are U = 235; Mo = 94.936; La = 138.950; $_0n^1$ = 1.009.
Answer. 5.32×10^{23} MeV

16. Calculate the energy released in joules and MeV in the following nuclear reaction :
$$_1H^2 + {}_1H^2 \rightarrow {}_2He^3 + {}_0n^1$$
Assume that masses of $_1H^2$, $_2He^3$, and $_0n^1$ are 2.0141, 3.0160 and 1.0087 in amu.
Answer. 5.22×10^{-3} J ; 3.2585 MeV