RADIO - ACTIVITY

S-1

(1) ${}^{114}_{49}In$, elements having odd no of neutrons and protons are likely to be radio active.

(2) ${}^{49}_{20}Ca \rightarrow {}^{40}_{20}Ca$ is stable, therefore to decrease $\frac{n}{p}$ ratio, β should be emitted.

${}^{195}_{80}Hg \longrightarrow {}^{200}_{80}Hg$ is stable, therefore to increase $\frac{n}{p}$ ratio, positron emitted.

$\cancel{{}^{8}_{5}B}$

${}^{8}_{5}B \longrightarrow {}^{10}_{5}B$ is stable, therefore to increase $\frac{n}{p}$ ratio, positron emitted.

${}^{150}_{67}Ho \rightarrow {}^{165}_{67}Ho$ is stable, therefore to increase $\frac{n}{p}$ ratio, positron emitted.

${}^{30}_{13}Al \rightarrow {}^{27}_{13}Al$ is stable, therefore to decrease $\frac{n}{p}$ ratio, β emitted.

$^{94}_{36}Kr \rightarrow {}^{84}_{36}Kr$, therefore to decrease n/p ratio.

$\therefore \beta$ emitted.

(8) $^{238}_{92}U \longrightarrow {}^{206}_{82}Pb + n_1 \times {}^{4}_{2}He + n_2 \times {}^{0}_{-1}e$

(I)

$238 = 206 + 4n_1 + 0 \times n_2$

$n_1 = 32/4 = 8$

$92 = 82 + 2n_1 + (-1) \times n_2$

$92 = 82 + 16 + (-n_2)$ | $n_2 = 6$

(II) $^{235}_{92}U \rightarrow {}^{A}_{Z}X + 7 \times {}^{4}_{2}He + 4 \times {}^{0}_{-1}e$

$92 = Z + 14 + (-4)$

$Z = 82$

$235 = A + 28 + 4 \times 0$

$A = 235 - 28$

$A = 207$

Ans = $^{207}_{82}Pb$

(9) $^{A_1}_{Z_1}X \longrightarrow {}^{A_2}_{Z_2}Y + 7 \times {}^{4}_{2}He + 6 \times {}^{0}_{-1}e$

difference between atomic number of parent and stable product $= Z_1 - Z_2$

$Z_1 = Z_2 + 7 \times 2 + 6 \times (-1)$

$Z_1 - Z_2 = 14 - 6 = 8$

(5) Activity $= A = N\lambda$

$N \rightarrow$ no of radioactive atoms.

$n = \frac{1}{200}$

$N = \frac{1}{200} \propto N_A$

$A = \frac{1}{200} \times 6 \times 10^{23} \times 4.8 \times 10^{-7}$ dpm

$= 1.44 \times 10^{15}$ dpm.

(6) $A = N \propto \lambda$

$1\,mCi = \frac{W}{220} \propto N_A \times \frac{\ln 2}{t_{1/2}}$

3.7×10^{7} dps $= \frac{W}{220} \times 6 \times 10^{23} \times \frac{0.693}{54.3}$

$W = 1.06 \times 10^{-15}$ Kg.

(7) $A = N \propto \lambda$

$A = 10^{12} \times \frac{\ln 2}{30 \times 24 \times 60 \times 60 \text{ sec}}$

$A = 2.67 \times 10^{5}$ dps

(8) $t = 2$ hr

Let initial activity $= A_0$

Activity after 2 hours $= A_t = \frac{A_0}{64}$

from I order Kinetics :—

$\lambda = \frac{1}{t} \ln \frac{A_0}{A_t}$

$\lambda = \frac{1}{2} \ln \frac{A_0}{A_0/64}$

$\lambda = \frac{1}{2} \ln 64$

$\lambda = 2.079$ hr^{-1}

(9) $\lambda = \frac{1}{10} \times \ln \frac{100}{20}$

(Since substance decays 20% in 10 min)

$N_0 = 5 \times 10^{20}$ atoms, $N_t = 10^{18}$, $t = ?$

$\lambda = \frac{1}{t} \ln \frac{N_0}{N_t}$

take $\ln 2 = 0.3$

$\frac{1}{10} \ln \frac{100}{80} = \frac{1}{t} \times \ln \frac{5 \times 10^{20}}{10^{18}}$

$t = 270$ min

$t = \frac{270}{60} = 4.5$ hr

(10) $t_{1/2} = 60$ days, $\lambda = \frac{\ln 2}{t_{1/2}} = \frac{\ln 2}{60}$

no of half life $= \frac{240}{60} = 4 = n$

After four half lives, remaining nuclei will be,

$$N_t = \frac{N_0}{(2)^n} = \frac{N_0}{2^4} = \frac{N_0}{16}$$

% of Radioactivity present $= \frac{N_t}{N_0} \times 100$

$= \frac{N_0}{16 \times N_0} \times 100 = 6.25\%$

(11) Decay constant will remain same after 9 and 18 year.

$\lambda_1 = \lambda_2$

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$$\frac{1}{t_1} \ln \frac{A_1}{A_2} = \frac{1}{t_2} \ln \frac{A_3}{A_4}$$

$$\frac{1}{9} \times \ln \frac{A_0}{A_0/3} = \frac{1}{18} \ln \frac{A_0}{A_0/x}$$

$$\frac{1}{9} \times \ln 3 = \frac{1}{18} \ln x$$

$$2 \ln 3 = \ln x$$

$$\boxed{x = 9}$$

(12) $${}^{A}_{Z}X_{(s)} \longrightarrow {}^{A-8}_{Z-4}Y_{(s)} + 2 \times {}^{4}_{2}He$$

$t=0,$ 5 mol

$t=16\,hr,$ $5-a$ $\quad a \quad$ $2a$ mol

Pressure is due to α particle.

$PV = nRT,$

$15 \times 24.6 = n_\alpha \times 0.082 \times 600$

$15 \times 24.6 = 2a \times 0.082 \times 600$

$a = 3.75$ mol

After 16 hours ; 1.25 mol of ${}^{A}_{Z}X$ will be left. % of ${}^{A}_{Z}X$ decomposed $= \frac{3.75}{5} \times 100$

$= 75\%$

$t_{75\%} = 2 \times t_{50\%}$

$t_{50\%} = \frac{16}{2} = \underline{\underline{8\,hr}}$

(13) Let initial tritium content = N_0

After 't' time, remaining tritium

content = $N_t = N_0 \times \frac{15}{100}$

from first order kinetics.

$$\lambda = \frac{1}{t} \times \ln \frac{N_0}{N_t} \quad \Big| \quad \lambda = \frac{\ln 2}{12.3}$$

$$t = \frac{1}{\lambda} \times \ln \frac{N_0}{N_0 \times 15/100}$$

$$t = \frac{12.3}{\ln 2} \times \ln \frac{100}{15}$$

$$t = 33.62 \text{ years.}$$

(14) $N_0 = 2 \times 10^3$ Bq or $2 \times 10^3 \times 60$ dpm.

$t_{1/2} = 15$ hrs.

Let V is the volume of blood in ml.

therefore activity will be –

$$N_t = 8 \times V \text{ dpm}$$

from first order kinetics.

$$\lambda = \frac{1}{t} \ln \frac{N_0}{N_t}$$

$$\frac{\ln 2}{\cancel{15}_3} = \frac{1}{\cancel{25}_5} \ln \frac{2 \times 10^3 \times 60}{8 \times V}$$

$$\ln (32)^{1/3} = \ln \frac{15 \times 10^3}{V}$$

$$\ln 3 = \ln \frac{15 \times 10^3}{V}$$

$$V = 5000 \text{ ml or } 5 L.$$

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(15) initally only U^{238} was present in the ore.

$$U^{238} \longrightarrow Pb^{206}$$

1 mol of U^{238} forms 1 mol of Pb^{206}.
and in final mixture 0.1 mol of U^{238} and 0.1 mol of Pb^{206} are present. So initial mole of U^{238} will be 0.2.

$$U^{238} \longrightarrow Pb^{206}$$

$t=0,\quad 0.2\text{ mol}$

$t=t,\quad 0.1\text{ mol} \qquad 0.1\text{ mol}$

$$\lambda = \frac{\ln 2}{t_{1/2}} = \frac{1}{t}\ln\frac{N_0}{N_t}$$

$$\frac{\ln 2}{4.5\times10^9} = \frac{1}{t}\ln\frac{0.2}{0.1}$$

$$t = \frac{\ln 2 \times 4.5\times10^9}{\ln 2}$$

$$t = 4.5\times10^9 \text{ year.}$$

short cut → since half amount of U^{238} converted into Pb^{206}. so time required will be one half life time.

Q(16) $t_{1/2} = 1.4\times10^9$ years

(i) $${}^{40}_{19}K \longrightarrow {}^{40}_{18}Ar + {}_{+}\beta^{0} + \nu$$

$$({}^{1}_{+}P \longrightarrow {}^{1}n + {}_{+}\beta)$$

(ii) $\,_{19}^{40}K \longrightarrow \,_{18}^{40}Ar + \,_{+1}^{0}\beta + \nu$

given : after time t, $\frac{K}{Ar} = \frac{1}{3}$

$t=0$ 49

$t=t'$ a 34

$$\lambda = \frac{\ln 2}{t_{1/2}} = \frac{1}{t}\ln\frac{N_0}{N_t}$$

$$\frac{\ln 2}{1.4\times10^9} = \frac{1}{t}\times\ln\frac{49}{9}$$

$$t = 2\times1.4\times10^9 = 2.8\times10^9 \text{ year}$$

Q(17)

$$\,_{19}^{40}K \xrightarrow{\lambda_1 = 9\times10^{-9}\,yr^{-1}} \,_{20}Ca^{40}$$

$$\,_{19}^{40}K \xrightarrow{\lambda_2 = 10^{-9}\,yr^{-1}} \,_{18}Ar^{40}$$

$$\lambda_{net} = \lambda_1 + \lambda_2 = 9\times10^{-9} + 10^{-9} = 10^{-8}\text{ year}^{-1}$$

$$\frac{Ar}{K} = \frac{3}{10}, \quad \frac{Ca}{Ar} = \frac{\lambda_1}{\lambda_2} = \frac{9}{1}$$

Let: Ar = 3 atoms,
then K = 10 atoms
and Ca = 27 atoms

$$\lambda_{net} = \frac{1}{t}\ln\frac{N_0}{N_t}$$

$$10^{-8} = \frac{1}{t}\ln\frac{40}{10}$$

$$t = \ln 4\times10^{8}\text{ year}$$

$$\boxed{x=4}$$

(18) (a) $^{14}_{7}N + ^{4}_{2}He \rightarrow ^{17}_{8}O + \underline{^{1}_{1}H}$.

(b) $^{9}_{4}Be + ^{4}_{2}He \rightarrow ^{12}_{6}C + \underline{^{1}_{0}n}$

(c) $^{9}_{4}Be(p, \alpha) \rightleftharpoons \underline{^{6}_{3}Li} + ^{4}_{2}He$

(d) $^{30}_{15}P \rightarrow ^{30}_{14}Si + \underline{^{0}_{+1}e}$

(e) $^{3}_{1}H \rightarrow ^{3}_{2}He + \underline{^{0}_{-1}e}$.

(f) $^{43}_{20}Ca(\alpha, p) \rightarrow ^{46}_{21}Sc$

(g) $^{23}_{11}Na + ^{4}_{2}He \rightarrow ^{26}_{12}Mg + \underline{^{1}_{1}H}$

(h) $^{64}_{29}Cu \rightarrow \beta^{+} + \underline{^{64}_{28}Ni}$

(i) $^{106}_{47}Ag \rightarrow ^{106}_{48}Cd + \underline{^{0}_{-1}e}$

(j) $^{10}_{5}B + ^{4}_{2}He \rightarrow ^{13}_{7}N + \underline{^{1}_{0}n}$

(19)

$$^{2}_{1}H + ^{2}_{1}H \rightarrow ^{4}_{2}He + Q,$$

mass 2.0141u 2.0141u 4.0024u

$$\Delta m = [(2 \times 2.0141) - 4.0024]$$

$$\Delta m = 0.0258$$

Energy released = Δm in amu $\times$ 931.5 Mev

$= 0.0258 \times 931.5 \simeq 24.0327$ Mev

approximate value of $Q = 24$.

Q (20)

$$^{2}_{1}H + ^{2}_{1}H \longrightarrow ^{3}_{2}He + ^{1}_{0}n$$

mass 2.020 2.020 3.016 1.008

$\Delta m = (2.020 + 2.020) - (3.016 + 1.008)$

$\Delta m = 0.016$

Energy Released = Δm in amu $\times$ 931.5 MeV

$= 0.016 \times 931.5$

$= 14.904$ MeV.