PROBLEM SOLVING TACTICS

Nuclear radius (r)= $R_0A^{1/3}$, where A= Mass no. , = 1.4×10^{-15}m

For calculation of geological dating :

(i) Calculation λ from $t_{1/2}, \lambda = \frac{0.693}{t_{1/2}}$

(ii) Calculate uranium converted into lead

(iii) Calculate total initial amount of uranium initially present

(iv) Apply , $t = \frac{2.3030}{\lambda}\log\frac{N_0}{N}$

For calculation in carbon dating method

(i) Calculated from $t_{1/2}$

(ii) m% activity of C-14 now present means $\frac{N_0}{N} = \frac{m}{100}$

(iii) Apply, $\lambda = \frac{2.3030}{t}\log\frac{N_0}{N}$

POINTS TO REMEMBER

Kinetics of Radioactive Disintegration: All radioactive isotopes decays spontaneously following first order kinetics, i.e, rate of decay (-dN/dt) is directly proportional to the amount of radioactive isotope (N).	$-\frac{dN}{dt} \propto N \quad \Rightarrow \quad -\frac{dN}{dt} \lambda N$ Where, 'λ' is decay constant. Integrating the above rate law gives $\lambda t = \mathrm{In}\left(\frac{N_0}{N}\right)$; N_0= Initial number of nuclides N= Number of nuclides remaining after time t. Also $N=N_0e^{-\lambda t}$.
Half-life $\left(t_{1/2}\right)$: Time in which half of the nuclides are decayed	$t_{1/2} = \frac{1}{\lambda}\mathrm{In}\left(\frac{N_0}{N_0/2}\right) = \frac{\mathrm{In}2}{\lambda}$
Activity (A) It is the instantaneous rate of decay.	$A = -\frac{dN}{dt} = \lambda N \quad \Rightarrow$ Initial activity $\left(A_0\right) = \lambda N_0$ Also $A = A_0 e^{-\lambda t}$
Units of Radioactivity: Curie (Ci) and Rutherford (Rd) Gray (Gy): 1Gy = 1 kg tissue receiving 1 J energy. If w0 gram of a radioisotope decay for 'n' half-lives, the amount of radio-isotope remaining undecayed (w) is given by the expression. It is a derived unit of ionizing radiation.	1Ci=3.7 x 10^{10} dps 1Rd = 10^6 dps $w = w_0\left(\frac{1}{2}\right)$

Total Binding Energy (BE) : It is the total energy released when a nucleus is formed from nucleons. BE is determined from mass defect (Δm) as BE = $(\Delta m)C^2$

$\Delta m = \sum$(Mass of nucleons – Mass of nucleus) (Δm = 1u correspond to BE=931 MeV)

Unstable nuclei decay by spontaneous emission of radioactive rays. Stability of a nucleus is accounted qualitatively by its N/P ratio (N=Number of neutrons and P=number of protons).

Up to Z=20, for stable nuclei, N/P=1 is required.

Above Z=20, more neutrons are required to shield the strong electrostatic repulsion between large number of like charged protons in a small nuclear volume, hence N/P> 1 is required for stability in case unstable nuclei, if N/P ratio is greater than that required for stability, β–emission takes place, eg,

$${}_7N^{16} \rightarrow {}_8O^{16} + \beta\left({}_{-1}e^0\right)$$

If N/P ratio is less than that required for stability, radio nuclide may decay by one of the following modes:

(i) Positron emission $\quad {}_5B^8 \rightarrow {}_4Be^8 + {}_{+1}\beta^0\left(\text{Positron } + {}_{+1}e^0\right)$

(ii) Electron capture $\quad {}_{20}Ca^{38} + {}_{-1}e^0 \rightarrow {}_{19}K^{38}$

Alpha (α) emission occurs when Z>82.