

NUCLEAR PHYSICS.

Mass defect & Nuclear Binding Energy

Unified atomic mass

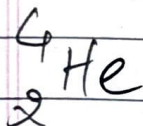
1 u is defined as mass of $\frac{1}{12}$ th of mass of C-12 isotope

$$1 u = 1.66 \times 10^{-27} \text{ kg.}$$

$$m_p = 1.007276 u$$

$$m_n = 1.008665 u$$

$$m_e = 0.000549 u.$$



$$\begin{aligned} & 2 \times 0.000549 + 2 \times 1.007276 \\ & + 2 \times 1.008665 \\ & = 4.031882 u. \end{aligned}$$

actual mass is 4.001508 u.

Mass defect of nucleus is difference between the ~~exp~~ expected mass of nuclei and total mass of separate nucleons.

$$\begin{aligned} \Delta m &= 4.031882 - 4.001508 \\ &= 0.030374 u. \end{aligned}$$

$$E = \underline{\Delta m \times c^2}$$

c - speed of light in vacuum

$$\Delta m = 0.030374$$

$$\Delta m = 0.03037 \times 1.66 \times 10^{-27}$$

$$E = 0.03037 \times 1.66 \times 10^{-27} \times 9 \times 10^8$$

$$= 4.54 \times 10^{-12} \text{ J}$$

1 eV is energy gained by $1e^-$ when accelerated through P.d of 1V

$$1 \text{ eV} = 1.6 \times 10^{-19} \times 1$$

$$= 1.6 \times 10^{-19} \text{ J}$$

$$1 \text{ MeV} = 1.6 \times 10^{-13} \text{ J}$$

$$E = \frac{4.54 \times 10^{-12}}{1.6 \times 10^{-13}}$$

$$= 28.4 \text{ MeV}$$

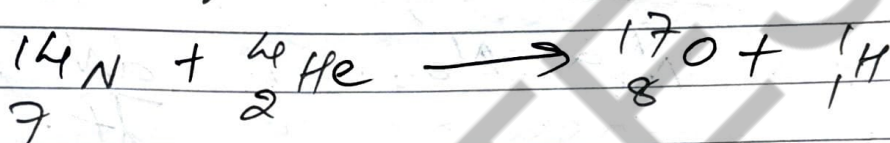
for mass in u is energy in MeV

$$1 \text{ u} = 934 \text{ MeV}$$

Binding Energy

Is the energy equivalent of mass defect of the nucleus. It is the energy required to separate to infinity of all nucleons in a nucleus.

Nuclear Equations



$$\text{Mass of N} = 14.003074 \text{ u}$$

$$\text{" " He} = 4.002604 \text{ u}$$

$$\text{O} = 16.99913 \text{ u}$$

$$\text{" " H} = 1.007825 \text{ u}$$

$$\text{Mass defect} = \sum \text{Mass}_{\text{react}} - \sum \text{Mass}_{\text{product}}$$

$$= 18.005678 - 18.006955$$

$$= -1.277 \times 10^{-3} \text{ u}$$

$$= 1.2 \text{ MeV.}$$

$\therefore$ 1.2 MeV of energy needs to be supplied for reaction to occur.

Stability of Nuclei

N_0 no. of nuclei at start.

$$t + dt \quad N_0 - dN$$

λ - decay constant $t = 0 \quad N = N_0$

$$N \propto N_0 \quad \frac{dN}{dt} \propto N$$

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

$$\int \frac{dN}{N} = -\lambda \int dt$$

$$\ln N = -\lambda t + C$$

$$t = 0 \quad N = N_0$$

$$\ln N_0 = 0 + C$$

$$\therefore \ln N = -\lambda t + \ln N_0$$

$$\ln N - \ln N_0 = -\lambda t$$

$$\ln \left(\frac{N}{N_0} \right) = -\lambda t$$

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

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

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Activity A is defined as number of nuclear decay per unit time.

$$1 \text{ Bq} = 1 \text{ s}^{-1}$$

$$A = \lambda N$$

$$A = A_0 e^{-\lambda t}$$

half life : Time taken for radioactive ~~dec.~~ material to decay to half its original

$$N = \frac{N_0}{2}$$

$$\therefore \frac{N_0}{2} = N_0 e^{-\lambda t}$$

$$\lambda t_{1/2} = \ln 2$$

$$\therefore t_{1/2} = \frac{\ln 2}{\lambda}$$

$$= \frac{0.693}{\lambda}$$