NUCLEAR PHYSICS.

Mass defect & Nuclear Binding Energy

Unified atomic Mass

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

$$1\,U = 1.66 \times 10^{-27}\ kg.$$

$m_p = 1.007276\ u$

$m_n = 1.008665\ u$

$m_e = 0.000549\ u.$

^4_2He

$2 \times 0.000549 + 2 \times 1.007276 + 2 \times 1.008665$

$= 4.031882\ u.$

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.

$\Delta m = 4.031882 - 4.001508$

$= 0.03037\ u.$

$$E = \Delta m \times c^2$$

c – speed of light in vacuum

Δm 0.030374

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

$E = 0.03037 \times 1.66 \times 10^{-27} \times 9 \times 10^{16}$

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

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

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

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

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

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

$= 28.4$ MeV.

for mass in u in energy in MeV

$1u = 934$ MeV.

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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

$$^{14}_{7}N + ^{4}_{2}He \longrightarrow ^{17}_{8}O + ^{1}_{1}H$$

Mass of N = 14.003074 u

" " He = 4.002604 u

" " O = 16.99913 u

" " H = 1.007825 u

Mass defect = $\Sigma Mass_{react} - \Sigma Mass_{product}$

= 18.005678 − 18.006955

= -1.277×10^{-3} u

= 1.2 MeV.

∴ 1.2 MeV of energy needs to supplied for reaction to occur.

Stabality of Nuclei

N_0 no. of nuclei at start.

$t+dt$. $N_0 - dN$.

λ - decay constant

$t=0 \quad N=N_0$

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

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

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

$$\ln N = -\lambda t + c.$$

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

$$\ln N_0 = 0 + c$$

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

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

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

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

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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

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

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

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

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

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