Problem-16

scitechgen@outlook.com

A given coin has a mass of 3.0 g. Calculate the nuclear energy that would be required to separate all the neutrons and protons from each other. For simplicity assume that the coin is entirely made of ${}_{29}Cu^{63}$ atoms (of mass 62.92960 u).

Solution:-

Given: Mass of coin $M = 3.0\,g$

$m({}_{29}Cu^{63}) = 62.92960\,u$.

We have to calculate binding energy.

First, we calculate the total no. of atoms in this coin:-

$$\text{Total no of atoms } N = \frac{N_A \times M}{A}$$

(N_A: Avogadro No; M: mass in g; A: mass no)

$$\therefore N = \frac{6.023 \times 10^{23} \times 3.0}{63}$$

$$\therefore N = 2.868 \times 10^{22} \text{ atoms}$$

Calculate mass defect for one atom:-

${}_{29}Cu^{63}$ has 29 protons and $63 - 29 = 34$ neutrons

$\therefore$ Mass defect of nucleus

$$\Delta m = 29m_p + 34m_n - m({}_{29}Cu^{63})$$

$\therefore \Delta m = (29 \times 1.007825) + (34 \times 1.008665) - 62.92960$

$\therefore \Delta m = 0.591935 \ u$

Calculate mass defect of all atoms in coin

$\Delta m_c = N \times \Delta m$

$= 2.868 \times 10^{22} \times 0.591935$

$\therefore \Delta m_c = 1.69767 \times 10^{22} \ u$

$\therefore \Delta m_c = 1.69767 \times 10^{22} \times 931.5$

$\therefore \Delta m_c = 1.581 \times 10^{25} \ MeV$ ✓

Convert this to Joule:

$\Delta m_c = 1.581 \times 10^{25} \times 1.6 \times 10^{-19}$

$= 2.529 \times 10^{12} \ J$ ✓ Ans

— x —