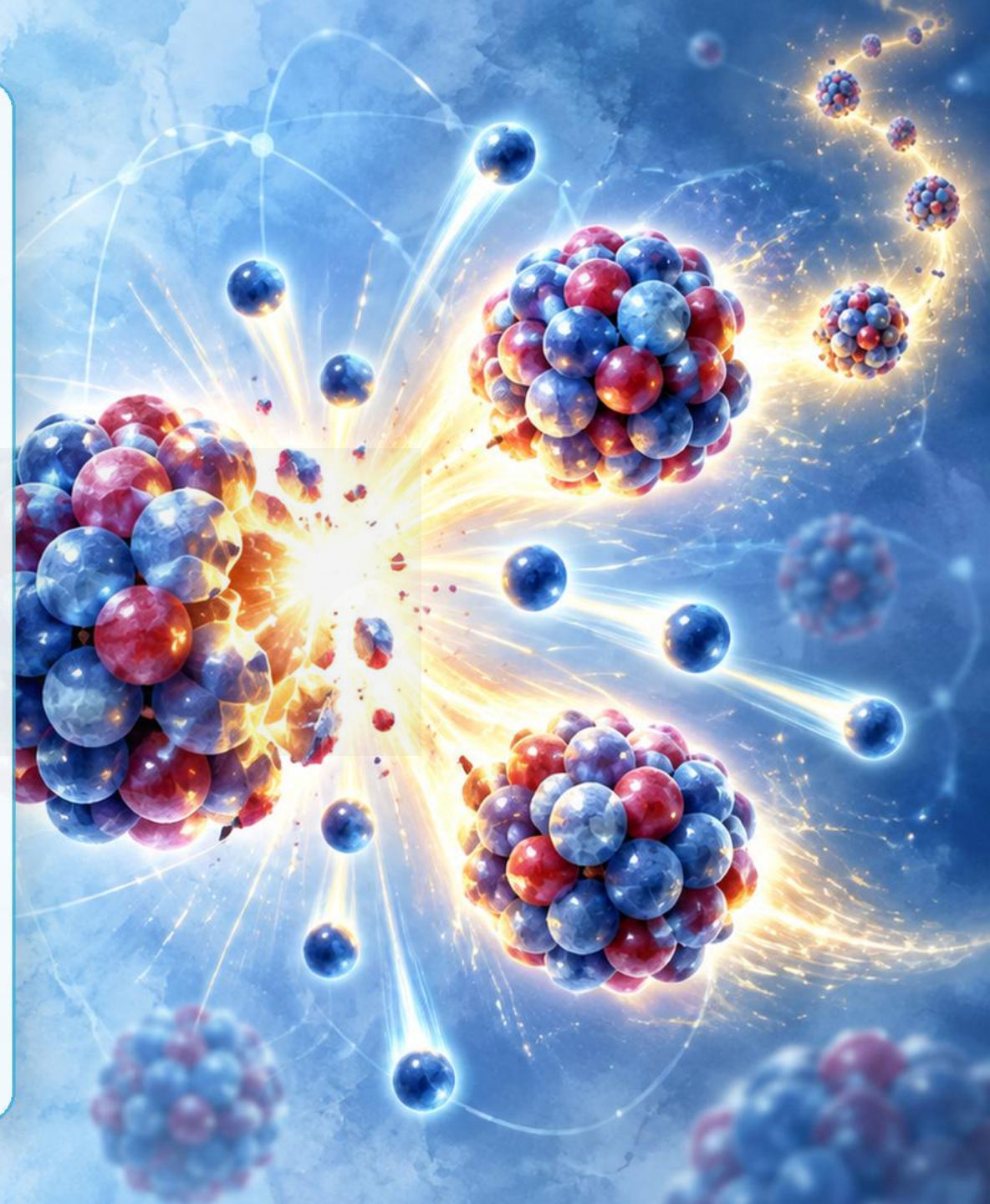


PHYSICS • CLASS 12

CHAPTER 13

Nuclei

NCERT SOLUTIONS



NITROGEN BINDING ENERGY – EXERCISE 13.1

Q. Obtain the binding energy in MeV of a $^{14}_7\text{N}$ nucleus. Given atomic mass $M(^{14}_7\text{N}) = 14.00307 \text{ u}$, neutral-hydrogen atomic mass $m_{\text{H}} = 1.007825 \text{ u}$, neutron mass $m_{\text{n}} = 1.008665 \text{ u}$, and $1 \text{ u } c^2 = 931.5 \text{ MeV}$.

Answer: A $^{14}_7\text{N}$ nucleus has $Z = 7$ protons and $N = A - Z = 7$ neutrons.

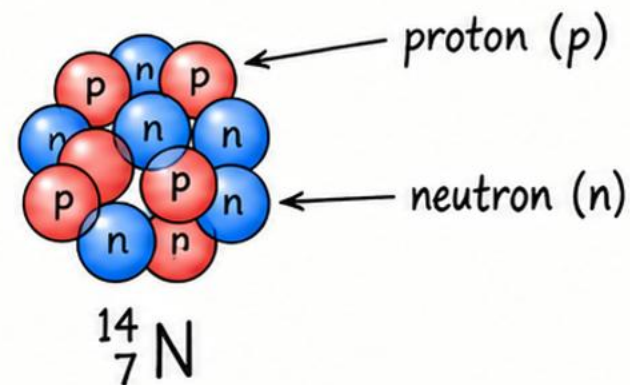
Since atomic masses are used, the hydrogen atomic masses account for the seven electrons in the neutral nitrogen atom, so they cancel.

$$Z = 7, \quad N = A - Z = 7$$

$$\Delta m = Zm_{\text{H}} + Nm_{\text{n}} - M_{\text{atom}}$$

$$\Delta m = 7(1.007825) + 7(1.008665) - 14.00307 = 0.11236 \text{ u}$$

$$E_{\text{B}} = \Delta mc^2 = 0.11236(931.5) = 104.66 \text{ MeV} \approx 104.7 \text{ MeV}$$



Binding energy of $^{14}_7\text{N}$ nucleus = 104.7 MeV per nucleus

IRON BINDING ENERGY – EXERCISE 13.2

Q. Find the total nuclear binding energy of ${}^{56}_{26}\text{Fe}$ in MeV. Given that the neutral atomic mass $M({}^{56}_{26}\text{Fe}) = 55.934939 \text{ u}$, $m_H = 1.007825 \text{ u}$, $m_n = 1.008665 \text{ u}$, and $1 \text{ u} c^2 = 931.5 \text{ MeV}$.

Answer: The binding energy of a nucleus is the energy needed to separate the nucleus into its nucleons (protons and neutrons).

For ${}^{56}_{26}\text{Fe}$, the number of protons $Z = 26$ and the number of neutrons $N = 56 - 26 = 30$.

The mass defect is

$$\begin{aligned}\Delta m &= Zm_H + Nm_n - M_{\text{atom}} \\ &= 26(1.007825) + 30(1.008665) - 55.934939 \\ &= 0.528461 \text{ u}.\end{aligned}$$

Hence, the total nuclear binding energy is

$$\begin{aligned}E_B &= \Delta mc^2 = 0.528461(931.5) = 492.26 \text{ MeV} \\ &\approx 492.3 \text{ MeV}.\end{aligned}$$

$E_B = 492.3 \text{ MeV}$

BISMUTH BINDING ENERGY — EXERCISE 13.2

Q. Second part of Exercise 13.2: find total nuclear binding energy of $^{209}_{83}\text{Bi}$ in MeV.
Given neutral atomic mass $M(^{209}_{83}\text{Bi}) = 208.980388 \text{ u}$, $m_H = 1.007825 \text{ u}$, $m_n = 1.008665 \text{ u}$,
 $1 \text{ u} c^2 = 931.5 \text{ MeV}$.

Answer: For $^{209}_{83}\text{Bi}$, the atomic number is $Z = 83$ and the neutron number is
 $N = 209 - 83 = 126$.

The mass defect is given by

$$\begin{aligned}\Delta m &= 83 m_H + 126 m_n - M_{\text{atom}} \\ &= 83(1.007825) + 126(1.008665) - 208.980388 \\ &= 1.760877 \text{ u}.\end{aligned}$$

Hence, the total nuclear binding energy is

$$\begin{aligned}E_B &= \Delta m c^2 = 1.760877(931.5) \\ &= 1640.26 \text{ MeV} \approx 1.640 \times 10^3 \text{ MeV}.\end{aligned}$$

$E_B = 1.640 \times 10^3 \text{ MeV}$

This is the total binding energy for one bismuth nucleus, not energy per nucleon.

COPPER COIN ENERGY – EXERCISE 13.3

Q. A 3.0 g coin is assumed entirely ${}^{63}_{29}\text{Cu}$ atoms of atomic mass 62.92960 u. Calculate the energy required to separate all protons and neutrons in the coin. Given $m_H = 1.007825$ u, $m_n = 1.008665$ u, $N_A = 6.023 \times 10^{23} \text{ mol}^{-1}$, $1 \text{ u c}^2 = 931.5 \text{ MeV}$, $1 \text{ MeV} = 1.6 \times 10^{-13} \text{ J}$.

Answer: Each atom has one Cu nucleus. The total separation energy is the number of nuclei times the nuclear binding energy.

① For ${}^{63}_{29}\text{Cu}$, $Z = 29$, $N = 34$.

$$\Delta m = 29(1.007825) + 34(1.008665) - 62.92960 = 0.591935 \text{ u.}$$

$$E_B \text{ per atom} = 0.591935(931.5) = 551.39 \text{ MeV.}$$

② Number of Cu atoms in 3.0 g coin:

$$N = \left(\frac{3.0}{62.92960} \right) (6.023 \times 10^{23}) = 2.871 \times 10^{22} \text{ atoms.}$$

③ Total separation energy:

$$E = (2.871 \times 10^{22})(551.39)(1.6 \times 10^{-13}) = 2.53 \times 10^{12} \text{ J.}$$

$$E = 2.53 \times 10^{12} \text{ J}$$

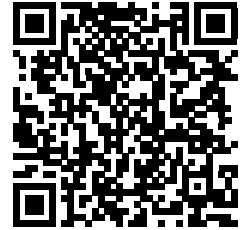


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