DRGP Institute

Chapter 13

Nuclei

Chapter 13
Nuclei

BOARD - 2013

1. An element A decays into element C by the following two step processes :

$$A \longrightarrow {}_{2}He^{4} + B$$

$$B \longrightarrow 2({}_{-1}e^{0}) + C$$

Select pair for isobars from elements A, B and C. 1

Solution - A → A (Atomic mass No.), Z (Atomic No.); B → A-4, Z-2; C → A-4, Z

→ Atomic No. of A & C are same ⇒ Isotope

→ Atomic mass No. of B & C are same ⇒ Isobar

2. Write the law of radioactive decay. Decay constant of a radioactive substance is 10^{-3} per year. Calculate its half-life time in year. 1 + 1 = 2

Not in syllabus.

BOARD - 2013 (Supp)

3. For which mass number binding energy per nucleon is maximum ? 1

⇒ For A = 56 (Iron)

BOARD - 2014

4. From the equation $R = R_o A^{\frac{1}{3}}$, show that the nuclear matter density is nearly constant. [Where R_o is a constant and A is the mass number.] 2

⇒ density $= \frac{\text{Mass}}{\text{Volume}}$

$$\rho = \frac{M}{V} \quad - (1)$$

$$V = \frac{4}{3}\pi R^3 = \frac{4}{3}\pi (R_o A^{1/3}) = \frac{4}{3}\pi R_o^3 A$$

& $M = Am$ { A × mass of one nucleon }

Put in eqⁿ (1)

$$\rho = \frac{Am}{\frac{4}{3}\pi R_o^3 A}$$

$$\rho = \frac{3m}{4\pi R_o^3}$$

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

$R_0 = 1.2 \times 10^{-15}$ m

$\rho = 2.3 \times 10^{17}$ kg/m^3

BOARD:- 2015

5. Write the relation in radius R and mass number A of a nucleus. 1

⇒ $R = R_0 A^{1/3}$

6. Define mass defect of a nucleus. Binding energy of ${}_8O^{16}$ is 127·5 MeV. Write the value of its 'binding energy per nucleon'. Write the value of 1 eV energy in joule. $1 + \frac{1}{2} + \frac{1}{2} = 2$

⇒ Mass defects - Difference b/w Mass of nucleons (n+p) & Actual mass is called Mass defects.

$\Delta M = Zm_p + (A-Z)M_n - M$

Binding Energy per nucleon -

$\overline{E_b} = \frac{E_b}{A}$

$\overline{E_b} = \frac{127.5}{16}$ {for ${}_8^{16}O$}

$\overline{E_b} = 7.96$ MeV

1eV = 1.6×10^{-19} J

BOARD:- 2016

7. Write the law of radioactive decay. A radioactive nucleus is decaying in the following way. Determine the mass number and atomic number of final product X_4 When initial nucleus has mass number A=238 and atomic number Z=92.

$$\begin{matrix} A \\ Z \end{matrix} X \xrightarrow{\alpha} X_1 \xrightarrow{\beta^-} X_2 \xrightarrow{\alpha} X_3 \xrightarrow{\gamma} X_4$$

⇒ ${}_{92}^{238}X \xrightarrow{\alpha} {}_{90}^{234}X_1 \xrightarrow{\beta^-} {}_{91}^{234}X_2 \xrightarrow{\alpha} {}_{89}^{230}X_3 \xrightarrow{\gamma} {}_{89}^{230}X$

α → A-4, Z-2 ; β^- → A (No change), Z+1 ; γ → No change

BOARD:- 2017

8. **[½ + ½ + 1 = 2]**

a) Define the activity of radioactive substances. Write its S.I. unit.

b) "The half life of $^{14}_{6}C$ is 5700 years." What does it mean?

Not in current syllabus

BOARD:- 2018

9. What does mean by mass defect? Establish relation between mass defect and nuclear binding energy. And hence write the expression for binding energy per nucleon.

⇒

Mass defects - Difference b/w Mass of nucleons (n+p) & Actual mass is called Mass defects.

$$\Delta M = Zm_p + (A-Z)M_n - M$$

Relation b/w Mass defect & Nuclear Binding Energy - Energy which binds nucleon's in nucleus is called Binding Energy.

$$E_b = (\Delta M)c^2$$

or

$$E_b = \Delta M \times 931 \text{ Mev}$$

Binding Energy Per Nucleon - Ratio of Binding energy and atomic Mass no. is called Binding energy per nucleon.

$$\overline{E_b} = \frac{E_b}{A}$$

BOARD:- 2018 (Supp)

10. Find per nucleon binding energy for Deutron ($_1H^2$) nucleus.

Given that

Mass of deutron nucleus = 2.013 *u*

Mass of Proton = 1.007 *u*

Mass of nutron = 1.008 *u*

and $1u = 931 \text{ Mev/c}^2$

⇒ (i) $\Delta M = Zm_p + (A-Z)m_n - M$

$\Delta M = 1 \times 1.007 + (2-1)1.008 - 2.013$

$\Delta M = 2.015 - 2.013$

$\Delta M = 0.002\ u$

(ii) $E_b = \Delta MC^2$ or $\Delta M \times 931\ MeV$

$E_b = 0.002 \times 931\ MeV$

$E_b = 1.862\ MeV$

(iii) $\overline{E_b} = \frac{E_b}{A} = \frac{1.862}{2} = 0.931\ MeV$

BOARD:- 2019

11. Write Rutherford-Soddy law of radioactive decay and derive related equation. Draw exponential decay curve of a radioactive substance. Write ratio of half life and mean life of a radioactive substance.

Not in current syllabus

BOARD:- 2020

12. A radioactive nucleus 'D' is decaying in the following way :

$$^{235}_{92}D \xrightarrow{\alpha\ decay} D_1 \xrightarrow{\beta^-\ decay} D_2 \xrightarrow{\alpha\ decay} D_3 \xrightarrow{\gamma\ decay} D_4$$

Determine the atomic number and mass number of D_4. **1 + 1 = 2**

⇒ $^{235}_{92}D \xrightarrow{\alpha} {}^{231}_{90}D_1 \xrightarrow{\beta^-} {}^{231}_{91}D_2 \xrightarrow{\alpha} {}^{227}_{89}D_3 \xrightarrow{\gamma} {}^{227}_{89}D_4$

α → A − 4, Z − 2

β^- → A (No change), Z + 1

γ → No change

D_4 → A = 227, Z = 89

BOARD:- 2020 (Supp)

13. What is nuclear fission and nuclear fusion ?

⇒ 1. Nuclear fission - In this heavy nucleus breaks into two or more lighter nuclei along with release of energy.

$$^{235}_{92}U + {}^{1}_{0}n \longrightarrow {}^{144}_{56}Ba + {}^{89}_{36}Kr + 3{}^{1}_{0}n$$

→ The source of energy in nuclear reactors, which produce electricity, is nuclear fission.

2. Nuclear fussion - when two light nuclei fuse to form a larger nucleus, energy is released is known as Nuclear fussion.

⇒ proton - proton cycle -

$$_1^1H + _1^1H \longrightarrow _1^2H + _1^0e (\beta) + \gamma + Energy \text{ ------- } (1)$$

$$_1^2H + _1^1H \longrightarrow _2^3He + \gamma + Energy \text{ ------- } (2)$$

$$_2^3He + _2^3He \longrightarrow _2^4He + _1^1H + _1^1H + Energy \text{ ----- } (3)$$

for (3) rxn (1)&(2) must occur twice.

BOARD - 2021

14. What is nuclear fission and nuclear fusion ?

BOARD - 2022

15. What is meant by mass defects and nuclear binding energy. Draw a graph between mass number and binding energy per nucleon.

⇒ (A) Mass defects - Difference b/w Mass of nucleons (n+p) & Actual mass is called Mass defects.

$$\Delta M = Zm_p + (A-Z)M_n - M$$

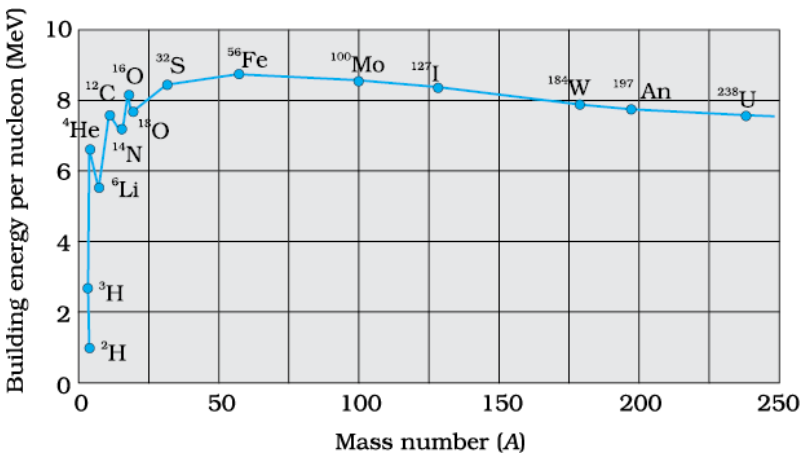
(B) Nuclear Binding Energy - Energy which binds nucleon's in nucleus is called Binding Energy.

$$E_b = (\Delta M)c^2$$

or

$$E_b = \Delta M \times 931 \text{ Mev}$$

(C) Graph -



16. Write three character of nuclear force.

⇒ 1. Nuclear force is strong force of attraction which hold together nucleon in tiny nucleus. It is 100 times stronger than electro static force.

2. It is short range force which acts in the range of 10^{-15}m.

3. This force is independent on charge & it acts b/w n-n, p-P, n-p.

BOARD:- 2023

17. Define the following.

i) nuclear fusion

ii) nuclear fission

iii) mass defect

⇒ (i) ✓ (ii) ✓ (iii) ✓

BOARD:- 2024

18. Those atoms which have the same atomic number but different mass number are called -

A) isobars B) isotones

C) isotopes D) isomers

19. Write Einstein's mass-energy equivalent relation.

⇒ According to Einstein, "Mass & Energy both are interchangeable."

$$E = mc^2$$

E = Energy

m = Mass

C = Speed of light

20. What is nuclear fission and nuclear fusion ?

Some imp. questions -

1. Controlled thermonuclear fusion - In controlled fusion reactors, the aim is to generate steady power by heating the nuclear fuel to a temperature in the range of 10^8K.

→ At these temp., the fuel is a mixture of +ve ions and electrons (plasma).

→ The challenge is to confine this plasma, since no container can stand such a high temp.

2. Radioactive decay - A nuclear phenomenon in which an unstable nucleus undergoes a decay.

→ A.H Becquerel discovered radioactivity.

→ Three types of radioactivity.

(i) α- decay

(ii) β- decay

(iii) γ- decay

3. Isotope, Isobar & Isotones

↓ 'Z' same, 'A' different

↓ 'Z' different, 'A' same

↳ Number of neutron is same.