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Radiant pressure when reflection & Absorption occur simultaneously

Let, K_r & K_a be reflection and absorption Coffi cient

$$K_a + K_r = 1$$

(F_T) = $F_{reflection} + F_{absorption}$

Total force

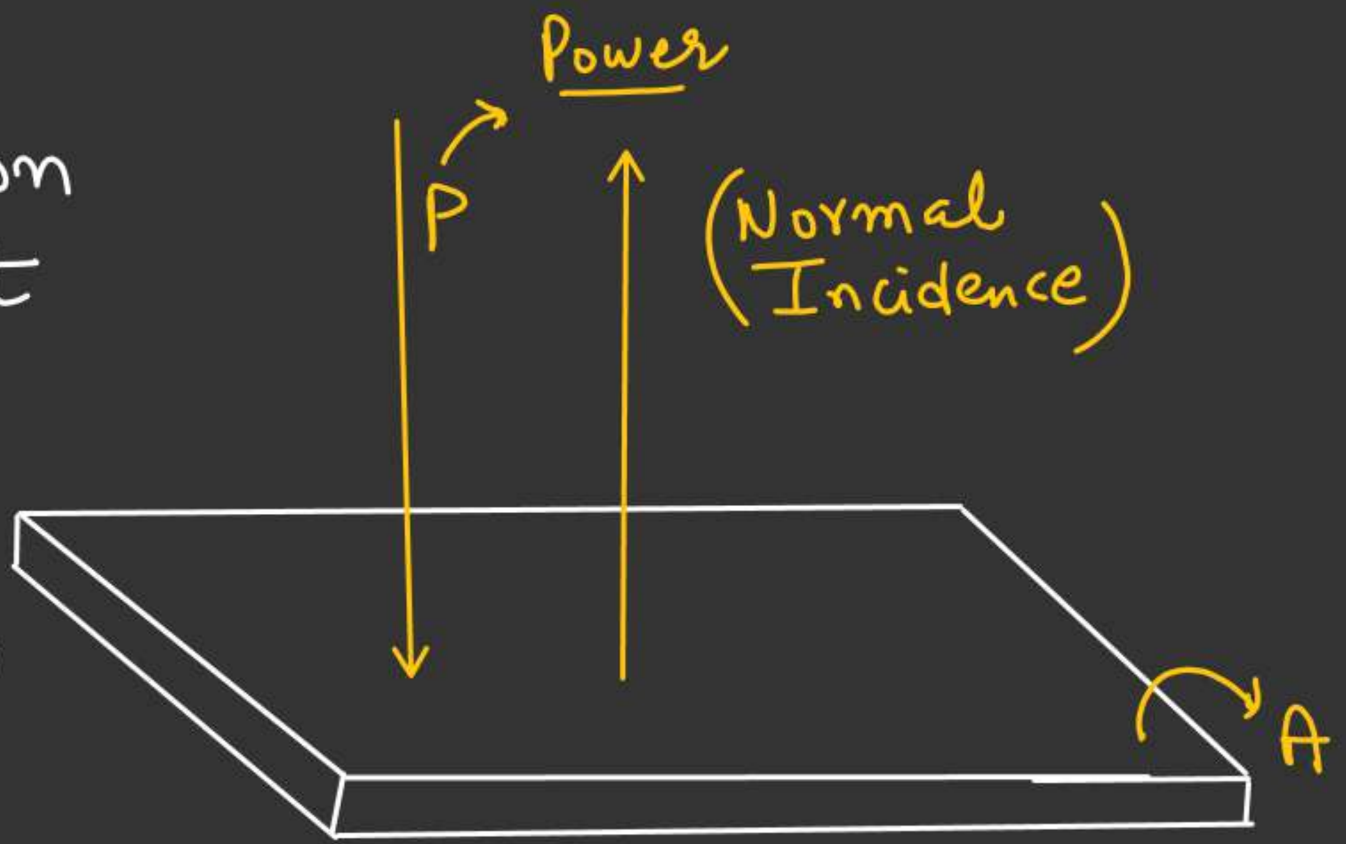
$$= K_r \frac{2P}{c} + K_a \frac{P}{c}$$

$$= \frac{P}{c}\left[2K_r + K_a\right]$$

$$F_T = \frac{P}{c}\left[2K_r + (1 - K_r)\right]$$

$$F_T = \frac{P}{c}$$

$$\boxed{F_T = \frac{P}{c}(1 + K_r)}$$



Total pressure $= \left(\frac{F_T}{A}\right)$

absorbed

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$$\boxed{{}^{A}_{Z}X}$$

Isotope ↳ (Same Atomic No)

Isobar (↳ Same Mass No)

Isotone ↳ Same (No neutrons)

$A =$ Mass No

↳ (No of Neutrons + No of proton)

↳ Collectively Called Nucleons.

$Z =$ (Atomic No)

↳ (No of proton) = (No of electron)

$A - Z =$ (No of Neutrons)

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Size of Nucleus :-

$$R \propto (A)^{1/3}$$

$$\boxed{R = R_0 (A)^{1/3}}$$

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

A = Atomic mass

Nuclear density

$m_p = m_n = m$

Am = Total mass of Nucleus.

$$\rho = \frac{(Am)}{\frac{4}{3}\pi R^3}$$

$$\rho = \frac{(mA)}{\frac{4}{3}\pi R_0^3 (A^{1/3})^3}$$

$$\rho = \left(\frac{m}{\frac{4}{3}\pi R_0^3}\right) = \left(\frac{3m}{4\pi R_0^3}\right)$$

$$\rho = \frac{3 \times 1.67 \times 10^{-27}}{4 \times 3.14 \times (1.2 \times 10^{-15})^3} = 2.3 \times 10^{17}$$

$$\boxed{\rho = 2.3 \times 10^{17}}$$

Independent of A.

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Atomic Mass Unit (a.m.u)

↳ = $\frac{1}{12}^{th}$ mass of $\left({}^{12}_{6}C\right)$

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

According to Einstein mass-energy equivalence relation

$$\Delta E = (\Delta m) c^2$$

$$\Delta E = (1.66 \times 10^{-27}) \times (3 \times 10^8)^2 \text{ J}$$

$$\Delta E = \frac{(1.66 \times 10^{-27}) \times (3 \times 10^8)^2}{(1.6 \times 10^{-19})}$$

$$\boxed{\begin{aligned} \Delta E &= 931.5 \text{ MeV.} \\ &\simeq 931 \text{ MeV} \end{aligned}}$$

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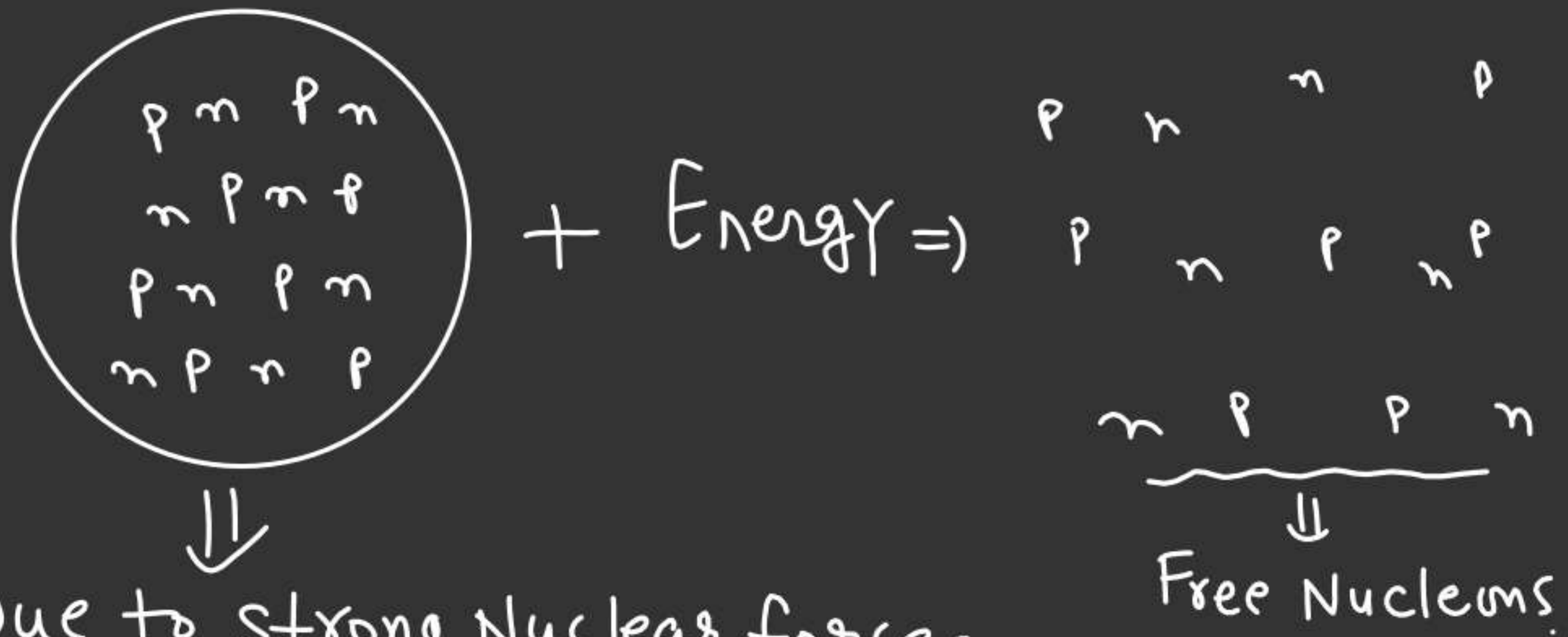
BINDING ENERGY



$\Downarrow$

Due to strong Nuclear forces proton & Neutron held together in a Small Volume. & the Nuclear force overcome the electrostatic repulsion b/w (P–P)

$\Downarrow$ Free Nucleons

$$\Delta m = \underbrace{\left[Z(m_p) + (A-Z)m_n\right]}_{\text{Mass of free Nucleons}} - \underbrace{\left[M_N\right]}_{\text{mass of Nucleus}}$$

Binding energy

$$= \Delta m \cdot c^2$$

$$= \left\{\left[Z(m_p) + (A-Z)m_n\right] - \left[M_N\right]\right\} c^2 \ (J)$$

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$$\boxed{B.E = \left[Z(m_p) + (A-Z)m_n - M_N\right]c^2}$$

Energy of 1 a.m.u
$= 931\ MeV$

B.E in terms Atomic mass.

$$M_N = m\left({}^{A}_{Z}X\right) - Z(m_{e^-})$$

(Mass of Nucleus) Mass of Atom

m_H = mass of hydrogen Atom.

$$B.E = \left\{Z(m_p) + (A-Z)m_n - \left[m\left({}^{A}_{Z}X\right) - Z m_{e^-}\right]\right\}$$

$$B.E = Z(m_p + m_e) + (A-Z)m_n - m\left({}^{A}_{Z}X\right)$$

$$\boxed{B.E = \left\{Z(m_H) + (A-Z)m_n - m\left({}^{A}_{Z}X\right)\right\}c^2}$$

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BINDING ENERGY PER NUCLEON

- ⇒ Tells about the Stability of Nucleus.
- ⇒ Binding Energy per Nucleon for Smallar Atomic mass increases rapidly up to $\left[{}^{56}_{26}Fe\right]$
- ⇒ For Higher Atomic masss B.E per Nucleon decreases. After $\left({}^{209}_{83}Bi\right)$ it decreases rapidly.

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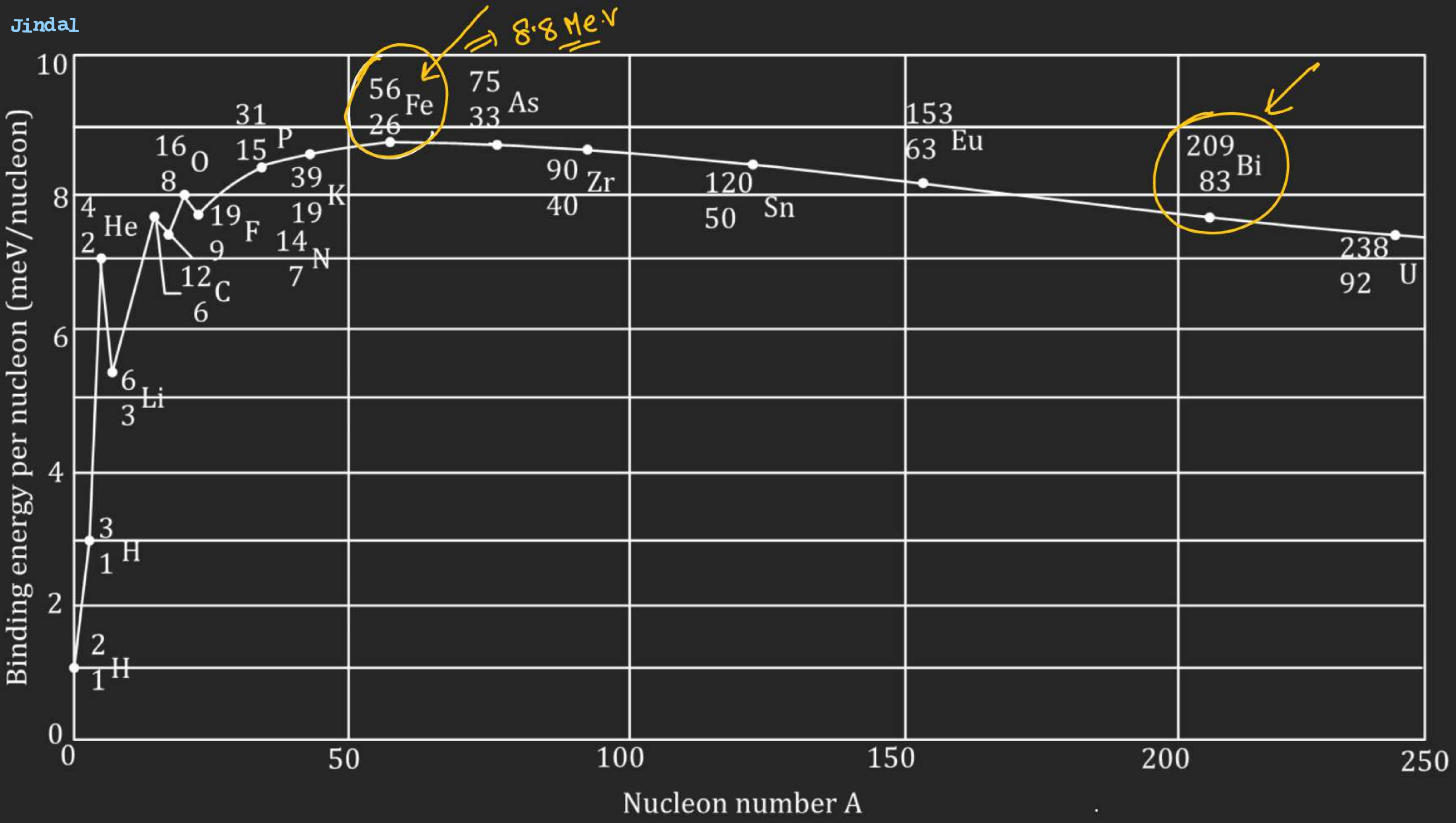

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Q.1 Read the following statements: [July 29, 2022 (II)]

(A) Volume of the nucleus is directly proportional to the mass number.

(B) Volume of the nucleus is independent of mass number.

(C) Density of the nucleus is directly proportional to the mass number.

(D) Density of the nucleus is directly proportional to the cube root of the mass number.

(E) Density of the nucleus is independent of the mass number.

Choose the correct option from the following options.

(a) (A) and (D) only

(c) (B) and (E) only

(b) (A) and (E) only.

(d) (A) and (C) only

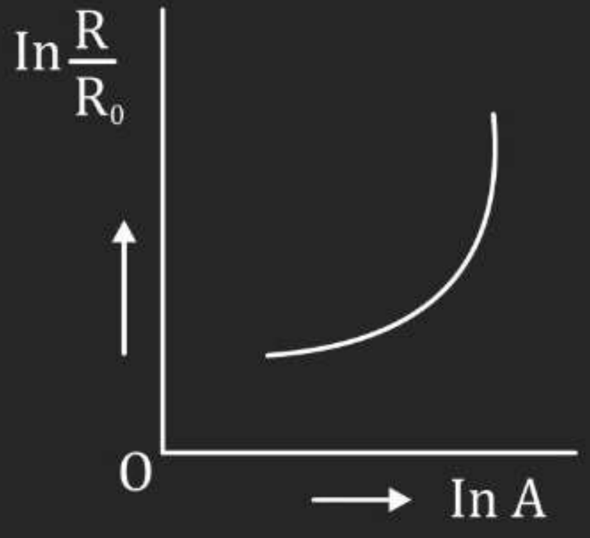
ATOM & NUCLEI

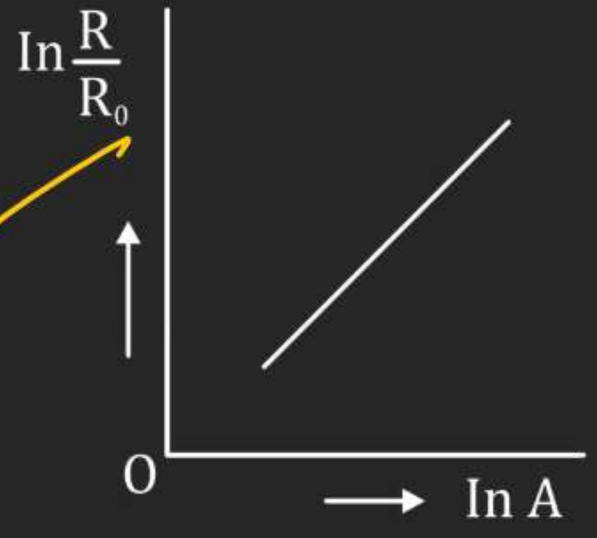
Q.2 Mass numbers of two nuclei are in the ratio of $4:3$. Their nuclear densities will be in the ratio of **[July 26,2022 (II)]**

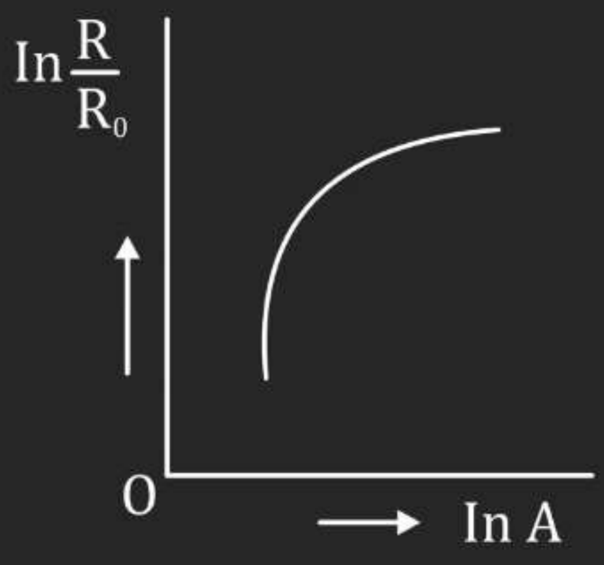
(A) $4:3$ (B) $\left(\frac{3}{4}\right)^{\frac{1}{3}}$ (C) $1:1$ (D) $\left(\frac{4}{3}\right)^{\frac{1}{3}}$

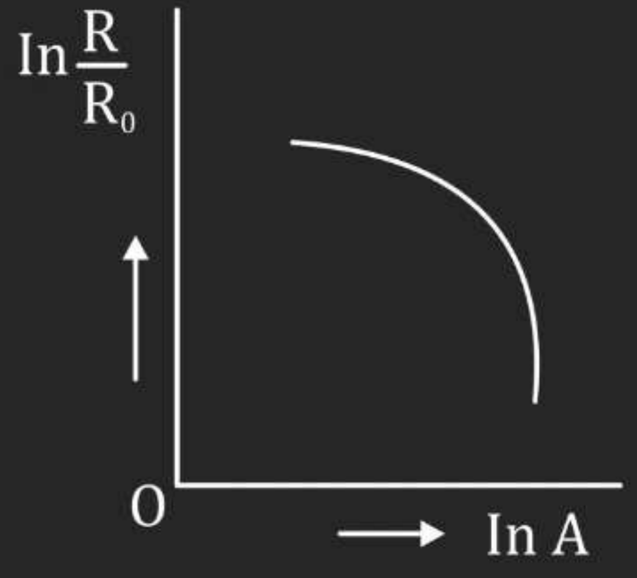
ATOM & NUCLEI

Q.3 Which of the following figure represents the variation of $\ln\left(\frac{R}{R_0}\right)$ with $\ln A$ (If R = radius of a nucleus and A = its mass number)? **[June 25, 2022 (II)]**

(A) 

(B) 

(C) 

(D) 

$R = R_0 (A)^{1/3}$.

$\ln R = \ln R_0 + \frac{1}{3} \ln A$

$\ln\left(\frac{R}{R_0}\right) = \frac{1}{3} \ln(A)$

$\Downarrow \quad \Downarrow \quad \Downarrow$

$y = m x$

ATOM & NUCLEI

Q.4 The radius R of a nucleus of mass number A can be estimated by the formula $R = (1.3 \times 10^{-15})A^{1/3}$ m. It follows that the mass density of a nucleus is of the order of : $\left(M_{\text{prot.}} \cong M_{\text{neut.}} \simeq 1.67 \times 10^{-27}\ \text{kg}\right)$ [Sep.03,2020(11)]

(A) $10^{3}\ \text{kg m}^{-3}$

(B) $10^{10}\ \text{kg m}^{-3}$

(C) $10^{24}\ \text{kg m}^{-3}$

(D) $10^{17}\ \text{kg m}^{-3}$

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Q.5 The ratio of the mass densities of nuclei of ^{40}Ca and ^{16}O is close to :

[8 April 2019 (II)]

(A) 1

(B) 0.1

(C) 5

(D) 2

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Q.6 An unstable heavy nucleus at rest breaks into two nuclei which move away with velocities in the ratio of 8:27. The ratio of the radii of the nuclei (assumed to be spherical) is: [15 April 2018]

(A) 8:27

(B) 2:3

(C) 3:2

(D) 4:9

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Q.6 Which of the following are the constituents of the nucleus? [2007]

(A) Electrons and protons

(B) Neutrons and protons

(C) Electrons and neutrons

(D) Neutrons and positrons

ATOM & NUCLEI

Q.7 If radius of the $^{27}_{13}\mathrm{Al}$ nucleus is estimated to be 3.6 fermi then the radius of $^{125}_{52}\mathrm{Te}$ nucleus be nearly [2005]

(A) 8 fermi

(B) 6 fermi

(C) 5 fermi

(D) 4 fermi

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Q.9 Two lighter nuclei combine to form a comparatively heavier nucleus by the relation given below: ${}_1^2X + {}_1^2X = {}_2^4Y$ **[July 26, 2022 (II)]**

The binding energies per nucleon ${}_1^2X$ and ${}_2^4Y$ are $1.1\,\text{MeV}$ and $7.6\,\text{MeV}$ respectively. The energy released in this process is ______ MeV.

$$\Delta E = \left[(7.6 \times 4) - [1.1 \times 2] \times 2\right] \times 931\ \text{MeV}$$

$$\Delta E =$$

Q.10 The Q-value of a nuclear reaction and kinetic energy of the projectile particle, K_p are related as:

(A) $Q = K_p$

(B) $(K_p + Q) < 0$

(C) $Q < K_p$

(D) $(K_p + Q) > 0$

Q.11 Nucleus A is having mass number 220 and its binding energy per nucleon is 5.6MeV. It splits in two fragments ' B ' and ' C ' of mass numbers 105 and 115. The binding energy of nucleons in ' B ' and ' C ' is 6.4MeV per nucleon. The energy Q released per fission will be :

(A) 0.8MeV

(B) 275MeV

(C) 220MeV

(D) 176MeV

ATOM & NUCLEI

Q.12 From the given data, the amount of energy required to break the nucleus of aluminium $^{27}_{13}\mathrm{Al}$ is _____ $\mathrm{x} \times 10^{-3}$ J **[July 25, 2021 (II)]**

Mass of neutron $= 1.00866\mathrm{u}$

Mass of proton $= 1.00726\mathrm{u}$

Mass of Aluminium nucleus $= 27.18846\mathrm{u}$

(Assume $1\mathrm{u}$ corresponds to xJ of energy)

(Round off to the nearest integer)

Q.13 Find the Binding energy per neucleon for ${}^{120}_{50}\mathrm{Sn}$. Mass of proton $\mathrm{m_p} = 1.00783\mathrm{U}$, mass of neutron $\mathrm{m_n} = 1.00867\mathrm{U}$ and mass of tin nucleus $\mathrm{m_{Sn}} = 119.902199\mathrm{U}$. **[Sep. 04. 2020 (II)]**

(take $1\mathrm{U} = 931\mathrm{MeV}$)

(A) $7.5\mathrm{MeV}$

(B) $9.0\mathrm{MeV}$

(C) $8.0\mathrm{MeV}$

(D) $8.5\mathrm{MeV}$

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Q.14 Consider the nuclear fission $Ne^{20} \rightarrow 2He^{4} + C^{12}$ **[10 Jan 2019 (II)]**

Given that the binding energy/nucleon of Ne^{20}, He^{4} and C^{12} are, respectively, 8.03 MeV, 7.07 MeV and 7.86 MeV, identify the correct statement:

(A) energy of $12.4\,\text{MeV}$ will be supplied

(B) $8.3\,\text{MeV}$ energy will be released

(C) energy of $3.6\,\text{MeV}$ will be released

(D) energy of $11.9\,\text{MeV}$ has to be supplied

Fission

Chadwick discovered neutron and after discovery of neutron Enrico Fermi found that new radioactive elements are produced, when neutron bombard various elements. Uranium nucleus broke into two nearly equal fragments, when a neutron was bombarded on a uranium target and great amount of energy was released. Various examples of such reactions are

$$ {}_{0}^{1}n + {}_{92}^{235}U \longrightarrow {}_{92}^{236}U \longrightarrow {}_{56}^{144}Ba + {}_{36}^{89}Kr + 3\,{}_{0}^{1}n $$

$$ {}_{0}^{1}n + {}_{92}^{235}U \longrightarrow {}_{92}^{236}U \longrightarrow {}_{51}^{133}Sb + {}_{41}^{99}Nb + 4\,{}_{0}^{1}n $$

$$ {}_{0}^{1}n + {}_{92}^{235}U \longrightarrow {}_{54}^{140}Xe + {}_{38}^{94}Sr + 2\,{}_{0}^{1}n $$

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Nuclear fusion - energy generations in stars

In a process two light nuclei combine to form a single larger nucleus and energy is released, this process is known as fusion. Some examples of fusion, liberating energy are as under

- Two protons combine to form a deutron a positron with a release of $0.42\,\text{MeV}$ energy

$$ {}_{1}^{1}\mathrm{H} + {}_{1}^{1}\mathrm{H} \longrightarrow {}_{1}^{2}\mathrm{H} + e^{+} + v + 0.42\,\text{MeV} $$

- Two deuterons combine to form the light isotope of helium.

$$ {}_{1}^{2}\mathrm{H} + {}_{1}^{2}\mathrm{H} \longrightarrow {}_{2}^{3}\mathrm{He} + n + 3.27\,\text{MeV} $$

- Two deuterons combine to form triton and a proton.

$$ {}_{1}^{2}\mathrm{H} + {}_{1}^{2}\mathrm{H} \longrightarrow {}_{1}^{3}\mathrm{H} + {}_{1}^{1}\mathrm{H} + 4.03\,\text{MeV} $$

In all above equations two positively charged particles combine to form a larger nucleus and this process is hindered by the Coulomb repulsion acts to prevent particles getting close enough to be within the range of their attractive nuclear forces and thus 'fusing'.