PARISHRAM

2026

Nuclei

PHYSICS Lecture - 1

BY - RAKSHAK SIR

Topics *to be covered*

1 Poora Chapter krenge LLs

Nuclear Size and Composition

Unit–VII	**Dual Nature of Radiation and Matter**	**12**
	Chapter–11: Dual Nature of Radiation and Matter	
Unit–VIII	**Atoms and Nuclei**	
	Chapter–12: Atoms	
	Chapter–13: Nuclei (Ratta)	

Chapter–13: Nuclei

Composition and size of nucleus, nuclear force

Mass-energy relation, mass defect; binding energy per nucleon and its variation with mass number; nuclear fission, nuclear fusion.

ATOMIC NUCLEUS: ITS CONSTITUENTS

1. According to **Rutherford's planetary model of atom**, the **entire positive charge and most of the mass of the atom are concentrated in a small volume called the nucleus and a suitable number of electrons revolve around it just as planets revolve around the sun.**

2. From the results of Rutherford scattering experiments, **nuclear size is found to be of the order of 10^{-14} m whereas the diameter of an atom is of the order of 10^{-10} m**. Hence most of the atom is empty

COMPOSITION OF A NUCLEUS

$A = 40$
$Z = 20$ Ca
$e^- = Z = 20$
no. of $p^+ = Z = 20$
no. of $n^0 = A - Z = 40 - 20$
$= 20$

- The **discovery of neutrons by Chadwick**, led Heisenberg to propose proton-neutron hypothesis in 1932.
- According to this hypothesis, protons and neutrons are the main building blocks of the nuclei of all atoms. Thus a nucleus of mass number A and atomic number Z contains Z protons and $(\mathrm{A}-\mathrm{Z})$ neutrons.
- The protons give positive charge to the nucleus, while protons and neutrons together give it mass.
- To neutralize the positive charge of the nucleus, i.e., to make the atom electrically neutral, the number of extra-nuclear electrons is Z.

COMPOSITION OF A NUCLEUS : PROTON

Proton: It is a **fundamental particle** which may be called **the nucleus of hydrogen**. It has a positive charge of 1.6×10^{-19}C It has a rest mass of 1.6726×10^{-27} kg, which is about 1836 times the rest mass of an electron. A proton has an intrinsic (spin) angular momentum equal to $1/2$.

$m_p = 1.67 \times 10^{-27}$ kg

$m_p > m_e$

COMPOSITION OF A NUCLEUS : NEUTRON

$q_{net} = 0$

Neutron: It is a charge-less fundamental particle having mass slightly greater than that of a proton. Its rest mass is 1.6749×10^{-27} kg. It has intrinsic angular momentum equal to that of a proton.

$$m_n = 1.67 \times 10^{-27}\,kg$$

$$m_n \approx m_p > m_e$$

COMPOSITION OF A NUCLEUS : NUCLEONS

Nucleons: Protons and neutrons which are present in the nuclei of atoms are collectively known as nucleons.

Atomic number: The number of protons in the nucleus is called the atomic number of the element. It is denoted by Z.

Z = No. of protons

Mass number: The total number of protons and neutrons present in a nucleus is called the mass number of the element. It is denoted by A.

COMPOSITION OF A NUCLEUS

- Number of protons in an atom = Z
- Number of electrons in an atom = Z
- Number of nucleons in an atom = A
- Number of neutrons in an atom = $A - Z$

$A = 15$

$Z = 7$

X

$A = Z + N$

$A - Z = N$

$15 - 7 = N$

$N = 8$

COMPOSITION OF A NUCLEUS : NUCLEAR MASS

Nuclear mass: The total mass of the protons and neutrons present in a nucleus is called the nuclear mass.

Nuclide: When an atom is talked of with particular reference to its nuclear composition, it is called a nuclide. Thus a nuclide is a specific nucleus of an atom characterized by its atomic number Z and mass number A.

$^{40}_{20}Ca$ $^{40}_{18}Ar$

It is symbolically represented as

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

where, $\mathrm{X}=$ chemical symbol of the element,
$\mathrm{Z}=$ atomic number, and
$\mathrm{A}=$ mass number.

COMPOSITION OF A NUCLEUS : ISOTOPES

Isotopes: The atoms of an element which have the **same atomic number but different mass number** are called isotopes. Such atoms contain the same number of protons and electrons but different number of neutrons.

Hydrogen has three isotopes: Hydrogen (protium) $^1_1\mathrm{H}$-its nucleus has just one proton ; deuterium ($^2_1\mathrm{H}$)-its nucleus has one proton and one neutron ; and tritium ($^3_1\mathrm{H}$)-its nucleus has one proton and two neutrons.

Lithium has two isotopes $^6_3\mathrm{Li}$ and $^7_3\mathrm{Li}$

$^1_1\mathrm{H}$ $^2_1\mathrm{H}$ $^3_1\mathrm{H}$

$^{35}_{17}\mathrm{Cl}$ $^{37}_{17}\mathrm{Cl}$

2,8,7 2,8,7

COMPOSITION OF A NUCLEUS : A.A.M.

Cl - 35.5 u

The different isotopes of an element are found to have different relative abundances. So the weighted average of the atomic masses of all the isotopes of an element is taken as its **average atomic mass**. For example, normal chlorine contains 75% of $^{35}_{17}Cl$ and 25% of $^{37}_{17}Cl$.

∴ Average atomic mass of chlorine :- 75% of 35 + 25% of 37

$$= \frac{75}{100} \times 35 + \frac{25}{100} \times 37$$

$$= 35.5\,u$$

QUESTION

The natural chlorine is found to be a mixture of two isotopes of masses 34.98 amu and 36.98 amu respectively. Their relative abundances are 75.4 and 24.6 percent respectively. Find the composite atomic mass of natural chlorine.

A 35.57 amu

B 35.47 amu

C 35.37 amu

D 35.27 amu

$$\text{A.A.M.} = 75.4\% \text{ of } 34.98 + 24.6\% \text{ of } 36.98$$

$$= \frac{75}{100} \times 35 + \frac{25}{100} \times 37$$

$$= 35.5$$

Solution:

The average atomic mass of chlorine is

$$m(\mathrm{Cl}) = \frac{75.4 \times 34.98 + 24.6 \times 36.98}{100}\,\mathrm{amu}$$

$$= \frac{2637.49 + 909.71}{100}\,\mathrm{amu} = 35.47\,\mathrm{amu}.$$

COMPOSITION OF A NUCLEUS : ISOBARS

Isobars: The atoms having the **same mass number but different atomic number** are called isobars. Such atoms contain different number of protons and electrons. So they differ in the chemical properties and occupy different positions in the periodic table.

Some examples of isobars are :

$^{3}_{1}\mathrm{H}$ and $^{3}_{2}\mathrm{He}$, as both have same $\mathrm{A} = 3$.

$^{37}_{17}\mathrm{Cl}$ and $^{37}_{16}\mathrm{S}$, as both have same $\mathrm{A} = 37$.

* $^{40}_{20}\mathrm{Ca}$ and $^{40}_{18}\mathrm{Ar}$, as both have same $\mathrm{A} = 40$.

COMPOSITION OF A NUCLEUS : ISOTONES

Isotones: The nuclides having **the same number of neutrons** are called isotones.

For example,

$^{37}_{17}Cl$ and $^{39}_{19}K$ are isotones, as both contain the same number of neutrons i.e., for both

20 ⟷ 20

$$N = A - Z = 20.$$

$^{198}_{80}Hg$ and $^{197}_{79}Pu$ are isotones, as for both

$$N = A - Z = 118$$

ATOMIC MASSES

Atomic mass unit: The mass of the carbon-12 atom is 1.992678×10^{-26} kg, which is very small. Therefore, it is useful to choose a convenient unit for expressing the mass of atoms. This unit is defined by taking mass of carbon- 12 atom equal to 12 atomic mass units.

1 a.m.u.

One atomic mass unit is defined as $\boxed{\frac{1}{12}\text{th of the actual mass of carbon-12 atom.}}$

Atomic mass unit is denoted by amu or just by u.

$$1\text{ amu} = \left(\frac{1}{12}\right) \times \text{ Mass of carbon}-12\text{ atom}$$

$$= \frac{1}{12} \times 1.992678 \times 10^{-26}\text{ kg}$$

$$\mathbf{1amu = 1.660565 \times 10^{-27}\ kg}$$

$\simeq$ $\boxed{1\text{amu} = 1.67 \times 10^{-27}\text{ kg}}$

m_n or m_p

ATOMIC MASSES

Mass of an electron,

$$m_e = 0.00055\text{amu} = 9.11 \times 10^{-31}\text{ kg}$$

Mass of a proton,

$$m_p = 1.0073\text{amu} = 1.6726 \times 10^{-27}\text{ kg}$$

Mass of a neutron,

$$m_n = 1.0086\text{amu} = 1.6749 \times 10^{-27}\text{ kg}$$

Mass of a hydrogen atom,

$$m_H = m_p + m_e = 1.0078\text{amu}$$

$m_n = 1$ amu

$m_p = 1$ amu

$m_e = 0$ amu

ELECTRON VOLT

It is defined as the energy acquired by an electron when it is accelerated through a potential difference of 1 volt and is denoted by eV.

$$\mathbf{1eV = 1.602 \times 10^{-19}\,J}$$

$W = qV$

$KE = eV$

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

$1\,e.v. = 1.6 \times 10^{-19}\,J$

atomic Mass unit

Mega - electron Volt

Relation between amu and MeV

The Einstein's mass-energy equivalence relation is

$$\boxed{E = mc^2}$$

This relation shows that the energy content of an object is equal to its mass times the square of the speed of light. To determine the energy equivalent of one atomic mass unit, we take

$$m = 1\text{amu} = 1.66 \times 10^{-27}\ \text{kg}$$

$$c = 2.998 \times 10^{8}\ \text{ms}^{-1}$$

$$E = 1.66 \times 10^{-27} \times (2.998 \times 10^{8})^{2}\ \text{J}$$

$$E = \frac{1.66 \times 10^{-27} \times (2.998 \times 10^{8})^{2}}{1.602 \times 10^{-19}}\ \text{eV}$$

$$E \simeq 931\text{MeV}$$

$$1\ \text{amu} \Rightarrow 931\ \text{MeV}$$

$E = 931 \text{MeV}$

$E = 931 \times 10^{6}\ \text{eV}$

NUCLEAR SIZE & DENSITY

Size of Nucleus :-

Volume of Nucleus $\propto$ Mass No.

$$V \propto A$$

$$\frac{4}{3}\pi R^3 \propto A$$

$$R^3 \propto A$$

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

Radius of Nucleus ← $\boxed{R = R_0 A^{1/3}}$

R_0 → 1.2 fermi

Density of Nucleus :-

$$\rho = \frac{\text{Mass}}{\text{Vol.}} = \frac{Am}{\frac{4}{3}\pi R^3}$$

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

$$= \frac{\cancel{A}m}{\frac{4}{3}\pi R_0^3 \cancel{A}} = \frac{m}{\frac{4}{3}\pi R_0^3}$$

Any Nucleus has this Density, independent of element

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

QUESTION

Express 16 mg mass into equivalent energy in eV.

$m = 16 mg \rightarrow e.V.$

(A) 11×10^{30} eV

(B) 10×10^{30} eV

(C) 9×10^{30} eV

(D) 8×10^{30} eV

$1 \text{ amu} \longrightarrow 931 \text{ MeV}$

$1.67 \times 10^{-27} \text{ kg} \Longrightarrow 931 \times 10^{6} \text{ eV}$

$\underbrace{1.67 \times 10^{-27} \times 1000 \times 10}_{m} \Longrightarrow \boxed{} \text{ e.V.}$

Solution:

Here $m = 16\text{mg} = 16 \times 10^{-6}\ \text{kg}$,

$c = 3 \times 10^{8}\ \text{ms}^{-1}$

$\therefore$ Equivalent energy,

$E = mc^2 = 16 \times 10^{-6} \times (3 \times 10^{8})^2\ \text{J}$

$$= \frac{16 \times 10^{-6} \times (3 \times 10^{8})^2}{1.6 \times 10^{-19}}\text{eV} = 9 \times 10^{30}\text{eV}$$

NUCLEAR FORCE

electrostatic ×

The average separation between two nucleons is about 10^{-15} m. At this separation, positively charged protons feel strong coulombic repulsion. Also the gravitational force of attraction between two nucleons is about 10^{-36} times smaller than the electrostatic repulsion, it cannot hold the nucleons together. So there must be some other strong attractive force acting between the nucleons that over-comes the electrostatic repulsion. This strong attractive interaction acting between the nucleons is called nuclear force or strong interaction.

Nuclear force is a strong attractive force that binds the protons and neutrons together inside a tiny nucleus.

PROPERTIES OF NUCLEAR FORCE

1. **Strongest interaction:** Nuclear force is the strongest interaction known in nature that holds the nucleons together despite the strong electrostatic repulsion between the protons. The relative strength of gravitational, electrostatic and nuclear forces is

$$F_g : F_c : F_n = 1 : 10^{36} : 10^{38}$$

2. **Short-range force:** Unlike gravitational and electrostatic forces, nuclear force is a short-range force. It operates only upto a very short distance of about $2 - 3\text{fm}$ from a nucleon.

PROPERTIES OF NUCLEAR FORCE

3. **Charge independent character:** It is seen from experiments that the attractive force between two neutrons (nn-force) is nearly equal to that between two protons (pp-force) or between a proton and a neutron (pn-force). Thus the nuclear force does not depend on the charge of the particles.

   In case of p-p nuclear force, there is a repulsive force between two protons, but this is weak compared to the strong nuclear force.

   1 2 3
   0 0 0

4. **Saturation effect:** Nuclear forces show saturation effect, i.e., a nucleon interacts only with its neighbouring nucleon. This property is supported by the fact that the binding energy per nucleon is same over a wide range of mass numbers.

PROPERTIES OF NUCLEAR FORCE

5. **Spin dependent character:** The nuclear force between two nucleons having parallel spins is stronger than that between two nucleons having antiparallel spins.

6. **Exchange forces:** In 1935, a Japanese physicist H.Yukawa suggested that the nuclear force between two nucleons arises from the constant exchange of particles, called mesons, between them.

7. **Non-central forces:** The nuclear force between two nucleons does not act along the line joining their centres.

Homework

→ Notes

→ Revision

PARISHRAM

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Lecture - 02

Nuclei

PHYSICS | Lecture - 2

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1 Poora Chapter krenge LLs

Binding Energy

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Chapter–13: Nuclei

Composition and size of nucleus, nuclear force

Mass-energy relation, mass defect; binding energy per nucleon and its variation with mass number; nuclear fission, nuclear fusion.

Mass of dadu :- 70 kg
Dadi :- 65 kg
Father :- 80 kg
Mataji :- 60 kg
LL :- 50 kg
sibling :- 65 kg

$\left.\right\}$ 390 kg

RDx $\rightarrow$ $\cancel{M = 390\ \text{kg}}$ $\rightarrow$ 350 kg

Nucleus $\longrightarrow$ Mass $= m_p \times 10 + m_n \times 10 = 20$ a.m.u.

Proton

Neutron

10

10

$\Delta m = 1$ amu

 $\rightarrow$ 19 a.m.u. ✓

MASS DEFECT

Δm = mass of individual n & p − mass of Nucleus

$\Delta m = Zm_p + (A-Z)m_n - m$

It is found that the mass of a stable nucleus is always less than the sum of the masses of its constituent protons and neutrons in their free state.
The difference between the rest mass of a nucleus and the sum of the rest masses of its constituent nucleons is called its mass defect.

Consider the nucleus ${}_{Z}^{A}X$. It has Z protons and (A − Z) neutrons. Therefore, its mass defect will be

$$\boxed{\Delta m = Zm_p + (A - Z)m_n - m}$$

where m_p, m_n and m are the rest masses of a proton, neutron and the nucleus ${}_{Z}^{A}X$ respectively.

PACKING FRACTION

The packing fraction of a nucleus is its mass defect per nucleon. Thus

$$\text{P.F. of a nucleus} = \frac{\text{Mass defect}}{\text{Mass number}} = \frac{\Delta m}{A}$$

- If P.F. is positive (as in case of nuclei with mass number less than 20 and above 200), then the nucleus is unstable.
- If P.F. is negative (as in case of nuclei with mass number between 20 and 200), then it indicates that some mass has been converted into energy which binds the nucleons together and so the nucleus is stable.
- Thus the P.F. is directly related to the availability of nuclear energy and the stability of the nucleus.

BINDING ENERGY

$BE = mc^2$

$\boxed{B.E. = (\Delta m)c^2}$

- The binding energy of a nucleus may be defined as the **energy required to break up a nucleus into its constituent protons and neutrons and to separate them to such a large distance that they may not interact with each other.**

- So the binding energy may also be defined as the **surplus energy which the nucleons give up by virtue of their attractions when they become bound together to form a nucleus.**

- The energy equivalent to the mass defect is radiated in the form of electromagnetic radiation when the nucleons combine to form a nucleus.

EXPRESSION FOR BINDING ENERGY

The nucleus ${}^{A}_{Z}X$ contains Z protons and ($A - Z$) neutrons. Its mass defect is

$$\Delta m = Zm_p + (A - Z)m_n - m_N$$

where m_N is the nuclear mass of ${}^{A}_{Z}X$. From Einstein's mass-energy equivalence, the binding energy of the nucleus is

$$\Delta E_b = \Delta m \times c^2 = \left[Zm_p + (A - Z)m_n - m_N\right]c^2$$

Now, in an atom the electrons are bound to the nucleus by electrostatic forces. So they have a binding energy of their own, which from the mass-energy equivalence is given by

$$(\Delta E_b)_e = \left[(m_N + Zm_e) - m\left(\frac{A}{Z}X\right)\right]c^2$$

where $m\left({}_{Z}^{A}X\right)$ is the atomic mass. The binding energy of electrons ($\approx$ eV to keV) is negligible compared to the binding energy of nucleons ($\approx 10^3$ MeV). It will be a safe approximation to take, $(\Delta E_b)_e = 0$

$$\therefore m_N + Zm_e - m\left(\frac{A}{Z}X\right) = 0$$

$$m_N = m\left(\frac{A}{Z}X\right) - Zm_e$$

Thus, in terms of atomic mass the equation becomes

$$\Delta E_b = \left[Zm_p + (A-Z)m_n - m\left(\frac{A}{Z}X\right) + Zm_e\right]c^2$$

$$\Delta E_b = \left[Z\left(m_p + m_e\right) + (A-Z)m_n - m\left(\frac{A}{Z}X\right)\right]c^2$$

But $m_p + m_e = m_H$ = mass of a hydrogen atom.

$\therefore$ The equation can be written in terms of m_H as

$$\Delta E_b = \left[Zm_H + (A-Z)m_n - m\left({}_{Z}^{A}X\right)\right]c^2$$

BINDING ENERGY PER NUCLEON

B.E.N.

The binding energy per nucleon is the average energy required to extract one nucleon from the nucleus. It is obtained by dividing the binding energy of a nucleus by its mass number. The expression for binding energy per nucleon can be written as

$$\Delta E_{bn} = \frac{\Delta E_b}{A} = \frac{\left[Zm_H + (A - Z)m_n - m\left({}_{Z}^{A}X\right)\right]c^2}{A}$$

The binding energy per nucleon gives a measure of the force which binds the nucleons together inside a nucleus.

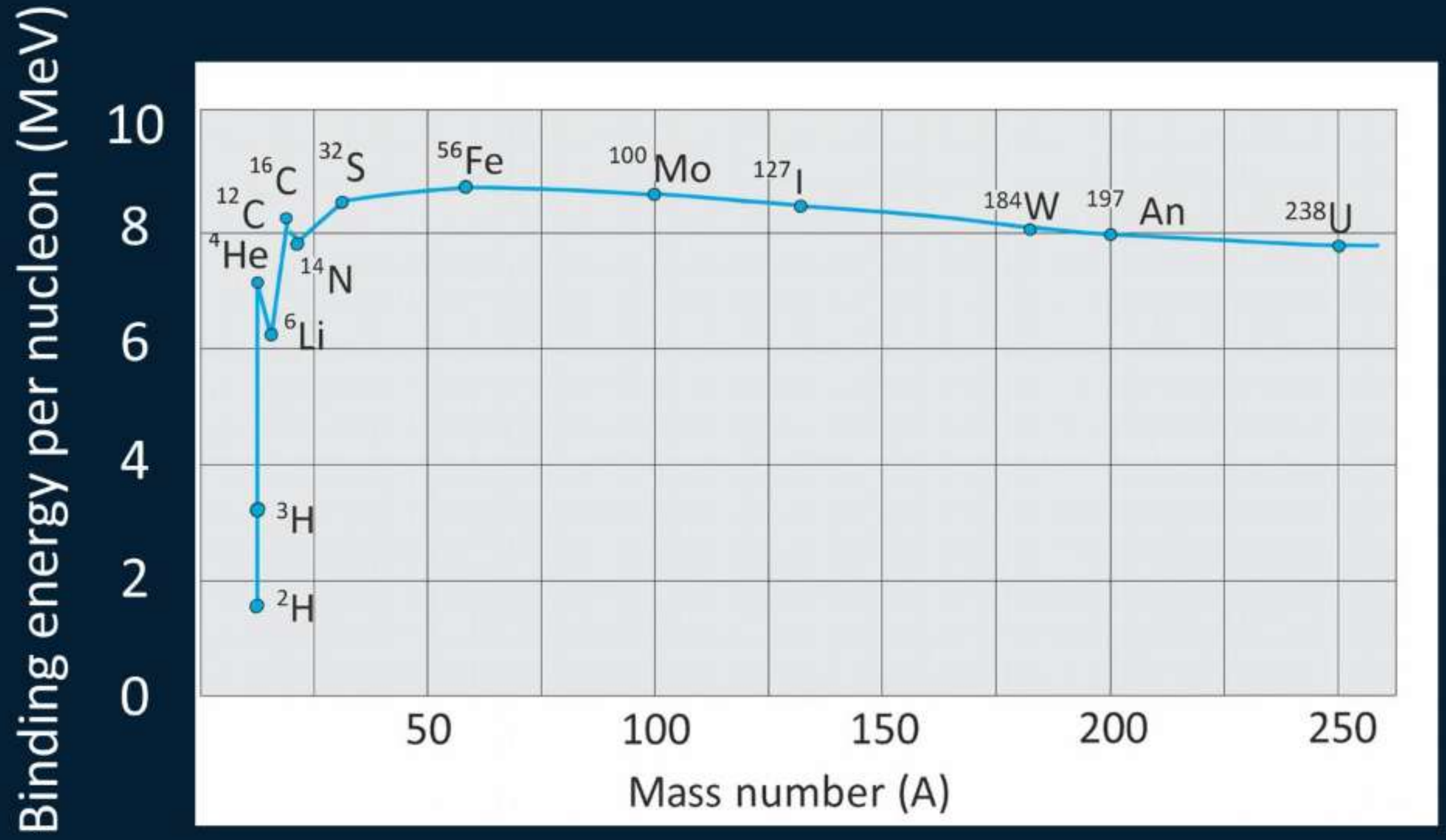
* V. imp.

BINDING ENERGY CURVE

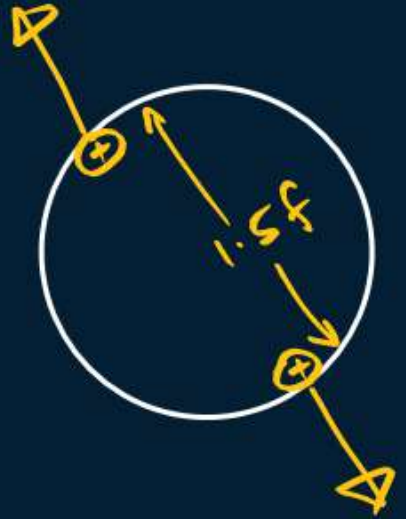
- Except for some nuclei like ${}_{2}^{4}\mathrm{He}$, ${}_{6}^{12}\mathrm{C}$ and ${}_{8}^{16}\mathrm{O}$, the values of binding energy per nucleon lie on or near a smooth curve.

- The B.E. /nucleon is small for light nuclei like ${}_{1}^{1}\mathrm{H}$, ${}_{1}^{2}\mathrm{H}$ and ${}_{1}^{3}\mathrm{H}$

- In the mass number range 2 to 20, there are well defined maxima and minima on the curve. The maxima occur for ${}_{2}^{4}\mathrm{He}$, ${}_{6}^{12}\mathrm{C}$ and ${}_{8}^{16}\mathrm{O}$, indicating the

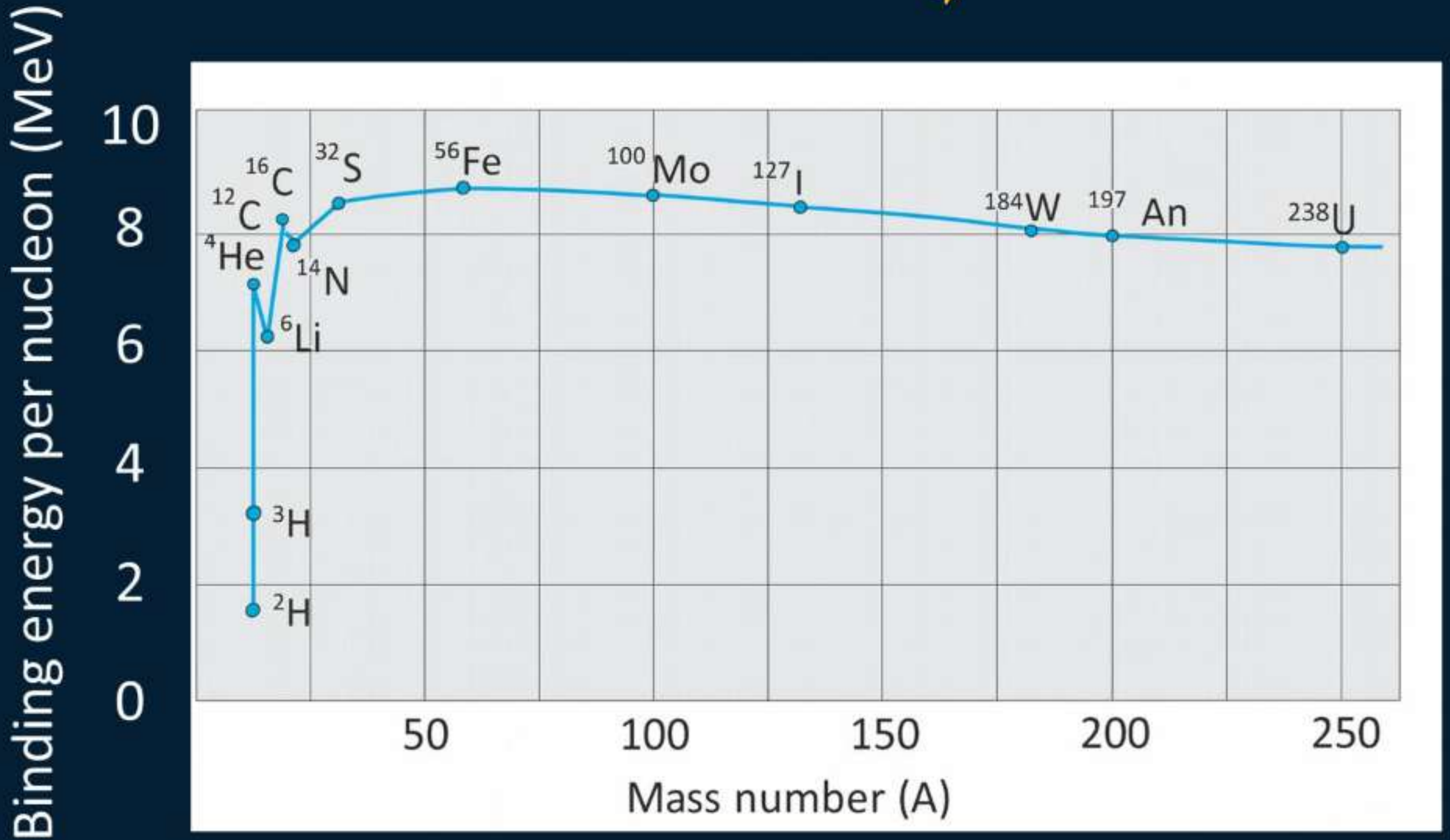


BINDING ENERGY CURVE



- The curve has a broad maximum close to the value 8.5MeV/ nucleon in the mass number range from about 40 to 120 . It has a peak value of 8.8MeV/ nucleon for $^{56}_{26}\mathrm{Fe}$.

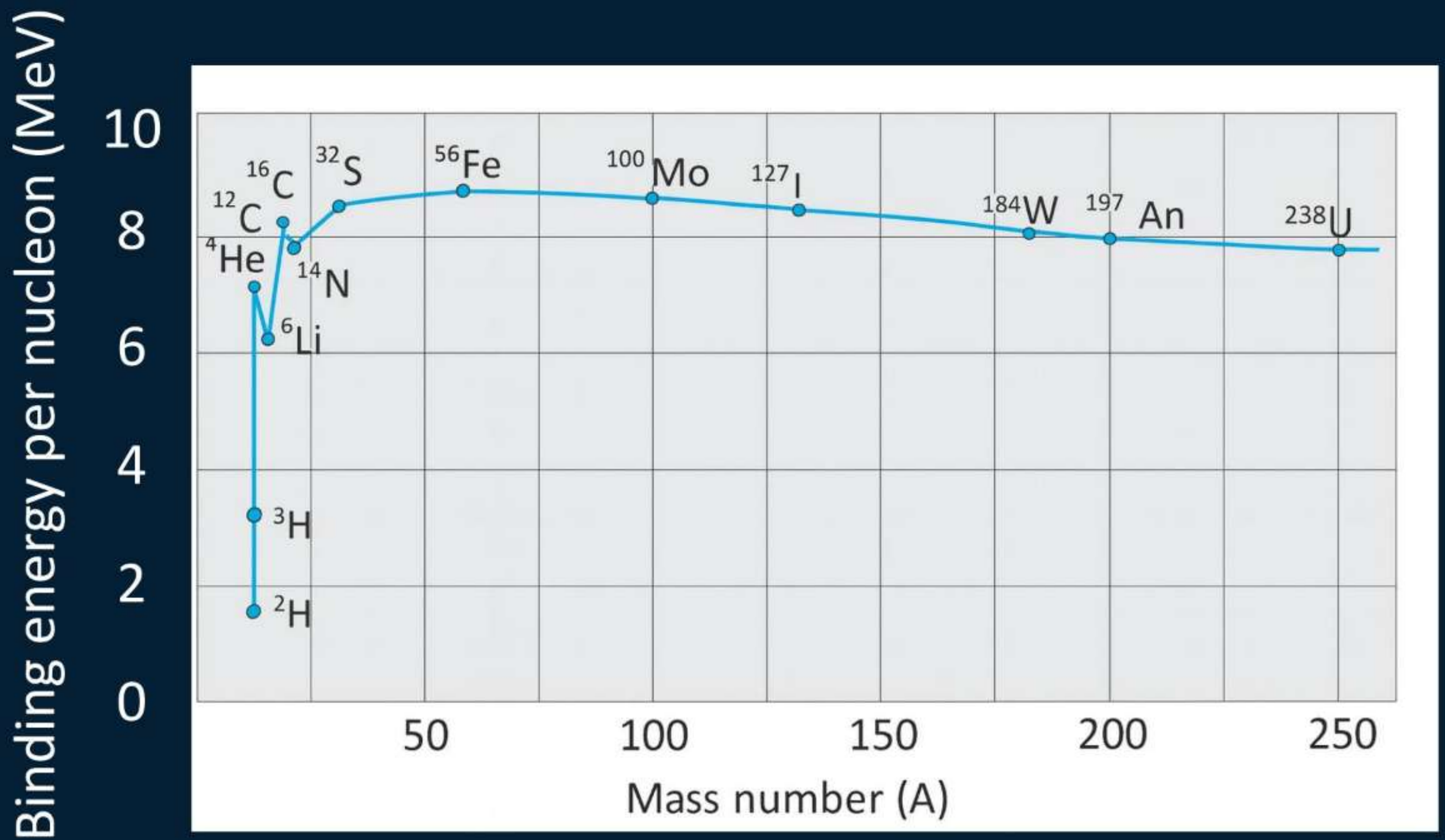
- As the mass number increases further, the B.E. / nucleon shows a gradual decrease and drops to 7.6 MeV/nucleon for $^{238}_{92}\mathrm{U}$. This decrease is due to coulomb repulsion between the protons which makes the heavier nuclei less stable.



IMPORTANCE OF BINDING ENERGY CURVE

The binding energy curve can be used to explain the phenomena of nuclear fission and nuclear fusion as follows:

- **Nuclear fission**. Binding energy per nucleon is smaller for heavier nuclei than the middle ones, i.e., heavier nuclei are less stable. When a heavier nucleus splits into the lighter nuclei, the B.E./nucleon changes from about $7.6 \mathrm{MeV}$ to $8.4 \mathrm{MeV}$. Greater binding energy of the product nuclei results in the liberation of energy. This is what happens in nuclear fission which is the basis of the atom bomb.
- **Nuclear fusion**. The binding energy per nucleon is small for light nuclei, i.e., they are less stable. So when two light nuclei combine to form a heavier nucleus, the higher binding energy per nucleon of the latter results in the release of energy. This is what happens in a nuclear fusion which is the basis of the hydrogen bomb.



Binding energy per nucleon (MeV)
10
8
6
4
2
0
^{16}C
^{32}S
^{56}Fe
^{100}Mo
^{127}I
^{12}C
^{184}W
^{197} An
^{238}U
^{4}He
^{14}N
^{6}Li
^{3}H
^{2}H
50
100
150
200
250
Mass number (A)

NUCLEAR REACTION

A reaction which involves the change of stable nucleus of one element into the nucleus of another element is called nuclear reaction. It is usually caused by bombarding the reacting species with suitable high energy particles.

NUCLEAR FISSION

The phenomenon in which a heavy nucleus $(A > 230)$ when excited splits into two smaller nuclei of nearly comparable masses is called nuclear fission.

In 1938, German scientists. Otto Hahn and Fritz Strassmann found that when uranium is bombarded by slow moving neutrons, a ${}^{235}_{92}U$ nucleus gets excited by capturing a slow moving neutron and splits into two nearly equal fragments like ${}^{141}_{56}Ba$ and ${}^{92}_{36}Kr$ along with the emission of 3 neutrons. The nuclear reaction involved can be written as

$$\mathbf{{}^{235}_{92}U + {}^{1}_{0}n \longrightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3\,{}^{1}_{0}n + Q}$$ Heat

The Q-value of this reaction is about 200MeV.

NUCLEAR FUSION

The process in which two light nuclei combine (at extremely high temperature) to form a single heavier nucleus is called nuclear fusion.

The mass of the heavier nucleus formed is less than the sum of the masses of the combining nuclei. The mass defect is released as energy in accordance with Einstein's mass-energy relation $\mathrm{E} = \Delta \mathrm{m}.\mathrm{c}^2$. For example, two protons combine to form a deuteron and a positron with release of $0.42\mathrm{MeV}$ energy :

$$ {}_1^1\mathrm{H} + {}_1^1\mathrm{H} \longrightarrow {}_1^2\mathrm{H} + \mathrm{e}^+ + \mathrm{v} + 0.42\mathrm{MeV} $$

Similarly, two deuterons combine either to form the light isotope of helium and a neutron or a triton and a proton :

$$ {}_1^2\mathrm{H} + {}_1^2\mathrm{H} \longrightarrow {}_2^3\mathrm{He} + {}_0^1\mathrm{n} + 3.27\mathrm{MeV} $$

$$ {}_1^2\mathrm{H} + {}_1^2\mathrm{H} \longrightarrow {}_1^3\mathrm{H} + {}_1^1\mathrm{H} + 4.03\mathrm{MeV} $$

Nuclear fission	Nuclear fusion
1. Here a heavy nucleus when excited gets split up into two smaller nuclei of nearly comparable masses.	Here two lighter nuclei fuse together to form a heavier nucleus.
2. The conditions of high temperature and pressure are not necessary for its occurrence. It can be carried on the earth.	The conditions of extremely high pressure and temperature are necessary for its occurrence. So it cannot be easily carried in a laboratory.
3. Neutrons are the link particles of this process.	Protons are the link particles of this process.
4. It is a quick process.	It occurs in several steps. There is sufficient time gap between initial and final steps.
5. Here the energy available per nucleon is small, about $\mathbf{0.85 MeV}$.	Here the energy available per nucleon is large, about $\mathbf{6.75 MeV}$.
6. The energy obtained from a unit mass of a fissionable material is smaller than that obtained in case of fusion.	The energy obtained from a unit mass of a fusible material is large.
7. It produces very harmful radioactive wastes.	The products of fusion are harmless.
8. The stock of fissionable fusion is limited.	The fuel required for fusion is available in plenty.

RADIOACTIVITY

γ x u v I m R

H. Becquerel discovered radioactivity in 1896 showed that radioactivity was a nuclear phenomenon in which an unstable nucleus undergoes a decay. This is referred to as radioactive decay. Three types of radioactive decay occur in nature :

$He^{2+} = \alpha^{++}$

(i) alpha-decay in which a helium nucleus is emitted.
(ii) beta-decay in which electrons or positrons (particles with the same mass as electrons, but with a charge exactly opposite to that of electron) are emitted
(iii) gamma-decay in which high energy (hundreds of keV or more) photons are emitted.

Homework

→ Notes

→ Revision