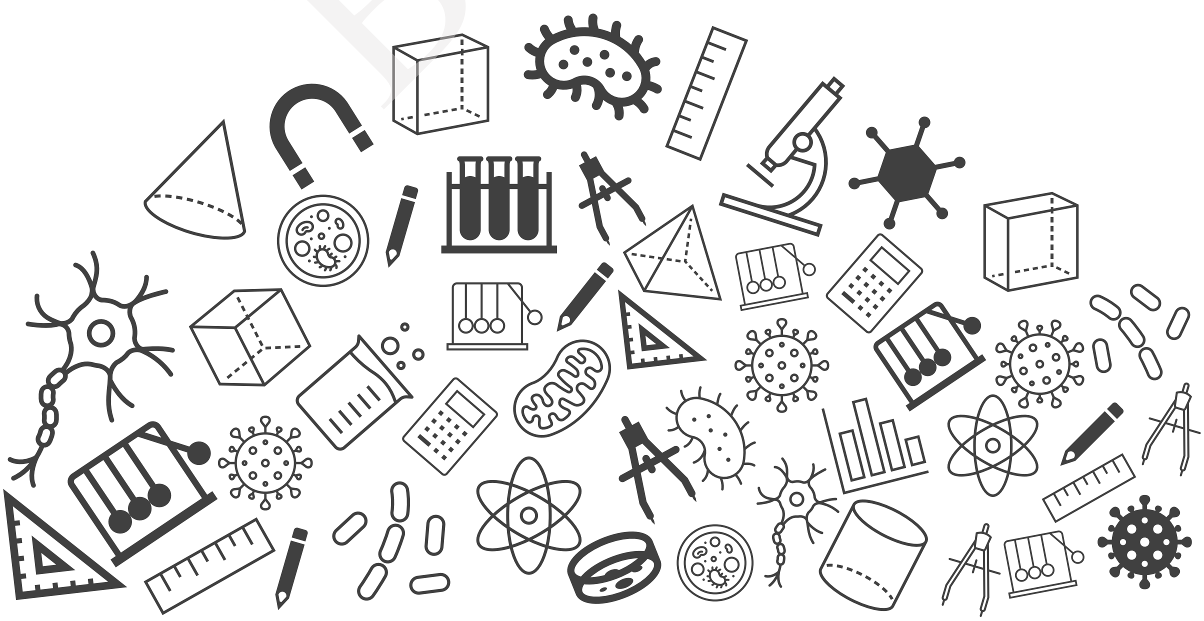
BYJU'S

Grade 09
Science Chapter Notes



BYJU'S Classes

Chapter Notes

Structure of the Atom

GRADE 09

Topics to Be Covered

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1.2 Proton
1.3 Neutron

2. Structure of an Atom

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2.2 Rutherford's Gold Foil Experiment
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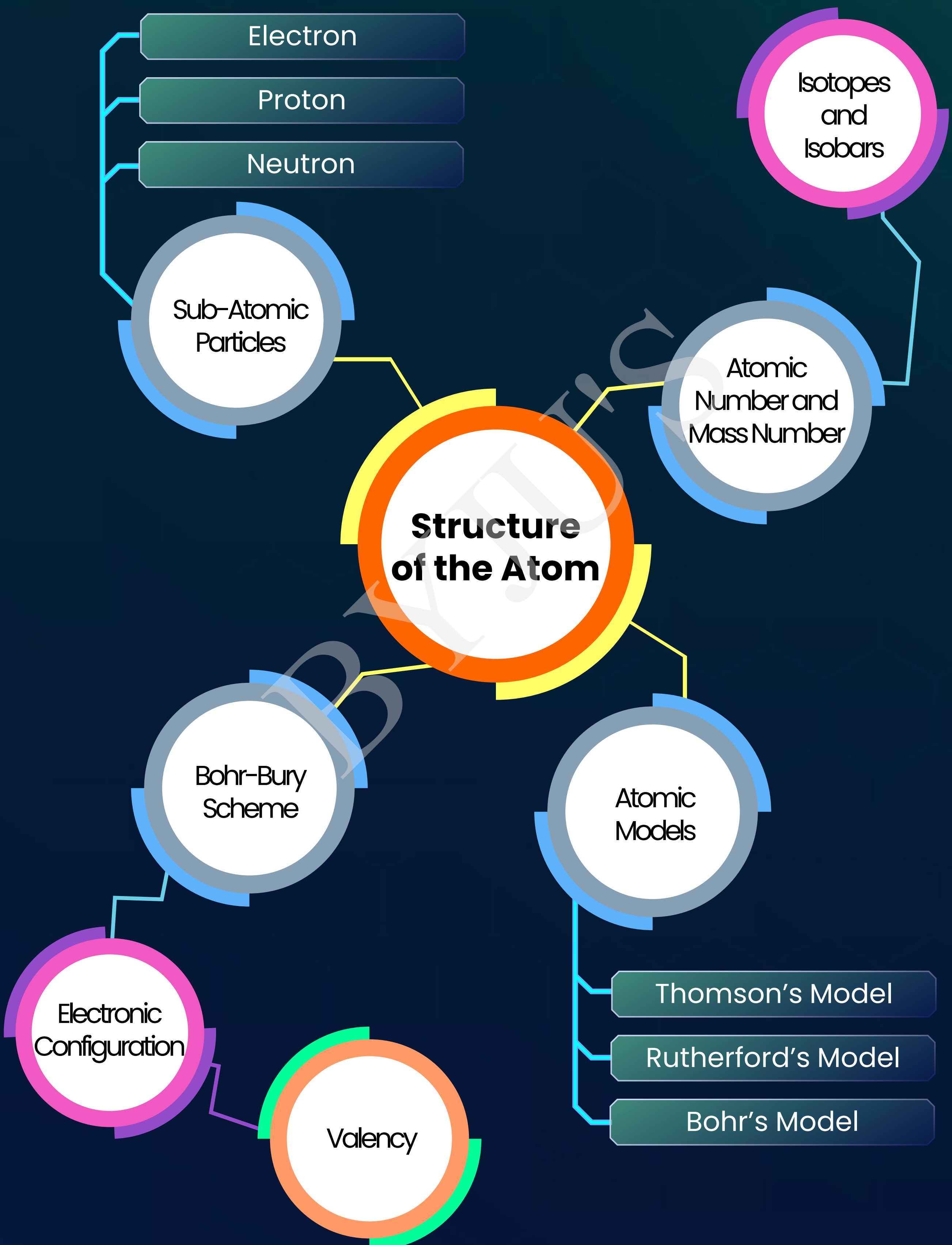
Mind Map



Structure of the Atom
Sub-Atomic Particles
Electron
Proton
Neutron
Atomic Number and Mass Number
Isotopes and Isobars
Atomic Models
Thomson's Model
Rutherford's Model
Bohr's Model
Bohr-Bury Scheme
Electronic Configuration
Valency

1. Sub-Atomic Particles

1.1 Electron (e^-)

- Discovered by J.J. Thomson.
- Has a charge of -1.
- Its mass is considered to be negligible as compared to the mass of the atom.

1.2 Proton (p^+)

- Discovery of canal rays by E. Goldstein in a gas discharge led to the discovery of protons.
- Has a charge of +1.
- Its mass is considered as one unit.

1.3 Neutron (n)

- Discovered by J. Chadwick in 1932.
- It is neutral as it does not contain any charge
- The mass of a neutron is nearly equal to the mass of a proton.

The mass of a proton is approximately 2000 times the mass of an electron.

Neutrons are present in the nucleus of all atoms, except hydrogen.

2.1 Thomson's Model of an Atom

- Thomson proposed the model of an atom that was similar to a Christmas pudding.

Thomson proposed that:

- An atom consists of a positively charged sphere and the electrons are embedded in it.
- The negative and positive charges are equal in magnitude. So, the atom as a whole is electrically neutral.

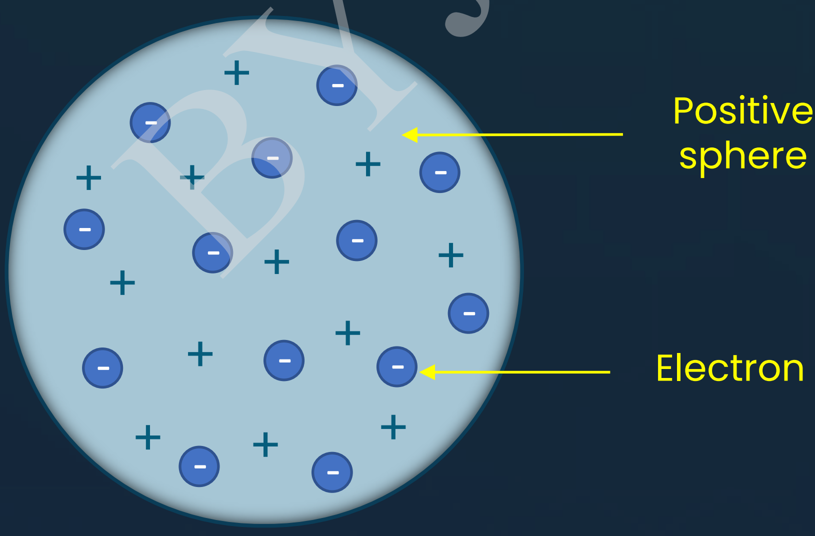


Fig. Thomson's model of an atom

2.2 Rutherford's Gold Foil Experiment

- Rutherford performed an alpha (α) particle scattering experiment to know the arrangement of electrons within an atom.
- In his experiment, fast-moving α-particles were bombarded on a thin gold foil.
- α-particles are the doubly-charged helium ions, having a mass of 4 u.
- He expected that the α-particles would be deflected by the sub-atomic particles in the gold atoms. Since the α-particles were much heavier than the protons, he did not expect to see large deflections.

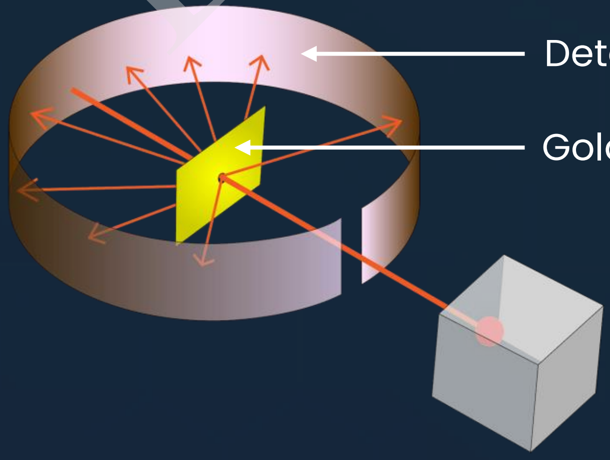


Fig. Rutherford's Gold Foil Experiment

2. Structure of an Atom

Observations of Gold Foil Experiment

- Most of the α-particles went across the gold foil without any deflection.
- Few α-particles underwent deflections by small angles.
- 1 in 12,000 α-particles got deflected by almost 180°.

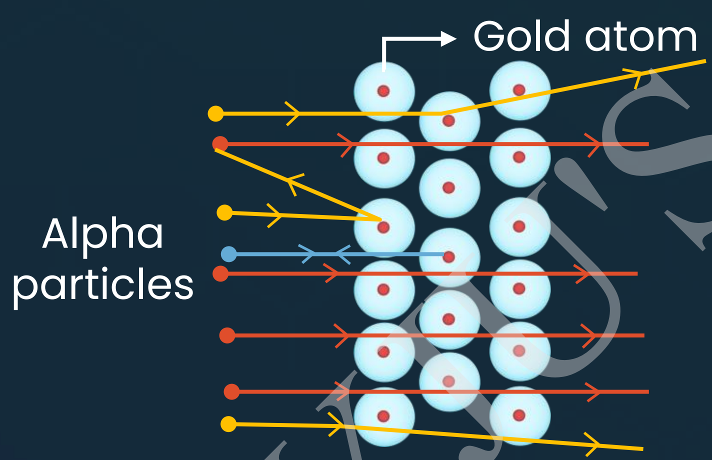


Fig. Scattering of α-particles by a gold foil

Conclusions of Gold Foil Experiment

- Most of the α-particles passed through the gold foil undeflected, indicating that most of the space inside the atom is empty.

- Few α-particles underwent slight deflections from their path, indicating that the positive charge of the atom occupies very little space.

- A very small fraction of α-particles were deflected by 180°, indicating that all the positive charge and mass of the gold atom were concentrated in a very small volume within the atom.

2.3 Rutherford's Atomic Model

- Atom consists of a dense positively charged centre called nucleus. Nearly all the mass of an atom resides in the nucleus.
- Electrons revolve around the nucleus in circular paths.
- The size of the nucleus is very small as compared to the size of the atom.

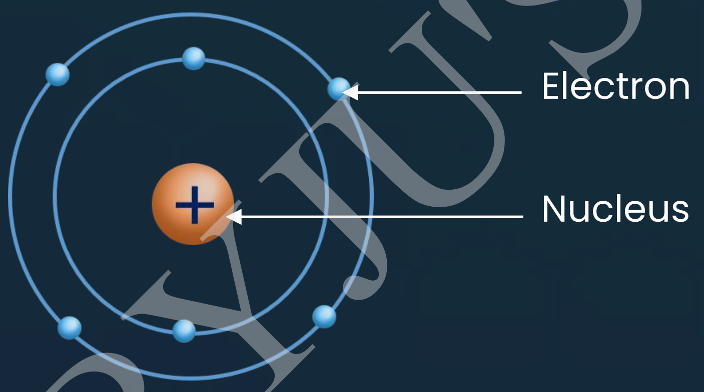


Fig. Rutherford's atomic model

Drawbacks of Rutherford's Atomic Model

The electrons in the circular orbit would lose energy due to acceleration and finally fall into the nucleus.

If this were so, an atom would have been highly unstable, and matter would not exist. But atoms are quite stable

Hence, Rutherford failed to explain the stability of atoms.

2.4 Bohr's Model of an Atom

- Electrons revolve around the nucleus in discrete orbits. These orbits or shells are known as energy levels.

- While revolving in discrete orbits, the electrons do not radiate energy.

- Orbits or shells are represented by the letters K, L, M, N, ... or the numbers, n=1, 2, 3, 4, ...

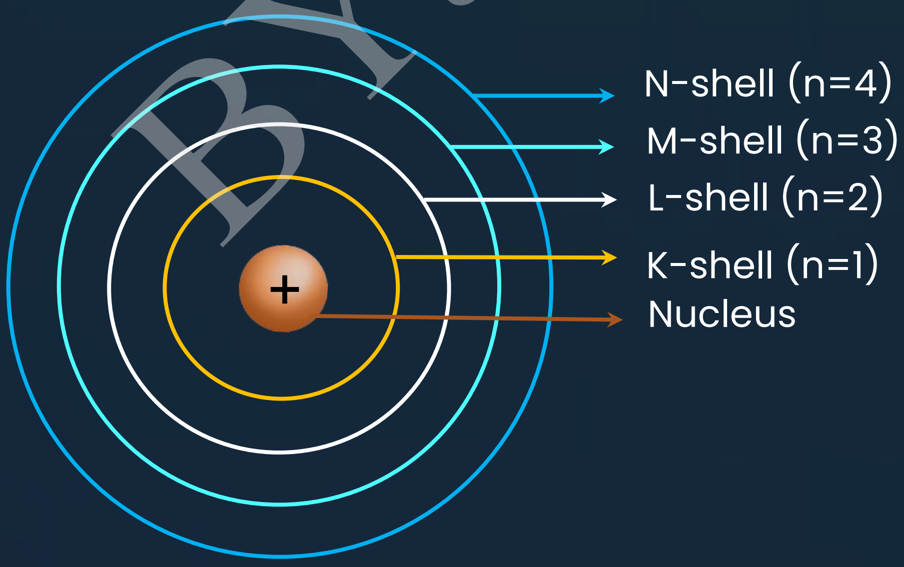


Fig. Energy levels in an atom

3. Distribution of Electrons in Different Shells

3.1 Bohr-Bury Scheme

The following rules are followed for writing the number of electrons in different energy levels or shells:

- The maximum number of electrons present in an orbit is given by the formula $2n^2$, where 'n' is the orbit number or energy level index, 1, 2, 3,....

Shell (n)	Maximum number of electrons ($2n^2$)
K (n = 1)	$2 \times 1^2 = 2$
L (n = 2)	$2 \times 2^2 = 8$
M (n = 3)	$2 \times 3^2 = 18$
N (n = 4)	$2 \times 4^2 = 32$

- The maximum number of electrons that can be accommodated in the outermost orbit is 8.
- Electrons are not accommodated in a given shell unless the inner shells are filled. That is, the shells are filled in a step-wise manner.

3. Distribution of Electrons in Different Shells

3.2 Electronic Configuration

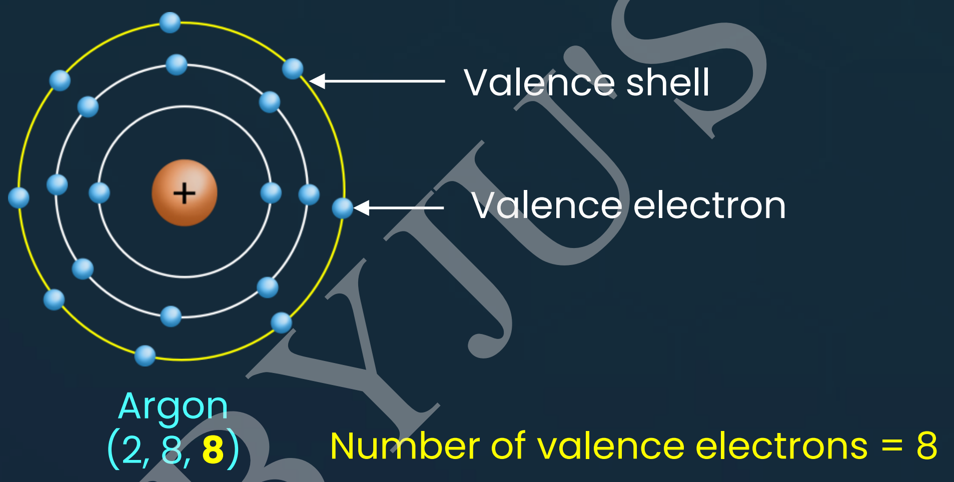
The distribution of electrons in different shells is known as the electronic configuration of an element.

Elements	Atomic number	Electronic configuration
Hydrogen (H)	1	1
Carbon (C)	6	2, 4
Nitrogen (N)	7	2, 5
Oxygen (O)	8	2, 6
Sodium (Na)	11	2, 8, 1
Magnesium (Mg)	12	2, 8, 2

4. Valency

4.1 Valence Electrons

- The electrons present in the outermost shell (valence shell) of an atom are known as the valence electrons.
- An atom with 8 valence electrons is said to possess an octet.



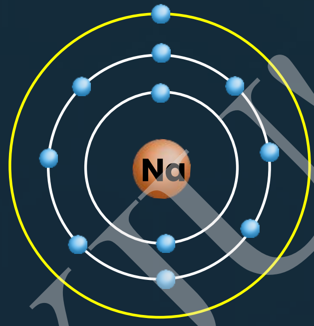
4.2 Introduction to Valency

- Valency is the combining capacity of an atom of an element.
- The number of electrons gained, lost or shared by an atom to complete the octet in its outermost shell, gives the valency of that atom.

4.3 Calculation of Valency

If an atom contains 4 or less than 4 valence electrons, then

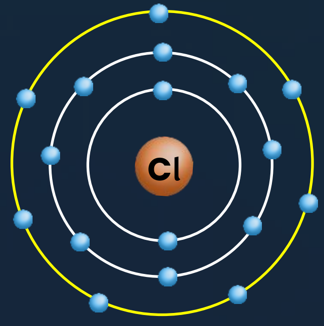
Valency = Number of valence electrons



Valency of sodium = 1

If an atom contains more than 4 valence electrons, then

Valency = 8 - Number of valence electrons



Valency of chlorine = 8-7 = 1

5. Atomic Number and Mass Number

5.1 Atomic Number (Z)

- The atomic number is defined as the total number of protons present in the nucleus of an atom.
- All atoms of an element have the same atomic number.

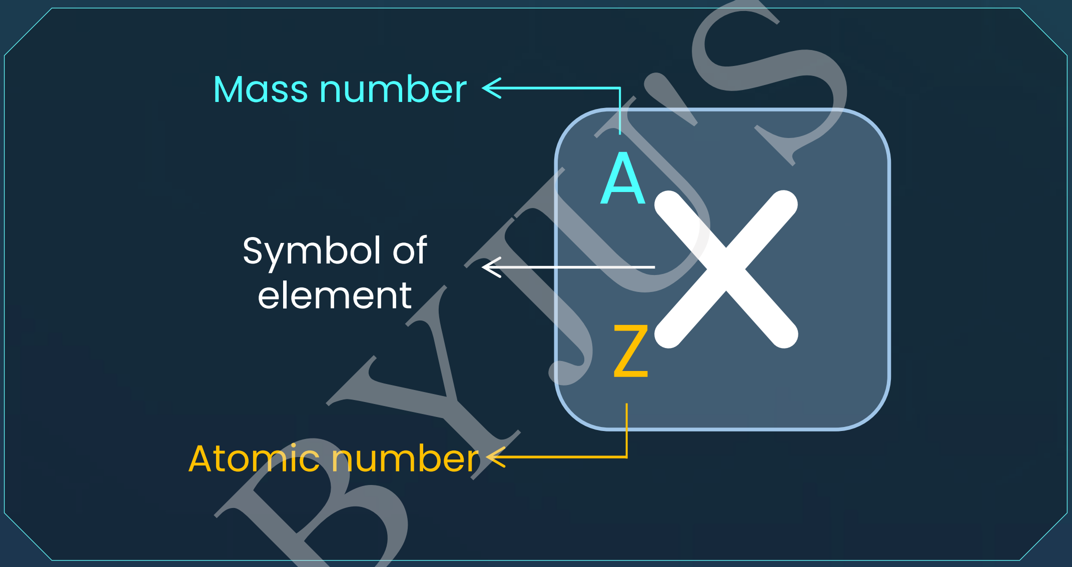
5.2 Mass Number (A)

- The mass number is defined as the sum of the total number of protons and neutrons present in the nucleus of an atom.
- Protons and neutrons reside in the nucleus of an atom. Hence, they are collectively known as nucleons.

5. Atomic Number and Mass Number

5.3 Notation for an Atom

- In the notation for an atom, the atomic number, mass number, and symbol of the element are to be written as:



- For example, nitrogen is written as $^{14}_{7}N$.

6. Isotopes and Isobars

6.1 Introduction to Isotopes

- Isotopes are the atoms of the same element, which have the same atomic number but different mass numbers.

For example,

Protium	Deuterium	Tritium
${}^{1}_{1}H$	${}^{2}_{1}H$	${}^{3}_{1}H$

- The chemical properties of isotopes are same, but their physical properties are different.

Average Atomic Mass of Isotopes

- If an element occurs in different isotopic forms, then we need to know the percentage of each isotopic form in nature and then the average atomic mass is calculated.

$$\text{Average atomic mass} = \frac{(M_1P_1 + M_2P_2 + M_3P_3 + ...)}{100}$$

M_1 and M_2 = Atomic mass of isotopes 1 and 2

P_1 and P_2 = Percentage abundance of isotopes 1 and 2

Applications of Isotopes

Isotope of uranium

Used as fuel in nuclear reactors.

Isotope of cobalt

Used in the treatment of cancer.

Isotope of iodine

Used in the treatment of goitre.

6.2 Introduction to Isobars

- Isobars are the atoms of different elements, which have different atomic numbers but same mass numbers.

For example,

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