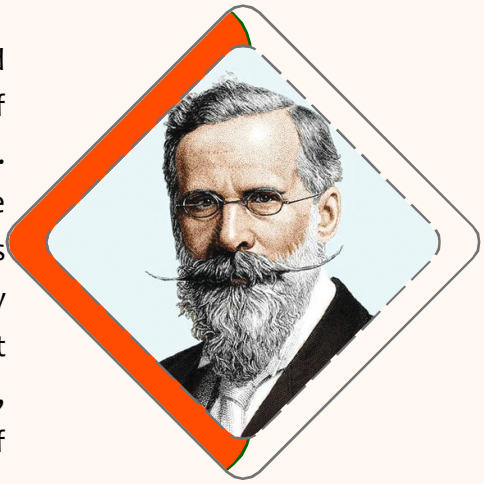
Chapter

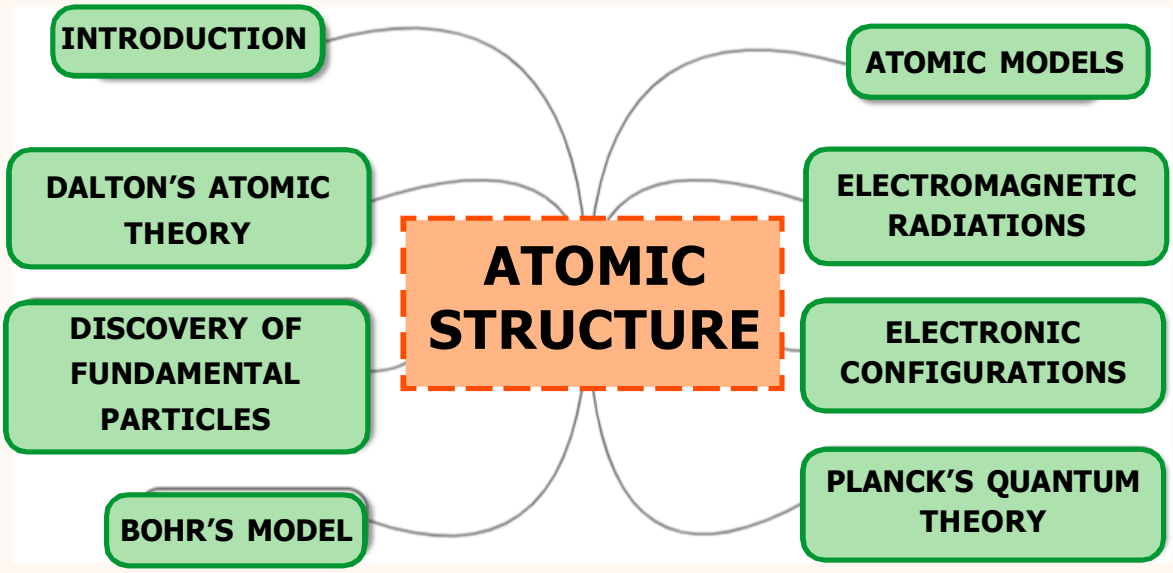
1

ATOMIC STRUCTURE

Sir William Crookes was a British chemist and physicist who attended the Royal College of Chemistry in London and worked on spectroscopy. He was a pioneer of vacuum tubes, inventing the Crookes tube which was made in 1875. Crookes was the inventor of the Crookes radiometer, which today is made and sold as a novelty item. His first important discovery was that of the element thallium, announced in 1861, and made with the help of spectroscopy. He developed the Crookes tubes, investigating cathode rays.



CONCEPT MAP



CONCEPT 1.1

INTRODUCTION: (Recapitulation):

All the materials around us are made up of very tiny particles called atoms, from the stars to your favourite ice cream. We might think that to make these all materials, there must be many different kinds of atoms. But the number of different kinds of atoms is surprisingly small. Till the date we know around 118 elements. Out of these about 90 are found in nature and the remaining are created in laboratory.

How can join together to make molecules? What makes some atoms more ready to do this? Why do hydrogen atoms pair up, but helium atoms remain single? To find answers for the questions like these, we need to first consider the structure of atom in general.

A major challenge before the scientists at the end of the 19th century was to reveal the structure of the atom as well as to explain its important properties. The elucidation of the structure of atoms is based on a series of experiments. One of the first indications that atoms are not indivisible. Many scientists explained presence of charged particles in an atom.

The Existence of Atom:

- The electrical nature of matter was known in 600 BC.
- **William Crookes** was the first to do the discharge tube experiment which lead to the conclusion of existence of charged particles inside the atom.
- The first important and experimental evidence of electrical nature of matter was established by **Faraday** in 1833. He showed that the flow of electricity is due to the flow of charged particles.
- The term electron was first suggested by **G. J. Stoney** for unit charge on a monovalent negative ion. Existence of electrons was later proved by J.J. Thomson.
- The idea of tiniest unit of matter (anu and paramanu) was propounded by **Maharshi Kanad** in vedic period in our country.
- **Democritus**, a Greek philosopher, proposed that matter is made up of extremely small particles called the “atoms”.

The first atomic theory was proposed by Dalton. He stated that:

- All matter consists of indivisible particles called atoms.
- Atoms of the same element are similar in shape and mass but differ from the atoms of other elements.
- Atoms cannot be created or destroyed.

- Atoms of different elements may combine with each other in a fixed, simple, whole number ratios to form compound atoms.
- Atoms of same element can combine in more than one ratio to form two or more compounds.
- The atom is the smallest unit of matter that can take part in a chemical reaction.

But today, the indivisibility of an atom was proved wrong, and Dalton's theory is almost discarded after the discovery of fundamental particles.

Sub-Atomic Particles:

Cathode rays were discovered by J.J.Thomson:

- Cathode rays travel in straight lines
- Cathode rays consist of material particles
- Cathode rays are affected by both electric and magnetic fields.
- The charge to mass ratio (e/m_e) for an electron (cathode rays particle) is constant and is found to be 1.76×10^{11} C/kg or 1.76×10^{8} C/g.
- Charge on the electron is -1.6022×10^{-19} C or -4.8×10^{-10} esu (electrostatic unit).
- Mass of the electron is 9.11×10^{-31} kg. The mass of electron is nearly equal to 1/1837 the mass of one atom of hydrogen.

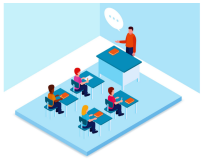
Anode rays or canal rays were discovered by Goldstein:

- Anode rays travel in straight lines.
- Anode rays cause mechanical motion and positively charged particles.
- Anode rays are deflected both in electric (towards negative plate) and magnetic fields (towards South pole).
- The e/m ratio of the particles in the anode rays is not constant and depends on the nature of gas taken in the discharge tube.
- The charge of proton is $+ 1.602 \times 10^{-19}$ C or $+ 4.8 \times 10^{-10}$ esu (electrostatic unit).
- The mass of proton is 1.672×10^{-24} g or 1.00727 amu

Neutrons were discovered by James Chadwick:

- The mass of a neutron is slightly more than that of a proton, i.e., 1.676×10^{-24} g compared to 1.672×10^{-24} g.
- Electrically a neutron is neutral, i.e., it has no charge.
- In a particular element, the number of neutrons in the nucleus of its atoms may vary.

Further research has proved that within the atom there are over 100 different kinds of subatomic particles, most important being positron, meson, neutrino etc.



CLASSROOM DISCUSSION QUESTIONS

CDQ 1.1

1. What was one of the first indications that atoms are not indivisible?

(A) Discovery of electrons by J.J. Thomson

(B) Faraday's experiment on electricity flow

(C) J.J. Thomson's discovery of cathode rays

(D) Dalton's atomic theory

2. Who was the first to suggest the term "electron" for a monovalent negative ion?

(A) William Crookes

(B) J.J. Thomson

(C) G. J. Stoney

(D) Democritus

3. Which Greek philosopher proposed that matter is made up of extremely small particles called "atoms"?

(A) Aristotle

(B) Socrates

(C) Plato

(D) Democritus

4. Who discovered cathode rays and their properties?

(A) J.J. Thomson

(B) Goldstein

(C) William Crookes

(D) Faraday

5. What is the charge on an electron?

(A) $+1.6022 \times 10^{-19}$ C

(B) -1.6022×10^{-19} C

(C) $+1.602 \times 10^{-19}$ C

(D) -1.602×10^{-19} C

6. What is the mass of an electron?

(A) 9.11×10^{-31} kg

(B) 1.672×10^{-24} g

(C) 1.00727 a.m.u

(D) 1.676×10^{-24} g

7. Who discovered anode rays or canal rays?

(A) J.J. Thomson

(B) Goldstein

(C) William Crookes

(D) Faraday

8. What is the charge of a proton?

(A) $+1.602 \times 10^{-19}$ C

(B) -1.6022×10^{-19} C

(C) $+1.6022 \times 10^{-19}$ C

(D) -1.602×10^{-19} C

9. Who discovered neutrons?

(A) J.J. Thomson

(B) Goldstein

(C) James Chadwick

(D) Faraday

10. What is the electrical charge of a neutron?

(A) Positive (B) Negative

(C) Neutral (D) Variable

MARK YOUR ANSWERS WITH PEN ONLY. Time Taken in Minutes

1 Ⓐ Ⓑ Ⓒ Ⓓ	2 Ⓐ Ⓑ Ⓒ Ⓓ	3 Ⓐ Ⓑ Ⓒ Ⓓ	4 Ⓐ Ⓑ Ⓒ Ⓓ	5 Ⓐ Ⓑ Ⓒ Ⓓ
6 Ⓐ Ⓑ Ⓒ Ⓓ	7 Ⓐ Ⓑ Ⓒ Ⓓ	8 Ⓐ Ⓑ Ⓒ Ⓓ	9 Ⓐ Ⓑ Ⓒ Ⓓ	10 Ⓐ Ⓑ Ⓒ Ⓓ

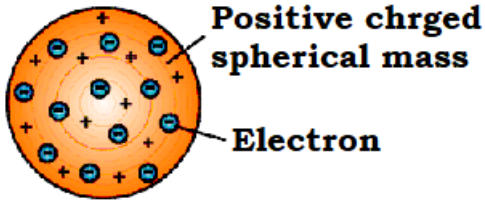
CONCEPT 1.2

Atomic models:

1. Thomson's model of atom:

Dalton suggested that the atom was indivisible and indestructible. But the discovery of two fundamental particles (electrons and protons) inside the atom, led to the failure of this aspect of Dalton's atomic theory. It was then considered necessary to know how electrons and protons are arranged within an atom. For explaining this, many scientists proposed various atomic models. **J.J. Thomson** was the first one to propose a model for the structure of an atom.

According to this model, an atom is made up of positively charged substance which is spread very thinly in the form of a sphere. Into this sphere negatively charged electrons are embedded. This can be compared to a watermelon, which has evenly distributed red spongy mass with the black seeds embedded in it. Thus, his model is also known as **watermelon model**.



Thomson's atomic model

Drawbacks of thomson's atomic model:

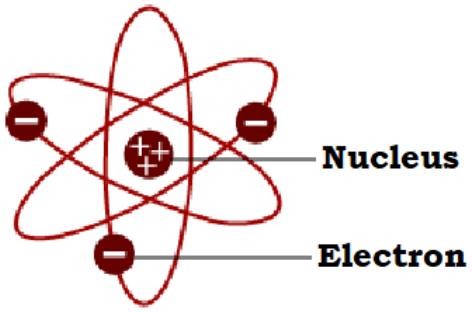
Although J.J.Thomson's model of atom was able to explain the overall electrical neutrality of the atom, this model was not accepted by fellow physicists, as it was unable to explain how positively charged particles are shielded from the negatively charged particles, without getting neutralized.

2. Rutherford's atomic model:

To explain the structure of atom, **E. Rutherford** conducted an experiment called alpha ray scattering experiment or gold foil experiment. Based on the conclusions from this experiment he proposed a model of atom commonly known as Rutherford's atomic model.

Postulates of Rutherford's atomic model:

1. Major portion of the atom is empty.
2. The whole mass of the atom is concentrated in the centre of atom called nucleus.
3. The positively charged particles are present in the nucleus of atom.
4. Size of nucleus is very small as compared to the size of atom.
5. Electrons revolve around the nucleus at high speeds in a circular path.



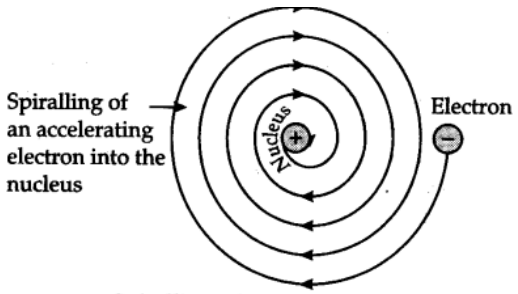
Rutherford's atomic model

6. There are two types of forces acting on the revolving electron in the atom.
   i) A centripetal force due to the electrostatic force of attraction between electrons and protons. Thus, force pulls the electrons towards the nucleus.
   ii) A centrifugal force due to the high speed with which the electrons revolve around the nucleus. This force is directed away from the nucleus. Due to these two opposing but equal forces the atom is stable.

Drawbacks of Rutherford's atomic model:

There were two fundamental defects in Rutherford's atomic model:

1. According to classical electromagnetic theory, any moving charged particle moving at a high speed in a circular path will radiate energy continuously. The electron when it moves around the nucleus should lose energy and get increasingly pulled towards the nucleus with greater force. Thus, the electron must spiral into the nucleus. The atom should collapse if this happens. But the atom is stable.



Spiralling of an accelerating electron into the nucleus with progressive loss of energy

2. Rutherford could not explain, why atomic spectra is discontinuous.

Atomic number (Z) and Mass number (A):

Each element has been assigned with an atomic number (Z) the number of protons present in the nucleus of an atom of that element. The number of protons in the nucleus of an atom determines the identity of the atom.

Atomic number (Z) = number of protons = number of electrons (in a neutral atom)

The mass number is the total number of protons and neutrons present in the nucleus of an atom of an element.

Protons and neutrons present in the nucleus of an atom are collectively known as nucleons. Therefore, the mass number is also known as nucleon number.

Mass number (A) = number of protons + number of neutrons

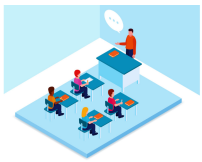
The number of neutrons (n) in an atom is equal to the difference between the mass number and the atomic number. i.e., $n = A - Z$

Do you know? i. It is to be noted that all the three quantities, atomic number, number of neutrons and mass number are positive integers.

ii. The atomic mass of an element corrected to the nearest whole number is its mass number.

For example, Atomic mass of P = 30.975 amu

Mass number of P = 31



CLASSROOM DISCUSSION QUESTIONS

CDQ 1.2

1. **What analogy did J.J. Thomson use to describe his atomic model?**
   (A) Soccer ball (B) Watermelon
   (C) Tennis ball (D) Orange
2. **What was a major drawback of Thomson's atomic model?**
   (A) Inability to explain the electrical neutrality of the atom
   (B) Lack of experimental evidence
   (C) Overemphasis on the nucleus
   (D) Complexity in visualization
3. **Which experiment led to the proposal of Rutherford's atomic model?**
   (A) Cathode ray experiment
   (B) Gold foil experiment
   (C) Millikan oil drop experiment
   (D) Alpha particle experiment
4. **According to Rutherford's atomic model, where is the mass of the atom concentrated?**
   (A) In the electrons
   (B) Spread evenly throughout the atom
   (C) In the nucleus
   (D) In the electron cloud
5. **What force is responsible for keeping electrons in orbit according to Rutherford's model?**
   (A) Centrifugal force
   (B) Electromagnetic force
   (C) Gravitational force
   (D) Centripetal force
6. **What was one of the fundamental defects in Rutherford's atomic model?**
   (A) Discontinuous atomic spectra
   (B) Lack of experimental support
   (C) Inability to explain the stability of the atom
   (D) Overemphasis on the electron cloud
7. **What is the atomic number of an element?**
   (A) The number of neutrons
   (B) The number of protons
   (C) The number of electrons
   (D) The total number of nucleons
8. **How is the mass number of an element calculated?**
   (A) By adding the number of protons and electrons
   (B) By subtracting the atomic number from the atomic mass
   (C) By counting the number of neutrons
   (D) By adding the number of protons and neutrons
9. **What is the relationship between the atomic number and the number of electrons in a neutral atom?**
   (A) They are always equal
   (B) They are inversely proportional
   (C) They are directly proportional
   (D) They are unrelated
10. **What term collectively refers to protons and neutrons in the nucleus of an atom?**
    (A) Electron cloud
    (B) Nucleons
    (C) Electromagnetic force
    (D) Subatomic particles

MARK YOUR ANSWERS WITH PEN ONLY. Time Taken in Minutes

1 Ⓐ Ⓑ Ⓒ Ⓓ	2 Ⓐ Ⓑ Ⓒ Ⓓ	3 Ⓐ Ⓑ Ⓒ Ⓓ	4 Ⓐ Ⓑ Ⓒ Ⓓ	5 Ⓐ Ⓑ Ⓒ Ⓓ
6 Ⓐ Ⓑ Ⓒ Ⓓ	7 Ⓐ Ⓑ Ⓒ Ⓓ	8 Ⓐ Ⓑ Ⓒ Ⓓ	9 Ⓐ Ⓑ Ⓒ Ⓓ	10 Ⓐ Ⓑ Ⓒ Ⓓ

CONCEPT 1.3

Representation of an Atom:

The most accepted way to denote the atom of an element X is as ${}^{A}_{Z}X$, where X is the symbol for the element with superscript A and subscript Z.

For example, the atomic number of carbon is 6 and the mass number is 12. The atomic and mass numbers of carbon can be represented as ${}^{12}_{6}C$.

Isotopes:

The atoms of an element, which are having same atomic number but different mass numbers are called isotopes.

Examples:

1. Hydrogen gas has three isotopes, namely **Protium** ($_1H^1$), **Deuterium** ($_1H^2$) and **Tritium** ($_1H^3$).
2. Carbon has three isotopes, namely $_6C^{12}$, $_6C^{13}$ and $_6C^{14}$, the most predominant isotope is $_6C^{12}$.

In the same way, chlorine has two isotopes, i.e., chlorine occurs in nature in two isotopic forms, with masses 35 u and 37 u in the ratio of 3: 1.

Obviously, the question arises: what should we take as the mass of chlorine atom? Let us find out. The mass of an atom of any natural element is taken as the average mass of all the naturally occurring atoms of that element. If an element has no isotopes, then the mass of its atom would be the same as the sum of protons and neutrons in it. But if an element occurs in isotopic forms, then we have to know the percentage of each isotopic form and then the average mass is calculated by using the formula

$$= \frac{\text{Mass no. of } 1^{st} \text{ isotope} \times \text{it's abondance} + \text{Mass no. of } 2^{nd} \text{ isotope} \times \text{it's abondance}}{\text{Total abondance}}$$

Chlorine with mass number 35 has 75% abundance and chlorine with mass number 37 has 25% abundance in the nature. The average atomic mass of chlorine atom, on the basis of above data, will be $\frac{(35\times 75) + (37\times 25)}{100} = 35.5\,u$

Solved examples:

1. Nitrogen is made up of two isotopes, N-14 and N-15. Given nitrogen's atomic weight is 14.007. What is the percent abundance of each isotope?

Sol: Percentage abundance of N-14 = x % (Let)

Percentage abundance of N-15 = (100 – x) % (Since total abundance = 100%)

Atomic weight of nitrogen = 14.007

$$\Rightarrow \quad \frac{(14\times x) + (15\times(100-x))}{100} = 14.007$$

$$x = 99.7$$

$\therefore$ The percentage abundance of N-14 = 99.7%

The percentage abundance of N-15 = 100 – 99.7 = 0.3%

Isobars:

The atoms which are having same mass number (i.e., nucleon number) but different atomic numbers are called isobars.

Example: Argon (Ar) and calcium (Ca) are isobars.

Element	Ar	Ca
Atomic mass	40	40
Atomic number	18	20

Isotones:

Atoms of different elements having same number of neutrons, but different atomic numbers and mass numbers are called isotones.

Example: $_{14}Si^{30}$ (14 protons, 16 neutrons) and $_{15}P^{31}$ (15 protons, 16 neutrons) are isotones because both have 16 neutrons.

Isotopic number:

The difference between the number of neutrons and protons of an atom is known as its isotopic number.

Example: Isotopic number of $_{6}C^{12}$ = Number of neutrons–number of protons

= 6 – 6 = 0

Isotopic number of $^{23}_{11}Na$ = Number of neutrons – number of protons

= 12 – 11 = 1

Isodiaphers:

The nuclides which have same isotopic number are known as isodiaphers.

Example: $^{234}_{90}Th$ and $^{238}_{92}U$ are isodiaphers.

Isotopic number of $^{234}_{90}Th$ = 144 – 90 = 54

Isotopic number of $^{238}_{92}U$ = 146 – 92 = 54

Isoelectronics:

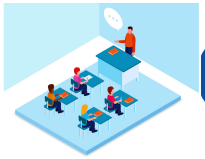
Elements or ions or molecules or any other species having same number of electrons in them are called isoelectronics or isoelectronic species.

Example: Na^+, Ne and F^- are isoelectronics. CO_2 and N_2O are isoelectronics.

Isosters:

Isosters are the molecules or ions with the same number of atoms and the same number of electrons are called isosters.

Example: CO_2 and N_2O are isosters.



CLASSROOM DISCUSSION QUESTIONS CDQ 1.3

1. What does the notation A ZX represent for an atom of element X?

(A) Number of electrons
(B) Mass number
(C) Atomic number
(D) Number of neutrons

2. What are isotopes of an element characterized by?

(A) Different atomic numbers and different mass numbers
(B) Different atomic numbers but same mass numbers
(C) Same atomic numbers but different mass numbers
(D) Same number of protons but different number of electrons

3. What is the most predominant isotope of carbon?

(A) 13_{6C} (B) 14_{6C}
(C) 12_{6C} (D) 12_{7C}

4. How is the average atomic mass of an element with isotopes calculated?

(A) Sum of protons and neutrons
(B) Average of all isotopes' atomic masses
(C) Weighted average based on isotopic abundances
(D) Total number of isotopes divided by the atomic number

5. Which pair of elements are examples of isobars?

(A) Nitrogen and Oxygen
(B) Argon and Calcium
(C) Carbon and Nitrogen
(D) Hydrogen and Helium

6. What is the difference between isotones?

(A) Atomic number
(B) Number of neutrons
(C) Atomic mass
(D) Number of electrons

7. What is the isotopic number of 2311Na?

(A) 11 (B) 12
(C) 10 (D) 1

8. What defines isodiaphers?

(A) Same number of neutrons
(B) Same atomic mass
(C) Same isotopic number
(D) Same number of protons

9. What characterizes iso-electronic species?

(A) Same atomic number
(B) Same number of protons
(C) Same number of neutrons
(D) Same number of electrons

10. What defines isosters?

(A) Same number of protons
(B) Same number of atoms and electrons
(C) Same atomic mass
(D) Same atomic number

MARK YOUR ANSWERS WITH PEN ONLY. Time Taken in Minutes

1 Ⓐ Ⓑ Ⓒ Ⓓ	2 Ⓐ Ⓑ Ⓒ Ⓓ	3 Ⓐ Ⓑ Ⓒ Ⓓ	4 Ⓐ Ⓑ Ⓒ Ⓓ	5 Ⓐ Ⓑ Ⓒ Ⓓ
6 Ⓐ Ⓑ Ⓒ Ⓓ	7 Ⓐ Ⓑ Ⓒ Ⓓ	8 Ⓐ Ⓑ Ⓒ Ⓓ	9 Ⓐ Ⓑ Ⓒ Ⓓ	10 Ⓐ Ⓑ Ⓒ Ⓓ

CONCEPT 1.4

Electromagnetic radiations:

Electromagnetic radiation (EMR) is a form of energy that is produced by the movement or oscillation of electrically charged particles traveling through vacuum or matter. These radiations do not need any medium for propagation. Light, electricity, and magnetism are all different forms of electromagnetic radiation.

Example: Visible light, ultraviolet radiation, infrared radiation, X-rays, γ-rays, etc.

Characteristics of electromagnetic radiations:

Electromagnetic radiation is released as photons, which are bundles of light energy that travel at the speed of light.

Electromagnetic radiation can travel through empty space (vacuum). Most other types of waves must travel through some sort of substance. For example, sound waves need either a gas, solid, or liquid to pass through in order to be heard.

The following are the important characteristics of electromagnetic radiations.

- All electromagnetic radiations travel with the velocity of light.
- These consist of electric and magnetic fields that oscillate in directions perpendicular to the direction in which the wave is travelling.

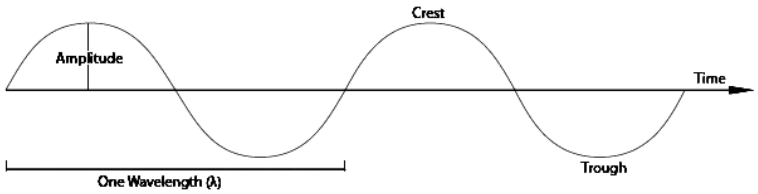
A wave or an electromagnetic radiation is always characterized by the following six characters:

Wavelength:

The distance between two nearest crests or nearest troughs is called the wavelength. It is denoted by λ and is measured in terms of centimetres (cm), angstroms (A°), micrometres (mm) or nanometres (nm).

$1\ A^{o} = 10^{-8}\ cm = 10^{-10}\ m$ $\quad 1\ \mu m = 10^{-4}\ cm = 10^{-6}\ m$

$1\ nm = 10^{-7}\ cm = 10^{-9}\ m$ $\quad 1\ cm = 10^{8} A^{o} = 10^{4}\ \mu m = 10^{7}\ nm$



Frequency:

It is defined as the number of waves which pass through a point in one second. It is denoted by the symbol ϑ (nu) and is measured in terms of cycles (or waves) per second (cps or s^{-1}) or hertz (Hz).

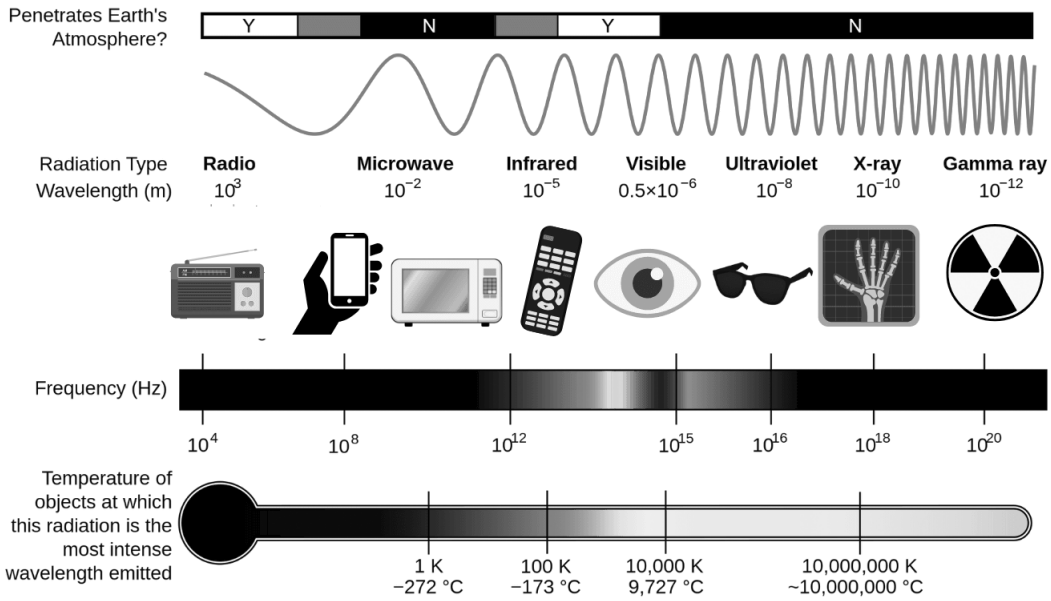
Frequency is inversely proportional to wavelength.

$\vartheta \alpha \frac{1}{\lambda} \Rightarrow \vartheta = \frac{c}{\lambda}$ Where 'c' is constant which is equal to velocity of light.

Thus, a wave of higher frequency has a shorter wavelength while a wave of lower frequency has a longer wavelength.

Do you know? Longer wavelength waves such as radio waves carry low energy; this is why we can listen to the radio without any harmful consequences. Shorter wavelength waves such as x-rays carry higher energy that can be hazardous to our health. Consequently, lead aprons are worn to protect our bodies from harmful radiation when we undergo x-rays.

Frequency and wavelengths of different electromagnetic radiation are as shown in the following electromagnetic spectrum:



Electromagnetic Spectrum with Radiations Types

Velocity of Electromagnetic Radiations:

It is defined as the distance covered in one second by the wave. It is denoted by the letter 'c'. All electromagnetic waves travel with the same velocity, i.e 3×10^{10} cm/sec.

Distance travelled in one second $c = \lambda \times \vartheta = 3 \times 10^{10}$ cm/sec

Solved example:

2. Calculate the frequency of a radiation with wavelength 480 nm.

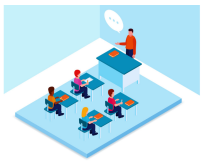
Sol: Given:

$\lambda = 480\text{nm} = 480\times10^{-9}\text{m} \qquad (\because 1\text{nm} = 10^{-9}\text{m})$

$c = 3\text{x}10^{8}\,\text{m/sec}$

Frequency, $\vartheta = \frac{c}{\lambda} = \frac{3\times10^{8}\,\text{ms}^{-1}}{480\times10^{-9}} = 6.25\times10^{14}\,\text{s}^{-1}$

$= 6.25 \text{ x } 10^{14}$ Hz



CLASSROOM DISCUSSION QUESTIONS

CDQ 1.4

1. What is electromagnetic radiation primarily composed of?

(A) Particles (B) Photons

(C) Atoms (D) Electrons

2. What characteristic defines the distance between two nearest crests or troughs of an electromagnetic wave?

(A) Amplitude

(B) Frequency

(C) Wavelength

(D) Velocity

3. In what units is wavelength commonly measured?

(A) Cycles per second

(B) Meters per second

(C) Nanometers or angstroms

(D) Hertz

4. How is frequency related to wavelength?

(A) Directly proportional

(B) Inversely proportional

(C) They are unrelated

(D) Varies randomly

5. What does the symbol ? represent in the context of electromagnetic radiation?

(A) Frequency

(B) Velocity

(C) Wavelength

(D) Amplitude

6. What unit is used to measure frequency?

(A) Angstroms

(B) Nanometers

(C) Hertz

(D) Meters per second

7. What does the symbol ? represent in the context of electromagnetic radiation?

(A) Velocity

(B) Wavelength

(C) Frequency

(D) Amplitude

8. What is the velocity of all electromagnetic waves?

(A) 3×10^{8} meters per second

(B) 3×10^{10} meters per second

(C) 3×10^{8} centimeters per second

(D) 3×10^{10} centimeters per second

9. How is the velocity of electromagnetic radiation related to wavelength and frequency?

(A) Directly proportional to wavelength and inversely proportional to frequency

(B) Inversely proportional to wavelength and directly proportional to frequency

(C) Independent of both wavelength and frequency

(D) Proportional to wavelength but inversely proportional to frequency

10. What is the frequency of electromagnetic radiation if its wavelength is 480 nm?

(A) 6.25×10^{14} Hz

(B) 4.8×10^{2} Hz

(C) 6.25×10^{8} Hz

(D) 4.8×10^{14} Hz

MARK YOUR ANSWERS WITH PEN ONLY. Time Taken in Minutes

1 Ⓐ Ⓑ Ⓒ Ⓓ	2 Ⓐ Ⓑ Ⓒ Ⓓ	3 Ⓐ Ⓑ Ⓒ Ⓓ	4 Ⓐ Ⓑ Ⓒ Ⓓ	5 Ⓐ Ⓑ Ⓒ Ⓓ
6 Ⓐ Ⓑ Ⓒ Ⓓ	7 Ⓐ Ⓑ Ⓒ Ⓓ	8 Ⓐ Ⓑ Ⓒ Ⓓ	9 Ⓐ Ⓑ Ⓒ Ⓓ	10 Ⓐ Ⓑ Ⓒ Ⓓ

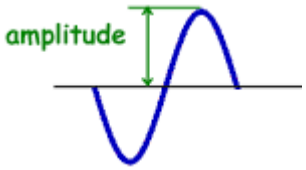
CONCEPT 1.5

Wave number:

This is the reciprocal of wavelength, i.e, the number of wavelengths per (unit length) centimetres. It is denoted by the symbol $\bar{\vartheta}$ (nu bar). $\bar{\vartheta} = \frac{1}{\lambda}$

It is expressed in cm^{-1} or m^{-1} .

Amplitude:



It is defined as the height of the crest or depth of the trough of a wave. It is denoted by the letter 'a'. It determines the intensity of the radiation.

The arrangement of various types of electromagnetic radiations in the order of their increasing or decreasing order of wavelengths or frequencies is known as electromagnetic spectrum.

Time period:

Time taken by the wave for one complete cycle or vibration is called time period. It is denoted by T. $T = \frac{1}{\vartheta}$

Unit: Seconds per cycle.

Solved example:

3. Calculate the wavelength and wave number of a photon having a frequency of 7.26×10^{14} Hz. ($c = 3\times10^{10}$ cm s^{-1})

Sol: Given: $\vartheta = 7.26\times 10^{14}$ Hz

$$\therefore \text{ Wavelength } = \lambda = \frac{c}{\vartheta} = \frac{3\times10^{10}}{7.26\times10^{14}} = 4.132\times10^{-5}\text{cm}$$

$$\text{Wave number } = \bar{\vartheta} = \frac{1}{\lambda} = \frac{1}{4.132\,x\,10^{-5}} = 2.42\,x\,10^{4}\,cm^{-1}$$

Planck's quantum theory:

Max Planck in 1901 presented a new theory on electromagnetic radiations which is known as Planck's quantum theory of radiation.

According to this theory:

- Substances absorb or emit light discontinuously in the form of small packets or bundles.
- The smallest packet of energy is called photon or quantum.
- The radiation is propagated in the form of waves. The energy of a quantum

is directly proportional to the frequency of the radiation. $E \alpha \vartheta$.

- The energy of a quantum is $E = h\vartheta = \frac{hc}{\lambda} = hc\,\bar{\vartheta}$

Where h is a constant known as Planck's constant.
Its numerical value is 6.625×10^{-27} erg-sec or 6.625×10^{-34} Joule-sec.

E = Energy in ergs or Joules,

c = Velocity of light = 3×10^{10} cm/sec = 3×10^{8} m /sec

ϑ = Frequency of radiation,

λ = Wavelength,

$\bar{\vartheta}$ = Wave number

A body can absorb or emit energy in whole number of quantum, $[E = n(h\vartheta)]$.

Solved examples:

4. Which has higher energy, a photon of violet light with wavelength 4000 A° or a photon of red light with wavelength 7000 A° [h = 6.62 ×10^{-34}Js]?

Sol: We known that, $E = h\vartheta = h, \frac{c}{\lambda}$

Given h = 6.62×10^{-34} Js, $C = 3\times10^{8}\,ms^{-1}$

For a photon of violet light,

$\lambda = 4000A^{o} = 4000\times10^{-10}\,m$

$E = 6.62\times10^{-34}\times\frac{3x10^{8}}{4\times10^{-7}} = 4.96\times10^{-19}\,J$

For a photon of red light,

$\lambda = 7000A^{o} = 7000\times10^{-10}\,m$

$E = 6.62\times10^{-34}\times\frac{3\times10^{8}}{7000\times10^{-10}} = 2.83\times10^{-19}\,J$

Hence, photon of violet light has higher energy than the photon of red light.

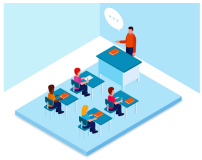
5. What is the ratio between the energies of two radiations one with a wavelength of 6000A° and other with 2000 A°?

Sol: $\lambda_1 = 6000A^{o}$ and $\lambda_2 = 2000A^{o}$

$E_1 = h\frac{c}{\lambda_1}$ and $E_2 = h\frac{c}{\lambda_2}$

Ratio: $\frac{E_1}{E_2} = \frac{h.c}{\lambda_1}\times\frac{\lambda_2}{hc} = \frac{\lambda_2}{\lambda_1} = \frac{2000}{6000} = \frac{1}{3}$

$\therefore$ $E_2 = 3E_1$ or $E_1 : E_2 = 1 : 3$



CLASSROOM DISCUSSION QUESTIONS

CDQ 1.5

1. What is wave number in terms of wavelength?

(A) The height of the crest or depth of the trough

(B) The number of wavelengths per centimeter

(C) The time taken by the wave for one complete cycle

(D) The distance covered in one second by the wave

2. Which characteristic determines the intensity of electromagnetic radiation?

(A) Amplitude

(B) Frequency

(C) Wavelength

(D) Velocity

3. According to Planck's quantum theory, what is the energy of a quantum directly proportional to?

(A) Amplitude

(B) Frequency

(C) Wavelength

(D) Wave number

4. What is the constant known as Planck's constant used for in Planck's quantum theory?

(A) To calculate time period

(B) To determine amplitude

(C) To find the energy of a quantum

(D) To measure wavelength

5. In the equation E = hv = hc/ λ , what does v represent?

(A) Frequency

(B) Velocity

(C) Amplitude

(D) Wavelength

6. Which color of light typically has higher energy, violet or red?

(A) Violet

(B) Red

(C) They have the same energy

(D) It depends on other factors

7. What does Planck's constant represent in the context of electromagnetic radiation?

(A) The energy of a quantum

(B) The speed of light

(C) The wavelength

(D) The frequency

8. How does the energy of a photon change with respect to its wavelength?

(A) It increases with increasing wavelength

(B) It decreases with increasing wavelength

(C) It remains constant regardless of wavelength

(D) It varies randomly

9. Which characteristic defines the height of the crest or depth of the trough of a wave?

(A) Wavelength

(B) Frequency

(C) Amplitude

(D) Wave number

10. According to Planck's quantum theory, in what form is radiation propagated?

(A) In the form of particles

(B) In the form of waves

(C) In the form of bundles

(D) In the form of vibrations

MARK YOUR ANSWERS WITH PEN ONLY. Time Taken in Minutes

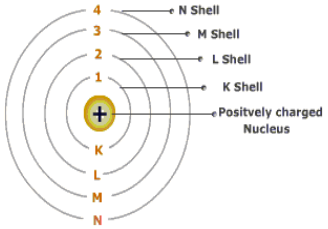
1 Ⓐ Ⓑ Ⓒ Ⓓ	2 Ⓐ Ⓑ Ⓒ Ⓓ	3 Ⓐ Ⓑ Ⓒ Ⓓ	4 Ⓐ Ⓑ Ⓒ Ⓓ	5 Ⓐ Ⓑ Ⓒ Ⓓ
6 Ⓐ Ⓑ Ⓒ Ⓓ	7 Ⓐ Ⓑ Ⓒ Ⓓ	8 Ⓐ Ⓑ Ⓒ Ⓓ	9 Ⓐ Ⓑ Ⓒ Ⓓ	10 Ⓐ Ⓑ Ⓒ Ⓓ

CONCEPT 1.6

Bohr's Model of Atom:

In 1913 one of Rutherford's students, Niels Bohr, proposed a model of atom that was consistent with Rutherford's model and the quantum theory of radiation.

Postulates of Bohr's Atomic Model:



- Electrons revolve around the nucleus with definite energy in concentric circular orbits called stationary orbits (or) shell. These orbits are denoted as **K, L, M, N....**
- The electrons have the least energy in the K-shell of an atom followed by the L-shell, M-shell etc.
- As long as the electron revolves in the same circular orbit energy is neither radiated nor absorbed.
- Energy of the electron changes only when it moves from one orbit to another orbit. Energy is absorbed when an electron jumps from an inner orbit to an outer orbit and vice-versa.
  Energy changes during the electron jumps from one orbit to another orbit is given by
  $\Delta E = E_2 - E_1 = h\vartheta$ where E_2 and E_1 are the energies of higher orbit and lower orbit respectively.

Defects of Bohr's atomic model:

- Bohr's theory could not explain the atomic spectra of higher elements such as He, Li, Be, B, C, ... which have more than one electron.
- Bohr's model could not explain even hydrogen spectrum obtained using high resolution spectroscopes. Each spectral line, on high resolution was found to consist of two closely spaced lines.
- It was observed that in the presence of electric & magnetic fields, each spectral line gets split up into closely spaced lines. These are known as stark effect & zeeman effect respectively. Bohr could not explain stark effect & zeeman effect.
- Bohr's theory could not account for the formation of chemical bonds.

Electronic Configuration: d

Distribution of electrons in different shells (orbits):

The systematic arrangement of electrons in different shells of an atom is called electronic configuration of that element.
For writing the electronic configuration of an atom we should know following:

1. Total number of electrons present in the atom.

2. Maximum number of electrons that can be accommodated in each shell of atom.

Bohr and **Bury** together proposed certain rules for better understanding the electronic configurations of atoms. They are:

i) The maximum number of electrons that can be accommodated in a shell is given by the formula $2n^2$, where n is the number of shells. According to this formula:

Maximum number of electrons in first shell (K-shell) = $2n^2 = 2(1)^2 = 2$
Maximum number of electrons in second shell (L-shell) = $2n^2 = 2(2)^2 = 8$
Maximum number of electrons in third shell (M-shell) = $2n^2 = 2(3)^2 = 18$
Maximum number of electrons in fourth shell (N-shell) = $2n^2 = 2(4)^2 = 32$

ii) The outermost shell (last shell) of any atom cannot have more than eight electrons even if it has a capacity of holding more electrons. For example, if M shell is the outermost shell of an atom, it can accommodate a maximum of 8 electrons only, although it has a capacity of accommodating maximum 18 electrons.

iii) An atom becomes stable if its outermost shell has 8 electrons, or if it has only one shell containing 2 electrons.

iv) The penultimate shell (last but one) can accommodate a maximum of 18 electrons.

v) Electrons do not enter into a new shell before the inner shell is completely filled.

Significance of electronic configuration:

The electronic configuration of an atom helps in predicting the chemical behaviour of an element.

- If an atom of element has completely filled (i.e. having 8 electrons) outermost shell, the element will be unreactive. This is called **octet** configuration. If the outermost shell is K shell and filled with two electrons, that is called **duplet** configuration.
- When the atom of an element has less than 8 electrons in its outermost shell, the element will be reactive or unstable.

Valence electrons and valency of elements:

Valence electrons: The electrons present in the outermost shell (valence shell) of an atom are called valence electrons.

Valency: The combining capacity of an element is called its valency.

Elements other than noble gases, contain less than 8 electrons in their outermost shells. These elements are chemically reactive and unstable. They tend to acquire the stable outermost electronic configuration of noble gases by gaining or losing or sharing electrons with other atoms.

Thus, the number of electrons gained, lost or shared by an atom to complete its octet or duplet is called the **valency** of that element.

Elements with less than four electrons in their valence shell will lose electrons and those elements with more than four electrons in their outermost shell will gain electrons so that they acquire octet or duplet configuration.

Electronic configuration and valency of first eighteen elements are as follows:

Atomic number	Element	Number of electrons	Electronic configuration	Valency
1	Hydrogen	1	1	1
2	Helium	2	**2**	0
3	Lithium	3	2,1	1
4	Beryllium	4	2,2	2
5	Boron	5	2,3	3
6	Carbon	6	2,4	4
7	Nitrogen	7	2,5	3
8	Oxygen	8	2,6	2
9	Fluorine	9	2,7	1
10	Neon	10	**2,8**	0
11	Sodium	11	2,8,1	1
12	Magnesium	12	2,8,2	2
13	Aluminium	13	2,8,3	3
14	Silicon	14	2,8,4	4
15	Phosphorus	15	2,8,5	3
16	Sulphur	16	2,8,6	2
17	Chlorine	17	2,8,7	1
18	Argon	18	**2,8,8**	0

Solved examples:

6. How many protons and neutrons are there in an atom of $^{13}_{6}C$?

Sol: Atomic number Z = 6

Mass number A = 13

Number of protons (p) = Z = 6

Number of neutrons (n) = A – Z = 13 – 6 = 7

7. The mass number of fluorine is 19 and the atomic number is 9. Calculate the number of neutrons in an atom of fluorine.

Sol: We have, the number of neutrons n = A – Z

The number of neutrons in an atom of fluorine = 19 – 9 = 10

8. Copper is made up of two isotopes, Cu-63 (72.5%) and Cu-65 (27.5%). What will be the atomic weight of copper?

Sol: Atomic weight of copper = $\frac{(63\times 72.5) + (65\times 27.5)}{100}$ = 63.5

$\therefore$ Atomic weight of copper = 63.5

9. Calculate the energy associated with photon of light having a wavelength 6000 Ao. [h=6.624 ×10^{-27} erg.sec]

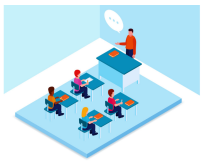
Sol: h = 6.624 ×10^{-27} erg.sec; c = 3 × 10^{10} cm/sec

$$\lambda = 6000A^{\circ} = 6000\times10^{-8}\,cm = 6\times10^{-5}cm$$

$$E = \frac{hc}{\lambda} = \frac{\left(6.624\times10^{-27}\right)\times\left(3\times10^{10}\right)}{6\times10^{-5}} = 3.312\times10^{-12}\,erg$$

The number of fundamental particles (electrons, protons and neutrons) present in the atoms of first twenty elements is shown in the following table:

Element name	Symbol	Atomic number (Z)	Mass number (A)	Number of protons (Z)	Number of electrons (Z)	Number of neutrons (A-Z)
Hydrogen	$_1H^1$	1	1	1	1	1 – 1 = 0
Helium	$_2He^4$	2	4	2	2	4 – 2 = 2
Lithium	$_3Li^7$	3	7	3	3	7 – 3 = 4
Beryllium	$_4Be^9$	4	9	4	4	9 – 4 = 5
Boron	$_5B^{11}$	5	11	5	5	11 – 5 = 6
Carbon	$_6C^{12}$	6	12	6	6	12 – 6 = 6
Nitrogen	$_7N^{14}$	7	14	7	7	14 – 7 = 7
Oxygen	$_8O^{16}$	8	16	8	8	16 – 8 = 8
Fluorine	$_9F^{19}$	9	19	9	9	19 – 9 = 10
Neon	$_{10}Ne^{20}$	10	20	10	10	20 – 10 = 10
Sodium	$_{11}Na^{23}$	11	23	11	11	23 – 11 = 12
Magnesium	$_{12}Mg^{24}$	12	24	12	12	24 – 12 =12
Aluminium	$_{13}Al^{27}$	13	27	13	13	27 – 13 = 14
Silicon	$_{14}Si^{28}$	14	28	14	14	28 – 14 = 14
Phosphorus	$_{15}P^{31}$	15	31	15	15	31 – 15 = 16
Sulphur	$_{16}S^{32}$	16	32	16	16	32 – 16 = 16
Chlorine	$_{17}Cl^{35}$	17	35	17	17	35 – 17 = 18
Argon	$_{18}Ar^{40}$	18	40	18	18	40 – 18 = 22
Potassium	$_{19}K^{39}$	19	39	19	19	39 – 19 = 20
Calcium	$_{20}Ca^{40}$	20	40	20	20	40 – 20 = 20



CLASSROOM DISCUSSION QUESTIONS

CDQ 1.6

1. What is a major postulate of Bohr's atomic model regarding the movement of electrons?

(A) Electrons revolve around the nucleus in elliptical orbits

(B) Electrons revolve around the nucleus in random paths

(C) Electrons revolve around the nucleus with definite energy in circular orbits

(D) Electrons revolve around the nucleus in hyperbolic orbits

2. According to Bohr's atomic model, when does the energy of an electron change?

(A) When it moves in a circular orbit

(B) When it moves from one circular orbit to another

(C) When it loses or gains protons

(D) When it absorbs or emits light

3. Which of the following is NOT a defect of Bohr's atomic model?

(A) Inability to explain atomic spectra of elements with more than one electron

(B) Inability to account for the formation of chemical bonds

(C) Inability to explain the Stark effect and Zeeman effect

(D) Inability to predict the energy of photons

4. What is the maximum number of electrons that can be accommodated in the second shell according to Bohr and Bury's rule?

(A) 2 (B) 8

(C) 18 (D) 32

5. How many protons and neutrons are there in an atom of 13C?

(A) Protons = 6, Neutrons = 6

(B) Protons = 6, Neutrons = 7

(C) Protons = 7, Neutrons = 6

(D) Protons = 7, Neutrons = 7

6. What is the maximum number of electrons in the third shell (M-shell) according to Bohr and Bury's rule?

(A) 2 (B) 8

(C) 18 (D) 32

7. What is the atomic weight of copper if it is composed of 72.5% Cu-63 and 27.5% Cu-65?

(A) 63.5 (B) 64.0

(C) 64.5 (D) 65.0

8. What is the energy associated with a photon of light with a wavelength of 6000 Å?

(A) 3.312×10^{-10} erg

(B) 3.312×10^{-12} erg

(C) 3.312×10^{-14} erg

(D) 3.312×10^{-16} erg

9. How many neutrons are there in an atom of fluorine with a mass number of 19 and an atomic number of 9?

(A) 9 (B) 10

(C) 18 (D) 19

10. Which element has an atomic number of 15 and a valency of 3?

(A) Nitrogen

(B) Oxygen

(C) Phosphorous

(D) Sulphur

MARK YOUR ANSWERS WITH PEN ONLY. Time Taken in Minutes

1 Ⓐ Ⓑ Ⓒ Ⓓ	2 Ⓐ Ⓑ Ⓒ Ⓓ	3 Ⓐ Ⓑ Ⓒ Ⓓ	4 Ⓐ Ⓑ Ⓒ Ⓓ	5 Ⓐ Ⓑ Ⓒ Ⓓ
6 Ⓐ Ⓑ Ⓒ Ⓓ	7 Ⓐ Ⓑ Ⓒ Ⓓ	8 Ⓐ Ⓑ Ⓒ Ⓓ	9 Ⓐ Ⓑ Ⓒ Ⓓ	10 Ⓐ Ⓑ Ⓒ Ⓓ

C.D.F. CONCEPTS, DEFINITIONS AND FORMULAE

1. Atoms are the basic building blocks of matter.
2. The first atomic theory was first proposed by **John Dalton**, known as Dalton's atomic theory.
3. **Cathode rays** were discovered by **J.J.Thomson.**
4. **Anode rays** or canal rays were discovered by **Goldstein.**
5. **Neutrons** were discovered by **James Chadwick**.
6. Neutrons are the neutral particles with unit mass.
7. The number of electrons or protons present in an atom of an element is called its **atomic number.** It is denoted by **Z**.
8. The sum of protons and neutrons in the atom of an element is called its **mass number**. It is denoted by **A**.
9. Number of neutrons n = A - Z.
10. **Isotopes** of an element have the same number of protons and electrons but differ in the number of neutrons.
11. **Isobars:** Atoms with same mass number with different atomic numbers are known as isobars
12. **Isotones** Atoms having same number of neutrons are known as isotones.
13. **Isoelectronics:** Elements or ions or molecules or any other species having same number of electrons in them are called isoelectronics.
14. **Isosters** Molecules of different substances which contain the same number of atoms, and the same total number of electrons are called isosters.
15. The distance between two nearest crests or nearest troughs is called the **wavelength**.
16. **Frequency** is defined as the number of waves which pass through a point in one second.
17. **Velocity** is defined as the distance covered in one second by the wave.
18. **Wave number** is the reciprocal of wavelength, i.e, the number of wavelengths per centimetres.
19. **Amplitude** is defined as the height of the crest or depth of the trough of a wave.
20. Time taken by the wave for one complete cycle or vibration is called **time period.**
21. According to **Planck**'s quantum theory the energy of a quantum is directly proportional to the frequency of the radiation. $E \alpha \vartheta$.
22. Electrons revolve around the nucleus with definite energy in concentric circular orbits called stationary **orbits** (or) **shells**. These orbits are denoted as **K, L, M, N...**
23. The maximum number of electrons that can be accommodated in a shell is given by the formula $2n^2$, where n is the number of shells.
24. The number of electrons gained, lost or shared by an atom to complete its octet or duplet is called the **valency** of that element.

ADVANCED WORKSHEET

Single Correct Answer Type (S.C.A.T)

1. The first atomic theory was proposed by:

(A) Democritus

(B) John Dalton

(C) William Crookes

(D) J.J. Thomson

2. The idea of smallest unit of matter (anu and paramanu) was proposed by:

(A) Democritus

(B) John Dalton

(C) William Crookes

(D) Maharshi kanad

3. Cathode rays were discovered by:

(A) William Crooks

(B) J.J. Thomson

(C) Rutherford

(D) Chadwick

4. The entire positive charge (or) protons are present in a central region called:

(A) Atom

(B) Electron

(C) Proton

(D) Nucleus

5. According to Rutherford:

(A) The neutrons revolve around the nucleus.

(B) The nucleus revolves around the electrons.

(C) The electrons revolve around the nucleus.

(D) The protons revolve around the nucleus.

6. The total number of protons and neutrons present in the nucleus of an atom is called:

(A) Atomic number

(B) Mass number

(C) Nucleons number

(D) Both B & C

7. The number of neutrons present in tritium is:

(A) 3 (B) 1

(C) 2 (D) 1

8. Which of the following pairs are not Isotopes?

(A) $_{6}C^{12}$ & $_{6}C^{14}$

(B) $_{7}N^{14}$ & $_{7}N^{15}$

(C) $_{8}O^{16}$ & $_{8}O^{18}$

(D) $_{8}O^{18}$ & $_{9}F^{19}$

9. Atoms having same number of neutrons are called:

(A) Isobar (B) Isomers

(C) Isotones (D) Isotopes

10. Which of the following is true regarding electromagnetic radiations?

(A) Do not require any medium for propagation

(B) They consist of both electric and magnetic fields

(C) All electromagnetic radiations travel with velocity of light

(D) All the above

11. The number of waves passing through a point per second is called:

(A) Wavelength

(B) Frequency

(C) Amplitude

(D) Velocity

12. The wavelength for a given type of electromagnetic radiation is:

(A) Directly proportional to frequency

(B) Inversely proportional to frequency

(C) Equal to frequency

(D) Directly proportional to wave number

13. As frequency increases energy of electromagnetic radiation:

(A) Decreases

(B) Increases

(C) Does not change

(D) First increases and then decreases

14. Quantum theory of radiation was proposed by:

(A) Bohr

(B) Rutherford

(C) Planck

(D) Dalton

15. The combining capacity of an element is called:

(A) Atomicity

(B) Valency

(C) Allotropy

(D) Isotopy

16. The smallest particle of an element that displays properties of that element is:

(A) Molecule

(B) Compound

(C) Atom

(D) Subatomic particle

17. The e/m ratio of anode rays depends upon:

(A) Nature of electrode

(B) Nature of residual gas

(C) Nature of discharge tube

(D) All the above

18. The heaviest particle among the following is:

(A) Meson

(B) Neutron

(C) Proton

(D) Electron

19. In the nucleus of $_{20}Ca^{40}$ there are:

(A) 40 protons and 20 electrons

(B) 20 protons and 40 electrons

(C) 20 protons and 20 neutrons

(D) 20 protons and 40 neutrons

20. Neutron is a fundamental particle which carries:

(A) No charge and no mass

(B) A charge –1 unit and no mass

(C) A charge of +1 and mass of one unit

(D) No charge and mass of one unit

21. An atom has 26 electrons, and its atomic weight is 56. The number of neutrons in the nucleus of the atom will be:

(A) 26 (B) 30

(C) 36 (D) 56

22. Mass number of an element is always equal to the sum of:

(A) Electrons and protons

(B) Electrons and neutrons

(C) Protons and neutrons

(D) None of these

23. Na+ ion is isoelectronic with:

(A) Li^+ (B) Mg^{2+}

(C) Ca^{2+} (D) Ba^{2+}

24. Select the pair of isobars from the following species $_{17}A^{37}$, $_{17}B^{35}$, $_{18}C^{37}$, $_{18}D^{36}$, $_{19}E^{38}$

(A) A and B (B) A and C

(C) C and E (D) C and D

25. Which of the following electromagnetic radiations has highest frequency?

(A) Red light

(B) Cosmic rays

(C) Ultraviolet rays

(D) None

26. The value of Max Planck's constant in C.G.S units is:

(A) 6.625×10^{-27}

(B) 6.625×10^{-34}

(C) 3×10^{8}

(D) 3×10^{10}

27. As the distance from the nucleus increases:

(A) Energy of the electron decreases

(B) Energy of the electron increases

(C) Does not affect energy of electron

(D) Depends on nature of atom

28. As the orbit number increases the energy difference between two adjacent orbits:

(A) Increases (B) Decreases

(C) Constant (D) Can not say

29. The wavelength of a blue light is 4800 Ao. The frequency of this light is:

(A) 6.25×10^{14} s^{-1}

(B) 6.25×10^{10} s^{-1}

(C) 6.25×10^{27} s^{-1}

(D) 6.25×10^{34} s^{-1}

30. Calculate the energy associated with a photon of light whose frequency is 3×10^{15} s^{-1}.

(A) 1.98×10^{-14} J

(B) 1.98×10^{-18} J

(C) 6.34×10^{-14} J

(D) 7.14×10^{-18} J

31. The electronic configuration 2,8,6 represents:

(A) Oxygen (B) Chlorine

(C) Argon (D) Sulphur

Multi Correct Question (M.C.Q)

32. Which one of the following is incorrect statement about proton?

(A) Proton is nucleus of hydrogen atom

(B) Proton is ionized hydrogen molecule

(C) Proton is ionized hydrogen atom

(D) Proton is α - particle

33. Which of the following statement(s) is / are correct about alpha particles?

(A) They carry +2 charge

(B) Their mass is 4 amu

(C) They have no electrons

(D) They are He^{2+} ions

34. Which of the following pairs are Isotopes?

(A) ${}_{18}Ar^{40}$ & ${}_{20}Ca^{40}$

(B) ${}_{6}C^{12}$ & ${}_{6}C^{14}$

(C) ${}_{17}Cl^{35}$ & ${}_{17}Cl^{37}$

(D) ${}_{8}O^{16}$ & ${}_{8}O^{18}$

35. Which of the following radiations is /are more energetic than microwaves?

(A) Red light

(B) X-ray

(C) UV rays

(D) Radio ways

36. The wavelength of an electromagnetic radiation is inversely proportional to:

(A) Velocity of light

(B) Wave number

(C) Energy

(D) Frequency

37. Bohr's theory is not applicable to:

(A) He (B) Li^{2+}

(C) He^{2+} (D) H^{+}

38. Which of the following elements have valency 2?

(A) Oxygen

(B) Magnesium

(C) Sulphur

(D) Beryllium

Comprehension Passage (C.P.T)

PASSAGE-I

The frequency (ϑ), velocity of light (C) and wave length (λ) of an electromagnetic radiation are related one to other. The other commonly used quantity specially in spectroscope is the wave number ($\bar{\vartheta}$).

39. Which of the following relations are correct?

(A) Frequency × wave length = velocity of light

(B) Energy = Planck's constant ×Frequency

(C) Frequency = velocity of light × wave number

(D) All

40. The wavelength of a radiation is 97540 cm. Calculate its frequency.

(A) $3.07 \times 10^5\ s^{-1}$

(B) $2.926 \times 10^{15} s^{-1}$

(C) $2.926 \times 10^{2} s^{-1}$

(D) $2.926 \times 10^{20} s^{-1}$

41. Light of any electromagnetic radiation travels in vacuum or air with a speed of:

(A) 3×10^8 m/s

(B) 3×10^2 m/s

(C) 2×10^8 m/s

(D) 1×10^8 m/s

PASSAGE-II

The electromagnetic spectrum includes all types of radiation, arranged by frequency and wavelength. From radio waves to gamma rays, frequency and energy increase, while wavelength decreases.

42. What happens to the energy and wavelength of electromagnetic waves as you move from radio waves to gamma rays?

(A) Energy increases, wavelength increases

(B) Energy decreases, wavelength increases

(C) Energy increases, wavelength decreases

(D) Energy and wavelength both decrease

43. According to the passage, which part of the electromagnetic spectrum is visible to the human eye?

(A) Gamma rays

(B) X-rays

(C) Visible light

(D) Infrared radiation

44. Which of the following electromagnetic waves has the lowest frequency?

(A) Ultraviolet

(B) Infrared

(C) X-rays

(D) Radio waves

Matrix Matching Type (M.M.T.)

SET-I

Column - I

45. Frequency

46. Wavelength

47. Wave number

48. Velocity of light

Column - II

(A) s^{-1}

(B) cm

(C) cm^{-1}

(D) cm/sec

(E) $\alpha \frac{1}{\text{wave length}}$

SET-II

Column - I

49. $^{16}_{8}O$ and $^{18}_{8}O$

50. $^{14}_{7}N$ and $^{15}_{7}N$

51. $^{40}_{18}Ar$ and $^{40}_{19}K$

52. $^{15}_{7}N$ and $^{16}_{8}O$

Column - II

(A) Isobars

(B) Isotones

(C) Isosters

(D) Isotopes

Assertion Reason Type (A.R.T.)

(A) Assertion and Reason are true and Reason is the correct explanation of Assertion

(B) Assertion and Reason are true but Reason is not the correct explanation of Assertion

(C) Assertion is true but Reason is false

(D) Assertion is false but Reason is true

53. Assertion (A): The frequency of radiation emitted when an electron jumps from a higher to a lower energy level is directly proportional to the energy difference between the levels.

Reason (R): According to Bohr's model, $\Delta E = h\upsilon$

54. Assertion (A): Bohr's model is successful in explaining the stability of the atom.

Reason (R): In Bohr's model, the electron spirals into the nucleus emitting radiation continuously.

Statement Type (S.T.)

(A) Both statements are correct

(B) Both statements are incorrect

(C) Statement I is correct statement II is incorrect

(D) Statement I is incorrect Statement II is correct

55. Statement I: A neutral atom has equal number of electrons and protons.

Statement II: A neutral atom has equal number of protons and neutrons.

56. **Statement I:** Cathode rays travel in straight line in the absence of electrical and magnetic fields.

Statement II: Cathode rays start from cathode side and move towards anode.

Integer Type Question (I.T.Q.)

57. The valency of sodium is _____.

58. Number of electrons present in the M shell of magnesium atom is ____.

Analytical Approach Type (A.A.T.)

59. Rutherford's α–particle scattering experiment shown that:

(i) electrons have negative charge.

(ii) the mass and positive charge of the atom is concentrated in the nucleus.

(iii) neutron exists in the nucleus.

(iv) most of the space in atom is empty.

Which of the above statements are correct?

(A) (i) and (iii) (B) (ii) and (iv)

(C) (i) and (iv) (D) (iii) and (iv)

60. Atomic models have been improved over the years. Arrange the following atomic models in the order of their chronicle order.

i) Rutherford's atomic model

ii) Thomson's atomic model

iii) Bohr's atomic model

(A) i, ii and iii (B) ii, iii and i

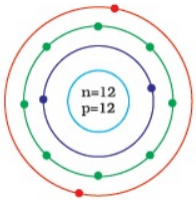
(C) ii, i and iii (D) iii, ii and i

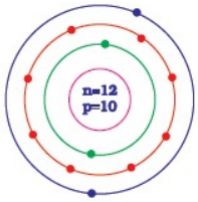
61. The ion of an element has 3 positive charges. Mass number of the atom is 27 and the number of neutrons is 14. What is the number of electrons in the ion?

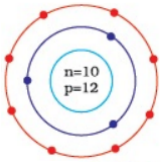
(A) 13 (B) 10

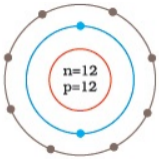
(C) 14 (D) 16

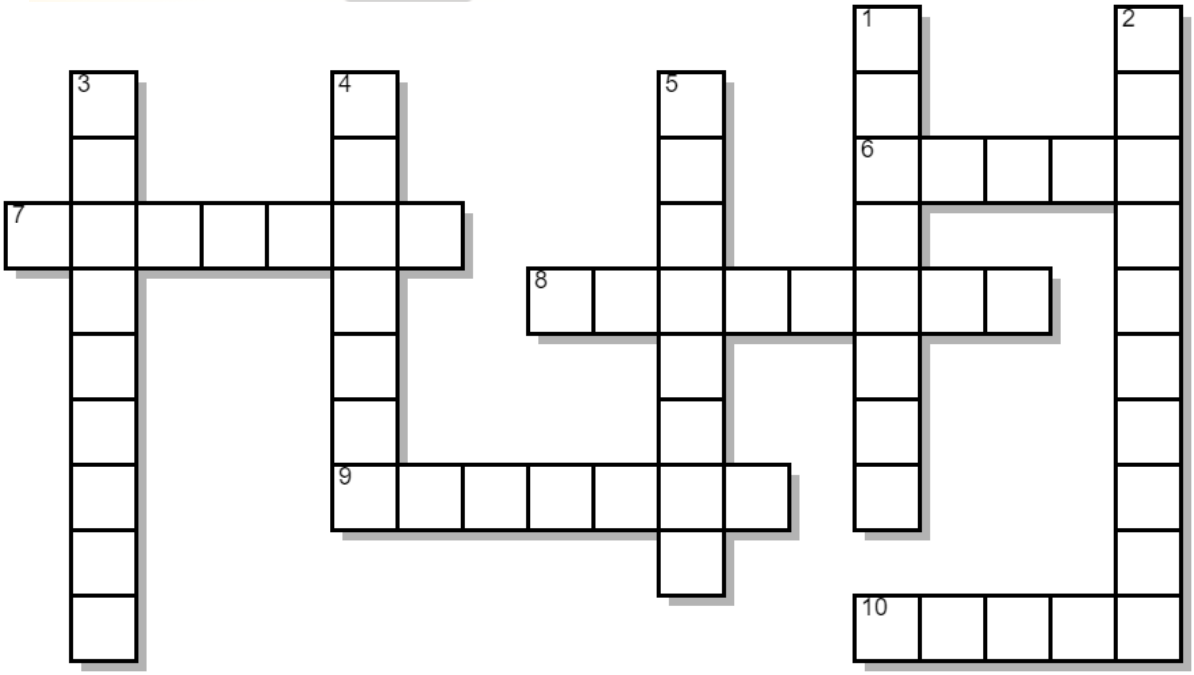
62. Identify the Mg^{2+} ion from the figures, n and p represent the number of neutrons and protons respectively.

(A) 

(B) 

(C) 

(D) 



Across: (→)

6. The circular path around the nucleus in which electron revolving is called:
7. The missing fundamental particle in protium
8. Mass number of an atom is equal to number of:
9. Heaviest particle among the fundamental particles
10. The concept of 'anu' and 'paramanu' was proposed by:

Down: (↓)

1. Atoms with same atomic number but different mass numbers are called:
2. Planetary model of atom was proposed by:
3. The number of waves passing through a point per second is called:
4. Cathode rays were discovered by:
5. Among fundamental particles the one with negative charge: