Chapter 2

Atomic Structure

- **Law of conservation of mass :** This law was stated by **Lavoisier** in 1744. It states that "In all physical and chemical changes, the total mass of reactants is equal to total mass of products."
- **Law of constant proportions (or constant composition) :** This law was first stated by **Proust** in 1797. According to the law "a *chemical compound* is always found to be made up of the *same elements* combined together in the *same proportions* by weight" e.g. the ratio of hydrogen and oxygen in pure water is always 1 : 8 by weight. This law is also called **law of definite proportions.**
- **Law of multiple proportions :** Whenever two elements form more than one compound, the different masses of one element that combine with the same mass of the other element are in the ratio of small whole numbers. This law was given by Dalton in 1804. For example, sulfur and oxygen form two different compounds which we call sulfur dioxide and sulfur trioxide.
- **Dalton's atomic theory :**

  Postulates of Dalton's Atomic Theory

  (i) Matter is made up of extremely small indivisible particles called **atoms**.

  (ii) Atoms of the same substance are identical in all respects i.e., they possess same *size, shape, mass, chemical properties* etc.

  (iii) Atoms of different substances are different in all respects i.e., they possess different size, shape, mass etc.

  (iv) Atom is the smallest particle that takes part in a chemical reaction.

  (v) Atoms of different elements may combine with each other in a fixed simple, whole number ratio to form **compound atoms**.

  (vi) Atoms can neither be created nor destroyed i.e., atoms are indestructible.
- **Atom :** It is the smallest particle of an element which can take part in a chemical change. It may or may not be capable of independent existence.

  [Atoms, the building blocks of all matter]
- **Drawbacks of Dalton's Atomic Theory :**

  (i) According to Dalton's atomic theory, atoms were thought to be indivisible. But, it is now known that under circumstances, atoms can be further divided into still smaller particles called electrons, protons and neutrons.

  (ii) Dalton's atomic theory said that all the atoms of an element have exactly the same mass. But, it is now known that atoms of the same element can have slightly different masses.

  (iii) Dalton's atomic theory said that atoms of different elements have different masses. But, it is now known that even atoms of different elements can have the same mass.

  (iv) It could explain the laws of chemical combination by mass but failed to explain the law of gaseous volumes.
- **Symbols :** The abbreviation used for lengthy names of elements are termed as their symbols. The symbol of an element is the **first letter** or the first and another letter of English name or Latin name of the element. While writing a symbol, the first letter is always **capital** and the second is always **small.**

  Examples :

Element	**English Name**	**Symbol**
Hydrogen	Hydrogen	H
Oxygen	Oxygen	O
Carbon	Carbon	C
Calcium	Calcium	Ca

Symbol derived from Latin Names

Element	**Latin Name**	**Symbol**
Sodium	Natrium	Na
Potassium	Kalium	K
Iron	Ferrum	Fe
Copper	Cuprum	Cu

- **Molecule :** It is the smallest particle of an element or compound that is capable of independent existence and shows all the properties of that substance.
- **Valency :** The electrons present in the outermost shell of an atom are known as **valence electrons**. These electrons determine the valency of an atom.

  Valency is equal to the number of valence electrons.

  In case the number of valence electrons is close to its full capacity. Then,

  $$\text{Valency} = 8 - \text{valence electrons}$$

  If outermost shell is completely filled then valency is **zero**.

  Valency is the combining capacity of an atom.

- The number of atoms present in a molecule of an element or a compound is known as its atomicity. e.g.

Element / Compound	Formula of a molecule	Atomicity
Hydrogen	H_2	2
Oxygen	O_2	2
Chlorine	Cl_2	2
Ozone	O_3	3
Water	H_2O	3
Ammonia	NH_3	4

- **Ion :** It is an electrically charged atom or group of atom. It is formed by the loss or gain of electrons by an atom. Ions are of two types :
  (i) **Cation :** It is positively charged ion and is formed by the loss of electron from an atom e.g. H^+, Na^+, Ca^{2+}, Al^{3+}, NH_4^+ etc.
  (ii) **Anion :** It is negatively charged ion and is formed by the gain of electrons by an atom, e.g. Cl^-, O^{2-}, C^-, F^-, CO_3^{2-}, PO_4^{3-} etc.

Table : Some common simple and Poly-Atomic Ions

Valency	Name	Symbol	Non-metallic	Symbol	Polyatomic	Symbol
I.	Sodium	Na^+	Hydrogen	H^+	Ammonium	$(NH_4)^+$
	Potassium	K^+	Hydride	H^-	Hydroxide	$(OH)^-$
II.	Copper (II) or Cupric	Cu^{2+}	Sulphide	S^{2-}	Carbonate	$(CO_3)^{2-}$
	Magnesium	Mg^{2+}	Oxide	O^{2-}	Sulphate	$(SO_4)^{2-}$
III.	Aluminium	Al^{3+}	Nitride	N^{3-}	Phosphate	$(PO_4)^{3-}$

- **Formula of simple and molecular compounds :**
  Binary compounds are those compounds which are made up of two different elements e.g. NaCl, KBr, CaO etc. Following rules are to be followed for writing the formula.
  (i) The valencies or charges on the ions must be balanced.
  (ii) For a compound made up of a **metal** and a **non-metal**, the symbol of metal is written first. While writing the name of such a compound the name of metal is written first e.g. Calcium oxide, CaO (Ca is metal, O is non-metal)
  (iii) In compounds formed with polyatomic ions, the ion is enclosed in a bracket before writing the number to indicate the ratio. While writing the formula for **molecular compounds.** We write the constituent elements and their valencies are shown on their top. Then by criss-cross these valencies are shown below the combining atoms emitting the positive or negative sign e.g.

H^{+1} ⤫ Cl^{-1} by criss-cross H_1Cl_1

- The atomic mass of an element is the numerical number which indicates how many times an atom of an element is heavier than $\frac{1}{12}$ of mass of an atom of carbon-12. *For example*, the atomic mass of magnesium (Mg) is 24 which indicates that one atom of magnesium is 24 times heavier than $\frac{1}{12}$ of a carbon-12 atom. The a.m.u. is abbreviated as 'u'. It is equal to mass of one atom of C-12.

Element	Atomic Mass (U)
Hydrogen (H)	1.0
Carbon (C)	12.0
Nitrogen (N)	14.0
Oxygen (O)	16.0
Sodium (Na)	23.0
Magnesium (Mg)	24.0
Chloride (Cl)	35.5
Calcium (Ca)	40.0

- The atomic mass of an element expressed in grams is known as gram atomic mass. (Gram atomic mass is also known as gram atomic weight)
- The number of times a molecule of a compound is heavier than the $\frac{1}{12}$ of the mass of C-12 atom, is known as its molecular mass.
- The molecular mass of a substance expressed in grams is known as gram molecular mass.
- **Calculations of molecular mass :** The molecular mass is equal to the sum of the atomic masses of all atoms present in one molecule of the substance. H_2O consists of two atoms of hydrogen and one atom of oxygen, so molecular mass of H_2O is equal to sum of atomic masses of two hydrogen atom (i.e., $2 \times 1 = 2$) and atomic mass of one atom of oxygen (i.e., $1 \times 16 = 16$). Thus molecular mass of $H_2O = 2 + 16 = 18$.

- **Formula unit mass :** It is equal to the sum of atomic masses of all the atoms in a formula unit. In case of **ionic compounds** like NaCl formula mass is **58.5** (23 + 35.5 = 58.5)
- **Mole concept :** The number of particles present in one mole (i.e. 6.023×10^{23} particles) is called **Avogadro's number or Avogadro's constant.** Mole is a collection of 6.022×10^{23} particles. They may be atoms, molecules, ions, electrons, protons etc.
- **Mole :**
  1 mole molecules = gm molecular mass
  Number of moles (in a substance)

$$= \frac{\text{Mass of substance in grams}}{\text{grams molecular mass}}$$

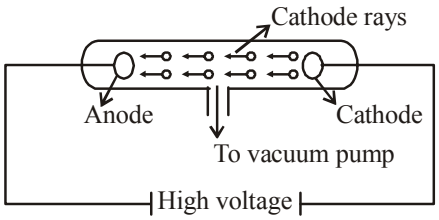
$$= \frac{\text{Volume of gas in litre (at N.T.P.)}}{22.4}$$

  One mole of magnesium (Mg) = 6.02×10^{23} magnesium atoms
  = 24 gram of Mg^{24}

  One mole of atomic nitrogen (N^{14}) = 6.02×10^{23} nitrogen atoms
  = 14 gram of N^{14}.

  One mole of molecular nitrogen (N_2) = 6.02×10^{23} N_2 molecules
  = 28 gram of N_2 molecules.
- **Mole and Gram Atomic Mass :** Since 1 mole of any atomic substance is equal to its gram atomic mass and contains 6.023×10^{23} atoms of that element therefore gram atomic mass of an element is defined as the mass of Avogadro number of atoms [i.e., mass of 6.023×10^{23} atoms]. For example,
  Mass of 6.023×10^{23} atoms of oxygen = 16 g
- **Mole and Gram Molecular Mass :** One gram molecular mass of any molecular substance is its gram molecular mass and contains 6.023×10^{23} molecules of that substance. Therefore, gram molecular mass of any substance is defined as the mass of Avagadro's number of molecules (i.e., mass of 6.023×10^{23} molecules) of that substance. For example,
  Mass of 6.023×10^{23} molecules of oxygen (O_2) = 32 g
- Mass of a single atom $= \frac{\text{Atomic mass (g mole}^{-1})}{6.023 \times 10^{23} \text{ atom}}$

  Mass of a single molecule $= \frac{\text{Molar mass (g mole}^{-1})}{6.023 \times 10^{23} \text{ molecules}}$
- In case of gases, a mole is defined as that amount of the gas which has a volume of 22.4 litres at STP.
  1 mole of CO_2 gas = 22.4 litres at NTP
  1 mole of helium gas (He) = 22.4 litres at NTP
- **Cathode rays (Electrons) :** When a *high potential difference* of 20,000 volts is applied *across a gas* taken in a *discharge tube* at *low pressure* of about 0.001 torr, some *radiations* are *emitted from the cathode***.** These move towards the anode. These rays are called *cathode rays* because *they emanate from the cathode.*



This experiment was done by **J.J. Thomson** an English physicist.

Properties of Cathode Rays :

(i) The cathode rays are constituted by fast moving *electrons.*
(ii) These rays travel in a *straight line.*
(iii) These rays posses *mechanical energy.*
(iv) These rays *produce heat* when focussed on metals.
(v) These rays produce *flourescenes* when focussed on metals.
(vi) They affects the photographic plate.
(vii) They are deflected by electric and magnetic field.
(viii) They ionize the gases through which they pass.

- **Anode rays or Canal rays or Positive rays (Protons) :** If we use a perforated cathode in the *discharge tube* and then apply high voltage and if the pressure is below 0.001 mm Hg, we will observe a new type of rays coming through perforation in the cathode. These rays were initially called *anode rays* as they move from anode side through the gas. In a discharge tube, when the *gas atoms lose electrons, they acquire a positive charge and move away from the anode.*

Properties of Anode Rays :

(i) They travel in a *straight line.*
(ii) They can produce *mechanical effects.*
(iii) Anode rays are *positively charged*.
(v) The nature of anode rays depends upon the gas taken in the discharge tube.
(vi) The mass of anode rays particles is almost equal to the mass of an atom from which it is formed.

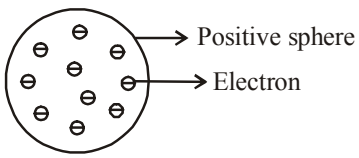
Note : Unlike cathode rays which originate from the metals or electrodes which constitute cathode, the anode rays never originate from anode. These are the positive residues which are left when electrons are knocked out of the atoms of the gases enclosed in the discharge tube.

- *Electron*, *proton* and *neutron* are subatomic particles.
  The credit for discovery of these particles goes to **Electron —** J.J. Thomson and **Proton** — E. Goldstein
  Another subatomic particle which is *neutral* and has a mass approx. equal to that of a proton was called **neutron** and was discovered by **chadwick**. The neutron is a neutral particle found in the nucleus of an atoms. Atom of all elements contain neutron (except hydrogen atom which does not contain neutron). The relative mass of neutron is 1 amu and it carries no charge (i.e., it is neutral)

Properties of atomic particles (Comparative)

Particle	Electron	Proton	Neutron
(i) Symbol	e or e^-	p	n
(ii) Nature	Negatively charged	Positively charged	neutral (no charge)
(iii) (a) Charge	(a) -1.6×10^{-19}C	(a) $+1.6 \times 10^{-19}$C	0
(b) Unit charge	(b) –1	(b) + 1	0
(iv) Mass (a) amu	(a) 0.0005486 amu	(a) 1.00753 amu	(a) 1.00893 amu
(b) kg	(b) 9.1×10^{-31}kg	(b) 1.67265×10^{-27} kg	(b) 1.67495×10^{-27} kg
(v) Location	Extra nuclear space	nucleus	nucleus
(vi) Notation	$_{-1}e^0$	$_1^1p$	$_0n^1$
(vii) Relative mass	1/1840	1	1

- **Thomsons Model of Atom :** J.J. Thomson was the first to propose separately structure of atom in the form of a model. He suggested the following structure in 1899, which was based on his experimental work.
Various postulates suggested are :
(i) Inside an atom electron are present.
(ii) These electrons are embedded in a sphere of positive charge
(iii) Mass of an atom is due to electrons only
(iv) The negative and positive charge balance each other
(v) Atom as a whole is neutral.



Drawbacks of Thomson's Model
This model failed to explain the results of experiments done by other scientists.

- **Rutherford's Model of the Atom :** Rutherford (1911) performed scattering experiment by bombarding fast moving α-particles, emitted from a radioactive substance, on thin foil (4×10^{-5} cm thick) of the metals like silver, gold, copper, platinum, etc.

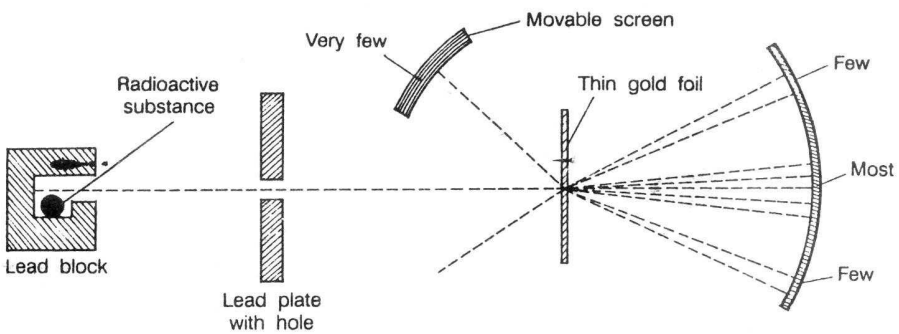


Fig. Rutherford's α -particle scattering experiment.

The observations led to the following conclusions.
(i) Most of the α-particles (nearly 99%) passed through the metal foil (Au, Ag, Pt, etc.) undeflected.
(ii) Some of the α-particles underwent deflection by small angles.
(iii) Very few α-particles (1 in 20,000) returned back suffering a deflection of 180°.

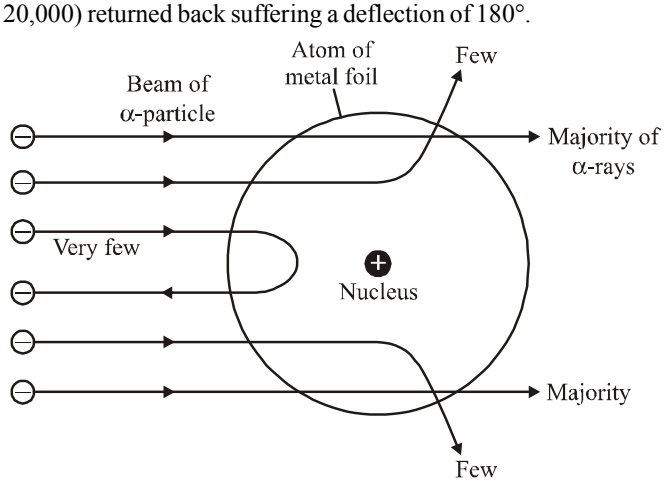


Fig. Scattering of α-particles

This experiment led Rutherford to conclude the main features as follows :

(i) Most of the space in the atom is largely empty as most of the α-particles pass straight through the atom.

(ii) Centre of the atom has a heavy positively charged body, called **nucleus**, which repel positively charged a-particles and thus explains the scattering phenomenon.

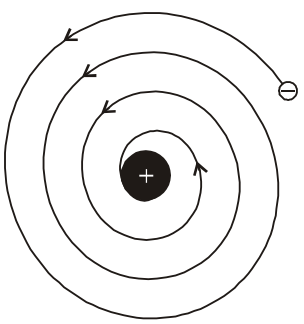
(iii) Whole of the atomic mass is concentrated in the nucleus i.e., the central nucleus is rigid and hence a-particles which strike on it are thrown back.

(iv) Since very few α-particles are deflected back, the size of the nucleus must be very small (radius nearly 10^{-13} cm) compared to the total volume of the the atom (radius nearly 10^{-8} cm). It shows that nucleus is 1/100000 in size compared to the total size of the atom.

Drawbacks of the Rutherford Theory :

An electron revolving around the nucleus in a circular path will continuously lose energy and fall into the nucleus. However, the nucleus is found to be quite stable. Thus, Rutherford could not explain the stability of the nucleus in the light of continuous loss of the energy of the electron.

The stability of the atom is explained by Bohr's theory of atom in terms of orbits of fixed energies.



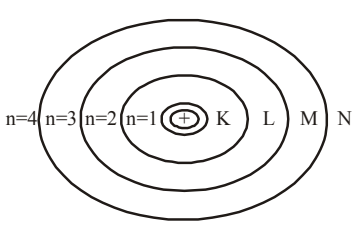
- **Bohr's Model of an Atom :** In order to explain the objections raised for Rutherford's model. **Neils Bohr** in 1912 gave a new model of atom called **Bohr's model.** Accoridng to this model

(i) An atom consists of a small positively charged **nucleus** situated at its centre.

(ii) The negatively charged electrons revolve around the nucleus in *certain definite circular paths* called *energy levels*.

(iii) Each energy level is associated with a *definite amount of energy*.

(iv) The energy levels are either numbered 1, 2, 3, 4 ($n = 1, 2, 3, 4$ ....) or designated as *K, L, M, N* ..... outwards from the nucleus.



(v) The change in energy of an electron takes place only when it jumps from a lower energy level to a higher energy level (gain of energy) or when it jumps from a higher energy level to a lower energy level (Loss of energy). It means that as long as the electrons remain in a given energy level, they neither gain nor lose energy and atom remains stable.

- **Arrangement of electrons in an atom :** The arrangement of electrons in various **shells** (energy levels) of an atom of the element is known as **Electronic configuration**.

The maximum number of electrons that could be put in a particular shell (i.e., energy levels was given by **Bohr** and **Bury**.

According to **Bohr-Bury Scheme**

(i) The maximum number of electrons that can be accommodated in any energy level is given by $2n^2$ where $n = 1, 2, 3, 4, ...$ (for *K, L, M, N*.....)

For $\frac{1st}{n}$ orbit or K-shell, it will be

$= 2 \times 1^2 = 2$

For $\frac{2nd}{n}$ orbit or L-shell, it will be

$= 2 \times 2^2 = 8$

For $\frac{3rd}{n}$ orbit or M-shell, it will be

$= 2 \times 3^2 = 18$

For $\frac{4th}{n}$ orbit or N-shell, it will be

$= 2 \times 4^2 = 32$

(ii) The maximum number of electrons in the outermost orbit will be 8 electrons even if it has capacity to accommodate more electrons.

(iii) The next to the outermost shell cannot accommodate more than 18 electrons even if it has a capacity to accommodate more.

(iv) Electrons are not accommodated in a given shell. Unless earlier shells are filled, that is stepwise filling of shells is followed.

- **Atomic Number :** Each element has been assigned an atomic number (Z) that describes the number of protons in the nucleus of an atom of that element. i.e., atomic number (Z) = number of proton = number of electron (in a neutral atom).

- **Mass Number :** The nucleus of an atom is also described by a mass number (A), which is the sum of the number of protons and neutrons in the nucleus. The difference between the mass number and the atomic number of an atom is therefore equal to the number of neutrons in the nucleus of that atom.

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

or Number of neutrons = A – Z

The carbon atom has a mass number of 12 because it contains six protons and six neutrons.

- **Isotopes :** Atoms with the same atomic number but different mass numbers are called isotopes. Carbon, for example, has the three naturally occurring isotopes shown in Figure : ^{12}C, ^{13}C, and ^{14}C. Carbon-12 (^{12}C) has six protons and six neutrons, ^{13}C has six protons and seven neutrons, and ^{14}C has six protons and eight neutrons.

  The characteristics of isotopes are:

  (i) They have different atomic masses (mass number)

  (ii) They have the same atomic number.

  (iii) They have the same electronic configuration.

  (iv) They have the same valence electrons.

  (v) They have the same chemical properties.

  (vi) They have slightly different physical properties.

Applications of Isotopes :

Isotopes are used in various fields. For example.

(i) Isotope of uranium is used as a fuel in nuclear reactor

(ii) Isotope of cobalt is used in treatment of cancer

(iii) Isotope of iodine is used in treatment of goitre.

- **Isobars :** Atoms whose atomic numbers are different but mass numbers are same. Such atoms are called isobars. Some important examples of Isobars are as follows : Argon $_{18}Ar^{40}$, Potassium $_{19}K^{40}$ and Calcium $_{20}Ca^{40}$ are Isobars.

  The characteristics of isobars are:

  (i) They have the same mass number.

  (ii) They have different atomic numbers.

  (iii) They have different number of protons.

  (iv) They have different electronic configurations.

  (v) They have different number of valence electrons.

  (vi) They have different chemical properties.

Exercise 1

DIRECTIONS : This section contains multiple choice questions. Each question has 4 choices (1), (2), (3) and (4) out of which only one is correct.

1. Neon is
   (1) monoatomic (2) diatomic
   (3) triatomic (4) tetra atomic
2. Which of the following has an atomicity of 4?
   (1) H_2O (2) NH_3
   (3) PCl_5 (4) CCl_4
3. The element present in water and hydrogen peroxide are
   (1) hydride and oxide
   (2) hydrogen and oxide
   (3) hydride and oxygen
   (4) hydrogen and oxygen.
4. The formula of barium phosphate is
   (1) $BaPO_4$ (2) $Ba_2(PO_4)_3$
   (3) $Ba(PO_4)_3$ (4) $Ba_3(PO_4)_2$
5. If the formula of a chloride of a metal is MCl_3, the formula of metal phosphate is
   (1) M_2PO_4 (2) MPO_4
   (3) M_2PO_4 (4) $M(PO_4)_3$
6. Which of the following is a binary compound of oxygen and hydrogen?
   (1) H_2O
   (2) H_2O_2
   (3) Both H_2O and H_2O_2
   (4) None of these
7. The weights of two elements A and B combining with one another are in the proportion of their
   (1) atomic weights (2) equivalent weights
   (3) valencies (4) atomic volumes
8. In a chemical change the total weight of the reacting substances compared to total weight of products is
   (1) never the same (2) always less
   (3) always more (4) always the same
9. The cathode ray experiment was done for the first time by
   (1) J.J. Thomson (2) John Dalton
   (3) Goldstein (4) Rutherford
10. The charge on an electron is
    (1) 1.6×10^{-6} coulombs
    (2) 1.6×10^{-20} coulombs
    (3) 1.6×10^{-19} coulombs
    (4) 1.6×10^{-16} coulombs
11. The nucleus of an atom contains
    (1) protons
    (2) electrons
    (3) protons and neutrons
    (4) neutrons
12. In an atom valence electron are present in
    (1) outermost orbit
    (2) next to outermost orbit
    (3) first orbit
    (4) any one of its orbit
13. The maximum number of electrons that can be accommodated in third shell (n = 3) is
    (1) 2 (2) 8
    (3) 18 (4) 10
14. In an atom, the constituent electrons
    (1) do not move
    (2) are uniformly distributed
    (3) move around the nucleus in fixed energy levels.
    (4) move around the nucleus in a random way.
15. What is the number of valence electrons of Al?
    (1) 1 (2) 2
    (3) 3 (4) 4
16. Which of the following statements is incorrect for cathode rays?
    (1) They move in straight line
    (2) Their nature depends upon the nature of gas present in the discharge tube.
    (3) They cost shadow of solid objects placed in their path
    (4) They get deflected towards positive charge.

17. The isotopes of an element have
(1) same number of neutrons
(2) same atomic number
(3) same mass number
(4) None of these

18. Which of the following statements is not correct for Bohr's model of an atom?
(1) The nucleus of an atom is situated at its centre
(2) The electrons move in circular orbits
(3) Electrons jumps from one orbit to another
(4) An electron neither loses nor gains energy when it jumps from one orbit to another.

19. The atomic number of an element is 11 and its mass number is 23. The correct order representing the number of electrons, protons and neutrons respectively in this atom is
(1) 11, 11, 12 (2) 11, 12, 11
(3) 12, 11, 11 (4) 23, 11, 23.

20. Which of the following pairs are isotopes?
(1) Oxygen and ozone
(2) Ice and steam
(3) Nitric oxide and nitrogen dioxide
(4) Hydrogen and deuterium.

21. An atom which has mass number of 14 and has neutron is an
(1) isotopes of oxygen
(2) isobar of oxygen
(3) isotope of carbon
(4) isobar of carbon

22. Which of the following have equal number of neutrons and protons?
(1) Hydrogen (2) Deuterium
(3) Fluorine (4) Chlorine

23. The relative atomic masses of many elements are not whole numbers because
(1) they cannot be determined accurately
(2) the atoms ionize during determination of their masses
(3) existence of isotopes
(4) presence of impurities

24. Which of the following has a charge of +1 and a mass of 1 amu ?
(1) A neutron (2) A proton
(3) An electron (4) A helium nucleus

25. Which of the following describes an isotope with a mass number of 99 that contains 56 neutrons in its nucleus ?
(1) $^{99}_{56}Ba$ (2) $^{43}_{56}Ba$
(3) $^{99}_{43}Tc$ (4) $^{56}_{43}Tc$

26. Which of the following isotopes is used as the standard for atomic mass ?
(1) ^{12}C (2) ^{16}O
(3) ^{13}C (4) ^{1}H

27. Which of the following is not a basic particle of an element?
(1) An atom (2) A molecule
(3) An ion (4) None of these

28. Which would be the electrical charge on a sulphur atom containing 18 electrons ?
(1) 2– (2) 1–
(3) 0 (4) 2+

29. Members of which of the following have similar chemical properties ?
(1) isotope
(2) isobars
(3) allotropes
(4) both isotopes and allotropes

30. A natural phenomenon that supports the experimental conclusion that atoms are divisible is
(1) allotropy (2) radioactivity
(3) cracking (4) None of these

31. While performing cathode ray experiments, it was observed that there was no passage of electric current under normal conditions. Which of the following can account for this observation ?
(1) Dust particles are present in air
(2) Carbon dioxide is present in air
(3) Air is a poor conductor of electricity under normal conditions
(4) None of the above

32. The fluorescence on the walls of discharge tube is due to–
(1) cathode rays (2) anode rays
(3) canal rays (4) None of the above

33. Which of the following electronic configurations is wrong–
(1) Be (3) = 2, 1 (2) O (8) = 2, 6
(3) S (16) = 2, 6, 8 (4) P (15) = 2, 8, 5

34. $^{55}_{25}Mn^{++}$ has –
(1) 25 protons and 30 neutrons
(2) 25 neutrons and 25 protons
(3) 25 electrons and 40 protons
(4) None of the above

35. Which one of the following statement is not true ?
(1) Most of the space in an atom is empty
(2) The total number of neutrons and protons is always equal in a neutral atom
(3) The total number of electrons and protons in an atom is always equal
(4) The total number of electrons in any energy level can be calculated by the formula $2n^2$

36. From amongst the following chemical species :
(a) $^{39}_{18}Ar$ (b) $^{40}_{19}K^{+}$
(c) $^{41}_{20}Ca^{++}$ (d) $^{42}_{20}Ca^{+}$
The one having identical electronic configurations are
(1) (a) and (b) (2) (b) and (d)
(3) (c) and (d) (4) (a), (b) and (c)

37. Which one of the following pairs is correctly matched ?
(1) Mass Spectrograph : Chadwick
(2) Atomic number : Moseley
(3) Neutron : Millikan
(4) Measurement of charge of an electron : Aston

38. Which one of the following sequences of the elements is correct with reference to their size?
(1) $Ca^{2+} < K^{+} < S^{2-} < Cl^{-}$
(2) $K^{+} > S^{2-} > Cl^{-} > Ca^{2+}$
(3) $Ca^{2+} < K^{+} < Cl^{-} < S^{2-}$
(4) $Cl^{-} > S^{2-} > K^{+} > Ca^{2}$

39. An atom has 7 electrons in its M-shell and contains 18 neutrons in its nucleus. What is its mass number ?
(1) 25 (2) 27
(3) 35 (4) 43

40. Consider the following pairs of ions of atoms:
(i) Na^+ and Ne (ii) Na^+ and K^+ (iii) K^+ and Cl^-
In which of these pairs are the ions/atoms isoelectronic with each other ?
(1) (i), (ii) and (iii) (2) (i) and (ii)
(3) (ii) and (iii) (4) (i) and (iii)

41. Which of the following compounds do not conform to the Law of Multiple Proportions?
(1) NaCl and $BaCl_2$
(2) CaO and Na_2O
(3) H_3PO_4 and $Ca_3(PO_4)_2$
(4) NaCl and AgCl

42. Which of the following exhibit variable valency?
(a) Sodium (b) Chromium
(c) Copper (d) Zinc
(1) (a) and (b) (2) (b) and (c)
(3) (c) and (d) (4) (b) and (d)

43. Which of the following pairs of substances illustrate the law of multiple proportions?
(i) CO, CO_2 (ii) H_2O, D_2O
(iii) N_2O, NO (iv) NaCl, NaI
Select the correct answer using the codes given below:
(1) (i) and (ii) (2) (ii) and (iii)
(3) (ii) and (iv) (4) (i) and (iii)

44. In a chemical reaction, A combines with B to form AB with C to form A_2C. What would be obtained if B and C combine together ?
(1) B_2C (2) BC
(3) BC_2 (4) B_3C

45. Which one of the following elements does not have two electrons in the K-shell ?
(1) Hydrogen (b) Helium
(3) Neon (d) Sulphur

46. An element X forms an oxide XO_3. What is the valency of X ?
(1) 1 (2) 2
(3) 3 (4) 6

47. The atomic number of an element X is 12. What is the formula of its azide ?
(1) X_2N_3 (2) $X(N_3)_2$
(3) X_3N_2 (4) XN_3

48. An element *A* has valencies equal to 3 and 5. It combines with another element *B* having valency equal to 2. What are formulae of the compounds thus formed?
(1) A_5B_3 and A_2B_5 (2) A_3B_2 and A_5B_2
(3) A_2B_3 and A_2B_5 (4) A_2B_3 and A_3B_5

49. The atomic weights are expressed in terms of atomic mass unit. Which one of the following is used as a standard?
(1) $^1H_1$ (2) $^{12}C_6$
(3) $^{16}O_8$ (4) $^{35}Cl_{17}$

50. Which one of the following laws explains the formation of carbon monoxide and carbon dioxide from carbon and oxygen?
(1) Law of conservation of mass
(2) Law of multiple proportions
(3) Law of reciprocal proportions
(4) Law of difinite proportions

51. What is the mass (in grams) of 3 moles of N?
(1) 14 (2) 28
(3) 42 (4) 56

52. Which of the following correctly represents 360 g of water?
(i) 2 moles of H_2O
(ii) 20 moles of water
(iii) 6.022×10^{23} molecules of water
(iv) 1.2044×10^{25} molecules of water
(1) (i) (2) (i) and (iv)
(3) (ii) and (iii) (4) (ii) and (iv)

53. Which of the following would weigh the highest?
(1) 0.2 mole of sucrose ($C_{12}H_{22}O_{11}$)
(2) 2 moles of CO_2
(3) 2 moles of $CaCO_3$
(4) 10 moles of H_2O

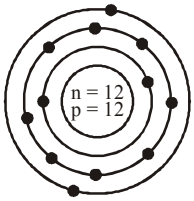
54. Dalton's atomic theory successfully explained
(i) Law of conservation of mass
(ii) Law of constant composition
(iii) Law of radioactivity
(iv) Law of multiple proportion
(1) (i), (ii) and (iii) (2) (i), (iii) and (iv)
(3) (ii), (iii) and (iv) (4) (i), (ii) and (iv)

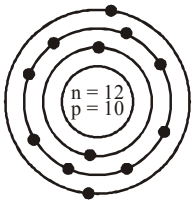
55. Which of the following statements about Rutherford's model of atom are correct?
(i) Considered the nucleus as positively charged
(ii) Established that the α–particles are four times as heavy as a hydrogen atom
(iii) Can be compared to solar system
(iv) Was in agreement with Thomson's model
(1) (i) and (iii) (2) (ii) and (iii)
(3) (i) and (iv) (4) only (i)

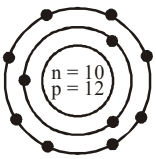
56. In the Thomson's model of atom, which of the following statments are correct?
(i) The mass of the atom is assumed to be uniformaly distributed over the atom
(ii) The positive charge is assumed to be uniformaly distributed over the atom
(iii) The electrons are uniformaly distributed in the positively charged sphere
(iv) The electrons attract each other to stabilise the atom
(1) (i), (ii) and (iii) (2) (i) and (iii)
(3) (i) and (iv) (4) (i), (iii) and (iv)

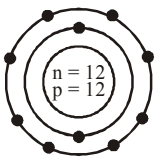
57. Rutherford's α–particle scattering experiment showed that
(i) electrons have negative charge
(ii) the mass and positive charge of the atom is concentrated in the nucleus
(iii) neutron exists in the nucleus
(iv) most of the space in atom is empty
Which of the above statements are correct?
(1) (i) and (iii) (2) (ii) and (iv)
(3) (i) and (iv) (4) (iii) and (iv)

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

(1) 

(2) 

(3) 

(4) 

59. In a sample of ethyl ethanoate ($CH_3COOC_2H_5$) the two oxygen atoms have the same number of electrons but different number of neutrons. Which of the following is the correct reason for it?
(1) One of the oxygen atoms has gained electrons
(2) One of the oxygen atoms has gained two neutrons
(3) The two oxygen atoms are isotopes
(4) The two oxygen atoms are isobars.

60. Atomic models have been improved over the years. Arrange the following atomic models in the order of their chronological order
(i) Rutherford's atomic model
(ii) Thomson's atomic model
(iii) Bohr's atomic model
(1) (i), (ii) and (iii) (2) (ii), (iii) and (i)
(3) (ii), (i) and (iii) (4) (iii), (ii) and (i)

61. In carbon disulphide (CS_2), the mass of sulphur in combination with 3.0 g of carbon is :
(1) 4.0 g (2) 6.0 g
(3) 64.0 g (4) 16.0 g

62. What mass of carbon dioxide (CO_2) will contain 3.011×10^{23} molecules?
(1) 11.0 g (2) 22.0 g
(3) 4.4 g (4) 44.0 g

63. Which of the following elements has same number of protons, electrons and neutrons?
(1) Al (2) Mg
(3) P (4) Cl

64. No. of valence electrons in an element $^{14}_{7}X$ is :
(1) 5 (2) 1
(3) 7 (4) 3

65. Which one of the following has the largest number of atoms?
(1) 71 g of Chlorine (2) 48 g of Magnesium
(3) 127 g of Iodine (4) 4 g of Hydrogen

66. What is the number of P atoms in 1 mole of P_4?
(1) 1.504×10^{23} (2) 6.023×10^{23}
(3) 1.209×10^{23} (4) 2.409×10^{24}

67. How many oxygen atoms are there in 63 g of HNO_3 ?
(1) 3 (2) 2.007×10^{23}
(3) 6.023×10^{23} (4) 1.807×10^{24}

Exercise 2

Matching Based MCQ

DIRECTIONS (Qs 1 to 8) : Match Column-I with Column-II and select the correct answer using the codes given below the columns.

1.

	Column - I	Column - II
(A)	H_2O	(p) 58.5
(B)	HNO_3	(q) 111
(C)	NaCl	(r) 18
(D)	$CaCl_2$	(s) 63
(E)	28 gm N_2	(t) 1 mole

(1) A – (r); B – (s), C – (p); D – (q); (E) – (t)
(2) A – (t); B – (s), C – (p); D – (q); (E) – (r)
(3) A – (s); B – (r), C – (p); D – (q); (E) – (t)
(4) A – (r); B – (p), C – (s); D – (q); E – (t)

2.

	Column I (Chemical compound)	Column II (Formula)
(A)	Ferric sulphate	(p) $FeSO_4$
(B)	Ferrous sulphate	(q) $NaHCO_3$
(C)	Sodium bicarbonate	(r) Na_2CO_3
(D)	Sodium carbonate	(s) $Fe_2(SO_4)_3$

(1) A – (s), B – (p), C – (r), D – (q)
(2) A – (r), B – (p), C – (q), D – (s)
(3) A – (s), B – (p), C – (q), D – (r)
(4) A – (p), B – (s), C – (q), D – (r)

3.

	Column I	Column II
(A)	Electron	(p) Chadwick
(B)	Proton	(q) J.J. Thomson
(C)	Nucleus	(r) Goldstein
(D)	Neutron	(s) Rutherford

(1) A – (q); B – (r); C – (s); D – (p)
(2) A – (s); B – (r); C – (q); D – (p)
(3) A – (p); B – (r); C – (s); D – (q)
(4) A – (q); B – (r); C – (p); D – (s)

4.

	Column I (Compounds of Nitrogen)	Column II (Valency)
(A)	N_2O	(p) 1
(B)	NO	(q) 2
(C)	N_2O_5	(r) 4
(D)	NO_2	(s) 5

(1) A – (p); B – (s); C – (r); D – (q)
(2) A – (p); B – (q); C – (r); D – (s)
(3) A – (p); B – (q); C – (s); D – (r)
(4) A – (s); B – (p); C – (r); D – (q)

5.

	Column - I	Column - II
(A)	Sodium	(p) Ag
(B)	Mercury	(q) Hg
(C)	Lead	(r) Na
(D)	Silver	(s) Pb

(1) A – (r); B – (q); C – (s); D – (p)
(2) A – (p); B – (q); C – (r); D – (s)
(3) A – (s); B – (q), C – (r), D – (p)
(4) A – (r), B – (q), C – (p), D – (s)

6.

	Column I Elements	Column II Molecules (Possible formulae)
(A)	Sulphur	(p) S_2, S_4, S_8, S
(B)	Phosphorus	(q) P_4, P, P_2, P_6
(C)	Ozone	(r) O_2, O_3, O, O_4
(D)	Helium	(s) He, He_2

(1) Sulphur–S_2, Phosphorus P, Ozone O, Helium He_2
(2) Sulphur–S_8, Phosphorus P_4, Ozone O_3, Helium He
(3) Sulphur–S, Phosphorus P_2, Ozone O_4, Helium He_2
(4) Sulphur–S_4, Phosphorus P_6, Ozone O_2, Helium He

7.

	Column I	Column II
(A)	9.033×10^{24} atoms	(p) 46 g of He
(B)	2 moles of Na	(q) 15 moles
(C)	11.2 L of O_2 at STP	(r) 3.011×10^{23} molecules
(D)	22 g of CO_2	(s) 16 g

(1) A – (q); B – (p); C – (s); D – (r)
(2) A – (p); B – (q); C – (s); D – (r)
(3) A – (p); B – (r); C – (s); D – (q)
(4) A – (q); B – (p); C – (r); D – (s)

8.

	Column I	Column II
(A)	Electron	(p) 1.00867 u
(B)	Proton	(q) 9.1×10^{-31} kg
(C)	Neutron	(r) 1.00728 u

(1) A – (q); B – (r); C – (p)
(2) A – (p); B – (q); C – (r)
(3) A – (r); B – (q); C – (p)
(4) A – (q); B – (p); C – (r)

Statement Based MCQ

9. Consider the following statements :
(a) Formula mass of Na_2O is 62 amu.
(b) Molar mass of ethyne (C_2H_2) is 26 g /mol.
Which of these statement(s) is/are correct?
(1) (a) only (2) (b) only
(3) Both (a) and (b) (4) Neither (a) nor (b)

10. Consider the following statements :
(a) Those particles which have more or less electrons than the normal atoms are called ions.
(b) Clusters of atoms that act as an ion is called Polyatomic ions.
Which of these statement(s) is/are correct?
(1) (a) only (2) (b) only
(3) Both (a) and (b) (4) Neither (a) nor (b)

11. Consider the following statements :
(a) 22gm. of CO_2 consist of 1 mole.
(b) Number of molecules in 4 gm of oxygen is 10^{22}.
(c) Mass of 1 mole of a substance is called its formula mass.
Which of these statement(s) is/are correct?
(1) (a) and (b) (2) (b) and (c)
(3) (a) and (c) (4) All are incorrect

12. Consider the following statements :
(a) Formula for sulphur dioxide is SO_2
(b) Water is an atom.
(c) In a pure chemical compound, elements are always present in a definite proportion by mass.
Which of these statement(s) is/are correct?
(1) (a) and (b) (2) (b) and (c)
(3) (a) and (c) (4) All are correct

13. Consider the following statements :
In $^{90}_{38}Sr^{2+}$:
(a) atomic number is 36
(b) number of electrons is 38
(c) number of neutrons is 52
(d) number of protons is 38
Which of these are correct ?
(1) (a) and (b) (2) (b) and (c)
(3) (c) and (d) (4) (a) and (d)

14. Which of the statements with regard to Isotopes and Isobars is/are correct?
(a) Isotopes have same mass number.
(b) Isobars have same atomic number.
Select the correct answer using the code given below:
(1) (a) only (2) (b) only
(3) Both (a) and (b) (4) Neither (a) nor (b)

15. Consider the following statements :
(a) Thomson proposed that the nucleus of an atom contains protons and neutrons.
(b) J.J. Thomson proposed that the nucleus of an atom contains only nucleons.
Which of these statement(s) is/are correct?
(1) (a) only (2) (b) only
(3) Both (a) and (b) (4) Neither (a) nor (b)

16. Consider the following statements :
(a) An electron has a mass that is much less than a proton.
(b) Any electron can only be found in one of the seven possible atomic shells.
(c) The innermost atomic shell can hold a maximum of 18 electrons.
Which of these statement(s) is/are correct?
(1) (a) and (b) (2) (b) and (c)
(3) Only (a) (4) Only (c)

17. Consider the following statements :
(a) Radioactive isotope of iodine is used for making the medicine called tincture iodine.
(b) There is no particle of matter smaller than an atom.
Which of these statement(s) is/are correct?
(1) (a) only (2) (b) only
(3) Both (a) and (b) (4) Neither (a) nor (b)

18. Consider the following statements :
(a) Atoms of an element may have more or less neutrons or electrons than other atoms of the same element.
(b) β-Particles are fast moving elections carrying negative charge.
Which of these statement(s) is/are correct?
(1) (a) only (2) (b) only
(3) Both (a) and (b) (4) Neither (a) nor (b)

Passage Based MCQ

DIRECTIONS (Qs. 19 to 27) : Read the passage(s) given below and answer the questions that follow.

PASSAGE - 1

Elements from A to F have in them the distribution of electrons, neutrons and protons as follows :

Atoms/ ions	Numbers of Electrons	Number of Neutrons	Number of Protons
A	4	4	3
B	10	12	11
C	17	18	17
D	17	20	17
E	18	22	18
F	19	21	19

Making use of these data, find

19. A pair of ions
(1) A and B (2) B and C
(3) D and E (4) E and F

20. A pair of isobars
(1) A and B (2) C and D
(3) E and F (4) C and E

21. A pair of isotopes
(1) A and B (2) C and D
(3) E and F (4) C and E

PASSAGE - 2

Ashok is conducting an experiment in laboratory involving compound *x*. One mole of compound *x* weighs 35 g. If he consumed 105 g of x in his experiment. Then

22. The no. of moles of x consumed in above experiment is
(1) 1 (2) 2
(3) 3 (4) 4

23. The name of compound x is
(1) NH_4OH (2) NaOH
(3) NaCl (4) Na_2O_2

24. If in another experiment only 70g of that substances is required. Then what will be the number of moles now ?
(1) 3 (2) 2
(3) 4 (4) 1

PASSAGE - 3

The number of electrons, protons and neutrons of 5 elements are given below :

Element	A	B	C	D	E
Electrons	4	18	17	11	17
Protons	6	18	17	9	17
Neutrons	6	22	20	10	18

25. Which of them is a cation?
(1) A (2) B
(3) C (4) D

26. Which of them is an anion?
(1) A (2) B
(3) C (4) D

27. Which is an atom of an inert gas?
(1) B (2) C
(3) D (4) E

Assertion Reason Based MCQ

DIRECTIONS (Qs. 28 to 36) : Following questions consist of two statements, one labelled as the **'Assertion'** and the other as **'Reason'**. You are to examine these two statements carefully and select the answer to these items using the code given below.

Code :

(1) Both A and R are individually true and R is the correct explanation of A:
(2) Both A and R are individually true but R is not the correct explanation of A.
(3) A is true but R is false
(4) A is false but R is true.

28. **Assertion :** Atomic weights of most of the elements are not whole numbers.
Reason : Atoms of most of the elements contain mixture of isotopes having different atomic weights.

29. **Assertion :** The standard unit for expressing the mass of an atom is 'u'.
Reason : 'u' is also called unified mass.

30. **Assertion :** Zinc is essential element for life and Cadmium is extremely toxic. Although both belong to same group in periodic table.
Reason : Zinc is useful as it is integral part of most of the enzymes. Cadmium is present in cigarette smoke, it accumulates in kidney and causes its malfunctioning. It replaces some of zinc in enzymes and thus prevents them from working.

31. **Assertion :** Both 12 g of Carbon and 32 g of Sulphur will have 6.022×10^{23} atoms.
Reason : 1 mole of an element contains 6.022×10^{23} atoms.

32. **Assertion :** Pure water obtained from different sources such as river, well, spring, sea, etc., always contain hydrogen and oxygen in the ratio of 1 : 8 by mass.
Reason : Mass of reactants and products during chemical changes is always equal.

33. **Assertion :** Both 106 g of sodium carbonate and 12 g of diamond have same number of carbon atoms.
Reason : Both 106 g of sodium carbonate and 12 g of diamond have 1 mole of carbon atoms.

34. **Assertion :** $_1H^1$, $_1H^2$ and $_1H^3$ are isotopes of hydrogen.
Reason : Nuclides of the same element of different mass numbers are called isotopes of that element.

35. **Assertion :** Out of electron, proton and neutron, the mass of electron is least.
Reason : The charge carried by an electron is 1.602×10^{-19} C.

36. **Assertion :** **Isobars** are atoms of the same element
Reason : They have different chemical properties.

Correct Definition Based MCQ

37. Electronic configuration is
    (1) arrangement of electrons in various shells of an atom of element
    (2) arrangement of protons in various shells of an atoms of element
    (3) arrangement of neutrons in various shells of an atom of element
    (4) arrangement of nucleons in various shells of an atom of element
38. Isobars are
    (1) atoms of different element with different atomic number but same mass number.
    (2) atoms of same element with different atomic number but same mass number.
    (3) atoms of different element with similar atomic number but different mass number
    (4) atoms of same element with similar atomic number but different mass number.
39. Mass number is the
    (1) sum of the number of protons, neutrons and electrons
    (2) number of protons.
    (3) number of electrons
    (4) sum of the number of protons and neutrons.
40. The valency of an element is
    (1) the mass of the element displacing 1 part by mass of hydrogen
    (2) the mass of the element combining with 8 parts by mass of oxygen
    (3) the number of atoms of hydrogen combining with 1 atom of the given element
    (4) the number of atoms in molecule of the given element

Feature Based MCQ

41. On the basis of following features identify correct option
    I. They are building blocks of all matter
    II. Smallest particle of an element which takes part in chemical change.
    (1) Electrons (2) Nucleons
    (3) Atoms (4) Molecules
42. On the basis of following features identify correct option
    I. Formed by the gain of electrons
    II. It is negatively charged
    III. It is called polyatomic ion.
    (1) NO_2^- (2) PO_4^{3-}
    (3) ClO^- (4) SO_3^{2-}
43. On the basis of following features identify correct option
    I. Travel in straight line
    II. They posses mechanical energy
    III. They produce heat when strikes metals
    (1) Anode rays (2) Cathode rays
    (3) Both (1) and (2) (4) Neither (1) nor (2)
44. On the basis of following features identify correct option
    I. It has a charge of 1.6×10^{-19}C
    II. It has a mass of 1.67265×10^{-27} kg
    (1) Neutron (2) Electron
    (3) Positron (4) Proton

Hints & SOLUTIONS

Exercise 1

1. **(1)** **2.** **(3)**

3. **(4)** Chemical formula of water and hydrogen peroxide are H_2O and H_2O_2 respectively.

4. **(4)**

5. **(2)** $MCl_3 \longrightarrow M^{3+} + 3Cl^-$

$M^{3+} + PO_4^{3-} \longrightarrow MPO_4$

6. **(3)** **7.** **(2)**

8. **(4)** Law of conservation of mass.

9. **(1)** **10.** **(3)** **11.** **(3)** **12.** **(1)**

13. **(3)** Maximum number of electrons that can be accommodated in any shell is given by $2n^2$. Thus for third shell $n = 3$, $2(3)^2 = 18$

14. **(3)** **15.** **(3)** **16.** **(2)** **17.** **(2)**

18. **(4)** Electron gain or loose energy during its transmission between various energy levels.

19. **(1)** **20.** **(4)** **21.** **(3)**

22. **(2)** Deuterium has one proton and one neutron.

23. **(3)** **24.** **(2)**

25. **(3)** Number of neutrons = Mass number – Atomic number
= 99 – 43 = 56

26. **(1)** **27.** **(2)** **28.** **(1)** **29.** **(3)**

30. **(2)** **31.** **(3)** **32.** **(1)**

33. **(3)** Right electronic configuration is 2, 8, 6

34. **(1)** **35.** **(2)**

36. **(3)** Electronic configuration of the following chemical species

$^{39}_{18}Ar$ 2, 8, 8

$^{40}_{19}K^+$ 2, 8, 8, 1

$^{41}_{20}Ca^{++}$ 2, 8, 8, 2] — identical electronic configurarion

$^{42}_{20}Ca^+$ 2, 8, 8, 2]

37. **(2)** **Scientist Discovery**
Moseley – Atomic number
Chadwick – Neutron
Millikan – Measurement of charge of an electron.
Aston – Mass spectrograph

38. **(3)** With increase in nuclear charge size of isoelectronic species decrease

$\therefore S^{2-} > Cl^- > K^+ > Ca^{2+}$

39. **(3)** Number of neutrons = 18

Number of electrons = Number of protons

$= 2 + 8 + 7 = 17$

Mass number = no. of protons + no. of neutrons

$= 17 + 18 = 35$

40. **(4)** The pairs of ions/atoms have same no. of e^- are said to be isoelectronic with each other.

Na^+ and Ne = $18e^-$ each

Na^+ and K^+ = $10e^-$ and $18e^-$ respectively

K^+ and Cl^- = $18e^-$ each

$\therefore$ Na^+ and Ne

K^+ and Cl^- are isoelectronic pairs.

41. **(4)** According to law of multiple proportions when two elements combine then the mass of one of the element which combine with fixed mass bear a simple whole number ratio.

$\therefore$ NaCl and AgCl do not confirm to the law of multiple proportions.

42. **(2)** Chromium and copper exhibits variable valency. They possess incomplete of d-subshells.

43. **(4)** According to law of multiple proportion, when two elements combine then the mass of one of the element which combine with fixed mass bear a simple whole number ratio.

Eg.	CO & CO_2,	N_2O & NO
	16 : 32	28 : 14
	1 : 2	2 : 1

44. **(1)** From AB valency of A = valency of B = 1

From A_2C, valency of C = 2

$\therefore$ Formula for compound formed by B and C is B_2C.

45. **(1)**

Atoms	**no.of e^{-1}s**	**e^- in shell (k)**
Hydrogen	1	1
Helium	2	2
Neon	10	2
Sulphur	16	2

$\therefore$ Hydrogen does not have 2^{e-} in the K-shell

46. **(3)** The valency of X is 3 in XO_3 because it is a trivalent oxide.

47. **(3)** An element X with atomic number 12 is magnesium.

Now, valency of Mg = + 2

Valency of N (azide) = – 3

$\therefore$ The formula of azide is Mg_3N_2

$$\overset{+2}{Mg} \times \overset{-3}{N} \quad \text{or} \quad X_3N_2$$

48. **(3)** Elements A B; Valencies 3 2 $\Big\}$ compound is A_2B_3

Elements A B; Valencies 5 2 $\Big\}$ compound is A_2B_5

49. **(2)** $^{12}C_6$ used as a standard in the expression of atomic weights in term of amu.

50. **(2)** Law of multiple proportions explains the formation of CO and CO_2, in these same weight of carbon that combines with weights of oxygen are in simple rate of 1 : 2.

51. **(3)**

52. **(4)** (ii) 20 moles of water = 20 × 18 g = 360 g of water, because mass of 1 mole of water is the same as its molar mass i.e., 18 g.

(iv) 1.2044×10^{25} molecules of water contains

$\frac{1.2044 \times 10^{25}}{N_A}$ number of moles, $N_A = 6.023 \times 10^{23}$

$\therefore \frac{1.2044 \times 10^{25}}{6.022 \times 10^{23}} = 20$ moles

20 moles of water = 20 × 18 g = 360 g of water

53. **(3)** Weight of a sample in gram = number of moles × molar mass

(1) 0.2 moles of $C_{12}H_{22}O_{11} = 0.2 \times 342 = 68.4$ g

(2) 2 moles of $CO_2 = 2 \times 44 = 88$ g

(3) 2 moles of $CaCO_3 = 2 \times 100 = 200$ g

(4) 10 moles of $H_2O = 10 \times 18 = 180$ g

54. **(4)** **55.** **(1)** **56.** **(1)** **57.** **(2)**

58. **(4)** Mg^{2+} ion has total 10 electrons (2, 8).

59. **(3)** Isotopes have same atomic number (number of protons) but different mass number (number of neutron + number of protons).

60. **(3)**

61. **(4)** In compound CS_2

12 g of carbon are combined with sulphur = 64 g

3 g of carbon are combined with sulphur

$$= \frac{(64g) \times (3g)}{(12g)} = 16g$$

62. **(2)** 6.022×10^{23} molecules of CO_2 correspond to mass = 44 g

3.011×10^{23} molecules of CO_2 correspond to mass = 22 g

63. **(2)** Mg is represented as $^{24}_{12}Mg$. It has protons, electrons and neutrons equal to 12 (all are same).

64. **(1)** The electronic configuration of element X is 2, 5. It has 5 valence electrons.

65. **(4)** 1 mole of Cl_2 = 34g = 6.023×10^{23} atoms

$$71g \text{ of } Cl_2 = \frac{6.023 \times 10^{23}}{34} \times 71$$

$= 12.577 \times 10^{23}$ atoms

1 mole of Mg = 24 g = 6.023×10^{23} atoms

$$48g \text{ of Mg} = \frac{6.023 \times 10^{23}}{24} \times 48$$

$= 12.046 \times 10^{23}$ atoms

1 mole of I_2 = 126 L = 6.023×10^{23} atoms

$$127g \text{ of } I_2 = \frac{6.023}{126} \times 127 \times 10^{23}$$

$= 6.070 \times 10^{23}$ atoms

1 mole of H_2 = 1g = 6.023×10^{23} atoms

$$4g \text{ of } H_2 = \frac{6.023 \times 10^{23} \times 4}{1}$$

$= 24.092 \times 10^{23}$ atoms

Hence, 4g of H_2 have largest number of atoms.

66. **(4)** One P_4 molecule is made up of four atoms of phosphorus
1 mole of P_4 molecules = 6.023×10^{23} atoms
4 mole of P_4 molecules = $6.023 \times 10^{23} \times 4$
$= 2.409 \times 10^{24}$ atoms

67. **(4)** No. of mol $= \frac{63}{\text{mol.weight of } HNO_3} = \frac{63}{63} = 1$ mole

No. of oxygen atoms = moles × no. of oxygen atoms present × Avogadro no.
$= 1 \times 6 \times 10^{23} \times 3$
$= 18 \times 10^{23}$
$= 1.8 \times 10^{24}$

Exercise 2

1. **(1)** **2.** **(3)** **3.** **(1)** **4.** **(3)**
5. **(1)** **6.** **(2)** **7.** **(1)** **8.** **(1)**
9. **(3)** **10.** **(3)**

11. **(4)** 1 mole of $CO_2 = 44$g
Mass of 1 mole of a substance is called molar mass.

12. **(3)** Water is a molecule containing hydrogen and oxygen atom. Its formula is H_2O.

13. **(3)** In $^{90}_{38}Sr^{2+}$, Atomic number = no. of protons = 38
Since it has lost $2e^-$ so no. of electrons = 38 – 2 = 36
Atomic mass = no. of protons + no. of neutrons
90 = 38 + no. of neutrons
90 – 38 = no. of neutrons
52 = no. of neutrons
Hence, no. of neutrons = 52, no. of protons = 38.

14. **(4)** The correct statements are
(i) Isotopes have same atomic number.
(ii) Isobars have same mass number.

15. **(4)** **16.** **(3)** **17.** **(4)** **18.** **(3)**

19. **(1)** In A and B number of electrons and protons are diffeent.

20. **(3)** In E and F sum of number of neutrons and protons are equal.

21. **(2)** In C and D number of protons and electrons are equal.

22. **(3)** **23.** **(1)** **24.** **(2)**

25. **(1)** No. of electrons < No. of protons.

26. **(4)** No. of electrons > No. of protons.

27. **(1)**

28. **(1)** Element is a mixture of isotopes, the atomic weights are not whole numbers but fractional integral values.

29. **(2)** **30.** **(1)** **31.** **(1)** **32.** **(2)**

33. **(1)**

34. **(1)** All the three have same atomic number i.e., 1 and different mass number 1, 2 and 3, respectively.

35. **(2)** **36.** **(4)** **37.** **(1)** **38.** **(1)**
39. **(4)** **40.** **(3)** **41.** **(3)** **42.** **(2)**
43. **(3)** **44.** **(4)**