CHAPTER-1
THE LANGUAGE OF CHEMISTRY

Topic-1 Elements, Radicals and Formulae

Revision Notes

- A simple and pure form of the matter that cannot be further decomposed to simplest form is called an **element.**
  Elements are formed by atoms. Similar types of atoms combine to form molecules.
- The number of atoms in a molecule of an element is called its **atomicity.**
  Molecules may be **mono atomic, diatomic** or even **polyatomic**.
- **Monoatomic :** Elements with single atom in their molecules, e.g., helium, neon, other inert gas molecules.
- **Diatomic :** Elements with two atoms in their molecules, e.g., hydrogen (H_2), oxygen (O_2).
- **Polyatomic :** Elements with more than two atoms in their molecules, e.g., Triatomic : Elements with three atoms in their molecules, e.g., ozone (O_3).
- **Tetra atomic :** Elements with four atoms in their molecules, e.g., phosphorus (P_4), etc.
- Johann Berzelius (1804) suggested a simple system of using letters as chemical symbols to represent elements.
  A chemical symbol is a short form used to represent an atom of an element. e.g., Sulphur, an element is represented by symbol 'S', Hydrogen as 'H' Cobalt as 'Co', Copper as 'Cu', Gold by 'Au', Silver by 'Ag', etc.
- A **chemical symbol** signifies name of the element, one atom of an element and an atomic mass of the element.
  A chemical symbol is used to represent the elements while writing a chemical equation.
- **Molecular formula** or **chemical formula** is the symbolic representation of molecule of an element or compound. e.g., nitrogen (N_2), chlorine (Cl_2), ammonium chloride (NH_4Cl), sodium carbonate (Na_2CO_3), etc.
- Molecular formula signifies the individual numbers of different atoms present in the molecule of a compound and the ratio of the individual masses of the elements present in the compound.
  A **valency** describes bonding capability of an atom or a radical.
  Valency is represented using a positive or negative integer.
  Valency is determined based on the number of electrons that would be added, lost or shared if an atom reacts with other atoms. Atoms gain or lose electrons to attain stability.
  When an atom loses an electron, it attains a positive charge and becomes a **cation**.
  When an atom gains an electron, it attains a negative charge and becomes an **anion**.
  Electrons in the outer shell are known as **valence electrons.** Elements with one, two, three electrons in their outer shell (generally metals) lose their valence electrons forming cations.

$$Na - e^- \rightarrow Na^+ \text{ (Univalent)}$$
$$2,\ 8,\ 1 \qquad\quad 2,\ 8$$
$$Mg - 2e^- \rightarrow Mg^{2+} \text{ (divalent)}$$
$$2,\ 8,\ 2 \qquad\quad 2,\ 8$$

Elements with five, six or seven electrons in their outer shell (generally non-metals) gain electrons to become stable forming anions.

$$Cl + e^- \rightarrow Cl^- \text{ (Univalent)}$$
$$(2,\ 8,\ 7) \qquad\quad 2,\ 8,\ 8$$
$$O + 2e^- \rightarrow O^{2-} \text{ (divalent)}$$
$$(2,\ 6) \qquad\quad 2,\ 8$$

No. of electrons (s) in outermost shell	1	2	3	4	5	6	7	8
Valency	1	2	3	4	3	2	1	0

- Valency of an element or of a radical is the number of hydrogen atoms that will combine with or displace one atom of that element or radical. e.g., a molecule of hydrogen chloride is formed by the combination of one atom of chlorine with one atom of hydrogen.

  H—Cl

  Certain elements show more than one valency *i.e.*, **variable valency**. It is due to the loss of electrons from the penultimate shell. e.g., Tin exhibits variable valencies of 2 and 4, thus as Stannous chloride $SnCl_2$ (Tin (II) chloride) and stannic chloride $SnCl_4$ (Tin (IV)chloride).

- A **radical** is an atom or group of atoms of similar or different elements that acts like a single unit and show positive or negative charge. e.g., **simple radical** Sodium (Na^+), **compound radical** (SO_4^{2-}).

- Acid base neutralisation reaction results in formation of salt and water. The salt formed contains positive ions which are contributed from base; hence they are called as **basic radicals**. While the salt containing negative ions are contributed from acid; thus,they are called as **acidic radicals.** So, basic radicals are positively charged ions *i.e.* cations while acidic radicals are negatively charged ions *i.e.*, anions.

  When a salt is dissolved in water it breaks up into basic radicals also called **electropositive radicals** and acidic radicals also called **electronegative radicals**. A list of examples of basic and acidic radicals are given below:

List of some basic radicals (electropositive radicals or cations)

Monovalent electropositive	Divalent electropositive	Trivalent electropositive	Tetravalent electropositive
1. Ammonium NH_4^+	1. Argentic [Silver (II)] Ag^{2+}	1. Aluminium Al^{3+}	1. Plumbic [Lead (IV)] Pb^{4+}
2. Aurous [Gold (I)] Au^+	2. Barium Ba^{2+}	2. Arsenic As^{3+}	2. Platinic [Platinum (IV)] Pt^{4+}
3. Argentous [Silver (I)] Ag^+	3. Calcium Ca^{2+}	3. Auric [Gold (III)] Au^{3+}	3. Stannic [Tin (IV)] Sn^{4+}
4. Cuprous [Copper (I)] Cu^+	4. Cupric [Copper (II)] Cu^{2+}	4. Bismuth Bi^{3+}	

List of some acidic radicals (electronegative radicals or anions)

Monovalent electronegative	Divalent electronegative	Trivalent electronegative	Tetravalent electronegative
1. Acetate CH_3COO^-	1. Carbonate CO_3^{2-}	1. Arsenate AsO_4^{3-}	1. Carbide C^{4-}
2. Bicarbonate or Hydrogen carbonate HCO_3^-	2. Dichromate $Cr_2O_7^{2-}$	2. Nitiride N^{3-}	2. Ferrocyanide $Fe(CN)_6^{4-}$
3. Bisuphide or Hydrogen sulphide HS^-	3. Oxide O^{2-}	3. Aluminate AlO_3^{3-}	
4. Bisulphate or Hydrogen sulphate HSO_4^-	4. Peroxide O_2^{2-}	4. Arsenite AsO_3^{3-}	

- **Writing chemical formula using criss-cross method**

  Write the symbol of basic radical first and then the symbol of acidic radical side by side.

  Write the valency of each atom on top of its symbol.

  Divide the valency number by their H.C.F., to get simplest ratio if any, by ignoring the + and – symbols. Swap the valencies of radicals.

  Write the swapped valency numbers to the lower right of the radicals. If the radical is group of atoms and has valency more than 1, enclose it within brackets.

Name of Compound	Symbols with valencies and charge	Exchange of valency	Formula
Magnesium chloride	Mg^{2+} Cl^-	Mg^2 Cl^1 → Mg_1 Cl_2	$MgCl_2$
Calcium oxide	Ca^{2+} O^{2-} [Dividing by H. C. F. it becomes Ca^{1+} O^{1-}]	Ca^1 O^1 → Ca_1 O_1	CaO Cancelling common factor
Aluminium hydroxide	Al^{3+} $(OH)^-$	Al^3 $(OH)^1$ → Al_1 $(OH)_3$	$Al(OH)_3$

Phosphorus trioxide	$P^{3+}\ O^{2-}$	$P^3\ O^2$ $P_2\ O_3$	P_2O_3
Sodium aluminate	$Na^+\ AlO_3^{3-}$	$Na\ AlO_3^3$ $Na_3\ (AlO_3)_1$	Na_3AlO_3

➢ **Naming compounds**

Naming of Certain Compound:

Compound	Preference	Suffix	Prefix	Examples
1. Metal and nonmetal	Metal followed by non metal	'ide' by nonmetal	–	Calcium + nitrogen → calcium nitride [Ca_3N_2]
2. Two nonmetal	–	–	tri or tetra or penta etc.	PCl_3 phosphorus trichloride PCl_5 phosphorus pentachloride
3. Tetra element and oxygen	1. Oxygen is represent 2. End name depends on number of oxygen atoms	– 'ite' (2 'O' atoms) 'ate' (3 'O' atoms)	'hypo' ('O' atom less than 2) – – 'Per' ('O' atom more than 3)	NaClO – sodium hypochlorite $NaClO_2$ – sodium chlorate $NaClO_3$ – sodium chlorate $NaClO_4$ – sodium perchlorate
4. Acids (a) Binary acids (b) Radicals of polyatomic 'groups'	Add to the name of second element Based on 2nd element in the molecules If no. of oxygen atom is less	'ic' – 'ous' instead of 'ic'	'hydro' – –	HCl – Hydrochloric acid HF – Hydrofloric acid H_2SO_4 – Second element sulphur thus name Sulphuric acid. HNO_3 – Second element nitrogen thus name Nitric acid. H_3PO_4 – Second element phosphorus thus name Phosphoric acid. H_2SO_3 – Sulphurous Acid HNO_2 – Nitrous Acid
5. Trival names (common names)	Do not follow systematic rule	–	–	Nitrogen trihydride is called 'ammonia' [NH_3] Dihydrogen oxide is called 'Water' [H_2O]

➢ **To calculate valency from formula**

The valency of elements can be determined based on the knowledge of the valencies of negative radicals and of the fact that the valency of :

Hydrogen [H] = 1 ;
Oxygen [O] = 2 ;
Chlorine [Cl] = 1

Method to find the valency	Example
1. Write the given formula.	NO^2
2. Interchange the subscript and write it as superscript.	N^2O^1
3. The valency of oxygen is taken as 2, therefore, multiply both the subscript by 2.	$N^{2\times2}O^{1\times2}$
4. The result gives the valency of the elements	N^4O^2

Thus, from the formula NO_2, we find that the valency of nitrogen here is 4.

Mnemonics

Concept Name: Isotopes of Hydrogen
Mnemonics: Daily Practice Test

Interpretations: P: Protium, D: Deuterium, T: Tritium

Key Words

- **Symbol:** is the short form that stands for the atom of a specific element.
- **Valency:** is the combining capacity of an atom or a radical. It is equal to the number of electrons (s) lost/gained or shared while combining with another atom or radical. Some elements, like iron, mercury, lead, show variable valencies.
- **Radical :** is an atom or a group of atoms of the same or different elements, that behave as a single unit and has positive or negative charge. A radical with positive charge is a cation, e.g., NH_4^+ (ammonium ion), Na^+ (sodium ion) and a radical with negative charge is an anion, e.g., Cl^- (chloride), CO_3^{2-} (carbonate).
- **Molecular formula :** is a shorthand notation for the molecule of a substance in term of symbols and numbers of atoms of each element present in it.

Topic-2 Balancing Chemical Equations, Relative Atomic and Molecular Masses

Revision Notes

Chemical Reaction :

- A **chemical reaction** is a process that leads to the transformation of one set of chemical substances to another. It is represented by a chemical equation.
- A complete chemical equation represents the reactants, products and their physical states symbolically in the reaction.
- The coefficients next to the symbols and formulae of entities are the absolute values of the stoichiometric numbers.
- The first chemical equation was diagrammed by Jean Beguin (1615).
- A chemical equation is the symbolic representation of a chemical reaction in the form of symbols and formulae, where in the reactant entities are given on the left-hand side and the product entities on the right-hand side.
- **Steps involved in writing a chemical reaction :**

  Write the formula of the reactants (substances involved) to left hand side with '+' sign in between them in their molecular forms.

  Write the formula of the products (substances formed) to right hand side with '+' sign in between them in their molecular forms.

  Write the arrow '→' symbol between reactants and products. Example,

  $CuSO_4 + 2NaOH \rightarrow Cu(OH)_2 + Na_2SO_4$

  REACTANTS PRODUCTS

  An unbalanced chemical equation is called a **skeleton equation**.

  A chemical equation is balanced so that the numbers of atoms of each element involved in a chemical reaction are same on the reactant and product sides of the equation. Equations must always be balanced in order to adhere **"Law of Conservation of Matter"**, as it states that 'matter can neither be created nor destroyed in the course of a chemical reaction'

  Example: $KNO_3 \rightarrow KNO_2 + O_2$
- In the above equation, as the number of atoms of O on both the sides is not same, the equation is not balanced. **The balanced form of equation is :**

  $2KNO_3 \rightarrow 2KNO_2 + O_2$
- **Chemical equation is balanced by two methods :**

  (i) Hit and Trial Method

  (ii) Partial Equation Method

Balancing the equation by Hit and Trial Method

This method is used to balance simple chemical equations by counting the number of atoms of each atoms of each element on both sides and trying to equalize them. Steps are given below :

(i) Count the number of times (frequency) an element occurs on either side.

(ii) The element with the least frequency of occurrence is balanced first.

(iii) When two or more element have the same frequency, the metallic element is balanced first.

Example : Balance the following equation :

$Cu + H_2SO_4 \rightarrow CuSO_4 + SO_2 + H_2O$

Solution :

Step 1 : Count the number of atoms of all the elements on either side of the chemical equation.

Element	Reactant Side	Product Side
Cu	1	1
H	2	2
S	1	2
O	4	7

Step 2 : Copper and hydrogen are equal on both sides, to equalise sulphur atoms multiply H_2SO_4 by 2.

Step 3 : To equalise hydrogen atoms, multiply H_2O by 2.

This gives the balanced equation.

$$Cu + 2H_2SO_4 \rightarrow CuSO_4 + SO_2 + 2H_2O$$

➢ **Information given by a balanced chemical equation :**

- About actual result of chemical change
- About the reactants involved and products formed
- About the chemical composition of a respective molecule
- About the molecular mass
- It proves law of conservation of mass.

➢ **Limitations of a Basic Chemical equation**

- It cannot give information about the time taken for the completion of the reaction.
- It cannot tell about the amount of heat given out or absorbed during the reaction.
- It cannot give information about the respective concentrations of reactants and products.
- It cannot give rate at which the reaction proceeds and whether it is reversible or irreversible and whether the reaction is completed or not.
- But, some of the above details can be mentioned in the chemical equation and make them more informative, like giving details about temperature, pressure, catalyst etc. above the arrow, stating the physical states (solid, liquid, gas) of reactants and products, stating the evolution or absorption of heat and also about the concentration of acids involved in the reactions.
- **The relative atomic mass** or atomic weight of an element is the number of times one atom of the element is heavier than $\frac{1}{12}$ times of the mass of an atom of carbon-12.
- Atomic mass is expressed in atomic mass units (a.m.u.).
- **Atomic mass unit** is defined as $\frac{1}{12}$ the mass of carbon atom C-12.
- **The relative molecular mass** (or molecular weight) of an element or a compound is the number that represents how many times one molecule of the substance is heavier than $\frac{1}{12}$ of the mass of an atom of carbon-12.
- **Molecular mass** of a substance is the sum of the atomic masses of the constituent atoms present in one molecule of that substance.
- **Percentage composition** of a compound is the percentage by weight of each element present in it.
- **Empirical formula** of a compound is the simplest formula which gives the simplest ratio in the whole numbers of atoms of different elements present in one molecule of the compound.
- **Empirical formula mass** is the sum of atomic masses of various elements present in the empirical formula.

Mnemonics

- **Concept:** Limitations of chemical equation.
- **Mnemonics:** Covid took health down the road.
- **Interpretation:**
- **Covid:** Concentration
- **Took:** Time
- **Health:** Heat
- **Down the road:** Direction of reaction

Key Words

- **The Relative atomic mass** or atomic weight of an element is the number of times an atom of the element is heavier than $\frac{1}{12}$ times of the mass of an atom of carbon-12.
- **The Relative molecular mass** (or molecular weight) of an element or a compound is the number that represents how many times one molecule of the substance is heavier than $\frac{1}{12}$ of the mass of an atom of carbon-12.
- The empirical formula of a compound is the simplest formula, which gives the simplest ratio in whole numbers of atoms of different elements present in one molecule of the compound.
- **Atomic mass unit (amu)** is equal to one twelfth the mass of an atom of Carbon-12 (atomic mass of carbon taken as 12)

Know the Formula

$$\text{Relative atomic mass} = \frac{\text{Mass of 1 atom of the element}}{\frac{1}{12}\text{th the mass of one C-12 atom}}$$

$$1 \text{ amu or } 1 \text{ u} = 1.6605 \times 10^{-24} \text{ g}$$

$$\text{Percentage of an element in a compound} = \frac{\text{Total wt. of the element in one molecule}}{\text{Gram molecular weight of the compound}} \times 100$$

CHAPTER-2
CHEMICAL CHANGES AND REACTIONS

Topic-1 Chemical reactions and its Characteristics

Revision Notes

- A **chemical reaction** is a process which involves breaking of chemical bonds of **reactants** and formation of new bonds to form new substances called **products**.

Characteristics of Chemical reactions

A chemical reaction is easily identified by some of the typical changes that takes place. They are:

- **Evolution of gas:** In many chemical reactions one of the products formed would be gas.
  e.g., When zinc reacts with dilute sulphuric acid, hydrogen gas is evolved, with effervescence.