CHAPTER

7 General Concepts of Chemistry

1. Definition

Chemistry is a branch of science which deals with study of matter and various changes it undergoes. It deals with the preparation, properties, reactions and structures of chemical elements and compounds.

For convenience the study of chemistry is sub-divided into various branches such as:

(i) Inorganic chemistry
(ii) Organic chemistry
(iii) Physical chemistry
(iv) Analytical chemistry
(v) Industrial chemistry

2. Valency

During the formation of molecules of compounds, atoms combine in certain fixed proportions. This is because of the fact that different atoms have different combining capacities.

The combining capacity of an atom or radical is known as its **valency.**

3. Ions or radicals

In addition to atoms and molecules, a third type of particles occurs in substances. These particles, called ions, or atoms or group of atoms that carry an electrical charge.

An **ion** is formed when electrons are removed from or added to an atoms or group of atoms.

When electrons is/are removed the resulting ion is called a **cation or basic radical.** A cation is positively charged ion. (e.g. Na^+).

When electron is/are added the resulting ion is called an **anion or acidic radicals.** An anion is negatively charged ion (e.g. , Cl^- , O_2^{2-})

An ion or radical is classified as monovalent, divalent, trivalent or tetravalent when the number of charges over it is 1, 2, 3 or 4 respectively.

4. Formula of Elements and Compounds

Formula of elements: The molecule of an element is denoted by writing the symbol of the element and, to the right and below it, a number expressing the number of atoms in the molecule.

Formula of compound : A molecule of a compound may be made up of atom of different elements linked up together chemically and in definite proportion by weight.

5. Chemical formula : It is of two types :

(i) Molecular formulae : Chemical formulae that indicate the actual number and type of atoms in a molecule is called molecular formulae.

(ii) Empirical formulae : Chemical formulae that indicate only the relative number of atoms of each type in a molecule is called empirical formulae.

6. Equivalent weight

(i) Equivalent weight of element

$$= \frac{\text{Atomic weight of element}}{\text{Valency of element}}$$

(ii) Eq. wt of an acid/base

$$= \frac{\text{Molecular mass}}{\text{Basicity of acid / Acidity of base}}$$

(iii) Eq. wt of salts

$$= \frac{\text{Formula mass}}{(\text{Valency of cation})(\text{No. of cations})}$$

7. Expression of strength /concentration of Solution

(i) Mass percent $= \frac{\text{Weight of solute (gm)}}{\text{Weight of solution (gm)}} \times 100$

(ii) Normality $= \frac{\text{Number of gram equivalents of solute}}{\text{Volume of solution (lit.)}}$

(iii) Molarity $= \frac{\text{Number of gram moles of solute}}{\text{volume of solution (lit.)}}$

(iv) Molality $= \frac{\text{Gram moles of solute}}{\text{Weight of solvent (kg)}}$

(v) Mole fraction : Mole fraction of solute

$$= X_A = \frac{n_A}{n_A + n_B}$$

$$\text{Mole fraction of solvent} = X_B = \frac{n_B}{n_A + n_B}$$

$$X_A + X_B = 1$$

8. **Chemical reaction :** The process in which a substance undergoes change to produce new substances with new properties are known as chemical reaction. For example magnesium carbonate when heated produces magnesium oxide and carbon dioxide (i.e. new substances with new properties).
   A chemical change is generally accompanied by a *change of state*, *change of colour*, *evolution of a gas* or *change of temperature* etc.
9. **Chemical equation :** The qualitative representation of a chemical reaction in a short hand or concise form in term of symbols and formulae, is called a chemical equation.
10. **Skeletal chemical equation or symbol equation :** A chemical equation written in the form of symbols and formulae is called a skeletal chemical equation.
11. **Balanced chemical equation :** A chemical equation in which number of atoms of each elements on L.H.S. (i.e. reactants) and R.H.S. (i.e.products) is equal is called a balanced chemical equation.
12. **Balancing of chemical equations :** The process of making the number of different elements on both side of the equation equal is known as balancing of chemical equation.
13. **Types of chemical reactions**
    Various types of chemical reactions are :-
    (i) Combination reactions : Combination reactions are those in which one element reacts with another to form a compound. This type of reactions are also known as synthesis reaction. For example, hydrogen combines with oxygen to give water.

$$2H_2(g) + O_2(g) \longrightarrow 2H_2O(\ell)$$

    (ii) Decomposition reactions : Decomposition reactions are those reactions in which a compound breaks down into simpler compounds (or substances). This type of reaction is simply the reverse of combination reactions. These reactions require energy in the form of heat, light, electricity, etc.
    (iii) Simple displacement reaction and simple substitutions : A displacement reaction is a reaction in which an atom, or group of atoms, present in a molecule is displaced by another atom. This type of reaction can be represented as follows:

$$AB + C \longrightarrow AC + B$$

(Compound) (New compound)

    (iv) Double displacement reactions or Double decomposition : The reactions in which mutual exchange of radicals takes place are known as double decomposition reactions. As a result of double decomposition reactions two new substances are formed.

Examples :

$$2NaCl + H_2SO_4 \longrightarrow Na_2SO_4 + 2HCl$$

Double-displacement reactions can be further classified as **precipitation,** gas **formation,** and **acid-base neutralization reactions.**

Precipitation reactions : A precipitation reaction occurs when two solutions are mixed together and a solid separates from the solution. The solid part that forms and separates form the solutions is called the precipitate the reaction given above is a precipitation reaction.

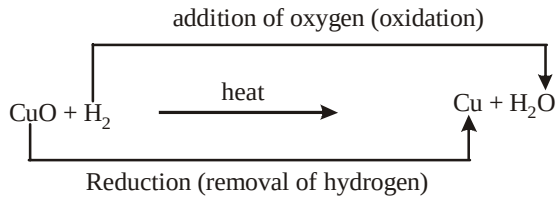
(v) Oxidation-Reduction Reactions

Oxidation : Oxidation is defined as a process which involve addition of oxygen or removal of hydrogen.

Reduction : The term reduction is defined as a process which involve the removal of oxygen or addition of hydrogen.

(vi) Redox reactions : Those reactions in which oxidation and reduction takes place simultaneously, are known as redox reactions.

Example :



(vii) Exothermic and endothermic reaction : Chemical reactions usually proceed with either liberation of heat or the absorption of heat.

When a chemical reaction liberates heat to the surroundings, it is said to be 'exothermic reaction' and when it absorbs the heat from the surroundings, it is said to be endothermic reaction.

$$N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$$

+ energy (Exothermic)

$$CaCO_3(s) \xrightarrow{\Delta} CaO(s) + CO_2(g) \text{(Endothermic)}$$

14. **Corrosion (erosion by chemical action) :** Corrosion is the degradation of metals and generally called rust.
    Corrosion causes damage to car bodies, iron railings, ships and to all objects made of metals, specially those of iron.
    Corrosion of iron is a serious problem.
15. **Rancidity :** The most important cause of deterioration in fats and fatty foods is oxidation of fats. What we perceive is an unpleasant change in the flavour and odour of a food, called rancidity.

EXERCISE

1. $Na_2S_2O_3$ represent the compound
   (a) sodium sulphate (b) sodium sulphite
   (c) sodium thiosulphate (d) None of these
2. Which one is a bivalent ion?
   (a) sodium (b) calcium
   (c) sulphide (d) Both (b) and (c)
3. The chromate and dicharomate ions are respectively
   (a) CrO_4^{2-} and $Cr_2O_7^{2-}$ (b) $Cr_2O_7^{2-}$ and CrO_4^-
   (c) CrO_4^- and CrO_5^- (d) CrO_4^{2-} and $Cr_2O_5^{2-}$
4. The formula of sodium pyrophosphate is
   (a) $Na_2P_2O_7$ (b) Na_3PO_4
   (c) $Na_4P_2O_7$ (d) Na_3PO_3
5. The branch of chemistry which deals with study of physical properties and conditions is
   (a) physical chemistry
   (b) analytical chemistry
   (c) nuclear chemistry
   (d) pharmaceutical chemistry
6. The branch of chemistry which deals with study of the methods of detection and determination of elements and compounds is
   (a) Physical chemistry (b) Nuclear chemistry
   (c) Analytical chemistry (d) Bio chemistry
7. Valency of an atom or radicals is
   (a) ionisation energy (b) electron affinity of atom
   (c) its combining capacity (d) size of atom
8. When electrons are added the resulting ion is called
   (a) basic radical (b) acidic radicals
   (c) neutral radical (d) None of these
9. Which of the following is most unreactive ?
   (a) Mg
   (b) Mg^+
   (c) Mg^{2+}
   (d) All above species are inert
10. Chemical formula of Aluminium sulphate is
    (a) $Al_2(SO_4)_3$ (b) $AlSO_4$
    (c) $Al_3(SO_4)_2$ (d) None of these
11. Select the one that represents a displacement reaction.
    (a) $NaCl + AgNO_3 \longrightarrow AgCl + NaNO_3$
    (b) $Zn + CuSO_4 \longrightarrow ZnSO_4 + Cu$
    (c) $HCl + NaOH \longrightarrow NaCl + H_2O$
    (d) $C + O_2 \longrightarrow CO_2$
12. Which one is a combination reaction ?
    (a) Formation of a mixture of carbon monoxide and hydrogen. When steam is passed over red hot iron.
    (b) Reaction of water with sodium metal to form sodium hydroxide and hydrogen.
    (c) $Ca(OH)_2 + Na_2CO_3 \longrightarrow 2NaOH + CaCO_3\downarrow$
    (d) Preparation of stannic chloride (Tin (iv) chloride) by passing chlorine gas into molten tin (Sn).
13. Which of the following involves combination of two elements?
    (a) $CaO + CO_2 \longrightarrow CaCO_3$
    (b) $4Na + O_2 \longrightarrow 2Na_2O$
    (c) $2SO_2 + O_2 \longrightarrow 2SO_3$
    (d) $NH_3 + HCl \longrightarrow NH_4Cl$
14. When hydrogen sulphide gas is passed through a blue solution of copper sulphate, a black precipitate of copper sulphide is formed. This is an example of
    (a) combination reaction
    (b) displacement reaction
    (c) decomposition reaction
    (d) double decomposition reaction
15. Which one is a decomposition reaction ?
    (a) $2HgO \xrightarrow{heat} 2Hg + O_2$
    (b) $CaCO_3 \xrightarrow{heat} CaO + CO_2$
    (c) $2H_2O \xrightarrow{Electrolysis} 2H_2 + O_2$
    (d) All the above reactions are decomposition reaction
16. The reactions in which two compounds exchange their radicals to form two new compounds are called
    (a) displacement reaction
    (b) decomposition reaction
    (c) double displacement reaction
    (d) isomerisation reaction
17. $CuO + H_2 \longrightarrow Cu + H_2O$
    Above reaction is an example of
    (a) Redox reaction
    (b) synthesis reaction
    (c) neutralisation reaction
    (d) decomposition reaction
18. In the reaction :
    $PbO + C \longrightarrow Pb + CO$
    (a) PbO is oxidised (b) PbO is oxidant
    (c) C is reductant (d) Both (b) and (c)
19. Chemical equations are balanced in accordance with the
    (a) Dalton's law
    (b) Law of conservation of mass
    (c) Law of definite composition
    (d) None of these
20. Which is not a balanced equation ?
    (a) $NaOH + HCl \longrightarrow NaCl + H_2O$
    (b) $Mg + CuSO_4 \longrightarrow MgSO_4 + Cu$
    (c) $Fe + Cl_2 \longrightarrow FeCl_3$
    (d) $Mg + 2HNO_3 \longrightarrow Mg(NO_3)_2 + H_2$
21. Which of the following statements is true about chemical equation ?
    (a) Mass is conserved
    (b) Atoms are conserved
    (c) Mass as well as atoms are conserved
    (d) Molecules are conserved

22. A molal solution is one that contains 1 mole of a solute in
(a) one litre of the solvent
(b) 1000 g of the solvent
(c) one litre of the solution
(d) 22.4 litres of the solution

23. The total number of atoms represented by the compound $CuSO_4.5H_2O$ is
(a) 27 (b) 21
(c) 5 (d) 8

24. The molecular formula P_2O_5 means that
(a) a molecule contains 2 atoms of P and 5 atoms of O
(b) the ratio of the mass of P to the mass of O in the molecule is 2:5
(c) there are twice as many P atoms in the molecule as there are O atoms
(d) the ratio of the mass of P to the mass of O in the molecule is 5 : 2

25. The empirical formula and molecular mass of a compound are CH_2O and 180 g respectively. What will be the molecular formula of the compound ?
(a) $C_9H_{18}O_9$ (b) CH_2O
(c) $C_6H_{12}O_6$ (d) $C_2H_4O_2$

26. The empirical formula of a compound is CH_2. One mole of this compound has a mass of 42 grams. Its molecular formula is :
(a) C_3H_6 (b) C_3H_8
(c) CH_2 (d) C_2H_2

27. Which of the following statements is not correct?
(a) A chemical equations tells us about the substances involved in a reaction.
(b) A chemical equations informs us about the symbols and formula of substances involved in a reaction
(c) A chemical equations tells us about the atom or molecules of the reactants and products involved in a reaction
(d) All are correct

28. $AgNO_3(aq) + NaCl(aq) \longrightarrow AgCl(s) + NaNO_3(aq)$
Above reaction is -
(a) precipitation reaction
(b) double displacement reaction
(c) combination reaction
(d) Both (a) and (b)

29. A redox reaction is one in which -
(a) both the substance are reduced
(b) both the substance are oxidised
(c) an acid is neutralised by the base
(d) one substance is oxidised while the other is reduced

30. An organic compound containing C, H and N gave the following analysis :
C = 40% ; H = 13.33% ; N = 46.67%
Its empirical formula would be
(a) $C_2H_7N_2$ (b) CH_5N
(c) CH_4N (d) C_2H_7N

31. An organic compound containing C, H and O gave on analysis C – 40% and H – 6.66%. Its empirical formula would be
(a) C_3H_6O (b) CHO
(c) CH_2O (d) CH_4O

32. Slow eating away of iron articles in the presence of moist air is called
(a) galvanisation (b) crystallisation
(c) rusting (d) neutralisation

33. Which of the following reaction is endothermic?
(a) $C + O_2 \longrightarrow CO_2$
(b) $CaCO_3 \longrightarrow CaO + CO_2$
(c) $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$
(d) $CaO + H_2O \longrightarrow Ca(OH)_2$

34. The observation that does not indicate a chemical reaction is
(a) change of temperature
(b) change of colour
(c) evolution of a gas
(d) None of these

35. Which one of the following is not an exothermic reaction ?
(a) Respiration
(b) Slaking of lime
(c) Burning of a candle
(d) Dipping of iron block in water

36. Which of the following statement is not correct ? To prevent food from getting rancid, we
(a) store the food in air-tight containers
(b) add antioxidants
(c) flush bags of chips with an inert gas
(d) increase the temperature of the food

37. In the following equations :
$NaCO_3 + xHCl \longrightarrow 2NaCl + CO_2 + H_2O$,
the value *x* is
(a) 1 (b) 2
(c) 3 (d) 4

38. Which of the following is not an endothermic process?
(a) Boiling of water
(b) Dissolving salts in water
(c) Dissolving conc. H_2SO_4 in water
(d) Evaporation of water

39. Rusting of an iron is an example of
(a) reduction (b) ionization
(c) oxidation (d) dissociation

40. Which of the following does not corrode when exposed to the atmosphere?
(a) Iron (b) Copper
(c) Gold (d) Silver

ANSWER KEY													
1	(c)	**7**	(c)	**13**	(b)	**19**	(b)	**25**	(c)	**31**	(c)	**37**	(b)
2	(d)	**8**	(b)	**14**	(d)	**20**	(c)	**26**	(a)	**32**	(c)	**38**	(c)
3	(a)	**9**	(c)	**15**	(d)	**21**	(c)	**27**	(d)	**33**	(b)	**39**	(c)
4	(c)	**10**	(a)	**16**	(c)	**22**	(b)	**28**	(d)	**34**	(d)	**40**	(c)
5	(a)	**11**	(b)	**17**	(a)	**23**	(b)	**29**	(d)	**35**	(d)		
6	(c)	**12**	(d)	**18**	(d)	**24**	(a)	**30**	(c)	**36**	(d)		

HINTS AND SOLUTIONS

2. (d) Ca^{++} and S^{--}
8. (b) $Cl + e^- \longrightarrow Cl^-$ (acidic radicals)
9. (c) Mg^{++} $(12 - 2 = 10e^-) = 2, 8$ hence have complete octel hence inert.
12. (d) $Sn + 2Cl_2 \longrightarrow SnCl_4$.
13. (b) Both Na and O_2 are elements.
14. (d) $CuSO_4 + H_2S \longrightarrow \underset{\text{(Black)}}{CuS\downarrow} + H_2SO_4$
(Blue)
15. (d) In all these reactions the reactants decompose to form simpler products.
17. (a) It involves oxidation and reduction.
18. (d) In this carbon reduces PbO to Pb so carbon (C) is reducing agent (reductant) PbO acts as oxidising agent (oxidant) as it oxidises C to CO.
20. (c) $2Fe + 3Cl_2 \longrightarrow 2FeCl_3$ (balanced chemical eqn.)
22. (b) Molal solution contains 1 mole of solute in 1000 g solvent.
23. (b) 1 atom of Cu + 1 atom of sulphur + 9 atoms of oxygen + 10 atoms of hydrogen. Total number of atoms in compound is 21.
25. (c) $n = \dfrac{180}{\text{Molecular mass of } CH_2O} = \dfrac{180}{30}$

$n = 6$
26. (a) Empirical formula of compound = CH_2
Molecular mass of the compound = 42
$\therefore\ n = 42/14 = 3$
$\therefore$ Hence molecular formula = C_3H_6
28. (d) This reaction is double displacement and precipitation as well because insoluble silver chloride gets precipitated.
30. (c) As the sum of the percentage of C, H & N is 100. Thus it does not contains O atom.

Table for empirical formula

Element	%	At. wt.	Rel. Number	Ratio
C	40.00	12	$\frac{40}{12} = 3.66$	$\frac{3.66}{3.33} = 1.09 \sim 1$
H	13.33	1	$\frac{13.33}{1} = 13.33$	$\frac{13.33}{3.33} = 4$
N	46.67	14	$\frac{46.67}{14} = 3.33$	$\frac{3.33}{3.33} = 1$

Hence empirical formula = CH_4N

31. (c)

Element	%	At.wt	Relative number	Ratio
C	40	12	$\frac{40}{12} = 3.33$	$\frac{3.33}{3.33} = 1$
H	6.66	1	$\frac{6.66}{1} = 6.66$	$\frac{6.66}{3.33} = 2$
O	53.34	16	$\frac{53.34}{16} = 3.33$	$\frac{3.33}{3.33} = 1$

(% of O in organic compound
$= 100 - (40 + 6.66) = 53.34\%$)
Empirical formula of organic compound = CH_2O.
32. (c) Rusting is a process in which iron gets converted into hydrated iron oxide in presence of moisture.

$$2Fe + \frac{3}{2}O_2 + xH_2O \longrightarrow \underset{\text{rust}}{Fe_2O_3.xH_2O}$$

33. (b) Heat is required to decompose calcium carbonate. Thus this reaction proceeds with absorption of heat therefore it is endothermic reaction.
34. (d) A chemical reaction is generally accompanied by a change of temperature, colour or evolution of a gas.
35. (d) No reaction occurs in this case.
36. (d) Increase the temperature of the food.
37. (b) $Na_2CO_3 + 2HCl \longrightarrow 2NaCl + CO_2 + H_2O$
38. (c) Dissolution of conc. H_2SO_4 in water produces a lot of heat.
39. (c) Rusting results in formation of iron oxide.
40. (c) Gold is a noble metal.