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Chemistry

Class-12 (Part-I)

For Rajasthan Board of Secondary Education

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2025

Price : ₹ 440/-

Sanjiv Prakashan, Jaipur

- Publisher :
  Sanjiv Prakashan
  Dhamani Market, Chaura Rasta,
  Jaipur-3
  email : sanjeevprakashanjaipur@gmail.com
  website : www.sanjivprakashan.com

- © Publisher

- Laser Typesetting :
  Sanjiv Prakashan (DTP Department), Jaipur

- Printer :
  Punjabi Press, Jaipur
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Sanjiv Prakashan,
Dhamani Market, Chaura Rasta,
Jaipur-302003

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Preface

We are extremely pleased to present this book according to latest syllabus of NCERT. The book has been written in easy and simple language so that students may assimilate the subject easily. We hope that students will get benefitted from it and teachers will appreciate our efforts. In comparison to other books available in market, this book has many such features which make it a unique book :

1. Theoretical subject-material is given in adequate and accurate description along with pictures.
2. The latest syllabus of NCERT is followed thoroughly.
3. Complete solutions of all the questions given at the end of the chapter in the textbook are given in easy language.
4. Topic wise summary is also given in each chapter for the revision of the chapter.
5. In every chapter, all types of questions that can be asked in the exam (Objective, Fill in the blanks, Very short, Short, Numerical and Long answer type questions) are given.
6. At the end of every chapter, multiple choice questions asked in various competitive exams are also given with solutions.

Valuable suggestions received from subject experts, teachers and students have also been given appropriate place in the book.

We wholeheartedly bow to the Almighty God, whose continuous inspiration and blessings have made the writing of this book possible.

We express our heartfelt gratitude to the publisher – Mr. Pradeep Mittal and Manoj Mittal of Sanjiv Prakashan, all their staff, laser type center and printer for publishing this book in an attractive format on time and making it reach the hands of the students.

Although utmost care has been taken in publishing the book, human errors are still possible, hence, valuable suggestions are always welcome to make the book more useful.

In anticipation of cooperation!

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SOLUTIONS

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Solution : Homogenous mixture of two or more substances (which do not react with each other) is known as solution. For example : Brass (mixture of Zn and Ni), German silver (mixture of Cu, Zn and Ni) and bronze (mixture of Cu and Sn).

Homogenous mixture means that the solute should be evenly distributed in the solvent. That is all parts of the solution should have the same composition and properties.

The substance present in large quantity in the solution is known as solvent and the substance which is present in less quantity is known as solute. The solvent determines the physical state of the solution.

The solution made up of two substances is called binary solution and the solution made up three substances is called ternary solution. Generally, only binary solutions are used.

At a certain temperature, when the maximum amount of solute is dissolved in a certain amount of solvent, it is called saturated solution, that is, no more solute can be dissolved in to it further. The solution in which the solute is dissolved in less quantity, that is, more solute can be dissolved in to it, is called unsaturated solution. Unsaturated solutions are also of two types : Dilute and Concentrated.

1.1 Types of Solutions

On the basis of the physical state of the solution, they can be classified in to three parts :

(a) Gaseous Solution : A solution in which the solvent is a gas but the solutes can be gases, liquids or solids. The solution made up of two gases is completely homogenous and it has the maximum solubility. That is to say, every gas is completely miscible with any other gas because in gaseous solution there is free movement of molecules of gases.

(b) Liquid Solution : A solution in which the solvent is liquid and the solute is gas, liquid, or solid, then it is called liquid solution.

The solution formed by using water as a solvent is called Aqueous solution.

(c) Solid Solution : When the particles of a solid, liquid or gas in molecular or atomic size, are dispersed irregularly in another solid substance, then it is called solid solution.

The above three types of solution can be arranged in the form of the following table.

Hence, a total of 9 types of solutions are possible.

Table : Types of Solutions

Type of solution	Solute	Solvent	Example
Gaseous	Gas	Gas	Mixture of oxygen and nitrogen gas ($O_2 + N_2$), air
solutions	Liquid	Gas	Mixture of chloroform in nitrogen gas, water vapour in air
	Solid	Gas	Solution of camphor in nitrogen gas, smoke

Liquid solutions	Gas	Liquid	Oxygen dissolved in water (O_2), ammoniacal water
	Liquid	Liquid	Ethanol dissolved in water (C_2H_5OH), $CHCl_3$ and CCl_4
	Solid	Liquid	Glucose dissolved in water ($C_6H_{12}O_6$), salts etc.
Solid solutions	Gas	Solid	Solution of hydrogen in palladium or Ni
	Liquid	Solid	Amalgam of mercury with sodium, brass, Hg and Zn
	Solid	Solid	Solution of copper in gold (Cu and Au), (Zn and Ni)

1.2 Expressing Concentration of Solutions

The amount of solute dissolved in a certain amount of solvent is known as the concentration of the solution. The composition of a solution is expressed by its concentration.

The quantitative description of the concentration of a solution is mainly done by two types of units :

(a) Weight-Volume units w/V

(b) Weight-Weight units w/w

(a) Weight-Volume units (w/V units) : In these, the solute is expressed in weight and the solvent or the solution is expressed in volume. These units depend on temperature because the volume changes when the temperature is increased. These consist of the following units :

(i) Mass Volume percentage (w/V%)

(ii) Molarity

(iii) Normality

(iv) Formality

(i) Mass-Volume percentage (w/V%) : The mass in grams of the solute dissolved in 100 ml of solution is called mass volume percentage.

$$\text{w/V\%} = \frac{\text{Amount of solute (in grams)}}{\text{Volume of solution (in milliliters)}} \times 100$$

(ii) Molarity (M) : The number of moles of solute dissolved in one litre of solution is called molarity (M) of solution.

$$\text{Molarity} = \frac{\text{Moles of solute}}{\text{Volume of solution (in litre)}}$$

$$= \frac{\text{Amount of solute (in gram)}}{\text{Molecular weight of solute} \times \text{Volume of solution (in litre)}}$$

If w grams of solute is dissolved in V ml of solution then

$$\text{Molarity (M)} = \frac{w \times 1000}{\text{M.W.} \times V}$$

M.W. = Molecular weight of solute

Example : 0.25 $molL^{-1}$ (0.25M) solution of NaOH means that 0.25 mole of NaOH is dissolved in one litre of solution.

(iii) Normality (N) : The number of gram equivalents of solute dissolved in one litre of solution is called normality (N) of the solution.

$$\text{Normality (N)} = \frac{\text{Gram equivalent of solute}}{\text{Volume of solution (in litre)}}$$

$$N = \frac{\text{Amount of solute (in gram)}}{\text{Equivalent weight of solute} \times \text{Volume of solution (in litre)}}$$

When w gram of solute is dissolved in V ml of solution, then

$$N = \frac{w \times 1000}{\text{E.W.} \times V}$$

E.W. = Equivalent weight of solute

To express the concentration of solutions, cm $\left(\frac{1}{2}\right)$, panty $\left(\frac{1}{5}\right)$, deci $\left(\frac{1}{10}\right)$ and centi $\left(\frac{1}{100}\right)$ etc. are used.

Hence, $\frac{N}{2}$ means cm. normal solution, similarly, $\frac{M}{100}$ means centi molar solution.

(iv) Formality (F) : When the solute is found in combined or dissociated form in the solution, then formality is used to express the concentration, for example, when benzoic acid is dissolved in benzene, it forms a dimer and for ionic compounds such as NaCl etc. Formula weight is used instead of molecular weight because no molecules are present in their solution.

The number of gram formula weight of solute dissolved in one litre of solution is called formality of the solution.

$$\text{Formality (F)} = \frac{\text{Gram formula weight of solute}}{\text{Volume of solution in (litre)}}$$

$$F = \frac{\text{Amount of solute (in gram)}}{\text{Molar mass of solute} \times \text{Volume of solution (in litre)}}$$

When w gram of solute is dissolved in V ml of solution, then

$$F = \frac{w \times 1000}{\text{F.W.} \times V}$$

F.W. = Formula weight of solute

When, Molecular weight = Equivalent weight = Formula weight

So, $M = N = F$

Equivalent weight : Equivalent weight of a substance is the number of weight parts which reacts with one weight part of hydrogen or eight weight part of oxygen or 35.5 weight part of chlorine or displace them from their compounds.

Equivalent weight of different substances can be determined by the following formulas :

Equivalent weight of acid

$$= \frac{\text{Molecular weight/Molar mass}}{\text{Number of replaceable } H^+ \text{ (Alkalinity)}}$$

Equivalent weight of bas

$$= \frac{\text{Molecular weight/Molar mass}}{\text{Number of replaceable } OH^- \text{(Acidity)}}$$

Equivalent weight of salt

$$= \frac{\text{Molecular weight/Molar mass}}{\text{Total positive or negative charge}}$$

Equivalent weight of oxidizer

$$= \frac{\text{Molecular weight/Molar mass}}{\text{Number of electrons accepted per molecule}}$$

Equivalent weight of reducing agent

$$= \frac{\text{Molecular weight/Molar mass}}{\text{Number of electrons given up per molecule}}$$

Equivalent weight of atom

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

(b) Weight-Weight units (W/W units) : In these units, both the solute and solvent are expressed in weight. These units do not depend on temperature because weight does not depend on temperature.

These consists of following units :

(i) Mass percentage (W/W%)

(ii) Mole fraction

(iii) Molality

(iv) Parts per million (ppm)

(i) Mass Percentage (W/W%) : The number of weight parts of a solute that is present in 100 weight parts of the solution is called mass percentage.

Mass percentage of an element in solution

$$= \frac{\text{Mass of component present in solution}}{\text{Total mass of solution}} \times 100$$

Mass of solution = Mass solute + Mass of solvent

Example : 10% glucose (mass%) (w/w) means that 10 g of glucose is dissolved in 90 g of water to make 100 g of solution. Mass percentage is used in chemical industry applications. For example, commercial bleaching solution contains 3.62 mass percent sodium hypochlorite in water.

(ii) Mole Fraction (X) : The mole fraction of an element present in a mixture is the ratio of the moles of that element in the mixture and the total moles of all the elements present in the mixture.

Therefore, the mole fraction of any element in the mixture

$$X = \frac{\text{Number of moles of an element}}{\text{Total number of moles of all element}}$$

Example : In a binary soluton, if the moles of components A and B are n_A and n_B, then the mole fraction of A and B will be

$$x_A = \frac{n_A}{n_A + n_B} \quad \text{and} \quad x_B = \frac{n_B}{n_A + n_B}$$

In a solution containing i component :

$$x_i = \frac{n_i}{n_1 + n_2 + ... + n_i} = \frac{n_i}{\sum n_i}$$

The mole fractions of all the components present in a given solution always have units, *i.e.*,

$$x_1 + x_2 + ... + x_i = 1$$

When the masses of A and B are W_A and W_B and their molecular weight are M_A and M_B, then

$$\text{Moles of A } (n_A) = \frac{W_A}{M_A} \text{ and}$$

$$\text{Moles of B } (n_B) = \frac{W_B}{M_B}$$

Mole percentage = Mole fraction × 100

(iii) Molality (m) : The number of moles of solute present in 1000 gram (1 kg) of solvent is called the molality of the solution.

$$\text{Molality (m)} = \frac{\text{Moles of solute}}{\text{Mass of solvent (in kilogram)}}$$

$$= \frac{\text{Weight of solute (in gram)}}{\text{Molecular weight of solute} \times \text{Mass of solvent (in kilogram)}}$$

When w gram of solute is present in W gram of solvents then the molality of the solution,

$$m = \frac{w \times 1000}{M.W. \times W}$$

Example : 1.00 mol kg^{-1} (1.00 m) KCl solution means that 1 mol KCl has been dissolved in 1 kg of water.

(iv) Parts per million (ppm) : The number of parts of a solute that are present in one million (10) parts of the solution is called ppm concentration of the solute.

When very minute amount of solute is present in the solution, then the concentration is expressed in parts per million (ppm).

Parts per million

$$= \frac{\text{Number of parts of solute}}{\text{Total number of parts of solution}} \times 10^6$$

Parts per million (ppm) concentration is expressed in mass-mass, volume-volume and mass-volume.

6×10^{-3} g of oxygen (O_2) is dissolved in one litre [1030 g] of sea water. This low concentration is expressed as 5.8 g per 100 g sea water [5.8 ppm].

The concentration of pollutants in water or atmosphere is usually expressed in $\mu g\ mL^{-1}$ or ppm.

Note : 10^9 is used in the place of 10^6 for ppm in parts per billion (ppb).

Another unit of concentration is volume percentage.

Volume percentage (V/V%) : The number of volume of solute dissolved in 100 volume of a solution is known as volume percentage.

Volume % of any component in solution

$$= \frac{\text{Volume of solute}}{\text{Total volume of solution}} \times 100$$

Example : 10% ethanol (V/V) means that 10 ml of ethanol is dissolved in so much water that the total volume of the solution becomes 100 ml.

Use : Ethylene Glycol $\underset{\text{HO}}{(\text{CH}_2}-\underset{\text{OH}}{\text{CH}_2)}$, 35% (V/V)

Solution is used to cool engine of vehicles (anti-freeze). At this concentration, the anti-freeze lowers the freezing point of water to 255.4K (– 17.6°C).

Important points :

(i) Normality of solution (N) = $\frac{w}{EW} \times \frac{d}{W} \times 1000$

w = weight of solute (in gram), d = density of solution

EW = equivalent weight of solute, W = mass of solution

Similarly,

Molarity of the solution = M = $\frac{w}{M.W} \times \frac{d}{W} \times 1000$

(ii) Normality (N) = Molarity (M) × n coefficient

n factor of coefficent is different for different substances. As,

n factor for acid = basicity of acid

n factor for base = acidity of base

(iii) Relationship between molarity (M) and molality (m)

$$\text{Molality (m)} = \frac{M}{d - \frac{MM_1}{1000}}$$

M = Number of moles of solute present in 1 litre of solution

d = Density of solution (g/ml)

M_1 = Molar mass of solute

or, $$M = m\left(d - \frac{MM_1}{1000}\right)$$

(iv) Relationship between Molarity (M) and mole fraction of solute (X_1) is

$$X_1 = \frac{M}{M + \frac{1000d - MM_1}{M_2}}$$

M_2 = Molar mass of solvent

(v) Relationship between molality (m) and mole fraction of solute (X_1) is

$$X_1 = \frac{mM_2}{1000 + mM_2}$$

M_2 = Molar mass of solvent

(vi) (i) Molarity equation : $M_1V_1 = M_2V_2$

(ii) Normality equation : $N_1V_1 = N_2V_2$

(iii) On mixing two acids or bases,

$$MV = M_1V_1 + M_2V_2$$

(iv) On adding base to acid,

$$MV = M_1V_1 + M_2V_2$$

Where, M_1 and M_2 are the molarities of the solution and V_1 and V_2 are their volume.

(v) Similarly,

$$NV = N_1V_1 + N_2V_2$$

(vi) And, $$NV = N_1V_1 - N_2V_2$$

Where, N_1 and N_2 are the normalities and V_1 and V_2 are their volume.

(vii) **Volume concentration of H_2O_2 solution :**

The dissociation of H_2O_2 solution occurs in the following way :

$$2H_2O_2 \longrightarrow 2H_2O + O_2$$

Hence, its concentration is expressed as volume concentration.

The volume of oxygen obtained from the dissociation of one volume of H_2O_2 solution at standard temperature and pressure (NTP or STP) is called its concentration.

20 volumes of H_2O_2 means that one volume of H_2O_2 dissociates to give 20 volumes of oxygen at NTP. That is, by dissociating one litre of H_2O_2 solution, 20 litre of O_2 will be obtained (at STP or NTP).

$$\text{Molarity of } H_2O_2 = \frac{\text{Volume Concentration}}{11.2}$$

$$\text{Normality of } H_2O_2 = \frac{\text{Volume Concentration}}{5.6}$$