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PREFACE

Dear Student,

Heartiest congratulations on making up your mind and deciding to be an engineer to serve the society.

As you are planning to take various Engineering Entrance Examinations, we are sure that this **STUDY PACKAGE** is going to be of immense help to you.

At NARAYANA we have taken special care to design this package according to the Latest Pattern of AIEEE, which will not only help but also guide you to compete for AIEEE & other State Level Engineering Entrance Examinations.

The salient features of this package include :

- > Power packed division of units and chapters in a scientific way, with a correlation being there.
- Sufficient number of solved examples in Physics, Chemistry & Mathematics in all the chapters to motivate the students attempt all the questions.
- All the chapters are followed by various types of exercises (Level-I, Level-II, Level-III and Questions asked in AIEEE and other Engineering Exams).

These exercises are followed by answers in the last section of the chapter. *This package will help you to know* what to study, how to study, time management, your weaknesses and improve your performance.

We, at NARAYANA, strongly believe that quality of our package is such that the students who are not fortunate enough to attend to our Regular Classroom Programs, can still get the best of our quality through these packages.

We feel that there is always a scope for improvement. We would welcome your suggestions & feedback.

Wish you success in your future endeavours.

THE NARAYANA TEAM

ACKNOWLEDGEMENT

While preparing the study package, it has become a wonderful feeling for the NARAYANA TEAM to get the wholehearted support of our Staff Members including our Designers. They have made our job really easy through their untiring efforts and constant help at every stage.

We are thankful to all of them.

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Theory

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Solved Examples

Exercises

Level-I

Level-II

Level-III

Questions asked in AIEEE and other Engineering Exams

Answers

SOLUTIONS

AIEEE Syllabus

Types of solutions, Units of concentration, Vapour-pressure of solutions and Raoult's law. Colligative properties. Determination of molecular mass. Non-ideal solutions and abnormal molecular masses. Volumetric analysis-concentration unit.

CONTENTS

- > Solutions
- > Solubility
- Methods of expressing concentration
- > Vapour pressure
- > Colligative properties
- Theory of dilute solutions

INTRODUCTION

In this chapter, we will explain properties of solutions that depend only on the number of solute particles and are independent of the chemical identity of the solute, such as the relative lowering of vapour pressure, elevation in boiling point, depression in freezing point and osmotic pressure are known as colligative properties. Further we will deal with quantitatively, the degree to which a solute behaves as though it were dissociated or associated can be expressed by the Van't Hoff factor (i). This factor has been defined as ratio of normal molecular mass to experimentally determined molecular mass.

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1. SOLUTION

A homogeneous mixture of two or more pure substances whose composition may be altered within certain limits is termed as solution.

1.1 CHARACTERISTICS OF SOLUTION

- (i) It is homogeneous in nature, yet retaining the properties of its constituents.
- (ii) It is made of two parts i.e. a solute and a solvent.
- (iii) The component which has the same physical state in pure form as the solution is called solvent and the other is called solute. Example, in case of solution of sugar and water, sugar is the solute and water is solvent.
- (iv) If both the components have same state as the solution, the one component which is in excess is called solvent and the other is called solute. Example, alcohol in water, benzene in toluene etc.

1.2 TYPES OF SOLUTION

	Solvent	Solute	Examples
1.	Gas	Gas	Mixture of gases, air.
2.	Gas	Liquid	Water vapour In air, mist.
3.	Gas	Solid	Sublimation of a solid Into a gas, smoke storms.
4.	Liquid	Gas	CO ₂ gas dissolve in water (aerated drink), soda water.
5.	Liquid	Liquid	Mixture of miscible liquids e.g. alcohol in water.
6.	Liquid	Solid	Salt in water, sugar in water.
7.	Solid	Gas	Adsorption of gases over metals, hydrogen over palladium.
8.	Solid	Liquid	Mercury in zinc, mercury in gold i.e. all amalgams.
9.	Solid	Solid	Homogeneous mixture of two or more metals
			(i.e. alloys) e.g. copper in gold. zinc in copper.

1.3 CAUSE OF MISCIBILITY OF LIQUIDS

- (i) Chemically alike liquids dissolve in one another. e.g. all alkanes are miscible in all proportions with one another because they are non-polar. Similarly polar liquid dissolves in each other; e.g. lower alcohol in water.
- (ii) Dipole interactions i.e. water and ether, water and phenol.
- (iii) Molecular size of liquids which are mutually soluble are also approximately same.

2. SOLUBILITY

The maximum amount of a solute that can be dissolved in 100 g of solvent at a given temperature (usually 25°C) is known its solubility at that temperature.

Solubility = $\frac{\text{Amount of substance dissolved}}{\text{Amount of solvent}} \times 100$

The solubility of a solute in a liquid depends upon the following factors

- (a) Nature of the solute i.e. ionic or covalent (polar or non-polar).
- (b) Nature of the solvent i.e. polar with high dielectric constant or non-polar.

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(c) Temperature - Usually the solubility of the solute increases with increase of temperature (e.g. KNO₃, NH₄Br) but in some cases increase in solubility is negligible (e.g. NaCl) and in cases of some salts (e.g. Na₂SO₄ and CeSO₄ solubility decreases with increase in temperature).

3. METHODS OF EXPRESSING THE CONCENTRATION OF A SOLUTION

There are many ways of expressing the concentration of a solution. These methods are as follows-

(i) Mass percentage -

It may be defined as the number of parts by mass of solute per hundred parts by mass of solution. For example, a 5% (by mass) solution of sugar in water means that 100 g of solution contain 5 g of sugar.

(ii) Volume percentage -

It may be defined as the number of parts by volume of solute per hundred parts by volume of solution. For example, a 25% (by volume) solution of ethyl alcohol means that 100 cm^3 . of the solution contain 25 cm³ of ethyl alcohol and 75 cm³ of water.

(iii) Normality -

Normality of a solution is defined as the number of gram equivalent of the solute dissolved per litre of the solution. It is represented by N. Mathematically.

Normality N =
$$\frac{\text{Mass of solute in grams per litre}}{\text{Equivalent mass of the solute}}$$

A solution having normality equal to one is called "normal solution". Such a solution contains one gram equivalent of solute per litre of solution. A seminormal solution contains $\frac{1}{2}$ gram equivalent. A decinormal solution contains $\frac{1}{10}$ gram equivalent and a centinormal solution contains $\frac{1}{100}$ gram equivalent of solute per litre of solution.

or Normality = $\frac{\text{Mass of the solute} \times 1000}{\text{Equivalent mass of the solute} \times \text{V}}$

or Mass of solute in gram (gm. eq. mass of solute)×volume of solution (L)

Where V is the volume in millilitre.

(iv) Molarity (M) -

Molarity of a solution is defined as the number of gm moles of the solute dissolved per litre of the solution. It is represented by capital M. Mathematically.

Molarity (M) =
$$\frac{\text{Mass of the solute in grams per litre}}{\text{Molecular mass of the solute}} = \frac{\text{gram moles of solute}}{\text{volume of solution in litre}}$$

or
$$M = \frac{\text{mass of solute} \times 1000}{\text{GMM of solute} \times \text{vol. of solution in ml}}$$

A solution having molarity "one" is called molar solution. It may be remembered that both normality as well as molarity of a solution changes with change in temperature.

(v) Molality (m) -

Molality of a solution may be defined as the number of gm moles of the solute dissolved in 1000 gm (1 kg) of the solvent. It is represented by small 'm'. Mathematically

Molality (m) = $\frac{\text{Mass of the solute in grams per kg of solvent}}{\text{Molecular mass of the solute}}$

A solution containing one mole of solute per 1000 gm of solvent (1 kg) has molality equal to one and is called molal solution. Molality is expressed in units of moles per kilogram (mol kg⁻¹). The molality of a solution does not change with temperature.

(vi) Mole fraction -

Mole fraction may be defined as the ratio of the number of moles of one component to the total number of moles of all the components (i.e. solute and solvent) present in the solution.

Let us suppose that a solution contains the components A and B and suppose that a gram of A and b gram of B are present in it. Let the molecular masses of A and B are M_A and M_B respectively.

Then number of moles of A are given by $n_A = \frac{a}{M_A}$

and number of moles of B are given by $n_B = \frac{b}{M_B}$ Total number of moles of A and B = $n_A + n_B$

Mole fraction of A, X_A = $\frac{n_A}{n_A + n_B}$

Mole fraction of B, $X_B = \frac{n_b}{n_A + n_B}$

Sum of mole fractions of all components is always one.

i.e.
$$X_A + X_B = \frac{n_A}{n_A + n_B} + \frac{n_B}{n_A + n_B} = 1$$

So if mole fraction of one component of a binary solution is known say X_B . then the mole fraction of $X_A = 1 - X_B$.

It may be noted that the mole fraction is always independent of the temperature.

(vii) Mole percent -

Mole percent is the number of moles of a component in 100 mole of the solute and solvent. Mole percent = Mole fraction x = 100

Example. for a solution containing 8 moles NH_3 and 12 moles of H_2O .

Mole fraction of NH₃,
$$X_{NH_3} = \frac{8 \text{ mole}}{12 \text{ moles} + 8 \text{ moles}} = \frac{2}{5}$$

Mole percent of $NH_3 = \frac{2}{5} \times 100 = 40$ mole %

(viii) Formality (F) -

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It may be defined as the number of gram formula masses of the ionic solutes dissolved per litre of the solution. Mathematically

Formality (F) = $\frac{\text{Mass of the ionic solute in gram per litre}}{\text{Formula mass of the solute}}$

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Commonly, the term formality is used to express the concentration of the ionic solids which do not exist as molecule but as network of ions.

(ix) Mass fraction -

If W_A is the mass of component A and W_B the mass of component B in the solution, then the mass fraction of component A and B is written as

Mass fraction of A = $\frac{W_A}{W_A + W_B}$

Mass fraction of B = $\frac{W_B}{W_A + W_B}$

(x) Parts per million (ppm) -

When a solute is present in trace amounts, its concentration is expressed in parts per million. It may be defined as the number of parts by mass of solute per million parts by mass of the solution.

Parts per million (ppm) = $\frac{\text{Mass of solute}}{\text{Mass of solution}} \times 10^6$

4. VAPOUR PRESSURE

The pressure exerted by the vapours above the liquid surface in equilibrium with the liquid at a given temperature is called vapour pressure of the liquid.

4.1 VAPOUR PRESSURE OF SOLUTIONS AND RAOULT'S LAW

When a small amount of a non-volatile solute is added to the liquid (solvent). it is found that the vapour pressure of the solution is less than that of the pure solvent. This is due to the fact that the solute particles occupy a certain surface area and as the evaporation is to take place from the surface only. the particles of the solvent will have a less tendency to change into vapour i.e. the vapour pressure of the solution will be less than that of the pure solvent and it is termed as **lowering of vapour pressure**.

The vapour pressure of the solutions of non-volatile solutes can be obtained by applying Raoult's law.

According to this law. the vapour pressure of a solution containing non-volatile solute is proportional to mole fraction of the solvent.

For a two component solution A (volatile) and B (non-volatile) the vapour pressure of solution is given by Vapour pressure of solution = Vapour pressure of solvent in solution \propto Mole fraction of solvent.

 $\mathsf{P} = \mathsf{P}_\mathsf{A} \, \varpropto \, \mathsf{X}_\mathsf{A}$

or $P_A = KX_A$

Where K is proportionality constant.

For pure liquid $X_A = 1$. then K becomes equal to the vapour pressure of the pure solvent which is denoted by P_A^0 .

Thus $P_A = P_A^0 X_A$

or $P_{solution} = P_{pure solvent} x$ mole fraction of solvent

In a solution of two miscible non-volatile liquids. A and B the partial vapour pressure P_A of the liquid A is proportional to its mole fraction X_A and the partial vapour pressure P_B of liquid B is proportional to its mole fraction X_B .

Thus $P_A \propto X_A$

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$$P_A = P_A^0 X_A$$

 $P_B \propto X_B$ Also

$$P_B = P_B^0 X_B$$

Where P^{0}_{A} and P^{0}_{B} are the vapour pressures of pure components A and B respectively.

This relation is called Raoult's law. It states that "For a solution of two or more miscible liquids, the partial vapour pressure of each component is directly proportional to its mole fraction".

Total vapour pressure of solution $P = P_A^0 X_A + P_B^0 X_B$

The solutions which obey Raoult's law are called Ideal solutions. For such solution, vapour pressure of the solution always lies between the vapour pressure of the pure components. Raoult's law is applicable only in case of dilute solutions.

4.2 RELATIVE LOWERING OF VAPOUR PRESSURE

For a solution of non-volatile solute with volatile solvent.

 $P = P_A \propto X_A$ P = vapour pressure of solution

 $P_A = P_A^o X_A$ $P_A =$ vapour pressure of solvent

If mole fraction of solute is X_B , then X_A = mole fraction of solvent and P_A^o = vapour pressure of pure solvent.

$$\begin{aligned} X_A + X_B &= 1 \text{ or } X_A = 1 - X_B \text{ or} \\ P_A &= P^o_A (1 - X_B) = P^o_A - P^o_A - P^o_A X_B \end{aligned}$$

or
$$P_A^o - P_A = P_A^o X_B$$
 or $X_B = \frac{P_A^o - P_A}{P_A^0}$

 $(P_A^o - P_A)$ is the lowering of vapour pressure whereas $\left(\frac{P_A^o - P_A}{P_A^o}\right)$ is called relative lowering of

vapour pressure. So Raoult's law can also be defined as "For a solution containing non-volatile solute, at a particular temperature. the relative lowering of vapour pressure is equal to mole fraction of the solute".

4.3 IDEAL SOLUTIONS

An ideal solution may be defined as the solution which obeys Raoult's law over the entire range of concentration and temperature and during the formation of which no change in enthalpy or volume takes place. So for ideal solutions

It should obey Raoult's law. (i)

i.e.
$$P_A = P_A^o X_A$$
 and $P_B = P_B^o X_B$

(ii) $\Delta H_{\text{mixture}} = 0$

(iii) $\Delta V_{\text{mixture}} = 0$

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There is no solution which behaves strictly as the ideal solution. However, the solution in which solvent solvent and solute-solute interactions are almost of the same type as solvent-solute interactions. behaves as ideal solutions. Example.

- (a) n-heptane and n-hexane
- (b) Chlorobenzene and bromobenzene
- (c) Benzene and toluene
- (d) Ethyl bromide and ethyl iodide

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Only very dilute solutions behave as ideal solutions.

4.4 NON-IDEAL SOLUTIONS

For a non-ideal solutions, the conditions are

(i) Raoult's law is not obeyed

i.e. $P_A \neq P_A^{\circ} X_A$ and $P_B \neq P_B^{\circ} X_B^{\circ}$

(ii) $\Delta H_{\text{mixture}} \neq 0$

(iii) $\Delta V_{\text{mixture}} \neq 0$

The non-ideal solutions are further classified into two catagories

- (a) Solutions with positive deviation and
- (b) Solutions with negative deviation.

4.5 SOLUTION WITH POSITIVE DEVIATION

It has the following characteristics

- (i) Solution in which solvent-solvent and solute–solute interactions are stronger than solvent-solute interactions.
- (ii) At intermediate composition vapour pressure of the solution is maximum.
- (iii) At intermediate composition boiling point is minimum.

So for the non-ideal solutions exhibiting positive deviations

- (i) $P_A > P_A^o X_A$ and $P_B > P_B^o X_B$
- (ii) $\Delta H_{mixture} = + ve$
- (iii) $\Delta V_{\text{mixture}} = + ve$

4.6 AZEOTROPE OR AZEOTROPIC MIXTURE

A solution which distills without change in composition is called azeotropic mixture or azeotrope. Example of positive deviation - A mixture of nhexane and ethanol

4.7 SOLUTION WITH NEGATIVE DEVIATION

It has the following characteristics

- (i) Solutions in which solvent-solvent and solutesolute interactions are weaker than solute-solvent interactions.
- (ii) At intermediate composition vapour pressure of the solution is minimum.
- (iii) At intermediate composition boiling point is maximum.

So for non-ideal solutions exhibiting negative deviations

- (i) $P_A < P_A^{\circ} X_A$ and $P_B < P_B^{\circ} X_B$
- (ii) $\Delta H_{mixture} = -ve$
- (iii) $\Delta V_{mixture} = -ve$

5. COLLIGATIVE PROPERTIES

The properties of dilute solutions containing nonvolatile solute, which depends upon relative number of solute and solvent particles but do not depend upon their nature are called colligative properties. Some of the colligative properties are

- (i) Relative lowering of vapour pressure:
- (ii) Elevation of boiling point;
- (iii) Depression of freezing point; and'
- (iv) Osmotic pressure.

5.1 RELATIVE LOWERING OF VAPOUR PRESSURE

As shown earlier the mathematical expression for relative lowering of vapour pressure is as follows

$$\frac{\Delta P}{P_A^0} = X_B = \text{mole fraction of solute}$$

 $\Delta P = P_A^o - P_A^o =$ lowering of vapour pressure

 P_A = vapour pressure of pure solvent

Molecular mass of non-volatile substance can be determined from relative lowering of vapour pressure

$$\frac{P_{A}^{0} - P}{P_{A}^{0}} = \frac{W_{B} / M_{B}}{W_{A} / M_{A} + W_{B} / M_{B}}$$

For dilute solution $W_B/M_B < W_A/M_A$ and hence W_B/M_B may be neglected in the denominator. So

$$\frac{P_{a}^{o} - P_{A}}{P_{A}^{o}} = \frac{W_{B} / M_{B}}{W_{A} / M_{A}} = \frac{W_{B}}{W_{A}} \times \frac{M_{A}}{M_{B}}$$

or
$$M_B = \frac{W_B / M_A}{W_A} \left(\frac{P_A^o}{P_A^o - P_A} \right)$$

5.2 ELEVATION OF BOILING POINT

The boiling points elevates when a non-volatile solute is added to a volatile solvent. Which occurs due to lowering of vapour pressure.

The boiling point of a liquid may be defined as the temperature at which its vapour pressure becomes equal to atmospheric pressure.

So when a non-volatile solute is added to a volatile solvent results lowering of vapour pressure and consequent elevation of boiling point

$$\Delta T_b \propto \Delta P \propto X_B;$$
 ΔT_b = elevation in B.P.
 ΔP = lowering of V.P.
or $\Delta T_b = KX_B$ X_B = mole fraction of solute

K = elevation constant

- or $\Delta T_{b} = K \frac{W_{B}}{M_{B}} \times \frac{M_{A}}{W_{A}} = K \frac{n_{B}}{W_{A}} \times M_{A}$
- If W_A is the weight of solvent in kg. then $\frac{n_B}{W_A}$ is equal to molality (m) of the solution.

$$\Delta T_{b} = KM_{A}m \text{ or } \Delta T_{b} = K_{b}m$$

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Where K_{b} is molal elevation constant or molal ebullioscopic constant.

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When molality of the solution is equal to one. then

 $\Delta T_{b} = K_{b}$

Hence molal elevation constant of the solvent may be defined as the elevation in its boiling point when one mole of non-volatile solute is dissolved per kg (1000 gm) of solvent. The unit of K_b are K kg mol⁻¹.

Because molality of solution m = $\frac{W_B}{M_B} \cdot \frac{1000}{W_A}$

So
$$\Delta T_{b} = K_{b} \frac{W_{B}}{M_{B}} \cdot \frac{1000}{W_{A}}$$
 $M_{B} = \frac{1000 \times K_{b} \times W_{B}}{\Delta T_{b} \times W_{A}}$

When the volume is taken as 1000 ml., then elevation in boiling point is known as molar elevation constant.

5.3 DEPRESSION IN FREEZING POINT

The freezing point of a pure liquid is fixed. If a non-volatile solute is dissolved in a liquid the freezing point of the solution is lowered. The freezing point is that temperature at which the solvent has the same vapour pressure in two phases. liquid solution and solid solvent. Since the solvent vapour pressure in solution is depressed. its vapour pressure will become equal to that of the solid solvent at a lower temperature

So
$$\Delta T_f \propto \Delta P \propto X_B$$

or
$$\Delta T_{f} = KX_{B} = K \frac{n_{B}}{n_{A} + n_{B}} = K \frac{W_{B}/M_{B}}{W_{A}/M_{A} + W_{B}/M_{B}}$$

For dilute solution $\frac{W_B}{M_B} < \frac{W_A}{M_A}$ and hence $\frac{W_B}{M_B}$ can be neglected in the denominator So.

$$\Delta T_{f} = K \frac{W_{B}/M_{B}}{W_{A}/M_{A}} = K \frac{n_{B} \times M_{A}}{W_{A}}$$

If W_A is the mass of solvent in kg. then $\frac{n_B}{W_A}$ is equal to molality (m) of the solution.

 Δ T_f = KM_Am or Δ T_f = K_fm (K x M_A = K_f)

Where K_f is molal depression constant. When molarity (m) of the solution is one. then

$$\Delta T_f = K_f$$

Hence molal depression constant or molal cryoscopic constant may be defined as "the depression in freezing point when one mole of non-volatile solute is dissolved per kilogram (1000 gm) of solvent" and molar depression constant is defined as "the depression in freezing point when one mole of nonvolatile solute is dissolved per litre (1000 ml) of solvent."

The molecular mass of the non-volatile solute may be calculated by the use of following mathematical equation

$$\mathsf{MB} = \frac{\mathsf{K}_{\mathsf{f}} \times \mathsf{W}_{\mathsf{B}} \times 1000}{\mathsf{W}_{\mathsf{A}} \times \Delta \mathsf{T}_{\mathsf{f}}}$$



Solvent	B.P.	К _b	F.P.	K _f
Acetic acid	118.1°C	2.93	17°C	3.9
Benzene	80.2°C	2.53	5.4°C	5.13
Water	100°C	0.53	0ºC	1.86

5.4 ANTIFREEZE SOLUTIONS

Water is used in radiators of vehicles as cooling liquid. If the vehicle is to be used at high altitudes where temperature is sub-zero. water would freeze in radiators. To avoid this problem. a solution of ethylene glycol in water is used in radiators which will lower the freezing point lower than zero.

The molar mass of ethylene glycol required per kilogram of solvent is calculated by the following formula

MV =
$$\frac{\Delta T_f}{K_r}$$
 k_f (water) = 1.86 K kg mol⁻¹

 Δ T_f = depression of freezing point

6. OSMOTIC PRESSURE

When a solution is separated from the pure solvent with the help of a semipermeable membrane. there occurs the flow of solvent molecules from the pure solvent to the solution side. The flow of solvent molecules from a region of higher concentration of solvent to the region of lower concentration of solvent is termed as the phenomenon of osmosis. This also happens when two solution of different concentrations are separated by a semipermeable membrane.

As a result of osmosis a pressure is developed which is termed as osmotic pressure. It is defined in various methods.

- (1) The excess hydrostatic pressure which builds up as a result of osmosis is called osmotic pressure.
- (2) The excess pressure that must be applied to the solution side to prevent the passage of solvent into it through a semipermeable membrane.
- (3) Osmotic pressure of a solution is equal to the negative pressure which must be applied to the solvent in order to just stop the osmosis.
- (4) The osmotic pressure of a solution may be defined as the extra pressure which should be applied to the solution to increase the 'chemical potential of solvent in solution equal to the chemical potential of the pure solvent at the same temperature.

7. ISOTONIC SOLUTION

The two solutions having equal osmotic pressure are termed as isotonic solution.

Hypertonic solution - A solution having higher osmotic pressure than some' other solution is said to be called hypertonic solution.

Hypotonic solution - A solution having a lower osmotic pressure relative to some other solution is called hypotonic solution.

Semipermeable Membrane

A membrane which allows the passage of solvent molecules but not that of solute. when a solution is separated from the solvent by it is known as semipermeable membrane.

Some example of it are as follows

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- (a) Copper ferrocyanide Cu₂[Fe(CN)₆];
- (b) Calcium phosphate membrane; and
- (c) Phenol saturated with water.

8. THEORY OF DILUTE SOLUTIONS

The osmotic pressure of a dilute solution was the same as the solute would have exerted if it were a gas at the same temperature as of the solution and occupied a volume equal to that of the solution. This generalization is known as **Van't Hoff theory of dilute solutions.**

The osmotic pressure is a colligative property. So the osmotic pressure is related to the number of moles of the solute by the following relation

 $\pi V = nRT$

$$\pi = \frac{n}{V} RT \qquad (\therefore \frac{n}{V} = C)$$
$$\pi = CRT$$

Here C = concentration of solution in moles per litre;

R = solution constant;

T = temperature in Kelvin degree;

n = number of moles of solute; and

V = volume of solution.

Equation A is called Van't Hoff's solution equation.

8.1 VAN'T HOFF-BOYLE'S LAW

If the temperature remaining constant the osmotic pressure of the solution is directly proportional to the molar concentration of the solute. ie.

	$\pi \propto C$	(T constant)
or	$\pi \propto \frac{n}{V}$	(T constant)

For a solution containing same amount at different volume. we will have $\pi \propto \frac{1}{V}$ (T constant)

i.e. osmotic pressure is inversely proportional to the volume.

8.2 VAN'T HOFF-CHARLE'S LAW

At constant volume. the osmotic pressure of a solution is directly proportional to its absolute temperature. i.e.

 $\pi \propto T$ (C constant)

Berkeley and Hartley's method is used to determine the osmotic pressure.

8.3 DETERMINATION OF MOLECULAR MASS FROM. OSMOTIC PRESSURE

The molecular mass of a substance i.e. solute can be calculated by applying the following formula

$$M = \frac{WRT}{\pi V}$$

Accurate molecular mass will only be obtained under following conditions

- (i) The solute must be non-volatile;
- (ii) The solution must be dilute; and
- (iii) The solute should not undergo dissociation or association in the solution.

Solution Constant R - The solution constant R has the same significance and value as the gas canstant. i.e.

R = 0.0821 litre-atm K⁻¹ mol⁻¹ = 8.314 X 10^{-7} erg K⁻¹mol⁻¹

 $= 8.314 \text{ JK}^{-1} \text{ mol}^{-1} = 8.314 \text{ Nm K}^{-1} \text{ mol}^{-1}$

Abnormal molecular masses - When the substances undergo dissociation or association in solution then the value of observed colligative property and value of calculate colligative property are quite different. As the dissociation and association cause changes in the number of particles as compared to usual condition.

8.4 VAN'T HOFF FACTOR

In 1886, Van't Hoff introduced a factor i called Van't Hoff factor to express the extent of association or dissociation of solute in solution.

Van't Hoff factor i = Normal molecular mass Observed molecular mass

In case of association, observed molecular mass being more than the normal the factor i has a value less than 1. But in case of dissociation, the Van't Hoff factor is more than 1 because the observed molecular mass has a lesser magnitude. In case there is no association or dissociation the value i becomes equal to 1. Therefore

 $i = \frac{Observed value of colligative property}{Calculated value of colligative property}$

Introduction of the Van't Hoff factor modifies the equations for the colligative properties as follows

Elevation of B.P. Δ T_b = iK_b m Depression of F.P. Δ T_f = iK_f m

Osmotic pressure $p = \frac{inRT}{V}$

From the value of'[it is possible to calculate degree of dissociation or degree of association of substance in solution by the following formula

$$i = \frac{(1-\alpha) + m\alpha}{1} = 1 + (m - 1)\alpha$$

So

Where α is the degree of dissociation and m is the number of particles per molecule. Similarly degree of association is calculated from 'i' by the following mathematical formula

$$\alpha = \frac{i-1}{1/(m-1)}$$

 $\alpha = \frac{i-1}{(m-1)}$

The ratio of Van't Hoff factor ,i to the number of ions furnished by. one molecule of the electrolyte! 'n' is known as the **osmotic coefficient.** It is denoted by g. Mathematically

Osmotic coefficient 'g' = $\frac{Van't \text{ Hoff factor 'i'}}{'n'}$

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S	50	D	Ľ	V	E	D)	E)	X	4	Ν	Λ	P			5	5

Example - 11.82 a metal required 32.5 mL of N HCl to dissolve it. What is equivalent weight for metal?(1)65(2)(2)75

	(3)	56	(4)	90
Solution :	∴ M	eq. of metal = Meq. of HCl or $\frac{1.82}{E}$	x 1000) = 32.5 x 1
	∴ E	= 56		Ans. (3)
Example - 2	Calc solut	ulate the amount of oxalic acid $(H_2C_2O_4$ ion.	2H ₂ O) required to obtain 250 ml of semimolar
	(1)	15.75 g	(2)	1.575 g
	(3)	157.5 g	(4)	None
Solution :	Mola Volu	rity of solution = 0.5 M me of solution = 250 ml		
	∴ r	nilli mole oxalic acid = M x V (ml) = $\frac{1}{2}$	x 250	or $\frac{W}{M} \times 1000 = 0.5 \times 250$
	÷	$w = \frac{250 \times 126}{2 \times 1000} = 15.76 \text{ g}$		Ans. (1)
Example - 3	The v in so obey	vapour pressure of pure liquid 'A' at 310º lution with liquid B is 72 torr. Calculate t ⁄s Raoult's law.	C is 12 he mol	20 torr. The vapour pressure of this liquid le fraction of 'A' in solution if the mixture
	(1)	0.06	(2)	0.9
	(3)	0.3	(4)	0.6
Solution :	Give	n is vapour pressure of pure componen	t 'A', P'	$^{0}A = 120 \text{ torr}$
	Parti	al pressure of A, P _A = 72 torr		
	Supp	pose its mole fraction is solution is X_A , t	hen ac	cording to Raoult's law.
		$PA = P^{o}A \cdot xA$		
		$72 = 120 \times xA$ or $xA = \frac{72}{120} =$	0.6	Ans. (4)
Example - 4	lf late wate	ent heat of fusion of ice is 80 cals per g a r.	t 0ºC,	calculate molal depression constant for
	(1)	18.63	(2)	186.3
	(3)	1.863	(4)	0.1863
Solution :	K _f =	$\frac{RT_{f}^{2}}{1000l_{v}}$ Here R = 2 cals, T _f = 0 + 27	3 = 27	/3 K, <i>l</i> _f = 80 cals
	K _f =	$\frac{2 \times 273 \times 273}{1000 \times 80} = 1.863$		Ans. (3)

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Example - 5	Calculate the molal elevation constant of water evaporates at 100° C with the absorption of 536 calories per gm (R = 2 cals)
	(1) 0.519°C (2) 0.0519°C
	(3) 1.519°C (4) 2.519°C
Solution :	Molal elevation constant of the solvent.
	Kb = $\frac{RT_b^2}{l_v \times 1000} = \frac{2 \times 373 \times 373}{536 \times 1000} = 0.519^{\circ}C$ Ans. (1)
Example - 6	214.2 gram of sugar syrup contains 34.2 gram of sugar. Calculate (i) molality of the solution and (ii) mole fraction of the sugar in the syrup $-$
	(1) 0.555m, 0.0099 (2) 0.455m, 0.0110
	(3) 0.355m, 0.0199 (4) None of these
Solution :	(i) Mass of sugar = 34.2 gram.
	Number of moles of sugar = $\frac{34.2}{\text{mol. mass}} = \frac{34.2}{34.2} = 0.1$
	Mass of water = $(214.2 - 34.2) = 180$ gram or $\frac{180}{1000}$ kg
	Number of moles of water = $\frac{180}{18} = 10$
	Molality = $\frac{\text{No. of moles of sugar}}{\text{Mass of water in kg}} = \frac{0.1}{180} \times 1000 = 0.555 \text{ m}$
	(ii) Total no. of moles = 10.0 + 0.1 = 10.1
	Mole fraction of sugar = $\frac{\text{No. of moles of sugar}}{\text{Total number of moles}} = \frac{0.1}{10.1} = 0.0099$ Ans. (1)
Example - 7	15 gram of methyl alcohol is dissolved in 35 gram of water. What is the mass percentage of methyl alcohol in solution?
	(1) 30% (2) 50%
	(3) 70% (4) 75%
Solution :	Total mass of solution = $(15 + 35)$ gram = 50 gram
	mass percentage of methyl alcohol = $\frac{\text{Mass of methyl alcohol}}{\text{Mass of solution}} \times 100 = \frac{15}{50} \times 100 = 30\%$
	Ans. (1)
Example - 8	Osmotic pressure of a sugar solution at 24°C is 2.5 atmospheres. Determine the concentration of the solution in gm mole per litre.
	(1) 0.0821 moles/litre (2) 1.082 moles/litre
	(3) 0.1025 moles/litre (4) 0.0827 moles/litre
Solution :	Here it is given that
	π = 2.5 atm, T = 24 + 273 = 297A ^o , S = 0.0821 lit. atm. deg ⁻¹ mol ⁻¹ , C = ?
	We know that $\pi = CST$ or $C = \frac{\pi}{ST} = \frac{2.5}{0.0821 \times 297} = 0.1025$ moles/litre Ans. (3)

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Example - 9	Twe of th of th	nty grams of a substance were dissolve e solution was found to be 600 mm of m e substance.	ed in 50 ercury a	0 ml. of water and the osmotic pressure at 15°C. Determine the molecular weight
	(1)	1120	(2)	1198
	(3)	1200	(4)	None of these
Solution :	Here	e it is given that		
	W	= 20 gm ; V = 500 ml. = $\frac{500}{1000}$ = 0.5 line	tre	
	π=	= 600 mm = $\frac{600}{760}$ atm ; T = 15 + 273 =	288ºA	. m = ?
	Acco	ording to Van't Hoff equation,		
	πV	= nST $\pi V = \frac{w}{m}$ ST		
	∴ I	m = $\frac{\text{wST}}{\pi \text{V}} = \frac{20 \times 0.0821 \times 288 \times 760}{600 \times 0.5}$	= 1198	Ans. (2)
Example - 10	0.15 than eleva	g of a substance dissolved in 15g of sol that of the pure solvent. Calculate the ation constant for the solvent is 2.16°C.	vent bo he mol	iled at a temperature higher by 0.216°C ecular weight of the substance. Molal
	(1)	216	(2)	100
	(3)	178	(4)	None of these
Solution :	Here	e it is given that		
	w =	$0.15 \text{ g}, \Delta \text{T}_{\text{b}} = 0.216^{\circ}\text{C}$		
	W =	15 g K _b = 2.16°C m?		
	Sub	stituting values in the expression,		
		$m = \frac{1000 \times K_b \times w}{\Delta T_b \times W}$		

 $m = \frac{1000 \times 2.16 \times 0.15}{0.216 \times 15} = 100$ Ans. (2)



LEVEL - I

- 1. The amount of anhydrous Na₂CO₃ present in 250 mL of 0.25 M solution is
 - (1) 6.625 g

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(3) 66.25 g

- 2. An example of colligative property is
 - (1) Freezing point
 - (2) Boiling point
 - (3) Vapour pressure
 - (4) Osmotic pressure
- 3. If P₀ and P are the vapour pressures of the solvent and solution respectively and n₁ and n₂ are the mole fractions of the solvent and solute respectively, then
 - (1) $P_s = P_0 n_1$ (2) $P_s = P_0 n_2$
 - (3) $P_0 = P_s n_2$ (4) $P_s = P_0 (n_1/n_2)$
- 4. If P₀ and P_s, are the vapour pressure of solvent and its solution respectively. N₁ and N₂ are the mole fraction of solvent and solute respectively then
 - (1) $P_s = P_0/N_2$
 - (2) $P_0 P_s = P_0 N_2$
 - (3) $P_s = P_0 N_2$
 - (4) $(P_0 P_s) / P_s = N_1 / (N_1 + N_2)$
- 5. A substance will be deliquescent if its vapour pressure is
 - (1) Equal to the atmospheric pressure.
 - (2) Equal to that of water vapour in the air
 - (3) Greater than that of water vapour in the air
 - (4) Lesser than that of water vapours in the air
- The lowering of vapour pressure of a solvent by the addition of a non-volatile solute to it, is directly 6. proportional to
 - (1) The strength of the solution
 - (2) The nature of the solute in the solution
 - (3) The atmospheric pressure
 - (4) All

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- (2) 6.0 g
 - (4) 6.225 g

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- 7. When a substance is dissolved in a solvent, the vapour pressure of solvent decreases. This brings
 - (1) An increase in b.pt. of the solution
 - (2) A decrease in b.pt of a solution
 - (3) An increase in f.pt of the solvent
 - (4) none
- 8. A solution of sulphuric acid in water exhibits
 - (1) Negative deviations from Raoult's law
 - (2) Positive deviations from Raoult's law
 - (3) Ideal properties
 - (4) The applicability of Henry's law
- 9. Which of the follwing is not correct for ideal solution
 - (1) Raoults law is obeyed for entire concentration range and temperatures
 - (2) $\Delta S_{mix} = 0$
 - (3) $\Delta V_{mix} = 0$
 - (4) $\Delta H_{mix} = 0$
- 10. An ideal solution is that which
 - (1) Shows positive deviation from Raoult's law
 - (2) Shows negative deviation from Raoult's law
 - (3) Has no connection with Raoult's law
 - (4) Obeys Raoult's law
- 11. 1000 gram aqueous solution of CaCO₃ contains 10 gram of carbonate. Concentration of solution is
 - (1) 10ppm (2) 100ppm
 - (3) 1000ppm (4) 10,000 ppm
- 12. Azeotropic mixture of water and HCI boils at 381.5 K. By distilling the mixture it is possible to obtain
 - (1) Pure HCI only
 - (2) Pure water only
 - (3) Neither HCI nor water
 - (4) Both water and HC! in pure state
- **13.** Which does not influence the solubility of a solid in a liquid solvent
 - (1) Nature of solute (2) Nature of solvent
 - (3) Temperature (4) Pressure
- **14.** Which solution will show maximum elevation in b.pt
 - (1) 0.1 M KCl (2) 0.1 M BaCl₂
 - (3) 0.1 M FeCl₃ (4) 0.1 M Fe₂(SO₄)₃

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- 15. In cold countries, ethylene glycol is added to water in the radiators of cars during winters. It results in
 - (1) Lowering in boiling point
 - (2) Reducing viscosity
 - (3) Reducing specific heat
 - (4) Lowering in freezing point
- 16. Which of the following 0.1 M aqueous solutions will have the lowest freezing point
 - (1) Potassium sulphate (2) Sodium chloride
 - (3) Urea

- (4) Glucose
- The use of common salts, e.g., NaCI or CaCI₂ anhydrous is made to clear snow on the roads. This causes
 - (1) A lowering in f. pt of water
 - (2) A lowering in m.pt of ice
 - (3) Ice melts at the temperature of atmosphere present at that time
 - (4) All

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- **18.** The correct relation ship between the boiling points of very dilute solutions of $AICI_3(t_1)$ and $CaCI_2(t_2)$ having the same molar concentration is .
 - (1) $t_1 = t_2$ (2) $t_1 > t_2$
 - (3) $t_2 > t_1$ (4) $t_2 \ge t_1$
- **19.** In the case of osmosis, solvent molecules move from
 - (1) Higher vapour pressure to lower vapour pressure
 - (2) Higher concentration to lower concentration
 - (3) Lower vapour pressure to higher vapour pressure
 - (4) Higher osmotic pressure to lower osmotic pressure
- 20. As a result of osmosis, thevolume of the concentrated solution
 - (1) Gradually decreases (2) Gradually increases
 - (3) Suddenly increases (4) none
- 21. The osmotic pressure of a solution of benzoic acid dissolved in benzene is less than expected because
 - (1) Benzoic acid is an organic solute
 - (2) Benzene is a non-polar solvent
 - (3) Benzoic acid dissociates in benzene
 - (4) Benzoic acid gets associated in benzene
- **22.** The spontaneous movement of solute particles from a more concentrated solution to less concentrated solution is called
 - (1) Osmosis (2) Diffusion
 - (3) Plasmolysis (4) Fusion

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- 23. Assuming each salt to be 90% dissociated which of the following will have highest osmotic pressure-
 - (1) Decinormal $AI_2(SO_4)_3$
 - (2) Decinormal BaCl₂
 - (3) Decinormal Na₂SO₄
 - (4) A solution obtained by mixing equal volumes of (2) and (3) and filtering
- 24. Two solutions have different osmotic pressures. The solution of higher osmotic pressure is called
 - (1) Isotonic solution
 - (2) Hypotonic solution
 - (3) Isotopic solution
 - (4) Hypertonic solution
- 25. Which one of the following pairs of solution can we expect to be isotonic at the same temperature
 - (1) 0.1 M urea and 0.1 M NaCl
 - (2) 0.1 M urea and 0.2 M MgCl₂
 - (3) 0.1 M NaCl and 0.1 M Na₂SO₄
 - (4) 0.1 M Ca(NO₃)₂ and 0.1 M Na₂SO₄

LEVEL - II

1.	The normality of 0.3 M phosphorus acid (H_3PO_3) is		
	(1) 0.1	(2)	0.9
	(3) 0.3	(4)	0.6
2.	The maximum amount of BaSO ₄ precipitated on mixing	g 20	mL of 0.5 M BaCl ₂ with 20 mL of 1 M H_2SO_4 is
	(1) 0.25 mole	(2)	0.5 mole
	(3) 1 mole	(4)	0.01 mole
3.	What weight of sodium hydroxide is required to neutra	alise	e 100 mL of 0.1 N HCI
	(1) 4.0 g	(2)	0.04 g
	(3) 0.4 g	(4)	2.0 g
4.	To prepare 0.1 M KMnO ₄ solution in 250 mL flask, the	e we	ight of KMnO ₄ required is
	(1) 4.80g	(2)	3.95g
	(3) 39.5g	(4)	0.48 g
5.	The density of NH_4OH solution is 0.6 g/mL. It contains	34%	$^{\rm 6}$ by weight of NH $_{\rm 4}$ OH. Calculate the normality
		$\langle \mathbf{O} \rangle$	40.11
	(1) 4.8 N	(2)	
•	(3) 0.5 N	(4)	
6.	100 mL each of 0.5 N NaOH, N/5 HCI and N/1 0 H_2 SO	V_4 are	e mixed together. The resulting solution will be
	(1) Acidic	(2)	Neutral
-	(3) Alkaline	(4)	None officese
7.	25 mL of 3.0 M HNO ₃ are mixed with 75 mL of 4.0 M Hi final mixture would be	NO ₃	intrie volumes are additive, the molarity of the
	(1) 325M	(2)	4.0M
	(3) 3.75M	(4)	3.50M
8.	H_3PO_4 is a tribasic acid and one of its salts is NaH ₂ PO	. v	Vhat volume of 1 M NaOH should be added to
	12 g NaH_2PO_4 (mol. wt. 120) to exactly convert it into	o Na	₃ PO ₄
	(1) 100 mL	(2)	300 mL
	(3) 200 mL	(4)	80 mL
9.	How many grams of NaOH will be needed to prepare	250	mL of 0.1 M solution
	(1) 1g	(2)	10g
	(3) 4g	(4)	6g
10.	How many grams of glucose be dissolved to make on	ne liti	re solution of 10% glucose
	(1) 10g	(2)	180g
	(3) 100g	(4)	1.8g
11.	The volume of 0.1 M H_2SO_4 required to neutralise 30) mL	of 2.0 M NaOH is
	(1) 100 mL	(2)	300 mL
	(3) 400 mL	(4)	200 mL
12.	100 mL of 0.3 N HCI solution were mixed with 200 mL of	of 0.6	$S N H_2 SO_4$ solution. The final acidic normality is
	(1) 0.9 N	(2)	0.6 N .
	(3) 0.5 N	(4)	0.4 N
13.	How much water is to be added to dilute 10 mL of 10	NH	CI to make it decinormal
	(1) 990 mL	(2)	1010 mL
	(3) 100 mL	(4)	1000 mL

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14.	The molality of 15% (wt.lvol.) solution of H_2SO_4 of der	nsity	[,] 11 g/cm ³ is approximately
	(1) 1.2	(2)	1.4
	(3) 1.8	(4)	1.6
15.	10 mL of concentrated H ₂ SO ₄ (18M) is diluted to one	itre.	The approximate strength of the dilute acid is
	(1) 18M	(2)	180M
	(3) 0.18M	(4)	1.8M
16.	Equal volumes of 0.1 M AgNO_3 and 0.2 M NaCl are mi will be	xed.	The concentration of NO_3^- ions in the mixture
	(1) 0.1 M	(2)	0.05 M
	(3) 0.2 M	(4)	0.15 M
17.	2.3 g of C_2H_5OH (mol. wt. 46) are dissolved in 500 m	Lof	water. The molarity of the solution is
	(1) 0.01	(2)	0.1
	(3) 0.05	(4)	2.0
18.	The volume of 0.25 M H_3PO_4 required to neutralise 28	5 mL	of 0.03 M Ca(OH) is
	(1) 1.32 mL	(2)	13.2 mL
	(3) 26.4 mL	(4)	2.0 mL
19.	The nature of mixture obtained by mixing 50 mL of 0.	1 Mł	H_2SO_4 and 50 mL of 0.1 M NaOH is
	(1) Acidic	(2)	Basic
	(3) Neutral	(4)	Amphoteric
20.	The solution A and Bare 0.1 and 0.2 molar in a substa	ance	. If 100 mL of A are mixed with 25 ml of B and
	there is no change in volume, then the final molarity o	f the	solution is
	(1) 0.15M	(2)	0.18M
	(3) 0.12M	(4)	0.30M
21.	The number of milli equivalents contained in 0.5 litre of	of 0.	2 N solution is
	(1) 0.1	(2)	100
	(3) 0.01	(4)	1.0
22.	The normality of 1 % (wt.lvol.) H_2SO_4 is nearly		
	(1) 0.02	(2)	0.2
	(3) 0.1	(4)	1
23.	The concentration of solution containing 0.5 mole H_3F	PO ₄	dissolved in 500 g water
	(1) 1m	(2)	1M
	(3) 1N	(4)	0.5M
24.	3.0 molal NaOH solution has a density of 1110 g/ml.	The	molarity of the solution is
	(1) 2.9732	(2)	3.05
	(3) 3.64	(4)	3.0504
25.	An aqueous solution of urea containing 18 g urea in 1	500	cm^3 of solution has a density of 1052 g/cm ³ .
	If the molecular weight of urea is 60, then the molality	of s	olution is
	(1) 0.2	(2)	0.192
	(3) 0.064	(4)	1.2

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LEVEL - III

1.	What is the molarity of H_2SO_4 solution that has a densit	y of 1.84 gm/cc at 35°C and contains 98% by weight
	(1) 4.18M	(2) 8.14M
	(3) 18.4M	(4) 18M
2.	In order to prepare 100 cm ³ of 0.250 M barium chloride	solution the amount of $BaCl_2.2H_2O$ re quired will be -
	(1) 0.250 moles	(2) 0.0025 moles
	(3) 2.5 moles	(4) 6.1 gram of BaCl ₂ .2H ₂ O
3.	0.2 moles of HCI and 0.1 moles of $CaCI_2$ were dissolv of CI ⁻ ions is	ed in water to have 500 ml of solution, the molarity
	(1) 0.04 M	(2) 0.8 M
	(3) 0.4 M	(4) 0.08 M
4.	The number of iodine atoms present in 40 mL solution	n of its 0.1 M solution -
	(1) 4.81×10^{21}	(2) 24.08×10^{21}
	(3) 0.408 x 10 ²³	(4) 6.02×10^{22}
5.	10 gram of glucose are dissolved in 150 gram of wate	er. The mass % of glucose is
	(1) 5%	(2) 6.25%
	(3) 93.75%	(4) 15%
6.	The volume strength of H_2O_2 solution is 10. What do	es it mean
	(1) At S.T.P. 10gm solution of H_2O_2 gives 10ml. of C	2
	(2) At S.T.P. 1gm equivalent of H_2O_2 gives 10ml. of G_2O_2	D_2
	(3) At ST.P. 10 litre solution of $\rm H_2O_2$ gives 10ml . of	0 ₂
	(4) At S.T.P. 1ml solution of H_2O_2 gives 10ml . of O_2	
7.	If 5.85 gm. of NaCI are dissolved in 90gms.of water the	ne mole fraction of NaCI is
	(1) 0.1	(2) 0.01
	(3) 0.02	(4) 0.2
8.	What is the strength in g per litre of a solution of H_2SO_4 1	2 ml of which neutralized 15ml of N/10 NaOH solution
	(1) 3.125 g/l	(2) 4.125 g/l
	(3) 5.125 g/l	(4) 6.125 g/l
9.	What weight of HNO ₃ is required to make 1 litre of 21 reaction: $3 \text{ Cu} + 8 \text{ HNO}_3 \rightarrow 3 \text{ Cu} (\text{NO}_3)_2 + 2 \text{NO} + 4 \text{ H}$	N solution to be used as an oxidising agent in the. $_2 O$
	(1) 63gm	(2) 21 gm
	(3) 42 gm	(4) 84gm
10.	What weight of ferrous ammonium sulphate is needer lent weight = 392)	d to prepare 100 ml of 0.1 normal solution (equiva-
	(1) 39.2 gram	(2) 3.92 gram
	(3) 1.96 gram	(4) 19.6 gram
	22	

11.

density equal to 1.05. The molality of solution is (1) 1.25 (2) 0.19 (3) 0.25 (4) 0.30 12. One among the following is an incorrect statement (1) Molality of a solution is dependent on the temperature (2) Molarity of a solution is dependent on the temperature (3) Normality of 0.5 M aqueous solution of H₂C₂O₄.2H₂O is 1 N (4) Molality of a, solution relates moles of solute and mass of solvent 13. What will be the normality of a solution obtained by mixing 0.45 Nand 0.60 N NaOH in the ratio 2 : 1 by volume -(1) 0.4N (2) 0.5N (3) 1.05N (4) 0.15N 14. 1.0 g of pure calcium carbonate was found to require 50 mL of dilute HCI for complete reactions. The strength of the HCI solution is given by (1) 4N (2) 2N (3) 0.4N (4) 0.2 N 15. If the vapour pressure of solutions of two liquids are less than those expected from ideal solution they are said to have (1) Negative deviation from ideal behaviour (2) Positive deviations from ideal behaviour (3) Ideal behaviour (4) Positive deviation for lower cone. and negative deviations for higher concentration Pure water freezes at 5.45°C at a certain place but a 0.374 m solution of tetra chloroethane in benzene 16. freezes at 3.55°C. The K_f for benzene is (2) 508 K kg mol⁻¹ (1) 5.08 K. kg mol⁻¹ (4) 50.8 °C kg mol⁻¹ (3) 0.508 K kg mol⁻¹ At certain Hill-station pure water boils at 99.725°C. If K_b for water is 0.513°C kg mol⁻¹. The boiling point 17. of 0.69 m solution of urea will be (1) 100.079°C (2) 103°C (4) Un predictable (3) 100.359°C The molar freezing point constant for water is 1.86 °C/mole. if 342 gm of cane sugar (C12H22O11) is 18 dissolved in 1000 gram of water, the solution will freeze at-(1) -1.86 °C (2) 1.86°C (3) -3.92 °c (4) 2.42°C 19. The melting points of most of the solid substance increase with an increase of pressure acting on them. However, ice melts at a temperature lower than its usual melting point, when the pressure is increased. This is because (1) ice is less dense than water (2) pressure generate heat (3) the chemical bonds break under pressure (4) ice is not a true solid - 23 -

An aqueous solution of non-electrolyte "A" with molecular mass 60 contains 6 g in 500 ml and has

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20.	At low concentrations, the statement that equimolal tions have equal osmotic pressures is true for	solut	ions under a given set of experimental condi-
	(1) All solutions	(2)	Solutions of non-electrolyte only
	(3) Solution of electrolyte only	(4)	None of these
21.	If the observed and theoretical molecular mass of Na of dissociation of NaCI is	ICI is	found to be 31.80 and 58.50, then the degree
	(1) 83.96%	(2)	8.39%
	(3) 90%	(4)	100%
22.	A 5.8% solution of NaCI has vapour pressure closest	t to	
	(1) 5.8 % solution of urea	(2)	2 m solution of glucose
	(3) 1 m solution of urea	(4)	5.8 % solution of glucose
23.	For dilute solution Raoult's law states that		
	(1) The lowering of vapour pressure is equal to the n	nole	fraction of the solute
	(2) The relative lowering of vapour pressure is equal	l to th	e mole fraction ofthe solute

- (3) The relative lowering of vapour pressure is proportional to the amount of solute in solution
- (4) The vapour pressure of the solution is equal to the mole fraction of the solvent
- 24. An azeotropic solution of two liquids has boiling point lower than either of them when it
 - (1) Shows a negative deviation from Raoult's law
 - (2) Shows no deviation from Raoult's law
 - (3) Shows positive deviation from Raoult's law
 - (4) Is saturated

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25. A 5% solution of cane sugar is isotonic with 0.877 % of X. The molecular weight of substance X is

- (1) 58.98 (2) 119.96
- (3) 95.58 (4
- 4) 400.00
 - (4) 126.98

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PROBLEMS ASKED IN COMPETITIVE EXAMINATIONS

	A 5.25% solution of a substance is isotonic with a 1.5 same solvent. If the densities of both the solutions a of the substance will be	5% solution of urea (molar mass = 60 g mol^{-1}) in the are assumed to be equal to 1.0 g cm ⁻³ , molar mass [AIEEE 2007]
	(1) 105.0 g mol ⁻¹	(2) 210.0 g mol ⁻¹
	(2) 90.0 g mol ⁻¹	(4) 115.0 g mol ⁻¹
2.	If an aqueous solution of glucose is allowed to freeze	e, then crystals of which will be separated out first?
		[DPMT 2005]
	(1) glucose	(2) water
	(3) both of these	(4) none of these
3.	If two substances A and B have $p_A^\circ: p_B^\circ = 1:2$ and have $p_A^\circ: p_B^\circ = 1:2$ and have $p_A^\circ: p_B^\circ = 1:2$ and p_B°	ave mole fraction in solution 1 : 2, then mole fraction [DPMT 2005]
	(1) 0.33	(2) 0.25
	(3) 0.52	(4) 0.2
4.	Solution A contains 7 g/L MgCl ₂ and solution B conta pressure of	ins 7 g/L of NaCl. At room temperature, the osmotic [DCE 2005]
	(1) solution A is greater than B	(2) both have same osmotic pressure
	(3) solution B is greater than A	(4) can't determine
5.	Which has minimum osmotic pressure?	[DCE 2005]
	(1) 200 ml of 2 M NaCl solution	(2) 200 ml of 1 M glucose solution
	(3) 200 ml of 2 M urea solution	(4) all have same
6.	X is dissolved in water. Maximum boiling point is obs	served when X is (0.1 M each) [DCE 2005]
	(1) CuSO ₄	(2) BaCl ₂
	(3) NaCl	(4) urea
7.	 (3) NaCl A solution of urea (mol. mass 56 g mol⁻¹) boils at 100 water are 1.86 and 0.512 K kg mol⁻¹ respectively, th 	(4) urea 0.18°C at the atmospheric pressure. If K _f and K _b for he above solution will freeze at [CBSE PMT 2005]
7.	(3) NaCl A solution of urea (mol. mass 56 g mol ⁻¹) boils at 100 water are 1.86 and 0.512 K kg mol ⁻¹ respectively, th (1) -6.54° C	(4) urea 0.18°C at the atmospheric pressure. If K_f and K_b for ie above solution will freeze at [CBSE PMT 2005] (2) -0.654 °C
7.	(3) NaCl A solution of urea (mol. mass 56 g mol ⁻¹) boils at 100 water are 1.86 and 0.512 K kg mol ⁻¹ respectively, th (1) -6.54° C (3) 6.54° C	 (4) urea 0.18°C at the atmospheric pressure. If K_f and K_b for the above solution will freeze at [CBSE PMT 2005] (2) -0.654°C (4) 0.654°C
7. 8.	 (3) NaCl A solution of urea (mol. mass 56 g mol⁻¹) boils at 100 water are 1.86 and 0.512 K kg mol⁻¹ respectively, th (1) -6.54°C (3) 6.54°C The vapour pressure of the two liquids 'P' and 'Q' pressure of the solution obtained by mixing 3 mole obtained	 (4) urea 0.18°C at the atmospheric pressure. If K_f and K_b for the above solution will freeze at [CBSE PMT 2005] (2) -0.654°C (4) 0.654°C are 80 and 60 torr respectively. The total vapour of P and 2 mole of Q would be [CBSE PMT 2005]
7. 8.	 (3) NaCl A solution of urea (mol. mass 56 g mol⁻¹) boils at 100 water are 1.86 and 0.512 K kg mol⁻¹ respectively, th (1) -6.54°C (3) 6.54°C The vapour pressure of the two liquids 'P' and 'Q' pressure of the solution obtained by mixing 3 mole of (1) 68 torr 	 (4) urea 0.18°C at the atmospheric pressure. If K_f and K_b for the above solution will freeze at [CBSE PMT 2005] (2) -0.654°C (4) 0.654°C (4) 0.654°C (5) are 80 and 60 torr respectively. The total vapour of P and 2 mole of Q would be [CBSE PMT 2005] (2) 140 torr
7. 8.	 (3) NaCl A solution of urea (mol. mass 56 g mol⁻¹) boils at 100 water are 1.86 and 0.512 K kg mol⁻¹ respectively, the (1) -6.54°C (3) 6.54°C The vapour pressure of the two liquids 'P' and 'Q' pressure of the solution obtained by mixing 3 mole of (1) 68 torr (3) 72 torr 	 (4) urea 0.18°C at the atmospheric pressure. If K_f and K_b for the above solution will freeze at [CBSE PMT 2005] (2) -0.654°C (4) 0.654°C (4) 0.654°C (5) are 80 and 60 torr respectively. The total vapour of P and 2 mole of Q would be [CBSE PMT 2005] (2) 140 torr (4) 20 torr
7. 8. 9.	 (3) NaCl A solution of urea (mol. mass 56 g mol⁻¹) boils at 100 water are 1.86 and 0.512 K kg mol⁻¹ respectively, th (1) -6.54°C (3) 6.54°C The vapour pressure of the two liquids 'P' and 'Q' pressure of the solution obtained by mixing 3 mole of (1) 68 torr (3) 72 torr The mole fraction of the solute in one molal aqueous 	 (4) urea 0.18°C at the atmospheric pressure. If K_f and K_b for the above solution will freeze at [CBSE PMT 2005] (2) -0.654°C (4) 0.654°C (4) 0.654°C (5) are 80 and 60 torr respectively. The total vapour of P and 2 mole of Q would be [CBSE PMT 2005] (2) 140 torr (4) 20 torr (5) solution is [CBSE PMT 2005]
7. 8. 9.	 (3) NaCl A solution of urea (mol. mass 56 g mol⁻¹) boils at 100 water are 1.86 and 0.512 K kg mol⁻¹ respectively, the (1) -6.54°C (3) 6.54°C The vapour pressure of the two liquids 'P' and 'Q' pressure of the solution obtained by mixing 3 mole of (1) 68 torr (3) 72 torr The mole fraction of the solute in one molal aqueous (1) 0.027 	 (4) urea 0.18°C at the atmospheric pressure. If K_f and K_b for the above solution will freeze at [CBSE PMT 2005] (2) -0.654°C (4) 0.654°C (4) 0.654°C (5) are 80 and 60 torr respectively. The total vapour of P and 2 mole of Q would be [CBSE PMT 2005] (2) 140 torr (4) 20 torr (5) solution is [CBSE PMT 2005] (2) 0.036
7. 8. 9.	 (3) NaCl A solution of urea (mol. mass 56 g mol⁻¹) boils at 100 water are 1.86 and 0.512 K kg mol⁻¹ respectively, the (1) -6.54°C (3) 6.54°C The vapour pressure of the two liquids 'P' and 'Q' pressure of the solution obtained by mixing 3 mole of (1) 68 torr (3) 72 torr The mole fraction of the solute in one molal aqueous (1) 0.027 (3) 0.018 	(4) urea 0.18°C at the atmospheric pressure. If K_f and K_b for the above solution will freeze at [CBSE PMT 2005] (2) -0.654°C (4) 0.654°C are 80 and 60 torr respectively. The total vapour of P and 2 mole of Q would be [CBSE PMT 2005] (2) 140 torr (4) 20 torr s solution is [CBSE PMT 2005] (2) 0.036 (4) 0.009
7. 8. 9.	 (3) NaCl A solution of urea (mol. mass 56 g mol⁻¹) boils at 100 water are 1.86 and 0.512 K kg mol⁻¹ respectively, the (1) -6.54°C (3) 6.54°C The vapour pressure of the two liquids 'P' and 'Q' pressure of the solution obtained by mixing 3 mole of (1) 68 torr (3) 72 torr The mole fraction of the solute in one molal aqueous (1) 0.027 (3) 0.018 Equimolar solutions in the same solvent have 	(4) urea 0.18°C at the atmospheric pressure. If K_f and K_b for the above solution will freeze at [CBSE PMT 2005] (2) -0.654°C (4) 0.654°C are 80 and 60 torr respectively. The total vapour of P and 2 mole of Q would be [CBSE PMT 2005] (2) 140 torr (4) 20 torr s solution is [CBSE PMT 2005] (2) 0.036 (4) 0.009 [AIIEE 2005]
7. 8. 9.	 (3) NaCl A solution of urea (mol. mass 56 g mol⁻¹) boils at 100 water are 1.86 and 0.512 K kg mol⁻¹ respectively, the (1) -6.54°C (3) 6.54°C The vapour pressure of the two liquids 'P' and 'Q' pressure of the solution obtained by mixing 3 mole of (1) 68 torr (3) 72 torr The mole fraction of the solute in one molal aqueous (1) 0.027 (3) 0.018 Equimolar solutions in the same solvent have (1) same boiling point but different freezing point 	 (4) urea 0.18°C at the atmospheric pressure. If K_f and K_b for the above solution will freeze at [CBSE PMT 2005] (2) -0.654°C (4) 0.654°C (4) 0.654°C (2) are 80 and 60 torr respectively. The total vapour of P and 2 mole of Q would be [CBSE PMT 2005] (2) 140 torr (4) 20 torr (5) solution is [CBSE PMT 2005] (2) 0.036 (4) 0.009
7. 8. 9.	 (3) NaCl A solution of urea (mol. mass 56 g mol⁻¹) boils at 100 water are 1.86 and 0.512 K kg mol⁻¹ respectively, the (1) -6.54°C (3) 6.54°C The vapour pressure of the two liquids 'P' and 'Q' pressure of the solution obtained by mixing 3 mole of (1) 68 torr (3) 72 torr The mole fraction of the solute in one molal aqueous (1) 0.027 (3) 0.018 Equimolar solutions in the same solvent have (1) same boiling point but different freezing point (2) same freezing point but different boiling points 	 (4) urea 0.18°C at the atmospheric pressure. If K_f and K_b for the above solution will freeze at [CBSE PMT 2005] (2) -0.654°C (4) 0.654°C (4) 0.654°C (2) are 80 and 60 torr respectively. The total vapour of P and 2 mole of Q would be [CBSE PMT 2005] (2) 140 torr (4) 20 torr (2) 0.036 (4) 0.009
7. 8. 9.	 (3) NaCl A solution of urea (mol. mass 56 g mol⁻¹) boils at 100 water are 1.86 and 0.512 K kg mol⁻¹ respectively, the (1) -6.54°C (3) 6.54°C The vapour pressure of the two liquids 'P' and 'Q' pressure of the solution obtained by mixing 3 mole of (1) 68 torr (3) 72 torr The mole fraction of the solute in one molal aqueous (1) 0.027 (3) 0.018 Equimolar solutions in the same solvent have (1) same boiling point but different freezing point (2) same freezing point but different boiling points (3) same boiling and same freezing points 	(4) urea 0.18 °C at the atmospheric pressure. If K_f and K_b for the above solution will freeze at [CBSE PMT 2005] (2) -0.654 °C (4) 0.654 °C are 80 and 60 torr respectively. The total vapour of P and 2 mole of Q would be [CBSE PMT 2005] (2) 140 torr (4) 20 torr s solution is [CBSE PMT 2005] (2) 0.036 (4) 0.009 [AIIEE 2005]

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11.	Two solutions of a substance (non-electrolyte) are mi solution + 520 mL of 1.2 M second solution. What is	ixed in the following manner : 480 mL of 1.5 M first the molarity of the final mixture? [AIIEE 2005]					
	(1) 1.20 M	(2) 1.50 M					
	(3) 1.344 M	(4) 2.70 M					
12.	Benzene and Toluene form nearly ideal solution. At 20°C, the vapour pressure of benzene is 75 torr and that of toluene is 22 torr. The partial vapour pressure of benzene at 20°C in a solution containing 78 g of beznene and 46 g of toluene in torr is [AIEEE 2005]						
	(1) 50	(2) 25					
	(3) 37.5	(4) 53.5					
13.	If α is the degre of dissociation of Na ₂ SO ₄ , the vant' Hoff factor (i) used for calculating the molecular mass is [AIIMS 2005]						
	(1) $1 + \alpha$	(2) $1 - \alpha$					
	(3) $1 + 2\alpha$	(4) $1 - 2\alpha$					
14.	The elevation in boiling point of a solution of 13.44 g mol ⁻¹ , molecular weight of $CuCl_2 = 134.4$].	of $CuCl_2$ in 1 kg of water is (Given $K_b = 0.52$ K kg [IIT 2005]					
	(1) 0.05	(2) 0.1					
	(3) 0.16	(4) 0.21					
15.	The volumes of 4 N HCl and 10 N HCl required to ma	ke 1 litre of 6 N HCl are [Kerala MEE 2004]					
	(1) 0.75 litre of 4 N HCl and 0.25 litre of 10 N HCl						
	(2) 0.25 litre of 4 N HCl and 0.75 litre of 10 N HCl						
	(3) 0.67 litre of 4 N HCl and 0.33 litre of 10 N HCl						
	(4) 0.80 litre of 4 N HCl and 0.20 litre of 10 N HCl						
16.	Ethylene glycol is added to water as antifreeze. It will	[Kerala CEE 2004]					
	(1) decrease the freezing point of water in winter and increase the boiling point of water in summer						
	(2) only decrease the freezing point of water						
	(3) only increase the boiling point of water						
	(4) be used for cleaning the radiator in a car						
17.	Mole fraction of solute in benzene is 0.2, then the mo	olality of the solution is [Bihar CECE 2004]					
	(1) 3.2	(2) 2					
	(3) 4	(4) 3.6					
18.	Vapour pressure of dilute aqueous solution of glucose of the solute is	e is 750 mm of mercury at 373 K. The mole fraction [J&K CET 2004]					
	(1) 1/76	(2) 1/7.6					
	(3) 1/38	(4) 1/10					
19.	Maximum freezing point falls in	[J&K CET 2004]					
	(1) camphor	(2) naphthalene					
	(3) benzene	(4) water					
20.	In 100 g of naphthalene, 2.423 g of S was dissolved. N $L_f = 35.7$ cal/g of naphthalene. Molecular formula of s	Melting point of naphthalene = 80.1° C. $\Delta T_f = 0.661^{\circ}$.Sulphur added is[Orissa JEE 2004]					
	(1) S ₂	(2) S ₄					
	(3) S ₆	(4) S ₈					

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21.	To neutralise completely 20 mL of 0.1 M aqueous so 0.1 M aqueous KOH solution required is	olution of phosphorous acid (F	H ₃ PO ₃), the volume of [AIEEE 2004]		
	(1) 10 mL	(2) 20 mL			
	(e) 40 mL	(4) 60 mL			
22.	6.02×10^{20} molecules of urea are present in 100 ml of its solution. The concentration of urea solution is				
			[AIEEE 2004]		
	(1) 0.001 M	(2) 0.01 M			
	(3) 0.02 M	(4) 0.1 M			
23.	A 0.004 M solution of Na_2SO_4 is isotonic with a 0. apparent degree of dissociation of $Na_2SO_{4 is}$	010 M solution of glucose at	the temperature. The [IIT 2004]		
	(1) 25%	(2) 50%			
	(3) 75%	(4) 85%			
24.	Camphor is often used in molecular mass determin	ation because	[CBSE PMT 2004]		
	(1) it is readily available				
	(2) it has a very high cryoscopic constant				
	(3) it is volatile				
	(4) it is solvent for organic substances				
25.	The average osmotic pressure of human blood is aqueous NaCl solution that could be used in the blo	s 7.8 bar at 37°C. What is the bod stream?	e concentration of an [AIIMS 2004]		
	(1) 0.15 mol/L	(2) 0.30 mol/L			
	$(2) 0 0 0 m a \mid l \mid l$	$(A) \bigcirc A \Box = a a / $			

(3) 0.60 mol/L (4) 0.45 mol/L



EXERCISES

LEVEL - I

1.	(1)	2.	(4)	3. (1)	4.	(2)	5.	(4)				
6.	(1)	7.	(1)	8. (1)	9.	(2)	10.	(4)				
11.	(4)	12.	(3)	13. (4)	14.	(4)	15.	(4)				
16.	(1)	17.	(4)	18. (2)	19.	(1)	20.	(2)				
21.	(4)	22.	(2)	23. (1)	24.	(4)	25.	(4)				
LEVEL - II												
1.	(4)	2.	(4)	3. (3)	4.	(2)	5.	(4)				
6.	(3)	7.	(3)	8. (3)	9.	(1)	10.	(3)				
11.	(2)	12.	(3)	13. (1)	14.	(4)	15.	(3)				
16.	(2)	17.	(2)	18. (4)	19.	(1)	20.	(3)				
21.	(2)	22.	(2)	23. (1)	24.	(1)	25.	(2)				
LEVEL - III												
1.	(3)	2.	(4)	3. (2)	4.	(1)	5.	(2)				
6.	(4)	7.	(3)	8. (4)	9.	(3)	10.	(2)				
11.	(2)	12.	(1)	13. (2)	14.	(3)	15.	(1)				
16.	(1)	17.	(1)	18 (1)	40	(1)	25.	(2)				
	(-)		(.)	10. (1)	19.	(4)						
21.	(1)	22.	(2)	23. (2)	19. 24.	(3)	25.	(1)				
21.	(1)	22.	(2)	23. (2)	19. 24.	(3)	25.	(1)				
21.		22.			19. 24.		25.	(1)				
21.		22. S A	(2) SKED IN CO	23. (2) OMPETITIVE E	19. 24. EX		25.	(1)				
21. PF	(1) ROBLEM (2)	22. S A 2.	(2) SKED IN C((2)	23. (2) OMPETITIVE E 3. (4)	19. 24. EX 4.	(3) AMINATION (3)	25. NS 5.	(1)				
21.PF1.6.	(1) ROBLEMS (2) (2)	22. S A 2. 7.	(2) SKED IN C (2) (2) (1)	23. (2) OMPETITIVE E 3. (4) 8. (3)	19. 24. EX 4. 9.	(3) AMINATION (3) (3)	25. NS 5. 10.	 (1) (2) (3) (2) 				
 21. PF 1. 6. 11. 12. 	(1) ROBLEMS (2) (2) (3) (4)	22. S A 2. 7. 12.	(2) SKED IN C((2) (2) (1) (1)	 23. (2) OMPETITIVE E 3. (4) 8. (3) 13. (3) 40. (4) 	19. 24. EX 4. 9. 14.	(4) (3) AMINATION (3) (3) (3) (4)	25. NS 5. 10. 15.	 (1) (2) (3) (4) 				
 21. PF 1. 6. 11. 16. 21. 	(1) ROBLEMS (2) (2) (3) (1) (2)	22. S A 2. 7. 12. 17.	(2) (2) (2) (2) (1) (1) (1)	 3. (4) 8. (3) 13. (3) 18. (1) 23. (2) 	19. 24. 4. 9. 14. 19.	(4) (3) AMINATION (3) (3) (3) (1)	25. 10 . 15. 20.	 (1) (2) (3) (3) (4) (4) 				

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