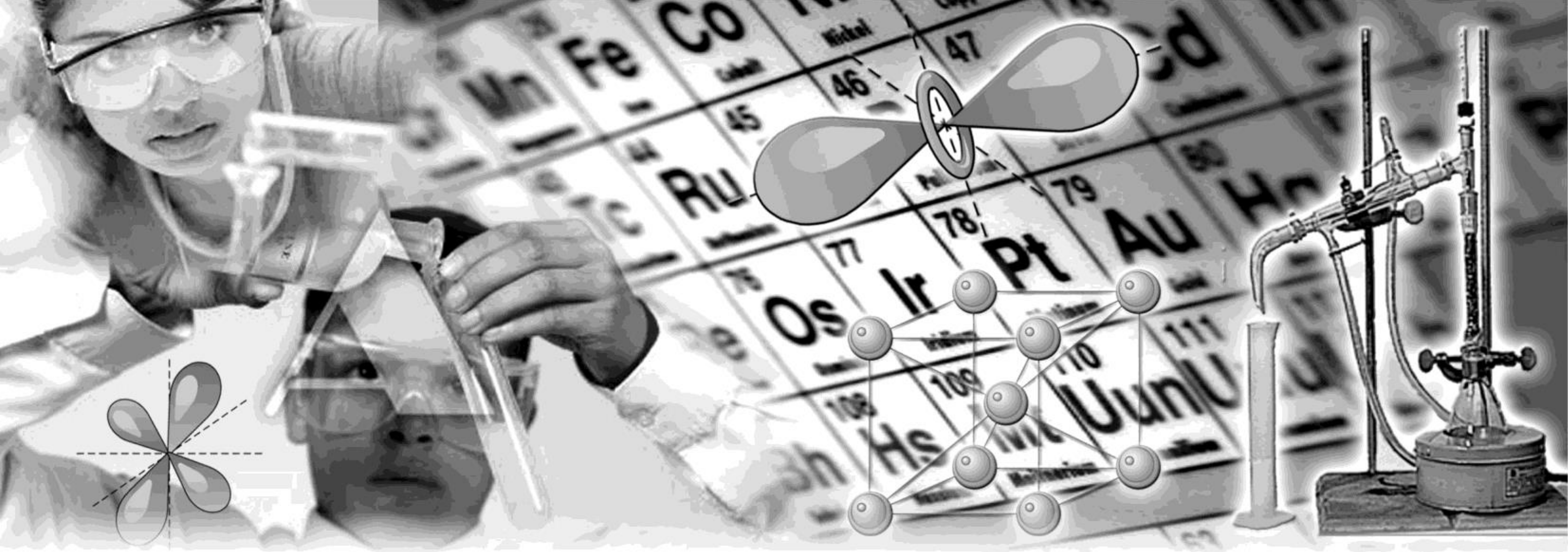


Chapter 4

Solution & Colligative properties

"A solution is a mixture in which substances are intermixed so intimately that they can not be observed as separate components". The dispersed phase or the substance which is to be dissolved is called **solute**, while the dispersion medium in which the solute is dispersed to get a homogenous mixture is called the **solvent**.

Solubility

"*Solubility of a substance may be defined as the amount of solute dissolved in 100gms of a solvent to form a saturated solution at a given temperature*". A ***saturated solution*** is a solution which contains at a given temperature as much solute as it can hold in presence of dissolveding solvent. Any solution may contain less solute than would be necessary to saturate it. Such a solution is known as ***unsaturated solution***. When the solution contains more solute than would be necessary to saturate it then it is termed as ***supersaturated solution***.

Kinds of solutions

All the three states of matter (gas, liquid or solid) may behave either as solvent or solute. Depending on the state of solute or solvent, mainly there may be following nine types of binary solutions.

Solvent	Solute	Example
Gas	Gas	Mixture of gases, air.
Gas	Liquid	Water vapours in air, mist.
Gas	Solid	Sublimation of a solid into a gas, smoke.
Liquid	Gas	CO_2 gas dissolved in water (aerated drinks).
Liquid	Liquid	Mixture of miscible liquids, e.g., alcohol in water.
Liquid	Solid	Salt in water, sugar in water.
Solid	Gas	Adsorption of gases over metals; hydrogen over palladium.
Solid	Liquid	Mercury in zinc, mercury in gold, $CuSO_4.5H_2O$.
Solid	Solid	Homogeneous mixture of two or more metals (alloys), e.g., copper in gold, zinc in copper.

Among these solutions the most significant type of solutions are those which are in liquid phase and may be categorised as, (1) Solid in liquid solutions, (2) Liquid in liquid solutions and (3) Gas in liquid solutions.

Methods of expressing concentration of solution

Concentration of solution is the amount of solute dissolved in a known amount of the solvent or solution. The concentration of solution can be expressed in various ways as discussed below,

(1) **Percentage :** It refers to the amount of the solute per 100 parts of the solution. It can also be called as parts per hundred (*pph*). It can be expressed by any of following four methods,

(i) ***Weight to weight percent***

$$\% \, w/w = \frac{\text{Wt. of solute}}{\text{Wt. of solution}} \times 100$$

Example : 10% Na_2CO_3 solution *w/w* means $10g$ of Na_2CO_3 is dissolved in $100\,g$ of the solution. (It means $10g$ Na_2CO_3 is dissolved in $90g$ of H_2O)

(ii) ***Weight to volume percent***

$$\% \, w/v = \frac{\text{Wt. of solute}}{\text{Volume of solution}} \times 100$$

Example : 10% Na_2CO_3 (*w/v*) means $10g$ Na_2CO_3 is dissolved in $100\,cc$ of solution.

(iii) ***Volume to volume percent***

$$\% \, v/v = \frac{\text{Vol. of solute}}{\text{Vol. of solution}} \times 100$$

Example : 10% ethanol (*v*/*v*) means $10\,cc$ of ethanol dissolved in $100\,cc$ of solution.

(iv) ***Volume to weight percent***

$$\% \, v/w = \frac{\text{Vol. of solute}}{\text{Wt. of solution}} \times 100$$

Example : 10% ethanol (*v*/*w*) means $10\,cc$ of ethanol dissolved in $100\,g$ of solution.

(2) **Parts per million (*ppm*) and parts per billion (*ppb*) :** When a *solute is present in trace quantities*, it is convenient to express the concentration in parts per million and parts per billion. It is the number of parts of solute per million (10^6) or per billion (10^9) parts of the solution. *It is independent of the temperature*.

$$ppm = \frac{\text{mass of solute component}}{\text{Total mass of solution}} \times 10^6$$

$$ppb = \frac{\text{mass of solute component}}{\text{Total mass of solution}} \times 10^9$$

(3) **Strength :** The strength of solution is defined as the amount of solute in grams present in one *litre* (or dm^3) of the solution. It is expressed in *g*/*litre* or (g/dm^3).

$$\text{Strength} = \frac{\text{Mass of solute in grams}}{\text{Volume of solution in litres}}$$

(4) **Normality (*N*) :** It is defined as the number of gram equivalents (equivalent weight in grams) of a solute present per *litre* of the solution. Unit of normality is gram equivalents *litre*$^{-1}$. Normality changes with temperature since it involves volume. When a solution is diluted x times, its normality also decreases by x times. Solutions in term of normality generally expressed as,

$N =$ Normal solution; $5N =$ Penta normal,

$10N =$ Deca normal; $N/2 =$ semi normal

$N/10 =$ Deci normal; $N/5 =$ Penti normal

$N/100$ or $0.01\ N =$ centinormal,

$N/1000$ or 0.001= millinormal

Mathematically normality can be calculated by following formulas,

(i) $\text{Normality } (N) = \dfrac{\text{Number of g.eq. of solute}}{\text{Volume of solution } (l)}$

(ii) $N = \dfrac{\text{Weight of solute in } g.}{\text{g. eq. weight of solute} \times \text{Volume of solution } (l)}$

(iii) $N = \dfrac{\text{Wt. of solute per litre of solution}}{\text{g eq. wt. of solute}}$

(iv) $N = \dfrac{\text{Wt. of solute}}{g\text{.eq. wt. of solute}} \times \dfrac{1000}{\text{Vol. of solution in } ml}$

(v) $N = \dfrac{\text{Percent of solute} \times 10}{\text{g eq. wt. of solute}}$,

(vi) $N = \dfrac{\text{Strength in } g\, l^{-1} \text{ of solution}}{\text{g eq. wt. of solute}}$

(vii) $N = \dfrac{\text{Wt\%} \times \text{density} \times 10}{\text{Eq. wt.}}$

(viii) If volume V_1 and normality N_1 is so changed that new normality and volume N_2 and V_2 then,

$$N_1V_1 = N_2V_2 \text{ (Normality equation)}$$

(ix) When two solutions of the same solute are mixed then normality of mixture (N) is

$$N = \frac{N_1V_1 + N_2V_2}{V_1 + V_2}$$

(x) Vol. of water to be added i.e., $(V_2 - V_1)$ to get a solution of normality N_2 from $V_1\ ml$ of normality N_1

$$V_2 - V_1 = \left(\frac{N_1 - N_2}{N_2}\right) V_1$$

(xi) If Wg of an acid is completely neutralised by $V\ ml$ of base of normality N

$$\frac{\text{Wt. of acid}}{\text{g eq. wt. of acid}} = \frac{VN}{1000}$$

Similarly, $\dfrac{\text{Wt. of base}}{\text{g eq. wt. of base}} = \dfrac{\text{Vol. of acid} \times N \text{ of acid}}{1000}$

(xii) When $V_a\ ml$ of acid of normality N_a is mixed with $V_b\ ml$ of base of normality N_b

(a) If $V_aN_a = V_bN_b$ (Solution neutral)

(b) If $V_aN_a > V_bN_b$ (Solution is acidic)

(c) If $V_bN_b > V_aN_a$ (Solution is basic)

(xiii) Normality of the acidic mixture $= \dfrac{V_aN_a + V_bN_b}{(V_a + V_b)}$

(xiv) Normality of the basic mixture $= \dfrac{V_bN_b + V_aN_a}{(V_a + V_b)}$

(xv) $N = \dfrac{\text{No. of meq }^{*}\text{ of solute}}{\text{Vol. of solution in } ml}$

(* 1 equivalent = 1000 milliequivalent or meq.)

(5) **Molarity (*M*) :** Molarity of a solution is the *number of moles of the solute per litre of solution (or*

number of millimoles per ml. of solution). Unit of molarity is ***mol/litre*** or ***mol/dm^3*** For example, a molar $(1M)$ solution of sugar means a solution containing 1 mole of sugar (*i.e.*, 342 *g* or 6.02×10^{23} molecules of it) per *litre* of the solution. Solutions in term of molarity generally expressed as,

$1M$ = Molar solution, $2M$ = Molarity is two,

$\frac{M}{2}$ or 0.5 M = Semimolar solution,

$\frac{M}{10}$ or 0.1 M = Decimolar solution,

$\frac{M}{100}$ or 0.01 M = Centimolar solution

$\frac{M}{1000}$ or 0.001 M = Millimolar solution

- Molarity is most common way of representing the concentration of solution.
- Molarity is depend on temperature as, $M \propto \frac{1}{T}$
- When a solution is diluted (x times), its molarity also decreases (by x times)

Mathematically molarity can be calculated by following formulas,

(i) $M = \frac{\text{No. of moles of solute } (n)}{\text{Vol. of solution in litres}}$,

(ii) $M = \frac{\text{Wt. of solute (in gm) per litre of solution}}{\text{Mol. wt. of solute}}$

(iii) $M = \frac{\text{Wt. of solute (in gm)}}{\text{Mol. wt. of solute}} \times \frac{1000}{\text{Vol. of solution in } ml.}$

(iv) $M = \frac{\text{No. of millimoles of solute}}{\text{Vol. of solution in } ml}$

(v) $M = \frac{\text{Percent of solute} \times 10}{\text{Mol. wt. of solute}}$

(vi) $M = \frac{\text{Strength in } gl^{-1} \text{ of solution}}{\text{Mol. wt. of solute}}$

(vii) $M = \frac{10 \times \text{Sp. gr. of the solution} \times \text{Wt.\% of the solute}}{\text{Mol. wt. of the solute}}$

(viii) If molarity and volume of solution are changed from M_1, V_1 to M_2, V_2. Then,

$$M_1V_1 = M_2V_2 \text{ (Molarity equation)}$$

(ix) In balanced chemical equation, if n_1 moles of reactant one react with n_2 moles of reactant two. Then,

$$\frac{M_1V_1}{n_1} = \frac{M_2V_2}{n_2}$$

(x) If two solutions of the same solute are mixed then molarity (M) of resulting solution.

$$M = \frac{M_1V_1 + M_2V_2}{(V_1 + V_2)}$$

(xi) Volume of water added to get a solution of molarity M_2 from $V_1\ ml$ of molarity M_1 is

$$V_2 - V_1 = \left(\frac{M_1 - M_2}{M_2}\right) V_1$$

Relation between molarity and normality

Normality of solution = molarity $\times \frac{\text{Molecular mass}}{\text{Equivalent mass}}$

Normality × equivalent mass = molarity × molecular mass

For an acid, $\frac{\text{Molecular mass}}{\text{Equivalent mass}}$ = Basicity

So, Normality of acid = molarity × basicity.

For a base, $\frac{\text{Molecular mass}}{\text{Equivalent mass}}$ = Acidity

So, Normality of base = Molarity × Acidity.

(6) **Molality (m) :** *It is the number of moles or gram molecules of the solute per* 1000 *g of the solvent*. Unit of molality is mol/kg. For example, a 0.2 molal $(0.2m)$ solution of glucose means a solution obtained by dissolving 0.2 mole of glucose in $1000\,gm$ of water. *Molality (m) does not depend on temperature* since it involves measurement of weight of liquids. *Molal solutions are less concentrated than molar solution*.

Mathematically molality can be calculated by following formulas,

(i) $m = \frac{\text{Number of moles of the solute}}{\text{Weight of the solvent in grams}} \times 1000$

(ii) $m = \frac{\text{Strength per 1000 grams of solvent}}{\text{Molecular mass of solute}}$

(iii) $m = \frac{\text{No. of } gm \text{ moles of solute}}{\text{Wt. of solvent in } kg}$

(iv) $m = \frac{\text{Wt. of solute}}{\text{Mol. wt. of solute}} \times \frac{1000}{\text{Wt. of solvent in } g}$

(v) $m = \frac{\text{No. of millimoles of solute}}{\text{Wt. of solvent in } g}$

(vi) $m = \frac{10 \times \text{solubility}}{\text{Mol. wt. of solute}}$

(vii) $m = \frac{1000 \times \text{wt.\% of solute } (x)}{(100 - x) \times \text{mol. wt. of solute}}$

(viii)

$$m = \frac{1000 \times \text{Molarity}}{(1000 \times \text{sp. gravity}) - (\text{Molarity} \times \text{Mol. wt. of solute})}$$

Relation between molarity (*M*) and molality (*m*)

Molality (m) = $\frac{\text{Molarity}}{\text{Density} - \frac{\text{Molarity} \times \text{molecular mass}}{1000}}$

$$\text{Molarity } (M) = \frac{\text{Molality} \times \text{density}}{1 + \frac{\text{Molality} \times \text{molecular mass}}{1000}}$$

(7) **Formality (F) :** Formality of a solution may be defined as the number of gram formula masses of the ionic solute dissolved per litre of the solution. It is represented by F. Commonly, the term formality is used to express the concentration of the ionic solids which do not exist as molecules but exist as network of ions. A solution containing one gram formula mass of solute per litre of the solution has formality equal to one and is called formal solution. It may be mentioned here that the *formality of a solution changes with change in temperature*.

Formality

$$(\text{F}) = \frac{\text{Number of gram formula masses of solute}}{\text{Volume of solution in litres}}$$

$$= \frac{\text{Mass of ionic solute } (g)}{(gm.\text{ formula mass of solute}) \times (\text{Volume of solution } (l))}$$

Thus, $F = \frac{W_B(g)}{GFM \times V(l)}$ or $\frac{W_B(g) \times 1000}{GFM \times V(ml)}$

(8) **Mole fraction (X) :** *Mole fraction may be defined as the ratio of number of moles of one component to the total number of moles of all the components (solvent and solute) present in the solution*. It is denoted by the letter X. It may be noted that *the mole fraction is independent of the temperature. Mole fraction is dimensionless*. Let us suppose that a solution contains the components A and B and suppose that $W_A g$ of A and $W_B g$ of B are present in it.

Number of moles of A is given by, $n_A = \frac{W_A}{M_A}$ and

the number of moles of B is given by, $n_B = \frac{W_B}{M_B}$

where M_A and M_B are molecular masses of A and B respectively.

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, $X_B = \frac{n_B}{n_A + n_B}$

The sum of mole fractions of all the components in the solution is always one.

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

Thus, if we know the mole fraction of one component of a binary solution, the mole fraction of the other can be calculated.

Relation between molality of solution (m) and mole fraction of the solute (X_A).

$$X_A = \frac{m}{55.5 + m}$$

(9) **Mass fraction :** Mass fraction of a component in a solution is the mass of that component divided by the total mass of the solution. For a solution containing $w_A gm$ of A and $w_B gm$ of B

Mass fraction of $A = \frac{w_A}{w_A + w_B}$; Mas fraction of $B = \frac{w_B}{w_A + w_B}$

It may be noted that molality, mole fraction, mass fraction etc. are preferred to molarity, normality, etc. because the former involve the weights of the solute and solvent where as later involve volumes of solutions. Temperature has no effect on weights but it has significant effect on volumes.

(10) **Demal unit (D) :** The concentrations are also expressed in “Demal unit”. One demal unit represents one mole of solute present in one litre of solution at $0^o C$.

Colligative properties

Certain properties of dilute solutions containing non-volatile solute do not depend upon the nature of the solute dissolved but depend only upon the concentration *i.e.*, the number of particles of the solute present in the solution. Such properties are called colligative properties. The four well known examples of the colligative properties are,

(1) Lowering of vapour pressure of the solvent.

(2) Osmotic pressure of the solution.

(3) Elevation in boiling point of the solvent.

(4) Depression in freezing point of the solvent.

Since colligative properties depend upon the number of solute particles present in the solution, the simple case will be that when the solute is a *non-electrolyte*. In case the solute is an electrolyte, it may split to a number of ions each of which acts as a particle and thus will affect the value of the colligative property.

Each colligative property is exactly related to other, Relative lowering of vapour pressure, elevation in boiling point and depression in freezing point are directly proportional to osmotic pressure.

Lowering of 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*. The vapour pressure of a liquid depends on,

(1) **Nature of liquid :** *Liquids, which have weak intermolecular forces, are volatile and have greater vapour pressure*. For example, dimethyl ether has greater vapour pressure than ethyl alcohol.

(2) **Temperature :** *Vapour pressure increases with increase in temperature*. This is due to the reason that with increase in temperature more molecules of the liquid can go into vapour phase.

(3) **Purity of liquid :** *Pure liquid always has a vapour pressure greater than its solution*.

Raoult's law : When a non-volatile substance is dissolved in a liquid, the vapour pressure of the liquid (solvent) is lowered. According to *Raoult's law* (1887), *at any given temperature the partial vapour pressure* (p_A) *of any component of a solution is equal to its mole fraction* (X_A) *multiplied by the vapour pressure of this component in the pure state* (p_A^0). That is, $p_A = p_A^0 \times X_A$

The vapour pressure of the solution (P_{total}) is the sum of the partial pressures of the components, *i.e.*, for the solution of two volatile liquids with vapour pressures p_A and p_B.

$$P_{total} = p_A + p_B = (p_A^0 \times X_A) + (p_B^0 \times X_B)$$

Alternatively, Raoult's law may be stated as "*the relative lowering of vapour pressure of a solution containing a non-volatile solute is equal to the mole fraction of the solute in the solution*."

Relative lowering of vapour pressure is defined as the ratio of lowering of vapour pressure to the vapour pressure of the pure solvent. It is determined by Ostwald-Walker method.

Thus according to Raoult's law,

$$\frac{p^0 - p}{p^0} = \frac{n}{n+N} = \frac{\frac{w}{m}}{\frac{w}{m} + \frac{W}{M}}$$

where, $p =$ Vapour pressure of the solution

$p^0 =$ Vapour pressure of the pure solvent

$n =$ Number of moles of the solute

$N =$ Number of moles of the solvent

w and $m =$ weight and mol. wt. of solute

W and $M =$ weight and mol. wt. of the solvent.

Limitations of Raoult's law

- Raoult's law is applicable only to *very dilute solutions*.
- Raoult's law is applicable to solutions containing non-volatile solute only.
- Raoult's law is not applicable to solutes which dissociate or associate in the particular solution.

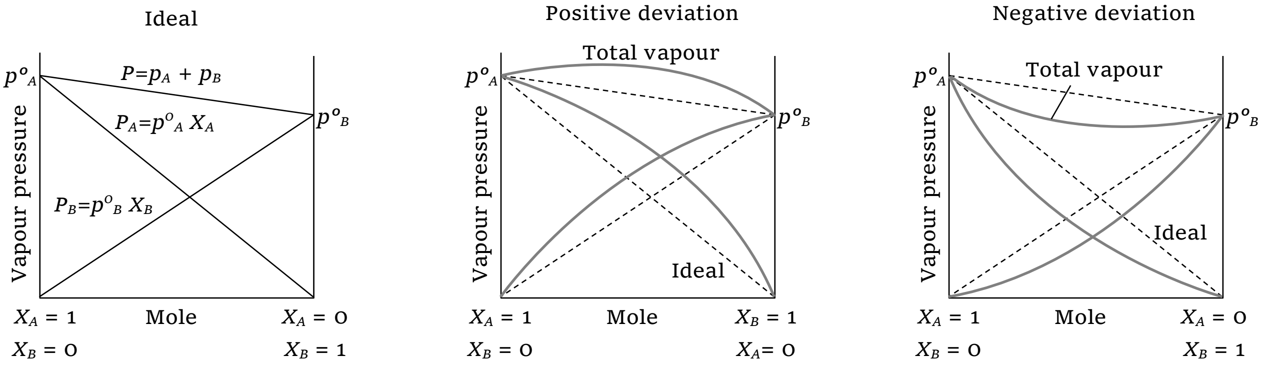
Ideal and Non-Ideal solution

Table: 4.1 Ideal and non-ideal solutions

Ideal solutions	**Non-ideal solutions**	
	Positive deviation from Raoult's law	**Negative deviation from Raoult's law**
1. Obey Raoult's law at every range of concentration.	1. Do not obey Raoult's law.	1. Do not obey Raoult's law.
2. $\Delta H_{\text{mix}} = 0;$ neither heat is evolved nor absorbed during dissolution.	2. $\Delta H_{\text{mix}} > 0.$ Endothermic dissolution; heat is absorbed.	2. $\Delta H_{\text{mix}} < 0.$ Exothermic dissolution; heat is evolved.
3. $\Delta V_{\text{mix}} = 0;$ total volume of solution is equal to sum of volumes of the components.	3. $\Delta V_{\text{mix}} > 0.$ Volume is increased after dissolution.	3. $\Delta V_{\text{mix}} < 0.$ Volume is decreased during dissolution.
4. $P = p_A + p_B = p_A^0 X_A + p_B^0 X_B$ *i.e.*, $p_A = p_A^0 X_A : p_B = p_B^0 X_B$	4. $p_A > p_A^0 X_A;\ p_B > p_B^0 X_B$ $\therefore\ p_A + p_B > p_A^0 X_A + p_B^0 X_B$	4. $p_A < p_A^0 X_A;\ p_B < p_B^0 X_B$ $\therefore\ p_A + p_B < p_A^0 X_A + p_B^0 X_B$
5. $A-A, A-B, B-B$ interactions should be same, *i.e.*, 'A' and 'B' are identical in shape, size and character.	5. $A-B$ attractive force should be weaker than $A-A$ and $B-B$ attractive forces. 'A' and 'B' have different shape, size and character.	5. $A-B$ attractive force should be greater than $A-A$ and $B-B$ attractive forces. 'A' and 'B' have different shape, size and character.

6. Escaping tendency of 'A' and 'B' should be same in pure liquids and in the solution.	6. 'A' and 'B' escape easily showing higher vapour pressure than the expected value.	6. Escaping tendency of both components 'A' and 'B' is lowered showing lower vapour pressure than expected ideally.
Examples: Dilute solutions; benzene + toluene: *n*-hexane + *n*-heptane; chlorobenzene + bromobenzene; ethyl bromide + ethyl iodide; *n*-butyl chloride + *n*-butyl bromide	Examples: Acetone +ethanol acetone + CS_2 : water + methanol; water + ethanol; CCl_4 + toluene; $CCl_4 + CHCl_3$; acetone + benzene; $CCl_4 + CH_3OH$; cyclohexane + ethanol	Examples: Acetone + aniline; acetone + chloroform; $CH_3OH + CH_3COOH$; $H_2O + HNO_3$ chloroform + diethyl ether; water + HCl; acetic acid + pyridine; chloroform + benzene

Graphical representation of ideal and non-ideal solutions



Azeotropic mixture

Azeotropes are defined as the mixtures of liquids which boil at constant temperature like a pure liquid and possess same composition of components in liquid as well as in vapour phase. Azeotropes are also called constant boiling mixtures because whole of the azeotropes changes into vapour state at constant temperature and their components can not be separated by fractional distillation. Azeotropes are of two types as described below,

(1) **Minimum boiling azeotrope :** For the solutions with positive deviation there is an intermediate composition for which the vapour pressure of the solution is maximum and hence, boiling point is minimum. At this composition the solution distills at constant temperature without change in composition. This type of solutions are called minimum boiling azeotrope. *e.g.,*

$$H_2O + C_2H_5OH, H_2O + C_2H_5CH_2OH$$

$$CHCl_3 + C_2H_5OH\ ,\ (CH_3)_2CO + CS_2$$

(2) **Maximum boiling azeotrope :** For the solutions with negative deviations there is an intermediate composition for which the vapour pressure of the solution is minimum and hence, boiling point is maximum. At this composition the solution distill`s at constant temperature without the change in composition. This type of solutions are called maximum boiling azeotrope. *e.g.,*

$$H_2O + HCl, H_2O + HNO_3, H_2O + HClO_4$$

Osmosis and Osmotic pressure of the solution

(1) Osmosis : The flow of solvent from pure solvent or from solution of lower concentration into solution of higher concentration through a semi-permeable membrane is called *Osmosis*. Osmosis may be divided in following types,

(i) ***Exo-Osmosis*** **:** The outward osmotic flow of water from a cell containing an aqueous solution through a semi-permeable membrane is called as Exo-osmosis. For example, egg (after removing hard shell) placed in conc. *NaCl* solutions, will shrink due to exo-osmosis.

(ii) ***Endo-osmosis*** **:** The inward flow of water into the cell containing an aqueous solution through a semipermeable membrane is called as endo-osmosis. *e.g.*, an egg placed in water swells up due to endo-osmosis.

(iii) ***Reverse osmosis* :** If a pressure higher than osmotic pressure is applied on the solution, the solvent will flow from the solution into the pure solvent through the semi-permeable membrane. Since here the flow of solvent is in the reverse direction to that observed in the usual osmosis, the process is called reverse osmosis.

Differences between osmosis and diffusion

Osmosis	Diffusion
In osmosis movement of molecules takes place through a semi-permeable membrane.	In diffusion there is no role of semi-permeable membrane.
It involves movement of only solvent molecules from one side to the other.	It involves passage of solvent as well as solute molecules from one region to the other.
Osmosis is limited to solutions only.	Diffusion can take place in liquids, gases and solutions.
Osmosis can be stopped or reversed by applying additional pressure on the solution side.	Diffusion can neither be stopped nor reversed

(2) **Osmotic pressure (π)**

The osmotic pressure of a solution at a particular temperature may be defined as the excess hydrostatic pressure that builds up when the solution is separated from the solvent by a semi-permeable membrane. It is denoted by π.

or

Osmotic pressure may be defined as the excess pressure which must be applied to a solution in order to prevent flow of solvent into the solution through the semi-permeable membrane.

or

Osmotic pressure is the excess pressure which must be applied to a given solution in order to increase its vapour pressure until it becomes equal to that of the solution.

(i) ***Measurements of osmotic pressure* :** Following methods are used for the measurement of osmotic pressure,

(a) Pfeffer's method, (b) Morse and Frazer's method, (c) Berkeley and Hartley's method, (d) Townsend's negative pressure method, (e) De Vries plasmolytic method.

(ii) ***Determination of molecular mass of non-volatile solute from osmotic pressure* (π) :** *The osmotic pressure is a colligative property.* For a given solvent the osmotic pressure depends only upon the molar concentration of solute but does not depend upon its nature. The following relation relates osmotic pressure to the number of moles of the solute,

According to Boyle Van't Hoff law (at conc. temp.)

$\pi \propto C$ .....(i)

According to Gaylussac Van't Hoff law (at conc. temp.)

$\pi \propto T$ .....(ii)

From equation (i) and (ii)

$\pi \propto CT$, $\pi = CRT$ (Van't Hoff equation)

$$\pi = \frac{n}{V}RT \quad \left(\therefore \quad C = \frac{n}{V}\right) \; ; \; \pi = \frac{w}{m}\frac{RT}{V} \quad \left(\therefore \quad n = \frac{w}{m}\right)$$

Here, C = concentration of solution in *moles* per *litre*

R = gas constant ; T = temperature

n = number of *moles* of solute ; V = volume of solution

m = molecular weight of solute ; w = weight of solute

(iii) Conditions for getting accurate value of molecular mass are,

(a) The solute must be non-volatile.

(b) The solution must be dilute.

(c) The solute should not undergo dissociation or association in the solution.

(iv) ***Relation of osmotic pressure with different colligative properties* :** Osmotic pressure is related to relative lowering of vapour pressure, elevation of boiling point and depression of freezing point according to the following relations,

(a) $\pi = \left(\frac{P_A^o - P_A}{P_A^o}\right) \times \frac{dRT}{M}$ (b) $\pi = \Delta T_b \times \frac{dRT}{1000 \times K_b}$

(c) $\pi = \Delta T_f \times \frac{dRT}{1000 \times K_f}$

In the above relations, π = Osmotic pressure; d = Density of solution at temperature T; R = Universal gas constant; M = Mol. Mass of solute; K_b = Molal elevation constant of solvent; K_f = Molal depression constant of solvent

(v) ***Isotonic, Hypertonic and Hypotonic solutions***

(a) *Isotonic or iso-osmotic solutions* : Two solutions of different substances having same osmotic pressure at same temperature are known as isotonic solutions.

For isotonic solutions, $\pi_1 = \pi_2$ Primary Condition .....(i)

$$\left.\begin{array}{ll} \text{Also,} & C_1 = C_2 \\ \text{or} & \frac{n_1}{V_1} = \frac{n_2}{V_2} \\ \text{or} & \frac{w_1}{m_1V_1} = \frac{w_2}{m_2V_2} \end{array}\right\} \text{Secondary Conditions}$$

.....(ii)

Eq. (ii) holds good only for those solutes which neither possess the tendency to get associate nor dissociate in solution, *e.g.*,

Urea and glucose are isotonic then, $\pi_1 = \pi_2$ and $C_1 = C_2$

Urea and $\underset{(dissociate)}{NaCl}$ are isotonic then, $\pi_1 = \pi_2$ but $C_1 \neq C_2$

Urea and $\underset{(associate)}{\text{Benzoic acid}}$ are isotonic then, $\pi_1 = \pi_2$ but $C_1 \neq C_2$

(b) *Hypertonic and hypotonic solution* : The solution which has more osmotic pressure than the other solution is called as hypertonic solution and the solution which has lesser osmotic pressure than the other is called as hypotonic solution.

The flow of solvent is always from lower osmotic pressure to higher osmotic pressure *i.e.* from hypotonic to hypertonic solution.

Elevation in b.pt. of the solvent (Ebullioscopy)

Boiling point of a liquid may be defined as the temperature at which its vapour pressure becomes equal to atmospheric pressure, i.e., 760 mm. Since the addition of a non-volatile solute lowers the vapour pressure of the solvent, solution always has lower vapour pressure than the solvent and hence it must be heated to a higher temperature to make its vapour pressure equal to atmospheric pressure with the result *the solution boils at a higher temperature than the pure solvent*. Thus sea water boils at a higher temperature than distilled water. If T_b is the boiling point of the solvent and T is the boiling point of the solution, the difference in the boiling point (ΔT or ΔT_b) is called the elevation of boiling point.

$$T - T_b = \Delta T_b \text{ or } \Delta T$$

Elevation in boiling point is determined by Landsberger's method and Cottrell's method. Study of elevation in boiling point of a liquid in which a non-volatile solute is dissolved is called as ebullioscopy.

Important relations concerning elevation in boiling point

(1) *The elevation of boiling point is directly proportional to the lowering of vapour pressure, i.e.,* $\Delta T_b \propto p^0 - p$

(2) $\Delta T_b = K_b \times m$

where $K_b =$ molal elevation constant or ebullioscopic constant of the solvent; $m =$ Molality of the solution, *i.e.,* number of moles of solute per $1000\,g$ of the solvent; $\Delta T_b =$ Elevation in boiling point

(3) $\Delta T_b = \dfrac{1000 \times K_b \times w}{m \times W}$ or $m = \dfrac{1000 \times K_b \times w}{\Delta T_b \times W}$

where, K_b is *molal elevation constant and* defined as *the elevation in b.pt. produced when 1 mole of the solute is dissolved in 1 kg of the solvent.*

w and W are the weights of solute and solvent and m is the molecular weight of the solute.

(4) $K_b = \dfrac{0.002(T_0)^2}{l_V}$

where $T_0 =$ Normal boiling point of the pure solvent; $l_V =$ Latent heat of evaporation in cal/g of pure solvent; K_b for water is $0.52 \text{ deg} - kg\ mol^{-1}$.

Depression in f.pt. of the solvent (Cryoscopy)

Freezing point is the temperature at which the liquid and the solid states of a substance are in equilibrium with each other or it may be defined as the temperature at which the liquid and the solid states of a substance have the same vapour pressure. It is observed that *the freezing point of a solution is always less than the freezing point of the pure solvent*. Thus the freezing point of sea water is low than that of pure water. The depression in freezing point (ΔT or ΔT_f) of a solvent is the difference in the freezing point of the pure solvent (T_s) and the solution ($T_{sol.}$).

$$T_s - T_{sol} = \Delta T_f \text{ or } \Delta T$$

$NaCl$ or $CaCl_2$ (anhydrous) are used to clear snow on roads. They depress the freezing point of water and thus reduce the temperature of the formation of ice.

Depression in freezing point is determined by Beckmann's method and Rast's camphor method. Study of depression in freezing point of a liquid in which a non-volatile solute is dissolved in it is called as cryoscopy.

Important relations concerning depression in freezing point.

(1) Depression in freezing point is directly proportional to the lowering of vapour pressure. $\Delta T_f \propto p^0 - p$

(2) $\Delta T_f = K_f \times m$

where $K_f =$ molal depression constant or cryoscopic constant; $m =$ Molality of the solution (i.e., no. of moles of solute per $1000\,g$ of the solvent); $\Delta T_f =$ Depression in freezing point

(3) $\Delta T_f = \dfrac{1000 \times K_f \times w}{m \times W}$ or $m = \dfrac{1000 \times K_f \times w}{\Delta T_f \times W}$

where K_f is *molal depression constant* and defined as the depression in freezing point produced when 1 mole of the solute is dissolved in $1 kg$ of the solvent. w and W are the weights of solute and solvent and m is the molecular weight of the solute.

(4) $K_f = \frac{R(T_0)^2}{l_f 1000} = \frac{0.002(T_0)^2}{l_f}$

where $T_0 =$ Normal freezing point of the solvent; $l_f =$ Latent heat of fusion/g of solvent; K_f for water is $1.86 \deg - kg\ mol^{-1}$

Colligative properties of electrolytes

The colligative properties of solutions, viz. lowering of vapour pressure, osmotic pressure, elevation in b.p. and depression in freezing point, depend on the total number of solute particles present in solution. Since the electrolytes ionise and give more than one particle per formula unit in solution, *the colligative effect of an electrolyte solution is always greater than that of a non-electrolyte of the same molar concentration*. All colligative properties are used for calculating molecular masses of non-volatile solutes. However osmotic pressure is the best colligative property for determining molecular mass of a non-volatile substance.

Colligative properties are depending on following factory

(1) Colligative properties $\propto$ Number of particles

$\propto$ Number of molecules

(in case of non-electrolytes)

$\propto$ Number of ions

(In case of electrolytes)

$\propto$ Number of moles of solute

$\propto$ Mole fraction of solute

(2) For different solutes of same molar concentration, the magnitude of the colligative properties is more for that solution which gives more number of particles on ionisation.

(3) For different solutions of same molar concentration of different non-electrolyte solutes, the magnitude of the colligative properties will be same for all.

(4) For different molar concentrations of the same solute, the magnitude of colligative properties is more for the more concentrated solution.

(5) For solutions of different solutes but of same percent strength, the magnitude of colligative property is more for the solute with least molecular weight.

(6) For solutions of different solutes of the same percent strength, the magnitude of colligative property is more for that solute which gives more number of particles, which can be known by the knowledge of molecular weight and its ionisation behaviour.

Abnormal molecular masses

Molecular masses can be calculated by measuring any of the colligative properties. The relation between colligative properties and molecular mass of the solute is based on following assumptions.

(1) The solution is dilute, so that Raoult's law is obeyed.

(2) The solute neither undergoes dissociation nor association in solution.

In case of solutions where above assumptions are not valid we find discrepencies between observed and calculated values of colligative properties. These anomalies are primarily due to

(i) Association of solute molecules.

(ii) Dissociation of solute molecules.

(i) ***Association of solute molecules*** **:** Certain solutes in solution are found to associate. This eventually leads to a decrease in the number of molecular particles in the solutions. Thus, it results in a decrease in the values of colligative properties.

$$\text{Colligative property} \propto \frac{1}{\text{molecular mass of solute}}$$

therefore, higher values are obtained for molecular masses than normal values for unassociated molecules.

(ii) ***Dissociation of solute molecules*** **:** A number of electrolytes dissociate in solution to give two or more particles (ions). Therefore, the number of solute particles, in solutions of such substances, is more than the expected value. Accordingly, such solutions exhibit higher values of colligative properties. Since colligative properties are inversely proportional to molecular masses, therefore, molecular masses of such substances as calculated from colligative properties will be less than their normal values.

Van't Hoff's factor (*i*) : In 1886, Van't Hoff introduced a factor '*i*' called Van't Hoff's factor, to express the extent of association or dissociation of solutes in solution. It is ratio of the normal and observed molecular masses of the solute, *i.e.*,

$$i = \frac{\text{Normal molecular mass}}{\text{Observed molecular mass}}$$

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's factor is more than 1 because the observed molecular mass has a lesser value than the normal molecular mass. In case there is no dissociation the value of '*i*' becomes equal to one.

Since colligative properties are inversely proportional to molecular masses, the Van't Hoff's factor may also be written as,

$$i = \frac{\text{Observed value of colligative property}}{\text{Calculated value of colligative property assuming no association or dissociation}}$$

$$i = \frac{\text{No. of particles after association or dissociation}}{\text{No. of particles before association or dissociation}}$$

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

Relative lowering of vapour pressure $= \frac{P_A^o - P_A}{P_A^o} = iX_B$

Elevation of boiling point, $\Delta T_b = ik_b m$

Depression in freezing point, $\Delta T_f = ik_f m$

Osmotic pressure, $\pi = \frac{inRT}{V}$; $\pi = iCRT$

From the value of '*i*', it is possible to calculate degree of dissociation or degree of association of substance.

Degree of dissociation (α) : It is defined as the fraction of total molecules which dissociate into simpler molecules or ions.

$\alpha = \frac{i-1}{m-1}$; m= number of particles in solution

Degree of association (α) : It is defined as the fraction of the total number of molecules which associate or combine together resulting in the formation of a bigger molecules.

$\alpha = \frac{i-1}{1/m-1}$; m = number of particles in solution.

Tips & Tricks

- A supersaturated solution is metastable.
- Dissolution of gases in liquid is always exothermic because $\Delta S = -$ve (non favourable factor) and in order to have $\Delta G = -$ve (spontaneous process), ΔH has to be –ve.
- 1 M aqueous solution is more concentrated than 1 m aqueous solution.
- Substances having high V.P. (e.g., petrol) evaporate more quickly than substances having low V.P. (e.g., motor oil).
- Babo's law : The lowering in vapour pressure of a solution caused by addition of an non-volatile solute is called as Babo's law.
- Konowaloff's rule : In case of a binary solution, at a fixed temperature, the vapour phase is richer in that component whose addition causes increase in total vapour pressure of the solution i.e., vapour phase is always richer in the more volatile component.
- When a non-volatile solute is added to the solvent, V.P. decrease, B.P. increase, F.P. decrease.
- Ethylene glycol is commonly added to car radiators to depress the freezing point of water. It is known as antifreeze.
- NaCl or $CaCl_2$ (anhydrous) are used to clear snow on roads. It depresses the freezing point of water and reduce the temperature at which ice is expected to be formed.
- Plasmolysis : When a plant cell is placed in a hypertonic solution, the fluid from the plant cell comes out and the cell shrinks. This phenomenon is called plasmolysis and is due to osmosis.
- Bursting of red blood cells when placed in water is due to osmosis.
- Gelatinous $Cu_2[Fe(CN)_6]$ and gelatinous $Ca_3(PO_4)_2$ are artificial semipermeable membranes.
- Semipermeable membrane of $Cu_2[Fe(CN)_6]$ dose not work in non aqueous solutions because it get dissolved in non aqueous solvents.
- Osmotic coefficient (g) is the ratio of van't Hoff factor (i) to the no. of ions furnished by one molecule of the electrolyte (N). i.e., $g = i / N$.

Ordinary Thinking

Objective Questions

Solubility

1. The solubility of a gas in water depends on **[MP PET 2002]**

(a) Nature of the gas (b) Temperature

(c) Pressure of the gas (d) All of the above

2. Which of the following is not correct for D_2O **[Orissa JEE 2002]**

(a) Boiling point is higher than H_2O

(b) D_2O reacts slowly than H_2O

(c) Viscosity is higher than H_2O at 25^o

(d) Solubility of *NaCl* in it is more than H_2O

3. The statement " The mass of a gas dissolved in a given mass of a solvent at any temperature is proportional to the pressure of the gas above the solvent" is **[AMU 2002]**

(a) Dalton's Law of Partial Pressures

(b) Law of Mass Action

(c) Henry's Law

(d) None of these

4. Which is correct about Henry's law **[KCET 2002]**

(a) The gas in contact with the liquid should behave as an ideal gas

(b) There should not be any chemical interaction between the gas and liquid

(c) The pressure applied should be high

(d) All of these

5. The statement "If 0.003 moles of a gas are dissolved in 900 *g* of water under a pressure of 1 atmosphere, 0.006 *moles* will be dissolved under a pressure of 2 atmospheres", illustrates**[JIPMER 1999]**

(a) Dalton's law of partial pressure

(b) Graham's law

(c) Raoult's law

(d) Henry's law

6. The solution of sugar in water contains **[BHU 1973]**

(a) Free atoms (b) Free ions

(c) Free molecules (d) Free atom and molecules

Method of expressing concentration of solution

1. $25\,ml$ of $3.0\,M\,HNO_3$ are mixed with $75\,ml$ of $4.0\,M\,HNO_3$. If the volumes are additive, the molarity of the final mixture would be **[DPMT 1986; MH CET 2001]**

(a) $3.25\,M$ (b) $4.0\,M$

(c) $3.75\,M$ (d) $3.50\,M$

2. The amount of anhydrous Na_2CO_3 present in 250 *ml* of 0.25 *M* solution is **[DPMT 2001]**

(a) 6.225 *g* (b) 66.25 *g*

(c) 6.0 *g* (d) 6.625 *g*

3. Dilute one litre 1 molar H_2SO_4 solution by 5 litre water, the normality of that solution is **[DPMT 1983]**

(a) $0.2N$ (b) $5\,N$

(c) $10\,N$ (d) 0.33 *N*

4. If 5.85 gms of $NaCl$ are dissolved in 90 gms of water, the mole fraction of $NaCl$ is

[CMC Vellore 1991; MP PMT 1994; AFMC 1998]

(a) 0.1 (b) 0.2

(c) 0.3 (d) 0.01

(e) 0.0196

5. The molarity of 0.006 mole of $NaCl$ in $100\,ml$ solution is

[Bihar MEE 1996]

(a) 0.6 (b) 0.06

(c) 0.006 (d) 0.066

(e) None of these

6. $9.8\,g$ of H_2SO_4 is present in 2 *litres* of a solution. The molarity of the solution is **[EAMCET 1991; MP PMT 2002]**

(a) $0.1M$ (b) $0.05M$

(c) $0.2M$ (d) $0.01M$

7. What will be the molarity of a solution containing $5\,g$ of sodium hydroxide in $250\,ml$ solution

[MP PET 1999; BHU 1999; KCET 1999; AIIMS 2000; Pb. CET 2000]

(a) 0.5 (b) 1.0

(c) 2.0 (d) 0.1

8. The normality of $0.3M$ phosphorus acid (H_3PO_3) is

[IIT 1999; AIIMS 2000]

(a) 0.1 (b) 0.9

(c) 0.3 (d) 0.6

9. Which of the following has maximum number of molecules

[CBSE PMT 2002]

(a) 16 *gm* of O_2 (b) 16 *gm* of NO_2

(c) 7 *gm* of N_2 (d) 2 *gm* of H_2

10. Molarity is expressed as **[JIPMER 1991; CBSE PMT 1991]**

(a) Gram/litre (b) Moles/litre

(c) Litre/mole (d) Moles/1000 *gms*

11. $20\,ml$ of HCl solution requires $19.85\,ml$ of $0.01\,M\,NaOH$ solution for complete neutralization. The molarity of HCl solution is

(a) 0.0099 (b) 0.099

(c) 0.99 (d) 9.9

12. How much of $NaOH$ is required to neutralise 1500 cm^3 of 0.1 *N* HCl (At. *wt.* of *Na* =23) **[KCET 2001]**

(a) 4 *g* (b) 6 *g*

(c) 40 *g* (d) 60 *g*

13. If 5.85 *g* of $NaCl$ (molecular weight 58.5) is dissolved in water and the solution is made up to 0.5 *litre*, the molarity of the solution will be **[AMU 1999; Pb**

(a) 0.2 (b) 0.4

(c) 1.0 (d) 0.1

14. A mixture has 18*g* water and 414*g* ethanol. The mole fraction of water in mixture is (assume ideal behaviour of the mixture)

(a) 0.1 (b) 0.4

(c) 0.7 (d) 0.9

15. The number of molecules in 4.25 *g* of ammonia is approximately **[CBSE PMT 2002]**

(a) 0.5×10^{23} (b) 1.5×10^{23}

(c) 3.5×10^{23} (d) 2.5×10^{23}

16. The largest number of molecules is in **[Kurukshetra CEE 1998]**

(a) $25\,g$ of CO_2 (b) $46\,g$ of C_2H_5OH

(c) $36\,g$ of H_2O (d) $54\,g$ of N_2O_5

17. If 1 *M* and 2.5 *litre NaOH* solution is mixed with another 0.5 *M* and 3 *litre NaOH* solution, then molarity of the resultant solution will be **[CBSE PMT 2002]**

(a) 1.0 *M* (b) 0.73 *M*

(c) 0.80 *M* (d) 0.50 *M*

18. When a solute is present in trace quantities the following expression is used **[Kerala CET (Med.) 2002]**

(a) Gram per million (b) Milligram percent

(c) Microgram percent (d) Nano gram percent

(e) Parts per million

19. When the concentration is expressed as the number of moles of a solute per litre of solution it known as

[Kerala CET (Med.) 2002]

(a) Normality (b) Molarity

(c) Mole fraction (d) Mass percentage

(e) Molality

20. The normality of 2.3 *M* H_2SO_4 solution is **[KCET 2000]**

(a) 2.3 *N* (b) 4.6 *N*

(c) 0.46 *N* (d) 0.23 *N*

21. The molarity of a solution made by mixing 50*ml* of conc. H_2SO_4 (36*N*) with 50 *ml* of water is **[MP PMT 200**

(a) 36 *M* (b) 18 *M*

(c) 9 *M* (d) 6 *M*

22. 171 *g* of cane sugar $(C_{12}H_{22}O_{11})$ is dissolved in 1 *litre* of water. The molarity of the solution is **[MP PMT 200**

(a) 2.0 *M* (b) 1.0 *M*

(c) 0.5 *M* (d) 0.25 *M*

23. The volumes of $4\,N\,HCl$ and $10\,N\,HCl$ required to make 1 litre of $6\,N\,HCl$ are **[Kerala PMT 2004]**

(a) 0.75 litre of 10 *N HCl* and 0.25 litre of 4 *N HCl*

(b) 0.25 litre of 4 *N HCl* and 0.75 litre of 10 *N HCl*

(c) 0.67 litre of 4 *N HCl* and 0.33 litre of 10 *N HCl*

(d) 0.80 litre of 4 *N HCl* and 0.20 litre of 10 *N HCl*

(e) 0.50 litre of 4 *N HCl* and 0.50 litre of 10 *N HCl*

24. Which statement is true for solution of 0.020 *M* H_2SO_4 **[DPMT 2001]**

(a) 2 *litre* of the solution contains 0.020 *mole* of SO_4^{2-}

(b) 2 *litre* of the solution contains 0.080 *mole* of H_3O^+

(c) 1 *litre* of the solution contains 0.020 *mole* H_3O^+

(d) None of these

25. 10 *litre* solution of urea contains 240*g* urea. The active mass of urea will be **[KCET 2000]**

(a) 0.04 (b) 0.02

(c) 0.4 (d) 0.2

26. 5 *ml* of *N HCl*, 20 *ml* of *N*/2 H_2SO_4 and 30 *ml* of *N*/3 HNO_3 are mixed together and volume made to one litre. The normally of the resulting solution is **[Kerala CET (Med.) 2003]**

(a) $\frac{N}{5}$ (b) $\frac{N}{10}$

(c) $\frac{N}{20}$ (d) $\frac{N}{40}$

(e) $\frac{N}{25}$

27. The amount of $K_2Cr_2O_7$ (*eq*. wt. 49.04) required to prepare 100 *ml* of its 0.05 *N* solution is**[JIPMER 2002]**

(a) 2.9424 *g* (b) 0.4904 *g*

(c) 1.4712 *g* (d) 0.2452 *g*

28. With increase of temperature, which of these changes **[AIEEE 2002]**

(a) Molality

(b) Weight fraction of solute

(c) Fraction of solute present in water

(d) Mole fraction

29. 25*ml* of a solution of barium hydroxide on titration with a 0.1molar solution of hydrochloric acid gave a *litre* value of 35 *ml*. The molarity of barium hydroxide solution was **[AIEEE 2003]**

(a) 0.07 (b) 0.14

(c) 0.28 (d) 0.35

30. 2.0 molar solution is obtained , when 0.5 *mole* solute is dissolved in **[MP PMT 2003]**

(a) 250 *ml* solvent (b) 250 *g* solvent

(c) 250 *ml* solution (d) 1000 *ml* solvent

31. How many *gram* of *HCl* will be present in 150 *ml* of its 0.52 *M* solution **[RPET 1999]**

(a) 2.84 *gm* (b) 5.70 *gm*

(c) 8.50 *gm* (d) 3.65 *gm*

32. The number of moles present in 2 *litre* of 0.5 *M* *NaOH* is **[MH CET 2001]**

(a) 0.5 (b) 0.1

(c) 1 (d) 2

33. 36*g* water and 828*g* ethyl alcohol form an ideal solution. The mole fraction of water in it, is**[MP PMT 2003**

(a) 1.0 (b) 0.7

(c) 0.4 (d) 0.1

34. What will be the normality of a solution containing 4.9 *g*. H_3PO_4 dissolved in 500 *ml* water **[MP PMT 2003]**

(a) 0.3 (b) 1.0

(c) 3.0 (d) 0.1

35. 3.0 molal *NaOH* solution has a density of 1.110 *g*/*ml*. The molarity of the solution is **[BVP 2003]**

(a) 3.0504 (b) 3.64

(c) 3.05 (d) 2.9732

36. Which of the following modes of expressing concentration is independent of temperature **CBSE PMT 1992, 95; MP PMT 1992; AIIMS 1997, 2001]**

(a) Molarity (b) Molality

(c) Formality (d) Normality

37. The molality of a solution is **[MP PMT 1996]**

(a) Number of moles of solute per 1000 *ml* of the solvent

(b) Number of moles of solute per 1000 *gm* of the solvent

(c) Number of moles of solute per 1000 *ml* of the solution

(d) Number of gram equivalents of solute per 1000 *ml* of the solution

38. The number of molecules in 16 *gm* of methane is **[MP PET/PMT 1998]**

(a) 3.0×10^{23} (b) 6.02×10^{23}

(c) $\frac{16}{6.02} \times 10^{23}$ (d) $\frac{16}{3.0} \times 10^{23}$

39. The number of moles of a solute in its solution is 20 and total number of moles are 80. The mole fraction of solute is **[MP PMT 1997]**

(a) 2.5 (b) 0.25

(c) 1 (d) 0.75

40. The normality of a solution of sodium hydroxide 100 *ml* of which contains 4 grams of *NaOH* is**[CMC Vellore**

(a) 0.1 (b) 40

(c) 1.0 (d) 0.4

41. Two solutions of a substance (non electrolyte) are mixed in the following manner 480 *ml* of 1.5*M* first solution + 520 *mL* of 1.2*M* second solution. What is the molarity of the final mixture **[AIEEE 2005]**

(a) 1.20 *M* (b) 1.50 *M*

(c) 1.344 *M* (d) 2.70 *M*

42. The normal amount of glucose in $100 ml$ of blood (8–12 hours after a meal) is **[BHU 1981]**

(a) $8 mg$ (b) $80 mg$

(c) $200\ mg$ (d) $800\ mg$

43. Molar solution means 1 mole of solute present in **[BCECE 2005]**

(a) 1000*g* of solvent (b) 1 litre of solvent

(c) 1 litre of solution (d) 1000*g* of solution

44. What will be the molality of a solution having $18 g$ of glucose (mol. wt. = 180) dissolved in $500 g$ of water

[MP PET/PMT 1998; CBSE PMT 2000; JIPMER 2001]

(a) $1 m$ (b) $0.5 m$

(c) $0.2 m$ (d) $2 m$

45. A solution of $Al_2(SO_4)_3\ \{d = 1.253\ gm/ml\}$ contain 22% salt by weight. The molarity, normality and molality of the solution is **[MP PET 2004]**

(a) 0.805 *M*, 4.83 *N*, 0.825 *M*

(b) 0.825 *M*, 48.3 N, 0.805 *M*

(c) 4.83 *M*, 4.83 *N*, 4.83 *M*

(d) None

46. Which of the following should be done in order to prepare $0.40 M\ NaCl$ starting with $100\ ml$ of $0.30 M\ NaCl$ (mol.wt. of $NaCl = 58.5$) **[BIT 1992]**

(a) Add $0.585\ g\ NaCl$ (b) Add $20\ ml$ water

(c) Add $0.010 ml\ NaCl$ (d) Evaporate $10 ml$ water

47. Which of the following solutions has the highest normality

[JIPMER 1991]

(a) 8 *gm* of *KOH* / litre (b) *N* phosphoric acid

(c) 6 *gm* of *NaOH* / 100 *ml* (d) $0.5 M\ H_2SO_4$

48. What volume of $0.8 M$ solution contains 0.1 mole of the solute **[AFMC 1984]**

(a) $100\ ml$ (b) $125\ ml$

(c) $500\ ml$ (d) $62.5 ml$

49. Hydrochloric acid solution *A* and *B* have concentration of $0.5 N$ and $0.1 N$ respectively. The volumes of solutions *A* and *B* required to make $2\ litres$ of $0.2 N$ *HCl* are

[KCET 1993]

(a) $0.5 l$ of $A + 1.5 l$ of B

(b) $1.5 l$ of $A + 0.5 l$ of B

(c) $1.0 l$ of $A + 1.0 l$ of B

(d) $0.75 l$ of $A + 1.25 l$ of B

50. Conc. H_2SO_4 has a density of 1.98 *gm/ml* and is 98% H_2SO_4 by weight. Its normality is **[MP PET 2002]**

(a) 2 *N* (b) 19.8 *N*

(c) 39.6 *N* (d) 98 *N*

51. The mole fraction of the solute in one molal aqueous solution is **[CBSE PMT 2005]**

(a) 0.027 (b) 0.036

(c) 0.018 (d) 0.009

52. With 63 *gm* of oxalic acid how many *litres* of $\frac{N}{10}$ solution can be prepared **[RPET 1999]**

(a) 100 *litre* (b) 10 *litre*

(c) 1 *litre* (d) 1000 *litre*

53. Molarity of $0.2 N\ H_2SO_4$ is **[KCET 2005]**

(a) 0.2 (b) 0.4

(c) 0.6 (d) 0.1

54. 10.6 grams of a substance of molecular weight 106 was dissolved in $100 ml$. $10 ml$ of this solution was pipetted out into a $1000 ml$ flask and made up to the mark with distilled water. The molarity of the resulting solution is **[EAMCET 1998]**

(a) $1.0 M$ (b) $10^{-2} M$

(c) $10^{-3} M$ (d) $10^{-4} M$

55. The mole fraction of water in 20% aqueous solution of H_2O_2 is **[EAMCET 1993]**

(a) $\frac{77}{68}$ (b) $\frac{68}{77}$

(c) $\frac{20}{80}$ (d) $\frac{80}{20}$

56. Mole fraction (X) of any solution is equal to

(a) $\frac{\text{No. of moles of solute}}{\text{Volume of solution in litre}}$

(b) $\frac{\text{No. of gram equivalent of solute}}{\text{Volume of solution in litre}}$

(c) $\frac{\text{No. of moles of solute}}{\text{Mass of solvent in kg}}$

(d) $\frac{\text{No. of moles of any constituent}}{\text{Total no. of moles of all constituents}}$

57. When $W_B gm$ solute (molecular mass M_B) dissolves in $W_A gm$ solvent. The molality M of the solution is

(a) $\frac{W_B}{W_A} \times \frac{M_B}{1000}$ (b) $\frac{W_B}{M_B} \times \frac{1000}{W_A}$

(c) $\frac{W_A}{W_B} \times \frac{1000}{M_B}$ (d) $\frac{W_A \times M_B}{W_B \times 1000}$

58. Normality (N) of a solution is equal to

(a) $\frac{\text{No. of moles of solute}}{\text{Volume of solution in litre}}$

(b) $\frac{\text{No. of gram equivalent of solute}}{\text{Volume of solution in litre}}$

(c) $\frac{\text{No. of moles of solute}}{\text{Mass of solvent in kg}}$

(d) None of these

59. The volume strength of $1.5\,N\,H_2O_2$ solution is **[CBSE PMT 1997; BHU 2002]**

(a) 4.8
(b) 5.2
(c) 8.8
(d) 8.4

60. How many *gm* of H_2SO_4 is present in $0.25\,gm$ mole of H_2SO_4 **[CPMT 1990]**

(a) 24.5
(b) 2.45
(c) 0.25
(d) 0.245

61. 20 *g* of hydrogen is present in 5 *litre* vessel. The molar concentration of hydrogen is **[DPMT 2000]**

(a) 4
(b) 1
(c) 3
(d) 2

62. To prepare a solution of concentration of 0.03 *g/ml* of $AgNO_3$, what amount of $AgNO_3$ should be added in 60 *ml* of solution **[AFMC 2005]**

(a) 1.8
(b) 0.8
(c) 0.18
(d) None of these

63. How many grams of dibasic acid (mol. wt. 200) should be present in $100\,ml$ of its aqueous solution to give decinormal strength **[AIIMS 1992; CBSE PMT 1999; AFMC 1999; KCET 2000; CPMT 2001]**

(a) $1\,g$
(b) $2\,g$
(c) $10\,g$
(d) $20\,g$

64. The weight of pure $NaOH$ required to prepare $250\,cm^3$ of $0.1N$ solution is **[KCET 1991; Kerala PMT 2004]**

(a) $4\,g$
(b) $1\,g$
(c) $2\,g$
(d) $10\,g$

65. If $20\,ml$ of $0.4\,N\,NaOH$ solution completely neutralises $40\,ml$ of a dibasic acid. The molarity of the acid solution is **[EAMCET 1987]**

(a) $0.1M$
(b) $0.2M$
(c) $0.3M$
(d) $0.4M$

66. Which of the following concentration factor is affected by change in temperature **[DCE 2002]**

(a) Molarity
(b) Molality
(c) Mole fraction
(d) Weight fraction

67. The distribution law is applied for the distribution of basic acid between **[UPSEAT 2001]**

(a) Water and ethyl alcohol
(b) Water and amyl alcohol
(c) Water and sulphuric acid
(d) Water and liquor ammonia

68. Which is heaviest **[CBSE PMT 1991]**

(a) 25 gm of mercury
(b) 2 moles of water
(c) 2 moles of carbon dioxide
(d) 4 gm atoms of oxygen

69. The molarity of a solution of Na_2CO_3 having $10.6\,g/500\,ml$ of solution is **[AFMC 1992; DCE 2000]**

(a) $0.2M$
(b) $2M$
(c) $20M$
(d) $0.02M$

70. On passing H_2S gas through a solution of Cu^+ and Zn^{+2} ions, *CuS* is precipitated first because **[AMU 2001]**

(a) Solubility product of *CuS* is equal to the ionic product of *ZnS*
(b) Solubility product of *CuS* is equal to the solubility product of *ZnS*
(c) Solubility product of *CuS* is lower than the solubility product of *ZnS*
(d) Solubility product of *CuS* is greater than the solubility product of *ZnS*

71. The number of moles of solute per kg of a solvent is called its **[DPMT 1983; IIT 1985; CPMT 1999]**

(a) Molarity
(b) Normality
(c) Molar fraction
(d) Molality

72. 1.0 *gm* of pure calcium carbonate was found to require 50 *ml* of dilute HCl for complete reaction. The strength of the HCl solution is given by **[CPMT 1986]**

(a) 4 *N*
(b) 2 *N*
(c) 0.4 *N*
(d) 0.2 *N*

73. Molecular weight of glucose is 180. A solution of glucose which contains 18 gms per litre is **[AFMC 1978]**

(a) 2 molal
(b) 1 molal
(c) 0.1 molal
(d) 18 molal

74. 0.5 *M* of H_2SO_4 is diluted from 1 litre to 10 litre, normality of resulting solution is **[AFMC 2005]**

(a) 1 *N*
(b) 0.1 *N*
(c) 10 *N*
(d) 11 *N*

75. If one mole of a substance is present in $1\,kg$ of solvent, then **[CPMT 1996]**

(a) It shows molar concentration
(b) It shows molal concentration
(c) It shows normality
(d) It shows strength gm/gm

76. The molality of 90% H_2SO_4 solution is [density=1.8 *gm/ml*] **[MP PMT 2004]**

(a) 1.8
(b) 48.4
(c) 9.18
(d) 94.6

77. The volume of water to be added to $100\,cm^3$ of 0.5 *N* H_2SO_4 to get decinormal concentration is

(a) 400 cm^3
(b) 500 cm^3
(c) 450 cm^3
(d) 100 cm^3

78. If 25 *ml* of 0.25 *M NaCl* solution is diluted with water to a volume of 500*ml* the new concentration of the solution is **[UPSEAT 2000, 01]**

(a) 0.167 *M*
(b) 0.0125 *M*
(c) 0.833 *M*
(d) 0.0167 *M*

79. 10 grams of a solute is dissolved in 90 grams of a solvent. Its mass percent in solution is

(a) 0.01
(b) 11.1
(c) 10
(d) 9

80. What is the molality of a solution which contains 18 *g* of glucose $(C_6H_{12}O_6)$ in 250 *g* of water **[UPSEAT 2001]**

(a) 4.0 *m*
(b) 0.4 *m*
(c) 4.2 *m*
(d) 0.8 *m*

81. Calculate the molality of 1 *litre* solution of 93% H_2SO_4 (weight/volume). The density of the solution is 1.84 *g* /*ml* **[UPSEAT 2000]**

(a) 10.43 (b) 20.36

(c) 12.05 (d) 14.05

82. Volume of water needed to mix with 10 *ml* 10*N* HNO_3 to get 0.1 *N* HNO_3 **[UPSEAT 2003]**

(a) 1000 *ml* (b) 990 *ml*

(c) 1010 ml (d) 10 *ml*

83. The sum of the mole fraction of the components of a solution is

(a) 0 (b) 1

(c) 2 (d) 4

84. Increasing the temperature of an aqueous solution will cause **[IIT Screening 1993]**

(a) Decrease in molality (b) Decrease in molarity

(c) Decrease in mole fraction (d)Decrease in % *w/w*

85. 1000 gms aqueous solution of $CaCO_3$ contains 10 gms of carbonate. Concentration of the solution is **[CPMT 1985]**

(a) 10 *ppm* (b) 100 *ppm*

(c) 1000 *ppm* (d) 10000 *ppm*

86. 3.65 *gms* of *HCl* is dissolved in 16.2 *gms* of water. The mole fraction of *HCl* in the resulting solution is **[EAMCET 2003]**

(a) 0.4 (b) 0.3

(c) 0.2 (d) 0.1

87. An aqueous solution of glucose is 10% in strength. The volume in which 1*gm* mole of it is dissolved will be **[AIIMS 1992; Pb. CET 2004]**

(a) 18 litre (b) 9 litre

(c) 0.9 litre (d) 1.8 litre

88. The concentration of an aqueous solution of $0.01 M\ CH_3OH$ solution is very nearly equal to which of the following **[BITS 1992]**

(a) $0.01\%\ CH_3OH$ (b) $0.01m\ CH_3OH$

(c) $x_{CH_3OH} = 0.01$ (d) $0.99 M\ H_2O$

(e) $0.01 N\ CH_3OH$

89. When 1.80 *gm* glucose dissolve in 90 *gm* of H_2O, the mole fraction of glucose is **[AFMC 2000]**

(a) 0.00399 (b) 0.00199

(c) 0.0199 (d) 0.998

90. 6.02×10^{20} molecules of urea are present in 100 ml of its solution. The concentration of urea solution is **[AIEEE 2004]**

(a) 0.02 M (b) 0.01 M

(c) 0.001 M (d) 0.1 M

(Avogadro constant, $N_A = 6.02 \times 10^{23} mol^{-1}$)

91. The number of moles of SO_2Cl_2 in 13.5*gm* is **[CPMT 1994]**

(a) 0.1 (b) 0.2

(c) 0.3 (d) 0.4

92. The weight of $H_2C_2O_4 . 2H_2O$ required to prepare 500 *ml* of 0.2*N* solution is **[EAMCET 1991]**

(a) 126 *g* (b) 12.6*g*

(c) 63*g* (d) 6.3*g*

93. In a solution of 7.8 *gm* benzene C_6H_6 and 46.0 *gm* toluene $(C_6H_5CH_3)$, the mole fraction of benzene in this solution is **[BHU 1981, 87]**

(a) 1 / 6 (b) 1 / 5

(c) 1 / 2 (d) 1 / 3

94. A solution contains $25\% H_2O$, $25\% C_2H_5OH$ and $50\% CH_3COOH$ by mass. The mole fraction of H_2O would be

(a) 0.25 (b) 2.5

(c) 0.503 (d) 5.03

95. A 5 molar solution of H_2SO_4 is diluted from 1 *litre* to 10 *litres*. What is the normality of the solution **[AFMC 2**

(a) 0.25 *N* (b) 1 *N*

(c) 2 *N* (d) 7 *N*

96. Molarity of a solution containing 1*g NaOH* in 250*ml* of solution is **[EAMCET 1990]**

(a) 0.1*M* (b) 1*M*

(c) 0.01 *M* (d) 0.001 *M*

97. What is molarity of a solution of *HCl* which contains 49% by weight of solute and whose specific gravity is 1.41 **[CPMT 2001; CBSE PMT 2001]**

(a) 15.25 (b) 16.75

(c) 18.92 (d) 20.08

98. *NaClO* solution reacts with H_2SO_3 as, $NaClO + H_2SO_3 \rightarrow NaCl + H_2SO_4$. A solution of *NaClO* used in the above reaction contained 15*g* of *NaClO* per litre. The normality of the solution would be **[AMU 1999]**

(a) 0.8 (b) 0.6

(c) 0.2 (d) 0.33

99. A solution contains 1.2046×10^{24} hydrochloric acid molecules in one dm^3 of the solution. The strength of the solution is **[KCET 2004]**

(a) 6 *N* (b) 2 *N*

(c) 4 *N* (d) 8 *N*

100. $10 N$ and $\frac{1}{10} N$ solution is called

(a) Decinormal and decanormal solution

(b) Normal and decinormal solution

(c) Normal and decanormal solution

(d) Decanormal and decinormal solution

101. When $7.1 gm\ Na_2SO_4$ (molecular mass 142) dissolves in $100\ ml\ H_2O$, the molarity of the solution is **[CBSE PMT 1991; MP PET 1993, 95]**

(a) 2.0 *M* (b) 1.0 *M*

(c) 0.5 M (d) 0.05 M

102. Molarity of 4% $NaOH$ solution is

(a) $0.1M$ (b) $0.5M$
(c) $0.01M$ (d) $1.0M$

103. When $6 gm$ urea dissolve in $180\, gm\, H_2O$. The mole fraction of urea is **[CPMT 1988]**

(a) $\frac{10}{10.1}$ (b) $\frac{10.1}{10}$
(c) $\frac{10.1}{0.1}$ (d) $\frac{0.1}{10.1}$

104. The normality of 10% (weight/volume) acetic acid is

[CPMT 1983]

(a) 1 N (b) 10 N
(c) 1.7 N (d) 0.83 N

105. Unit of mole fraction is **[BHU 1998, 2005]**

(a) *Moles/litre* (b) *Moles/litre*^{2}
(c) Moles–litre (d) Dimensionless

106. Normality of $2M$ sulphuric acid is

[AIIMS 1991, 92; Pb. CET 2002]

(a) $2N$ (b) $4N$
(c) $N/2$ (d) $N/4$

107. Molar concentration (M) of any solution =

(a) $\frac{\text{No. of moles of solute}}{\text{Volume of solution in litre}}$

(b) $\frac{\text{No. of gram equivalent of solute}}{\text{Volume of solution in litre}}$

(c) $\frac{\text{No. of moles of solute}}{\text{Mass of solvent in kg}}$

(d) $\frac{\text{No. of moles of any constituent}}{\text{Total no. of moles of all constituents}}$

108. If $5.0 gm$ of $BaCl_2$ is present in $10^6 gm$ solution, the concentration is

(a) 1 *ppm* (b) 5 *ppm*
(c) 50 *ppm* (d) 1000 *ppm*

109. 1 Molar solution contains **[DPMT 2002]**

(a) 1000*g* of solute (b) 1000*g* of solvent
(c) 1 *litre* of solvent (d) 1 *litre* of solution

110. To neutralise completely 20 mL of 0.1 M aqueous solution of phosphorous acid (H_3PO_3), the volume of 0.1 M aqueous KOH solution required is

(a) 40 *mL* (b) 20 *mL*
(c) 10 *mL* (d) 60 *mL*

111. On dissolving 1 mole of each of the following acids in 1 litre water, the acid which does not give a solution of strength $1N$ is

(a) HCl (b) Perchloric acid
(c) HNO_3 (d) Phosphoric acid

112. How many grams of $NaOH$ will be required to neutralize 12.2 grams of benzoic acid **[MP PMT 1999]**

(a) $40\, gms$ (b) $4 gms$
(c) $16 gms$ (d) $12.2 gms$

113. $10 ml$ of conc. H_2SO_4 (18 molar) is diluted to 1

[EAMCET 1987]

litre. The approximate strength of dilute acid could be **[JIPMER 1991]**

(a) 0.18 N (b) 0.09 N
(c) 0.36 N (d) 1800 N

114. The normality of 10 *lit.* volume hydrogen peroxide is

[Kerala CET (Med.) 2003]

(a) 0.176 (b) 3.52
(c) 1.78 (d) 0.88
(e) 17.8

115. Essential quantity of ammonium sulphate taken for preparation of 1 molar solution in 2 litres is

(a) $132\, gm$ (b) $264\, gm$
(c) $198\, gm$ (d) $212\, gm$

116. In a mixture of 1 *gm* H_2 and 8 *gm* O_2, the mole fraction of hydrogen is **[Orissa JEE 2002]**

(a) 0.667 (b) 0.5
(c) 0.33 (d) None of these

117. A solution of $CaCl_2$ is $0.5 mol/litre$, then the moles of chloride ion in $500 ml$ will be **[MP PMT 1986]**

(a) 0.25 (b) 0.50
(c) 0.75 (d) 1.00

118. What is the molarity of H_2SO_4 solution, that has a density 1.84 *gm/cc* at 35^oC and contains solute 98% by weight

[AIIMS 2001]

(a] 4.18 M (b) 8.14 M
(c) 18.4 M (d) 18 M

119. A certain aqueous solution of $FeCl_3$ (formula mass =162) has a density of $1.1 g/ml$ and contains $20.0\% FeCl_3$. Molar concentration of this solution is **[Pb. PMT 1998]**

(a) 0.028 (b) 0.163
(c) 1.27 (d) 1.47

120. If 0.50 mol of $CaCl_2$ is mixed with 0.20 mol of Na_3PO_4, the maximum number of moles of $Ca_3(PO_4)_2$ which can be formed, is

(a) 0.70 (b) 0.50
(c) 0.20 (d) 0.10

[AIEEE 2004]

121. An X molal solution of a compound in benzene has mole fraction of solute equal to 0.2. The value of X is

[KCET 1996; DCE 2001]

(a) 14 (b) 3.2
(c) 4 (d) 2

[MP PET 1993]

122. Molecular weight of urea is 60. A solution of urea containing $6g$ urea in one litre is **[BHU 1996, 99]**

(a) 1 molar (b) 1.5 molar
(c) 0.1 molar (d) 0.01 molar

123. The molar solution of sulphuric acid is equal to

[MP PET 1999]

(a) N solution (b) $2N$ solution
(c) $N/2$ solution (d) $3N$ solution

124. The weight of sodium carbonate required to prepare 500 *ml* of a semi- normal solution is **[JIPMER 1999]**

(a) 13.25 *g* (b) 26.5 *g*
(c) 53 *g* (d) 6.125 *g*

125. $200 ml$ of a solution contains $5.85 g$ dissolved sodium chloride. The concentration of the solution will be $(Na = 23; Cl = 35.5)$ **[MP PMT 1999]**

(a) 1 molar (b) 2 molar
(c) 0.5 molar (d) 0.25 molar

126. Molarity of a solution prepared by dissolving 75.5 *g* of pure KOH in 540 *ml* solution is **[BHU 1999]**

(a) 3.05 *M* (b) 1.35 *M*
(c) 2.50 *M* (d) 4.50 *M*

127. Which one of the following is an extensive property **[KCET 1998]**

(a) Molar volume (b) Molarity
(c) Number of moles (d) Mole fraction

128. Addition of conc. HCl to saturated $BaCl_2$ solution precipitates $BaCl_2$; because **[AMU 2000]**

(a) It follows from Le Chatelier's principle
(b) Of common-ion effect
(c) Ionic product (Ba^{++}), (Cl^-) remains constant in a saturated solution
(d) At constant temperature, the product (Ba^{2+}), $(Cl^-)^2$ remains constant in a saturated solution

129. How much water is needed to dilute 10 *ml* of 10 *N* hydrochloric acid to make it exactly decinormal (0.1 *N*) **[EAMCET 1982]**

(a) 990 ml (b) 1000 ml
(c) 1010 ml (d) 100 ml

130. The formula weight of H_2SO_4 is 98. The weight of the acid in $400 ml$ of $0.1 M$ solution is **[EAMCET 1987]**

(a) $2.45 g$ (b) $3.92 g$
(c) $4.90 g$ (d) $9.8 g$

131. The molarity of pure water is **[CPMT 1974, 88, 90; CMC Vellore 1991; RPET 1999; NCERT 1974, 76; MP PMT 1999; AMU 2002]**

(a) 55.6 (b) 5.56
(c) 100 (d) 18

132. The molarity of a $0.2 N\ Na_2CO_3$ solution will be **[MP PMT 1987; Pb. CET 2004]**

(a) 0.05 M (b) 0.2 M
(c) 0.1 M (d) 0.4 M

133. How many moles of water are present in 180 *g* of water **[JIPMER 1991; DPMT 1982; Manipal MEE 1995]**

(a) 1 mole (b) 18 mole
(c) 10 mole (d) 100 mole

134. If we take $44 g$ of CO_2 and $14 g$ of N_2 what will be mole fraction of CO_2 in the mixture **[KCET 1990]**

(a) 1/5 (b) 1/3
(c) 2/3 (d) 1/4

135. What is the volume of $0.1 N\ HCl$ required to react completely with $1.0 g$ of pure calcium carbonate $(Ca = 40, C = 12$ and $O = 16)$ **[KCET 1998]**

(a) $150\ cm^3$ (b) $250\ cm^3$
(c) $200\ cm^3$ (d) $100\ cm^3$

136. The amount of $NaOH$ in gms in $250\ cm^3$ of a $0.100\ M\ NaOH$ solution would be

(a) 4 *gm* (b) 2 *gm*
(c) 1 *gm* (d) 2.5 *gm*

137. 4.0 *gm* of $NaOH$ are contained in one decilitre of solution. Its molarity would be

(a) 4 *M* (b) 2 *M*
(c) 1 *M* (d) 1.5 *M*

138. When 90 *gm* of water is mixed with 300 *gm* of acetic acid. The total number of moles will be

(a) 5 (b) 10
(c) 15 (d) 20

139. A molal solution is one that contains one mole of a solute in **[NCERT 1983; DPMT 1983; CPMT 1985; IIT 1986; MP PMT 1987; EAMCET 1990; MP PET 1994, 99]**

(a) 1000 gm of the solvent
(b) One litre of the solvent
(c) One litre of the solution
(d) 22.4 litres of the solution

140. What weight of ferrous ammonium sulphate is needed to prepare 100 *ml* of 0.1 normal solution (mol. wt. 392) **[CPMT 1983]**

(a) 39.2 gm (b) 3.92 gm
(c) 1.96 gm (d) 19.6 gm

141. If 18 gm of glucose $(C_6H_{12}O_6)$ is present in 1000 *gm* of an aqueous solution of glucose, it is said to be **[CPMT 1986]**

(a) 1 molal (b) 1.1 molal
(c) 0.5 molal (d) 0.1 molal

142. The number of moles of KCl in $1000\ ml$ of 3 molar solution is **[NCERT 1973]**

(a) 1 (b) 2
(c) 3 (d) 1.5

143. The unit of molality is **[Pb. CET 2003]**

(a) Mole per litre (b) Mole per kilogram
(c) Per mole per litre (d) Mole litre

144. A solution contains 1 mole of water and 4 mole of ethanol. The mole fraction of water and ethanol will be

(a) 0.2 water + 0.8 ethanol

(b) 0.4 water + 0.6 ethanol

(c) 0.6 water + 0.8 ethanol

(d) 0.8 water + 0.2 ethanol

Colligative properties

1. The magnitude of colligative properties in all colloidal dispersions is ....than solution **[AMU 1999]**

(a) Lower (b) Higher

(c) Both (d) None

2. Equimolar solutions in the same solvent have **[AIEEE 2005]**

(a) Same boiling point but different freezing point

(b) Same freezing point but different boiling point

(c) Same boiling and same freezing points

(d) Different boiling and different freezing points

3. Which of the following is a colligative property

[AFMC 1992; CBSE PMT 1992; MP PMT 1996, 2003]

(a) Osmotic pressure (b) Boiling point

(c) Vapour pressure (d) Freezing point

4. The colligative properties of a solution depend on

[CPMT 1984; MP PMT 1993; UPSEAT 2001; Kerala PMT 2002]

(a) Nature of solute particles present in it

(b) Nature of solvent used

(c) Number of solute particles present in it

(d) Number of moles of solvent only

5. Which of the following is not a colligative property

[BHU 1982; CPMT 1988; DPMT 1985; MP PET 1999]

(a) Osmotic pressure

(b) Elevation in B.P.

(c) Vapour pressure

(d) Depression in freezing point

6. Which of the following is not a colligative property

[MP PET 2001; CPMT 2001; Pb. CET 2001]

(a) Optical activity

(b) Elevation in boiling point

(c) Osmotic pressure

(d) Lowering of vapour pressure

7. Colligative properties of a solution depends upon

[MP PMT 1994, 2002]

(a) Nature of both solvent and solute

(b) The relative number of solute and solvent particles

(c) Nature of solute only

(d) Nature of solvent only

8. Which is not a colligative property

[CPMT 1984; BHU 1982; Manipal MEE 1995]

(a) Refractive index

(b) Lowering of vapour pressure

(c) Depression of freezing point

(d) Elevation of boiling point

9. Which of the following is a colligative property

[BHU 1990; NCERT 1983; MP PMT 1983; DPMT 1981, 83; MP PET/PMT 1998; AIIMS 1999; Pb. CET 2000]

(a) Surface tension (b) Viscosity

(c) Osmotic pressure (d) Optical rotation

10. Colligative properties are used for the determination of

[Kerala CET (Engg.) 2002]

(a) Molar Mass

(b) Equivalent weight

(c) Arrangement of molecules

(d) Melting point and boiling point

(d) Both (a) and (b)

11. What does not change on changing temperature

[DCE 2001]

(a) Mole fraction (b) Normality

(c) Molality (d) None of these

Lowering of vapour pressure

1. Vapour pressure of CCl_4 at $25^{\circ}C$ is $143 mm$ of Hg $0.5 gm$ of a non-volatile solute (mol. wt. = 65) is dissolved in $100 ml\ CCl_4$. Find the vapour pressure of the solution (Density of $CCl_4 = 1.58\ g/cm^2$) **[CBSE PMT 1998]**

(a) $141.43\ mm$ (b) $94.39\ mm$

(c) $199.34\ mm$ (d) $143.99\ mm$

2. For a solution of volatile liquids the partial vapour pressure of each component in solution is directly proportional to

(a) Molarity (b) Mole fraction

(c) Molality (d) Normality

3. "The relative lowering of the vapour pressure is equal to the mole fraction of the solute." This law is called

[MP PET 1997, 2001]

(a) Henry's law (b) Raoult's law

(c) Ostwald's law (d) Arrhenius's law

4. The relative lowering of vapour pressure produced by dissolving 71.5 *g* of a substance in 1000 *g* of water is 0.00713. The molecular weight of the substance will be

[DPMT 2001]

(a) 18.0 (b) 342

(c) 60 (d) 180

5. When mercuric iodide is added to the aqueous solution of potassium iodide, the **[IIT 1987]**

(a) Freezing point is raised

(b) Freezing point is lowered

(c) Freezing point does not change

(d) Boiling point does not change

6. Vapour pressure of a solution is **[EAMCET 1988; MP PET 1994]**

(a) Directly proportional to the mole fraction of the solvent

(b) Inversely proportional to the mole fraction of the solute

(c) Inversely proportional to the mole fraction of the solvent

(d) Directly proportional to the mole fraction of the solute

7. When a substance is dissolved in a solvent the vapour pressure of the solvent is decreased. This results in **[NCERT 1981]**

(a) An increase in the b.p. of the solution

(b) A decrease in the b.p. of the solvent

(c) The solution having a higher freezing point than the solvent

(d) The solution having a lower osmotic pressure than the solvent

8. If P^o and P are the vapour pressure of a solvent and its solution respectively and N_1 and N_2 are the mole fractions of the solvent and solute respectively, then correct relation is

(a) $P = P^o N_1$ (b) $P = P^o N_2$

(c) $P^o = P N_2$ (d) $P = P^o (N_1 / N_2)$

9. An aqueous solution of methanol in water has vapour pressure **[MNR 1986]**

(a) Equal to that of water

(b) Equal to that of methanol

(c) More than that of water

(d) Less than that of water

10. The pressure under which liquid and vapour can coexist at equilibrium is called the

(a) Limiting vapour pressure

(b) Real vapour pressure

(c) Normal vapour pressure

(d) Saturated vapour pressure

11. Which solution will show the maximum vapour pressure at 300 K **[DPMT 2001]**

(a) 1 M $C_{12}H_{22}O_{11}$ (b) 1 M CH_3COOH

(c) 1 M $NaCl_2$ (d) 1 M $NaCl$

12. The relative lowering of the vapour pressure is equal to the ratio between the number of **[EAMCET 1991; CBSE PMT 1991]**

(a) Solute moleules and solvent molecules

(b) Solute molecules and the total molecules in the solution

(c) Solvent molecules and the total molecules in the solution

(d) Solvent molecules and the total number of ions of the solute

13. $5 cm^3$ of acetone is added to $100 \, cm^3$ of water, the vapour pressure of water over the solution

(a) It will be equal to the vapour pressure of pure water

(b) It will be less than the vapour pressure of pure water

(c) It will be greater than the vapour pressure of pure water

(d) It will be very large

14. At 300 K, when a solute is added to a solvent its vapour pressure over the mercury reduces from 50 *mm* to 45 *mm*. The value of mole fraction of solute will be

(a) 0.005 (b) 0.010

(c) 0.100 (d) 0.900

15. A solution has a 1 : 4 mole ratio of pentane to hexane. The vapour pressure of the pure hydrocarbons at 20°C are 440 *mmHg* for pentane and 120 *mmHg* for hexane. The mole fraction of pentane in the vapour phase would be **[CBSE PMT 2005]**

(a) 0.549 (b) 0.200

(c) 0.786 (d) 0.478

16. Benzene and toluene form nearly ideal solutions. At 20°C, the vapour pressure of benzene is 75 *torr* and that of toluene is 22 *torr*. The parial vapour pressure of benzene at 20°C for a solution containing 78*g* of benzene and 46*g* of toluene in *torr* is **[AIEEE 2005]**

(a) 50 (b) 25

(c) 37.5 (d) 53.5

17. The vapour pressure lowering caused by the addition of 100 *g* of sucrose(molecular mass = 342) to 1000 *g* of water if the vapour pressure of pure water at $25^o C$ is 23.8 *mm Hg* **[RPET 1999]**

(a) 1.25 *mm Hg* (b) 0.125 *mm Hg*

(c) 1.15 *mm Hg* (d) 00.12 *mm Hg*

18. Which of the following is incorrect **[J & K 2005]**

(a) Relative lowering of vapour pressure is independent

(b) The vapour pressure is a colligative property

(c) Vapour pressure of a solution is lower than the vapour pressure of the solvent

(d) The relative lowering of vapour pressure is directly proportional to the original pressure

19. Among the following substances the lowest vapour pressure is exerted by

(a) Water
(b) Mercury
(c) Kerosene
(d) Rectified spirit

20. According to Raoult's law the relative lowering of vapour pressure of a solution of volatile substance is equal to **[CBSE PMT 1995; BHU 2001]**

(a) Mole fraction of the solvent
(b) Mole fraction of the solute
(c) Weight percentage of a solute
(d) Weight percentage of a solvent

21. When a substance is dissolved in a solvent, the vapour pressure of the solvent is decreased. This results in **[MP PMT 1983; NCERT 1981]**

(a) An increase in the boiling point of the solution
(b) A decrease in the boiling point of solvent
(c) The solution having a higher freezing point than the solvent
(d) The solution having a lower osmotic pressure than the solvent

22. The vapour pressure of a liquid depends on

(a) Temperature but not on volume
(b) Volume but not on temperature
(c) Temperature and volume
(d) Neither on temperature nor on volume

23. Which one of the statements given below concerning properties of solutions, describes a colligative effect **[AIIMS 2003]**

(a) Boiling point of pure water decreases by the addition of ethanol
(b) Vapour pressure of pure water decreases by the addition of nitric acid
(c) Vapour pressure of pure benzene decreases by the addition of naphthalene
(d) Boiling point of pure benzene increases by the addition of toluene

24. The atmospheric pressure is sum of the **[Kerala CET (Med.) 2002]**

(a) Pressure of the biomolecules
(b) Vapour pressure of atmospheric constituents
(c) Vapour pressure of chemicals and vapour pressure of volatiles
(d) Pressure created on to atmospheric molecules

25. The vapour pressure of pure liquid *A* is 0.80 *atm*. On mixing a non-volatile *B* to *A*, its vapour pressure becomes 0.6 *atm*. The mole fraction of B in the solution is **[MP PET 2003]**

(a) 0.150
(b) 0.25
(c) 0.50
(d) 0.75

26. Lowering of vapour pressure is highest for **[BHU 1997]**

(a) Urea
(b) $0.1M$ glucose
(c) $0.1\,M\,MgSO_4$
(d) $0.1\,M\,BaCl_2$

27. An aqueous solution of glucose was prepared by dissolving 18 *g* of glucose in 90 *g* of water. The relative lowering in vapour pressure is **[KCET 2002]**

(a) 0.02
(b) 1
(c) 20
(d) 180

28. "Relative lowering in vapour pressure of solution containing non-volatile solute is directly proportional to mole fraction of solute". Above statement is **[AFMC 2004]**

(a) Henry law
(b) Dulong and Petit law
(c) Raoult's law
(d) Le-Chatelier's principle

29. An ideal solution was obtained by mixing methanol and ethanol. If the partial vapour pressure of methanol and ethanol are $2.619\,kPa$ and $4.556\,kPa$ respectively, the composition of the vapour (in terms of mole fraction) will be **[Pb. PMT 1998]**

(a) 0.635 methanol, 0.365 ethanol
(b) 0.365 methanol, 0.635 ethanol
(c) 0.574 methanol, 0.326 ethanol
(d) 0.173 methanol, 0.827 ethanol

30. The vapour pressure of two liquids *P* and *Q* are 80 and 600 torr, respectively. The total vapour pressure of solution obtained by mixing 3 *mole* of *P* and 2 *mole* of *Q* would be **[CBSE PMT 2005]**

(a) 140 torr
(b) 20 torr
(c) 68 torr
(d) 72 torr

31. The vapour pressure of benzene at a certain temperature is $640\,mm$ of Hg. A non-volatile and non-electrolyte solid weighing $2.175\,g$ is added to $39.08\,g$ of benzene. The vapour pressure of the solution is $600\,mm$ of Hg. What is the molecular weight of solid substance **[CBSE PMT 1999; AFMC 1999]**

(a) 49.50
(b) 59.6
(c) 69.5
(d) 79.8

32. Which one of the following is the expression of Raoult's law

(a) $\frac{p-p_s}{p}=\frac{n}{n+N}$
(b) $\frac{p_s-p}{p}=\frac{N}{N+n}$
(c) $\frac{p-p_s}{p_s}=\frac{N}{N-n}$
(d) $\frac{p_s-p}{p_s}=\frac{N-n}{N}$

$p =$ vapour pressure of pure solvent
$p_s =$ vapour pressure of the solution
$n =$ number of moles of the solute
$N =$ number of moles of the solvent

33. Which has maximum vapour pressure **[DPMT 2001]**

(a) HI
(b) HBr
(c) HCl
(d) HF

34. When a non-volatile solute is dissolved in a solvent, the relative lowering of vapour pressure is equal to

[BHU 1979; IIT 1983]

(a) Mole fraction of solute

(b) Mole fraction of solvent

(c) Concentration of the solute in grams per litre

(d) Concentration of the solute in grams 100 *ml*

35. 60 *gm* of Urea (*Mol. wt* 60) was dissolved in 9.9 *moles*, of water. If the vapour pressure of pure water is P_o, the vapour pressure of solution is **[DCE 2000]**

(a) 0.10 P_o (b) 1.10 P_o

(c) 0.90 P_o (d) 0.99 P_o

36. The vapour pressure of water at $20^{\circ}C$ is 17.54 *mm*. When 20*g* of a non-ionic, substance is dissolved in 100*g* of water, the vapour pressure is lowered by 0.30 *mm*. What is the molecular weight of the substances **[UPSEAT 2001]**

(a) 210.2 (b) 206.88

(c) 215.2 (d) 200.8

37. In an experiment, 1 *g* of a non-volatile solute was dissolved in 100 *g* of acetone (mol. mass = 58) at 298*K*. The vapour pressure of the solution was found to be 192.5 *mm Hg*. The molecular weight of the solute is (vapour pressure of acetone = 195 *mm Hg*)

[CPMT 2001; CBSE PMT 2001; Pb CET 2002]

(a) 25.24 (b) 35.24

(c) 45.24 (d) 55.24

38. How many grams of CH_3OH should be added to water to prepare $150\,ml$ solution of $2\,M\,CH_3OH$ **[CBSE PMT 1994]**

(a) 9.6 (b) 2.4

(c) 9.6×10^3 (d) 2.4×10^3

39. The vapour pressure of a solvent decreased by $10\,mm$ of mercury, when a non-volatile solute was added to the solvent. The mole fraction of the solute in the solution is 0.2. What should be the mole fraction of the solvent, if decrease in the vapour pressure is to be $20\,mm$ of mercury

[CBSE PMT 1998]

(a) 0.8 (b) 0.6

(c) 0.4 (d) 0.2

40. For a dilute solution, Raoult's law states that

[CPMT 1987; BHU 1979; IIT 1985; MP PMT 2004; MNR 1988; AMU 2002]

(a) The lowering of vapour pressure is equal to mole fraction of solute

(b) The relative lowering of vapour pressure is equal to mole fraction of solute

(c) The relative lowering of vapour pressure is proportional to the amount of solute in solution

(d) The vapour pressure of the solution is equal to the mole fraction of solvent

41. The vapour pressure of a solvent *A* is 0.80 *atm* When a non-volatile substance *B* is added to this solvent its vapour pressure drops to 0.6 *atm*. What is mole fraction of *B* in solution

(a) 0.25 (b) 0.50

(c) 0.75 (d) 0.90

42. Determination of correct molecular mass from Raoult's law is applicable to

(a) An electrolyte in solution

(b) A non-electrolyte in a dilute solution

(c) A non-electrolyte in a concentrated solution

(d) An electrolyte in a liquid solvent

43. If two substances *A* and *B* have $P_A^0 : P_B^0 = 1:2$ and have mole fraction in solution 1 : 2 then mole fraction of *A* in vapours **[DPMT 2005]**

(a) 0.33 (b) 0.25

(c) 0.52 (d) 0.2

44. A dry air is passed through the solution, containing the 10 gm of solute and 90 gm of water and then it pass through pure water. There is the depression in weight of solution wt by 2.5 gm and in weight of pure solvent by 0.05 gm. Calculate the molecular weight of solute **[Kerala CET 2005]**

(a) 50 (b) 180

(c) 100 (d) 25

(e) 51

Ideal and Non-ideal solution

1. Which of the following liquid pairs shows a positive deviation from Raoult's law

[MP PET 1993; UPSEAT 2001; AIEEE 2004]

(a) Water-nitric acid (b) Benzene-methanol

(c) Water-hydrochloric acid (d)Acetone-chloroform

2. Which one of the following is non-ideal solution

(a) Benzene + toluene

(b) n-hexane + n-heptane

(c) Ethyl bromide + ethyl iodide

(d) $CCl_4 + CHCl_3$

3. A non ideal solution was prepared by mixing 30 ml chloroform and 50 ml acetone. The volume of mixture will be **[Pb. CET 2003]**

(a) > 80 ml (b) < 80 ml

(c) = 80 ml (d) ≥ 80 ml

4. Which pair from the following will not form an ideal solution

(a) $CCl_4 + SiCl_4$ (b) $H_2O + C_4H_9OH$

(c) $C_2H_5Br + C_2H_5I$ (d) $C_6H_{14} + C_7H_{16}$

5. An ideal solution is that which **[MP PMT 1996]**

(a) Shows positive deviation from Raoult's law

(b) Shows negative deviation from Raoult's law
(c) Has no connection with Raoult's law
(d) Obeys Raoult's law

6. Which one of the following mixtures can be separated into pure components by fractional distillation **[CPMT 1987]**
(a) Benzene – toluene (b) Water – ethyl alcohol
(c) Water – nitric acid (d) Water – hydrochloric acid

7. All form ideal solutions except **[DPMT 1983; MP PET 1997]**
(a) C_2H_5Br and C_2H_5I (b) C_6H_5Cl and C_6H_5Br
(c) C_6H_6 and $C_6H_5CH_3$ (d) C_2H_5I and C_2H_5OH

8. Which property is shown by an ideal solution **[MP PET 2002]**
(a) It follows Raoult's law (b) $\Delta H_{mix} = 0$
(c) $\Delta V_{mix} = 0$ (d) All of these

9. When two liquid A and B are mixed then their boiling points becomes greater than both of them. What is the nature of this solution
(a) Ideal solution
(b) Positive deviation with non ideal solution
(c) Negative deviation with non ideal solution
(d) Normal solution

10. In mixture *A* and *B* components show *–ve* deviation as **[AIEEE 2002]**
(a) $\Delta V_{\text{mix}} > 0$
(b) $\Delta H_{\text{mix}} < 0$
(c) *A-B* interaction is weaker than *A-A* and *B-B* interaction
(d) *A-B* interaction is strong than *A-A* and *B-B* interaction

11. In which case Raoult's law is not applicable
(a) $1M\ NaCl$ (b) 1 M urea
(c) 1 M glucose (d) 1 M sucrose

12. A solution that obeys Raoult's law is **[EAMCET 1993]**
(a) Normal (b) Molar
(c) Ideal (d) Saturated

13. An example of near ideal solution is
(a) n-heptane and n-hexane
(b) $CH_3COOH + C_5H_5N$
(c) $CHCl_3 + (C_2H_5)_2O$
(d) $H_2O + HNO_3$

14. A mixture of liquid showing positive deviation in Raoult's law is
(a) $(CH_3)_2CO + C_2H_5OH$ (b) $(CH_3)_2CO + CHCl_3$
(c) $(C_2H_5)_2O + CHCl_3$ (d) $(CH_3)_2CO + C_6H_5NH_2$

15. All form ideal solution except **[UPSEAT 2001]**
(a) C_2H_5Br and C_2H_5I (b) C_2H_5Cl and C_6H_5Br
(c) C_6H_6 and $C_6H_5CH_3$ (d) C_2H_5I and C_2H_5OH

16. Formation of a solution from two components can be considered as **[CBSE PMT 2003]**
(i) Pure solvent → separated solvent molecules ΔH_1
(ii) Pure solute → separated solute molecules ΔH_2
(iii) Separated solvent and solute molecules → solution ΔH_3
Solution so formed will be ideal if
(a) $\Delta H_{\text{soln}} = \Delta H_3 - \Delta H_1 - \Delta H_2$
(b) $\Delta H_{\text{soln}} = \Delta H_1 + \Delta H_2 + \Delta H_3$
(c) $\Delta H_{\text{soln}} = \Delta H_1 + \Delta H_2 - \Delta H_3$
(d) $\Delta H_{\text{soln}} = \Delta H_1 - \Delta H_2 - \Delta H_3$

17. Identify the mixture that shows positive deviation from Raoult's law **[Kerala CET (Engg.) 2002]**
(a) $CHCl_3 + (CH_3)_2CO$ (b) $(CH_3)_2CO + C_6H_5NH_2$
(c) $CHCl_3 + C_6H_6$ (d) $(CH_3)_2CO + CS_2$
(e) $C_6H_5N + CH_3COOH$

18. When acetone is added to chloroform, then hydrogen bond is formed between them.These liquids show
(a) Positive deviation from Raoult's law
(b) Negative deviation from Raoult's law
(c) No deviation from Raoult's law
(d) Volume is slightly increased

19. Which of the following is true when components forming an ideal solution are mixed **[AMU 2000]**
(a) $\Delta H_m = \Delta V_m = 0$ (b) $\Delta H_m > \Delta V_m$
(c) $\Delta H_m < \Delta V_m$ (d) $\Delta H_m = \Delta V_m = 1$

20. The liquid pair benzene-toluene shows **[MP PET 1995]**
(a) Irregular deviation from Raoult's law
(b) Negative deviation from Raoult's law
(c) Positive deviation from Raoult's law
(d) Practically no deviation from Raoult's law

21. The solution which shows negative or positive deviation by Raoult's law, is called
(a) Ideal solution (b) Real solution
(c) Non-ideal solution (d) Colloidal solution

22. Which of the following does not show positive deviation from Raoult's law
(a) Benzene-Chloroform
(b) Benzene-Acetone
(c) Benzene-Ethanol
(d) Benzene-Carbon tetrachloride

23. Which of the following mixture shows positive deviation by ideal behaviour
(a) $CHCl_3 + (CH_3)_2CO$ (b) $C_6H_6 + C_6H_5CH_3$
(c) $H_2O + HCl$ (d) $CCl_4 + CHCl_3$

24. Which property is not found in ideal solution
(a) $P_A \neq P_A^o \times X_A$ (b) $\Delta H_{mix} \neq 0$
(c) $\Delta V_{mix} \neq 0$ (d) All of these

25. Which of the following is not correct for ideal solution **[JIPMER 1997]**

(a) $\Delta S_{mix} = 0$ (b) $\Delta H_{mix} = 0$

(c) It obeys Raoult's law (d) $\Delta V_{mix} = 0$

26. Which of the following does not show negative deviation from Raoult's law

(a) Acetone-Chloroform (b) Acetone-Benzene

(c) Chloroform-Ether (d) Chloroform-Benzene

27. A mixture of benzene and toluene forms **[MP PMT 1993]**

(a) An ideal solution (b) Non-ideal solution

(c) Suspension (d) Emulsion

28. Which of the following is an ideal solution

(a) Water + ethanol

(b) Chloroform + carbon tetrachloride

(c) Benzene + toluene

(d) Water + hydrochloric acid

29. When ethanol mixes in cyclohexane; cyclohexane reduces the intermolecular forces between ethanol molecule. In this, liquid pair shows

(a) Positive deviation by Raoult's law

(b) Negative deviation by Raoult's law

(c) No deviation by Raoult's law

(d) Decrease in volume

30. Liquids *A* and *B* form an ideal solution **[AIEEE 2003]**

(a) The enthalpy of mixing is zero

(b) The entropy of mixing is zero

(c) The free energy of mixing is zero

(d) The free energy as well as the entropy of mixing are each zero

Azeotropic mixture

1. The azeotropic mixture of water $(b.p. 100^{\circ}C)$ and $HCl (b.p. 85^{\circ}C)$ boils at $108.5^{\circ}C$. When this mixture is distilled it is possible to obtain **[IIT 1981]**

(a) Pure HCl

(b) Pure water

(c) Pure water as well as pure HCl

(d) Neither HCl nor H_2O in their pure states

2. An azeotropic solution of two liquids has boiling point lower than either when it

(a) Shows a negative deviation from Raoult's law

(b) Shows no deviation from Raoult's law

(c) Shows positive deviation from Raoult's law

(d) Is saturated

3. A liquid mixture boils without changing constituent is called **[DPMT 1982; CPMT 1987]**

(a) Stable structure complex

(b) Binary liquid mixture

(c) Zeotropic liquid mixture

(d) Azeotropic liquid mixture

4. Azeotropic mixture are **[CPMT 1982]**

(a) Constant temperature boiling mixtures

(b) Those which boils at different temperatures

(c) Mixture of two solids

(d) None of the above **[MP PMT 2001]**

5. A mixture of two completely miscible non-ideal liquids which distil as such without change in its composition at a constant temperature as though it were a pure liquid. This mixture is known as

(a) Binary liquid mixture (b) Azeotropic mixture

(c) Eutectic mixture (d) Ideal mixture

Osmosis and Osmotic pressure of the solution

1. If 3 *gm* of glucose (*mol. wt.* 180) is dissolved in 60 *gm* of water at $15^{\circ}C$. Then the osmotic pressure of this solution will be

(a) 0.34 atm (b) 0.65 atm

(c) 6.57 atm (d) 5.57 atm

2. The concentration in *gms* per *litre* of a solution of cane sugar $(M = 342)$ which is isotonic with a solution containing $6\,gms$ of urea $(M = 60)$ per *litre* is **[Orissa PMT 1989]**

(a) 3.42 (b) 34.2

(c) 5.7 (d) 19

3. Osmotic pressure is 0.0821 *atm* at temperature of $300\,K$. Find concentration in *mole/litre* **[Roorkee 1990]**

(a) 0.033 (b) 0.066

(c) 0.33×10^{-2} (d) 3

4. Osmotic pressure of a solution containing 0.1 mole of solute per litre at $273\,K$ is (in *atm*) **[CPMT 1988]**

(a) $\frac{0.1}{1} \times 0.08205 \times 273$ (b) $0.1 \times 1 \times 0.08205 \times 273$

(c) $\frac{1}{0.1} \times 0.08205 \times 273$ (d) $\frac{0.1}{1} \times \frac{273}{0.08205}$

5. A solution contains non-volatile solute of molecular mass M_p. Which of the following can be used to calculate molecular mass of the solute in terms of osmotic pressure (*m* = Mass of solute, *V* = Volume of solution and π = Osmotic pressure) **[NCERT 1978; IIT 1981]** **[CBSE PMT 2002]**

(a) $Mp = \left(\frac{m}{\pi}\right) VRT$ (b) $Mp = \left(\frac{m}{V}\right) \frac{RT}{\pi}$

(c) $Mp = \left(\frac{m}{V}\right) \frac{\pi}{RT}$ (d) $Mp = \left(\frac{m}{V}\right) \pi RT$

6. The osmotic pressure of a 5% (*wt/vol*) solution of cane sugar at $150^{\circ}C$ is **[AMU 1999]**

(a) 2.45 *atm* (b) 5.078 *atm*

(c) 3.4 *atm* (d) 4 *atm*

7. The relationship between osmotic pressure at $273\,K$ when $10\,g$ glucose (P_1), $10\,g$ urea (P_2) and $10\,g$ sucrose (P_3) are dissolved in $250\,ml$ of water is **[CBSE PMT 1996]**

(a) $P_1 > P_2 > P_3$ (b) $P_3 > P_1 > P_2$

(c) $P_2 > P_1 > P_3$ (d) $P_2 > P_3 > P_1$

8. In osmosis **[DPMT 1985]**

(a) Solvent molecules move from higher concentration to lower concentration

(b) Solvent molecules move from lower to higher concentration

(c) Solute molecules move from higher to lower concentration

(d) Solute molecules move from lower to higher concentration

9. Semipermeable membrane is that which permits the passage of**[BHU 1979; CPMT 1977, 84, 90; MP PMT 1994]**

(a) Solute molecules only

(b) Solvent molecules only

(c) Solute and solvent molecules both

(d) Neither solute nor solvent molecules

10. Two solutions *A* and *B* are separated by semi-permeable membrane. If liquid flows form *A* to *B* then **[MH CET 2000]**

(a) *A* is less concentrated than *B*

(b) *A* is more concentrated than *B*

(c) Both have same concentration

(d) None of these

11. A 5% solution of canesugar (mol. wt. =342) is isotonic with 1% solution of a substance X. The molecular weight of X is

(a) 34.2 (b) 171.2

(c) 68.4 (d) 136.8

12. Which of the following colligative properties can provide molar mass of proteins (or polymers or colloids) with greater precision **[Kerala PMT 2004]**

(a) Relative lowering of vapour pressure

(b) Elevation of boiling point

(c) Depression in freezing point

(d) Osmotic pressure

(e) Rast's method

13. The average osmotic pressure of human blood is 7.8 bar at $37^{\circ}C$. What is the concentration of an aqueous $NaCl$ solution that could be used in the blood stream **[AIIMS 2004]**

(a) $0.16\ mol/L$ (b) $0.32\ mol/L$

(c) $0.60\ mol/L$ (d) $0.45\ mol/L$

14. A solution of sucrose(molar mass = 342 *g/mol*) is prepared by dissolving 68.4 *g* of it per *litre* of the solution, what is its osmotic pressure (*R* = 0.082 *lit. atm.* $k^{-1}\ mol^{-1}$) at 273*k*

[UPSEAT 2001]

(a) 6.02 *atm* (b) 4.92 *atm*

(c) 4.04 *atm* (d) 5.32 *atm*

15. Blood has been found to be isotonic with**[CPMT 1994]**

(a) Normal saline solution

(b) Saturated $NaCl$ solution

(c) Saturated KCl solution

(d) Saturated solution of a 1 : 1 mixture of $NaCl$ and KCl

16. If 20 *g* of a solute was dissolved in 500 *ml* of water and osmotic pressure of the solution was found to be 600 *mm* of *Hg* at $15^{\circ}C$, then molecular weight of the solute is

[BHU 2004]

(a) 1000 (b) 1200

(c) 1400 (d) 1800

17. The osmotic pressure of 0.4% urea solution is 1.66 atm and. that of a solution of suger of 3.42 % is 2.46 atm. When both the solution are mixed then the osmotic pressure of the resultant solution will be **[MP PMT 1985]**

(a) 1.64 atm (b) 2.46 atm

(c) 2.06 atm (d) 0.82 atm

18. Blood is isotonic with **[DCE 2000]**

(a) 0.16 M $NaCl$ (b) Conc. $NaCl$

(c) 50 % $NaCl$ (d) 30 % $NaCl$

19. Which inorganic precipitate acts as semipermeable membrane **or** The chemical composition of semipermeable membrane is**[CPMT 1984, 9**

(a) Calcium sulphate (b) Barium oxalate

(c) Nickel phosphate (d) Copper ferrocyanide

20. **[CBSE PMT 1998]** The osmotic pressure of $1m$ solution at $27^{\circ}C$ is**[CPMT 1999]**

(a) 2.46 *atm* (b) 24.6 *atm*

(c) 1.21 *atm* (d) 12.1 *atm*

21. Osmotic pressure of a solution can be measured quickly and accurately by**[JIPMER 1991; CPMT 1983]**

(a) Berkeley and Hartley's method

(b) Morse's method

(c) Pfeffer's method

(d) De Vries method

22. The solution in which the blood cells retain their normal form are with regard to the blood**[CBSE PMT 1991]**

(a) Isotonic (b) Isomotic

(c) Hypertonic (d) Equinormal

23. The osmotic pressure of a solution is given by the relation

[CPMT 1983, 84, 87, 93, 94]

(a) $P = \frac{RT}{C}$ (b) $P = \frac{CT}{R}$

(c) $P = \frac{RC}{T}$ (d) $\frac{P}{C} = RT$

24. The osmotic pressure of a solution is directly proportional to

(a) The molecular concentration of solute

(b) The absolute temperature at a given concentration

(c) The lowering of vapour pressure

(d) All of the above

25. What would happen if a thin slice of sugar beet is placed in a concentrated solution of $NaCl$ **[CMC Vellore 1986]**

(a) Sugar beet will lose water from its cells

(b) Sugar beet will absorb water from solution

(c) Sugar beet will neither absorb nor lose water

(d) Sugar beet will dissolve in solution

26. The osmotic pressure of a dilute solution is given by **[MP PMT 1987]**

(a) $P = P_o x$ (b) $\pi V = nRT$

(c) $\Delta P = P_o N_2$ (d) $\frac{\Delta P}{P_o} = \frac{P_o - P}{P_o}$

27. Which statement is wrong regarding osmotic pressure (P), volume (V) and temperature (T) **[MP PMT 1985]**

(a) $P \propto \frac{1}{V}$ if T is constant

(b) $P \propto T$ if V is constant

(c) $P \propto V$ if T is constant

(d) PV is constant if T is constant

28. Isotonic solutions have **[DPMT 1984; MP PMT 1986]**

(a) Equal temperature (b) Equal osmotic pressure

(c) Equal volume (d) Equal amount of solute

29. Which of the following associated with isotonic solutions is not correct **[AMU 2002]**

(a) They will have the same osmotic pressure

(b) They have the same weight concentrations

(c) Osmosis does not take place when the two solutions are separated by a semipermeable membrane

(d) They will have the same vapour pressure

30. Isotonic solution have the same **[EAMCET 1979; JIPMER 1991, 2002; AFMC 1995; MP PMT 2002]**

(a) Density (b) Molar concentration

(c) Normality (d) None of these

31. A 0.6% solution of urea (molecular weight = 60) would be isotonic with **[NCERT 1982; DCE 2002]**

(a) $0.1M$ glucose (b) $0.1M\,KCl$

(c) 0.6% glucose solution (d) 0.6% KCl solution

32. The value of osmotic pressure of a 0.2 M aqueous solution at 293K is **[AMU 2002]**

(a) 8.4 *atm* (b) 0.48*atm*

(c) 4.8 *atm* (d) 4.0 *atm*

33. Diffusion of solvent through a semi permeable membrane is called **[AFMC 2003]**

(a) Diffusion (b) Osmosis

(c) Active absorption (d) Plasmolysis

34. Solutions having the same osmotic pressure under a given set of conditions are known as **[BHU 1979; EAMCET CPMT 1990; MP PMT 1999; AFMC 1999, 2001]**

(a) Hypertonic (b) Hypotonic

(c) Normal (d) Isotonic

35. At low concentrations, the statement that equimolal solutions under a given set of experimental conditions have equal osmotic pressure is true for **[EAMCET 1979; BHU 1979]**

(a) All solutions

(b) Solutions of non-electrolytes only

(c) Solutions of electrolytes only

(d) None of these

36. Which one of the following would lose weight on exposure to atmosphere **[NCERT 1975]**

(a) Concentrated H_2SO_4

(b) Solid $NaOH$

(c) A saturated solution of CO_2

(d) Anhydrous sodium carbonate

37. The molecular weight of $NaCl$ determined by osmotic pressure method will be

(a) Same as theoritical value

(b) Higher than theoritical value

(c) Lower than theoritical value

(d) None of these

38. The osmotic pressure of solution increases, if **[CPMT 1985, 87, 91]**

(a) Temperature is decreased

(b) Solution concentration is increased

(c) Number of solute molecules is increased

(d) Volume is increased

39. At the same temperature, following solution will be isotonic **[MP PMT 1985]**

(a) 3.24 *gm* of sucrose per litre of water and 0.18 *gm* glucose per litre of water

(b) 3.42 *gm* of sucrose per litre and 0.18 *gm* glucose in 0.1 litre water

(c) 3.24 *gm* of sucrose per litre of water and 0.585 *gm* of sodium chloride per litre of water

(d) 3.42 *gm* of sucrose per litre of water and 1.17 *gm* of sodium chloride per litre of water

40. The osmotic pressure of a decinormal solution of $BaCl_2$ in water is

(a) Inversely proportional to its celsius temperature

(b) Inversely proportional to its absolute temperature

(c) Directly proportional to its celsius temperature

(d) Directly proportional to its absolute temperature

41. Blood cells will remain as such in **[CPMT 2004]**

(a) Hypertonic solution (b) Hypotonic solution

(c) Isotonic solution (d) None of these

42. The osmotic pressure of a dilute solution is directly proportional to the

(a) Diffusion rate of the solute

(b) Ionic concentration

(c) Elevation of B.P.

(d) Flow of solvent from a concentrated to a dilute solution

43. The osmotic pressure in atmospheres of 10% solution of canesugar at $69^{o}C$ is **[AFMC 1991]**

(a) 724 (b) 824

(c) 8.21 (d) 7.21

44. Which of the following molecules would diffuse through a cell membrane **[NCERT 1978]**

(a) Fructose (b) Glycogen

(c) Haemoglobin (d) Catalase

45. Two solutions of KNO_3 and CH_3COOH are prepared separately. Molarity of both is $0.1M$ and osmotic pressures are P_1 and P_2 respectively. The correct relationship between the osmotic pressures is **[CPMT 1983, 84; Pb CET 2004]**

(a) $P_2 > P_1$ (b) $P_1 = P_2$

(c) $P_1 > P_2$ (d) $\frac{P_1}{P_1 + P_2} = \frac{P_2}{P_1 + P_2}$

46. The osmotic pressure of a dilute solution of a non-volatile solute is **[JIPMER 1999]**

(a) Directly proportional to its temperature on the centigrade scale

(b) Inversely proportional to its temperature on the Kelvin scale

(c) Directly proportional to its temperature on the Kelvin scale

(d) Inversely proportional to its temperature on the centigrade scale

47. Osmotic pressure of a urea solution at $10^{o}C$ is $500\ mm$. Osmotic pressure of the solution become 105.3 *mm*. When it is diluted and temperature raised to $25^{o}C.$ The extent of dilution is

(a) 6 Times (b) 5 Times

(c) 7 Times (d) 4 Times

48. If a $0.1M$ solution of glucose (mol. wt. 180) and $0.1\,\text{molar}$ solution of urea (mol. wt. 60) are placed on the two sides of a semipermeable membrane to equal heights, then it will be correct to say **[CBSE PMT 199**

(a) There will be no net movement across the membrane

(b) Glucose will flow across the membrane into urea solution

(c) Urea will flow across the membrane into glucose solution

(d) Water will flow from urea solution into glucose solution

[MP PMT 1987]

49. At constant temperature, the osmotic pressure of a solution

[CPMT 1986]

(a) Directly proportional to the concentration

(b) Inversely proportional to the concentration

(c) Directly proportional to the square of the concentration

(d) Directly proportional to the square root of the concentration

50. The solution containing $4.0\,gm$ of a polyvinyl chloride polymer in 1 litre of dioxane was found to have an osmotic pressure 6.0×10^{-4} atmosphere at $300\,K$, the value of R used is 0.082 litre atmosphere $mole^{-1}k^{-1}$. The molecular mass of the polymer was found to be **[NCERT 1978]**

(a) 3.0×10^{2} (b) 1.6×10^{5}

(c) 5.6×10^{4} (d) 6.4×10^{2}

51. Solvent molecules pass through the semipermeable membrane is called

[CPMT 1983; MP PMT 1987; RPET 2000; DCE 2004]

(a) Electrolysis (b) Electrophoresis

(c) Cataphoresis (d) Osmosis

52. If molecular weight of compound is increased then sensitivity is decreased in which of the following methods

[DCE 2001]

(a) Elevation in boiling point(b) Viscosity

(c) Osmosis (d) Dialysis

53. If solubility of $NaCl$ at $20^{o}C$ is 35 *gm* per 100 *gm* of water. Then on adding 50 *gm* of $NaCl$ to the same volume at same temperature the salt remains undissolved is

(a) 15 *gm* (b) 20 *gm*

(c) 50 *gm* (d) 35 *gm*

54. Which of the following associated with isotonic solution is not correct

[MP PET 2004]

(a) They will have the same osmotic pressure

(b) They have the same weight concentration

(c) Osmosis does not take place when the two solutions are separated by a semipermeable membrane

(d) They will have the same vapour pressure

55. If osmotic pressure of a solution is $2 atm$ at $273 K$, then at $546 K$, the osmotic pressure is

(a) 0.5 *atm* (b) 1 *atm*

(c) 2 *atm* (d) 4 *atm*

56. In osmosis reaction, the volume of solution

(a) Decreases slowly (b) Increases slowly

(c) Suddenly increases (d) No change

57. As a result of osmosis the volume of solution **[JIPMER 2000]**

(a) Increases (c) Decreases

(c) Remains constant (d) Increases or decreases

58. A solution of urea contain 8.6 gm/litre (*mol. wt.* 60.0). It is isotonic with a 5% solution of a non-volatile solute. The molecular weight of the solute will be **[MP PMT 1986]**

(a) 348.9 (b) 34.89

(c) 3489 (d) 861.2

59. One mole each of urea, glucose and sodium chloride were dissolved in one litre of water Equal osmotic pressure will be produced by solutions of **[MH CET 1999]**

(a) Glucose and sodium chloride

(b) Urea and glucose

(c) Sodium chloride and urea

(d) None of these

60. Which of the following aqueous solutions produce the same osmotic pressure **[Roorkee 1999]**

(a) 0.1 *M* $NaCl$ solution

(b) 0.1 *M* glucose solution

(c) 0.6 *g* urea *in* 100 *ml* solution

(d) 1.0 *g* of a non-electrolyte solute (*X*) in 50 *ml* solution (Molar mass of *X* = 200)

61. Which of the following aqueous solutions are isotonic $(R = 0.082$ atm $K^{-1} mol^{-1})$ **[Roorkee Qualifying 1998]**

(a) $0.01 M$ glucose

(b) $0.01 M\ NaNO_3$

(c) $500 ml$ solution containing $0.3 g$ urea

(d) $0.04\ N\ HCl$

Elevation of boiling boint of the solvent

1. The latent heat of vapourisation of water is $9700\ Cal/mole$ and if the *b.p.* is $100°C$, ebullioscopic constant of water is **[CBSE PMT 1989]**

(a) $0.513°C$ (b) $1.026°C$

(c) $10.26°C$ (d) $1.832°C$

2. The molal elevation constant of water $= 0.52°C$. The boiling point of 1.0 molal aqueous KCl solution (assuming complete dissociation of KCl), therefore, should be **[BHU 1987]**

(a) $100.52°C$ (b) $101.04°C$

(c) $99.48°C$ (d) $98.96°C$

3. The rise in the boiling point of a solution containing 1.8 *gram* of glucose in $100 g$ of a solvent in $0.1°C$. The molal elevation constant of the liquid is **[CPMT 1999]**

(a) 0.01 K/m (b) $0.1 K/m$

(c) $1 K/m$ (d) $10 K/m$

4. If $0.15 g$ of a solute dissolved in $15 g$ of solvent is boiled at a temperature higher by $0.216°C$ than that of the pure solvent. The molecular weight of the substance (molal elevation constant for the solvent is $2.16°C$) is **[CBSE PMT 1999; BHU 1997]**

(a) 1.01 (b) 10

(c) 10.1 (d) 100

5. Pressure cooker reduces cooking time for food because **[MP PMT 1987; NCERT 1975; CPMT 1991; AIEEE 2003]**

(a) Heat is more evenly distributed in the cooking space

(b) Boiling point of water involved in cooking is increased

(c) The higher pressure inside the cooker crushes the food material

(d) Cooking involves chemical changes helped by a rise in temperature

6. Which of the following statements is correct for the boiling point of solvent containing a dissolved solid substance **[NCERT 1972, 74]**

(a) Boiling point of the liquid is depressed

(b) Boiling point of the liquid is elevated

(c) There is no effect on the boiling point

(d) The change depends upon the polarity of liquid

7. When a substance is dissolved in a solvent, the vapour pressure of solvent decreases. It brings **[BHU 2004]**

(a) A decrease in boiling point of solution

(b) An increase in boiling point of the solution

(c) A decrease in freezing point of the solution

(d) An increase in freezing point of the solution

8. Elevation in boiling point was $0.52°C$ when $6 gm$ of a compound X was dissolved in $100\ gm$ of water. Molecular weight of X is (K_b for water is 0.52 per 1000 *gm* of water)

[CPMT 1989]

(a) 120 (b) 60

(c) 180 (d) 600

9. If the solution boils at a temperature T_1 and the solvent at a temperature T_2 the elevation of boiling point is given by

[MP PET 1996]

(a) $T_1 + T_2$ (b) $T_1 - T_2$

(c) $T_2 - T_1$ (d) $T_1 \div T_2$

10. If for a sucrose solution elevation in boiling point is 0.1°*C* then what will be the boiling point of *NaCl* solution for same molal concentration **[BHU 1998, 2005]**

(a) 0.1°*C* (b) 0.2°*C*

(c) 0.08°*C* (d) 0.01°*C*

11. The molal elevation constant is the ratio of the elevation in B.P. to **[CPMT 1982]**

(a) Molarity (b) Molality

(c) Mole fraction of solute (d) Mole fraction of solvent

12. The molal boiling point constant for water is $0.513^{o}C\,kg\,mol^{-1}$. When 0.1 mole of sugar is dissolved in $200\,ml$ of water, the solution boils under a pressure of one atmosphere at

(a) $100.513^{o}C$ (b) $100.0513^{o}C$

(c) $100.256^{o}C$ (d) $101.025^{o}C$

13. Value of gas constant *R* is **[AIEEE 2002]**

(a) 0.082 *litre atm* (b) 0.987 *cal* $mol^{-1}K^{-1}$

(c) 8.3 *J* $mol^{-1}K^{-1}$ (d) 83 *erg* $mol^{-1}K^{-1}$

14. The temperature, at which the vapour pressure of a liquid becomes equal to the atmospheric pressure is known as

[Pb. PMT 2000]

(a) Freezing point (b) Boiling point

(c) Absolute temperature (d) None of these

15. The elevation in boiling point of a solution of 13.44*g* of $CuCl_2$ in 1*kg* of water using the following information will be

(Molecular weight of $CuCl_2$ = 134.4 and K_b = 0.52 *K molal*$^{-1}$)

[IIT 2005]

(a) 0.16 (b) 0.05

(c) 0.1 (d) 0.2

16. When 10*g* of a non-volatile solute is dissolved in 100 *g* of benzene, it raises boiling point by $1^{o}C$ then molecular mass of the solute is (K_b for benzene =2.53*k*-*m*$^{-1}$) **[BHU 2002]**

(a) 223 *g* (b) 233 *g*

(c) 243 *g* (d) 253 *g*

17. An aqueous solution containing 1*g* of urea boils at $100.25^{o}C$. The aqueous solution containing 3 *g* of glucose in the same volume will boil at (Molecular weight of urea and glucose are 60 and 180 respectively)

[CBSE PMT 2000]

(a) $100.75^{o}C$ (b) $100.5^{o}C$

(c) $100.25^{o}C$ (d) $100^{o}C$

18. When common salt is dissolved in water

[CBSE PMT 1988; MP PET 1995; DCE 2000]

(a) Melting point of the solution increases

(b) Boiling point of the solution increases

(c) Boiling point of the solution decreases

(d) Both melting point and boiling point decreases

19. During the evaporation of liquid **[DCE 2003]**

(a) The temperature of the liquid will rise

(b) The temperature of the liquid will fall

(c) May rise or fall depending on the nature

(d) The temperature remains unaffected

20. At higher altitudes the boiling point of water lowers because

[NCERT 1972; CPMT 1994; J & K 2005]

(a) Atmospheric pressure is low

(b) Temperature is low

(c) Atmospheric pressure is high

(d) None of these

21. The elevation in boiling point for one molal solution of a solute in a solvent is called **[MH CET 2001]**

(a) Boiling point constant (b) Molal elevation constant

(c) Cryoscopic constant (d) None of these

22. A solution of 1 molal concentration of a solute will have maximum boiling point elevation when the solvent is

[MP PMT 2000]

(a) Ethyl alcohol (b) Acetone

(c) Benzene (d) Chloroform

23. Mark the correct relationship between the boiling points of very dilute solutions of $BaCl_2 (t_1)$ and $KCl (t_2)$, having the same molarity **[CPMT 1984, 93]**

(a) $t_1 = t_2$

(b) $t_1 > t_2$

(c) $t_2 > t_1$

(d) t_2 is approximately equal to t_1

Depression of freezing point of the solvent

1. Molal depression constant for water is $1.86^{o}C$. The freezing point of a 0.05 molal solution of a non-electrolyte in water is

[MNR 1990; MP PET 1997]

(a) $-1.86^{o}C$ (b) $-0.93^{o}C$

(c) $-0.093^{o}C$ (d) $0.93^{o}C$

2. The amount of urea to be dissolved in 500 *ml* of water (K =18.6 $K\ mole^{-1}$ in 100*g* solvent) to produce a depression of $0.186^{o}C$ in freezing point is **[MH CET 2000]**

(a) 9 *g* (b) 6 *g*

(c) 3 *g* (d) 0.3 *g*

3. The maximum freezing point falls in **[MP PMT 1986]**

(a) Camphor (b) Naphthalene

(c) Benzene (d) Water

4. Which one of the following statements is FALSE **[AIEEE 2004]**

(a) The correct order of osmotic pressure for 0.01 M aqueous solution of each compound is $BaCl_2 > KCl > CH_3COOH >$ sucrose.

(b) The osmotic pressure (π) of a solution is given by the equation $\pi = MRT$ where M is the molarity of the solution.

(c) Raoult's law states that the vapour pressure of a component over a solution is proportional to its mole fraction.

(d) Two sucrose solutions of same molality prepared in different solvents will have the same freezing point depression.

5. Solute when dissolved in water **[MADT Bihar 1981]**

(a) Increases the vapour pressure of water

(b) Decreases the boiling point of water

(c) Decreases the freezing point of water

(d) All of the above

6. The freezing point of a solution prepared from $1.25\,gm$ of a non-electrolyte and $20\,gm$ of water is $271.9\,K$. If molar depression constant is $1.86\,K\,mole^{-1}$, then molar mass of the solute will be **[AFMC 1998; CPMT 1999]**

(a) 105.7 (b) 106.7

(c) 115.3 (d) 93.9

7. What is the freezing point of a solution containing $8.1\,g\,HBr$ in $100\,g$ water assuming the acid to be 90% ionised (K_f for water $= 1.86\,K\,mole^{-1}$) **[BHU 1981; Pb CET 2004]**

(a) $0.85^{o}C$ (b) $-3.53^{o}C$

(c) $0^{o}C$ (d) $-0.35^{o}C$

8. If K_f value of H_2O is 1.86. The value of ΔT_f for $0.1m$ solution of non-volatile solute is

(a) 18.6 (b) 0.186

(c) 1.86 (d) 0.0186

9. 1% solution of $Ca(NO_3)_2$ has freezing point **[DPMT 1982, 83; CPMT 1977]**

(a) $0^{o}C$ (b) Less than $0^{o}C$

(c) Greater than $0^{o}C$ (d) None of the above

10. A solution of urea (mol. mass 56*g* mol^{-1}) boils at 100.18°*C* at the atmospheric pressure. If K_f and K_b for water are 1.86 and 0.512*K* *kg* mol^{-1} respectively the above solution will freeze at **[CBSE PMT 2**

(a) – 6.54°*C* (b) 6.54°*C*

(c) 0.654°*C* (d) –0.654°*C*

11. The molar freezing point constant for water is $1.86^{o}C\,mole^{-1}$. If 342 gm of canesugar $(C_{12}H_{22}O_{11})$ are dissolved in 1000 *gm* of water, the solution will freeze at **[NCERT 1977; CPMT 1989; Roorkee 2000; DCE 2004]**

(a) $-1.86^{o}C$ (b) $1.86^{o}C$

(c) $-3.92^{o}C$ (d) $2.42^{o}C$

12. An aqueous solution of a non-electrolyte boils at $100.52^{o}C$. The freezing point of the solution will be

(a) $0^{o}C$ (b) $-1.86^{o}C$

(c) $1.86^{o}C$ (d) None of the above

13. The freezing point of one molal $NaCl$ solution assuming $NaCl$ to be 100% dissociated in water is (molal depression constant = 1.86) **[CPMT 1985; BHU 1981; MP PMT 1997; UPSEAT 2001]**

(a) $-1.86^{o}C$ (b) $-3.72^{o}C$

(c) $+1.86^{o}C$ (d) $+3.72^{o}C$

14. Heavy water freezes at **[CPMT 1993]**

(a) $0^{o}C$ (b) $3.8^{o}C$

(c) $38^{o}C$ (d) $-0.38^{o}C$

15. After adding a solute freezing point of solution decreases to – 0.186. Calculate ΔT_b if $K_f = 1.86$ and $K_b = 0.521$. **[Orissa JEE 2002, 04; MP PET/PMT 1998; AIEEE 2000]**

(a) 0.521 (b) 0.0521

(c) 1.86 (d) 0.0186

16. Given that ΔT_f is the depression in freezing point of the solvent in a solution of a non-volatile solute of molality m, the quantity $\lim\limits_{m \to 0}\left(\frac{\Delta T_f}{m}\right)$ is equal to **[IIT 1994; UPSEAT 2001]**

(a) Zero (b) One

(c) Three (d) None of the above

17. The freezing point of 1 percent solution of lead nitrate in water will be **[NCERT 1971, 72; CPMT 1972; JIPMER 1991]**

(a) Below $0^{o}C$ (b) $0^{o}C$

(c) $1^{o}C$ (d) $2^{o}C$

18. What is the effect of the addition of sugar on the boiling and freezing points of water **[Kerala CET (Med.) 20**

(a) Both boiling point and freezing point increases

(b) Both boiling point and freezing point decreases

(c) Boiling point increases and freezing point decreases

(d) Boiling point decreases and freezing point increases

19. During depression of freezing point in a solution the following are in equilibrium**[IIT Screening 2003]**

(a) Liquid solvent, solid solvent

(b) Liquid solvent, solid solute

(c) Liquid solute, solid solute

(d) Liquid solute solid solvent

20. 1.00 *gm* of a non-electrolyte solute dissolved in 50 *gm* of benzene lowered the freezing point of benzene by 0.40 *K*. K_f for benzene is 5.12 *kg mol*$^{-1}$. Molecular mass of the solute will be **[DPMT 2004]**

(a) $256\ g\,mol^{-1}$ (b) $2.56\ g\,mol^{-1}$

(c) $512 \times 10^3\ g\,mol^{-1}$ (d) $2.56 \times 10^4\ g\,mol^{-1}$

21. 0.440 *g* of a substance dissolved in 22.2 *g* of benzene lowered the freezing point of benzene by $0.567\,^oC$. The molecular mass of the substance $(K_f = 5.12^o C\,mol^{-1})$

[BHU 2001; CPMT 2001]

(a) 178.9 (b) 177.8

(c) 176.7 (d) 175.6

22. Which of the following aqueous molal solution have highest freezing point**[UPSEAT 2000, 01, 02; MNR 1988]**

(a) Urea (b) Barium chloride

(c) Potassium bromide (d) Aluminium sulphate

23. Which will show maximum depression in freezing point when concentration is 0.1*M*

[IIT 1989; MNR 1990; UPSEAT 2000; 03; BCECE 2005]

(a) *NaCl* (b) Urea

(c) Glucose (d) K_2SO_4

24. The freezing point of a 0.01*M* aqueous glucose solution at 1 atmosphere is $-0.18\,^oC$. To it, an addition of equal volume of 0.002 *M* glucose solution will; produce a solution with freezing point of nearly **[AMU 1999]**

(a) $-0.036\,^oC$ (b) $-0.108\,^oC$

(c) $-0.216\,^oC$ (d) $-0.422\,^oC$

25. What should be the freezing point of aqueous solution containing $17\,gm$ of C_2H_5OH in $1000\,gm$ of water (water K_f = 1.86 $\deg - kg\,mol^{-1}$ **[MP PMT 1986]**

(a) $-0.69\,^oC$ (b) $-0.34\,^oC$

(c) 0.0^oC (d) $0.34\,^oC$

26. In the depression of freezing point experiment, it is found that the **[IIT 1999]**

(a) Vapour pressure of the solution is less than that of pure solvent

(b) Vapour pressure of the solution is more than that of pure solvent

(c) Only solute molecules solidify at the freezing point

(d) Only solvent molecules solidify at the freezing point

27. Calculate the molal depression constant of a solvent which has freezing point $16.6\,^oC$ and latent heat of fusion $180.75\ Jg^{-1}$. **[Orissa JEE 2005]**

(a) 2.68 (b) 3.86

(c) 4.68 (d) 2.86t6

Colligative properties of electrolyte

1. If O.P. of 1 *M* of the following in water can be measured, which one will show the maximum O.P.

[NCERT 1975; CPMT 1977; JIPMER 2001]

(a) $AgNO_3$ (b) $MgCl_2$

(c) $(NH_4)_3PO_4$ (d) Na_2SO_4

2. Which of the following solution in water possesses the lowest vapour pressure **[BHU 1996]**

(a) $0.1(M)\,NaCl$ (b) $0.1(N)\,BaCl_2$

(c) $0.1(M)\,KCl$ (d) None of these

3. Which of the following solutions in water will have the lowest vapour pressure **[Roorkee 2000]**

(a) 0.1 *M*, *NaCl* (b) 0.1 *M*, Sucrose

(c) 0.1 *M*, $BaCl_2$ (d) 0.1 *M* Na_3PO_4

4. The vapour pressure will be lowest for **[CPMT 2004]**

(a) 0.1 M sugar solution (b) 0.1 M *KCl* solution

(c) 0.1 M $Cu(NO_3)_2$ solution (d)0.1 M $AgNO_3$ solution

5. Osmotic pressure of 0.1 M solution of *NaCl* and Na_2SO_4 will be **[AFMC 1978]**

(a) Same

(b) Osmotic pressure of *NaCl* solution will be more than Na_2SO_4 solution

(c) Osmotic pressure of Na_2SO_4 solution will be more than *NaCl*

(d) Osmotic pressure of $NaSO_4$ will be less than that of *NaCl* solution

6. Which of the following solutions has highest osmotic pressure **[CPMT 1977]**

(a) 1*M NaCl* (b) 1 M urea

(c) 1 M sucrose (d) 1 M glucose

7. Which one has the highest osmotic pressure

[CBSE PMT 1991; DPMT 1991; MP PET 1994]

(a) $M/10\ HCl$ (b) $M/10$ urea

(c) $M/10\ BaCl_2$ (d) $M/10$ glucose

8. In equimolar solution of glucose, *NaCl* and $BaCl_2$, the order of osmotic pressure is as follow

[CPMT 1988, 93; MP PMT/PET 1988; MP PET 1997, 2003]

(a) Glucose $> NaCl > BaCl_2$

(b) $NaCl > BaCl_2 >$ Glucose

(c) $BaCl_2 > NaCl >$ Glucose

(d) Glucose $> BaCl_2 > NaCl$

9. The osmotic pressure of which solution is maximum (consider that deci-molar solution of each 90% dissociated)

[MP PMT 2003]

(a) Aluminium sulphate

(b) Barium chloride

(c) Sodium sulphate

(d) A mixture of equal volumes of (b) and (c)

10. At $25^\circ C$, the highest osmotic pressure is exhibited by $0.1M$ solution of **[CBSE PMT 1994; AIIMS 2000]**

(a) $CaCl_2$

(b) KCl

(c) Glucose

(d) Urea

11. Which of the following will have the highest boiling point at 1 *atm* pressure **[MP PET/PMT 1998]**

(a) $0.1 M\ NaCl$

(b) $0.1M$ sucrose

(c) $0.1M\ BaCl_2$

(d) $0.1M$ glucose

12. Which one of the following would produce maximum elevation in boiling point

[MP PMT 1985; CPMT 1990; NCERT 1982]

(a) 0.1 M glucose

(b) 0.2 M sucrose

(c) 0.1 M barium chloride

(d) 0.1 M magnesium sulphate

13. Which of the following solutions will have the highest boiling point **[DPMT 1991; CPMT 1991]**

(a) 1% glucose

(b) 1% sucrose

(c) 1% $NaCl$

(d) 1% $CaCl_2$

14. Which one of the following aqueous solutions will exhibit highest boiling point **[AIEEE 2004]**

(a) 0.015 M urea

(b) $0.01\ M\ KNO_3$

(c) $0.01\ M\ Na_2SO_4$

(d) $0.015\ M$ glucose

15. Which of the following aqueous solutions containing 10 gm of solute in each case has highest B.P.

(a) $NaCl$ solution

(b) KCl solution

(c) Sugar solution

(d) Glucose solution

16. 0.01 molar solutions of glucose, phenol and potassium chloride were prepared in water. The boiling points of

(a) Glucose solution = Phenol solution = Potassium chloride solution

(b) Potassium chloride solution > Glucose solution > Phenol solution

(c) Phenol solution > Potassium chloride solution > Glucose solution

(d) Potassium chloride solution > Phenol solution > Glucose solution

17. Which one has the highest boiling point **[CBSE PMT 1990]**

(a) $0.1N\ Na_2SO_4$

(b) $0.1N\ MgSO_4$

(c) $0.1M\ Al_2(SO_4)_3$

(d) $0.1M\ BaSO_4$

18. Which of the following solutions boils at the highest temperature **[AMU 2001]**

(a) 0.1 M glucose

(b) 0.1 M $NaCl$

(c) 0.1 M $BaCl_2$

(d) 0.1 M Urea

19. $0.01M$ solution each of urea, common salt and Na_2SO_4 are taken, the ratio of depression of freezing point is

[Roorkee 1990]

(a) 1 : 1 : 1

(b) 1 : 2 : 1

(c) 1 : 2 : 3

(d) 2 : 2 : 3

20. Which has the minimum freezing point **[CPMT 1991]**

(a) One molal $NaCl$ solution

(b) One molal KCl solution

(c) One molal $CaCl_2$ solution

(d) One molal urea solution

21. Which of the following has lowest freezing point

[NCERT 1981]

(a) $0.1M$ aqueous solution of glucose

(b) $0.1M$ aqueous solution of $NaCl$

(c) $0.1M$ aqueous solution of $ZnSO_4$

(d) $0.1M$ aqueous solution of urea

22. The freezing points of equimolar solutions of glucose, KNO_3 and $AlCl_3$ are in the order of **[AMU 2000]**

(a) $AlCl_3 < KNO_3 <$ Glucose

(b) Glucose $< KNO_3 < AlCl_3$

(c) Glucose $< AlCl_3 < KNO_3$

(d) $AlCl_3 <$ Glucose $< KNO_3$

23. Which of the following will have the highest F.P. at one atmosphere

[BHU 1982; MP PMT 1987, MP PET/PMT 1988]

(a) $0.1M\ NaCl$ solution

(b) $0.1M$ sugar solution

(c) $0.1M\ BaCl_2$ solution

(d) $0.1M\ FeCl_3$ solution

24. Which of the following will produce the maximum depression in freezing point of its aqueous solution

[MP PMT 1996]

(a) $0.1M$ glucose

(b) $0.1M$ sodium chloride

(c) $0.1M$ barium chloride

(d) $0.1M$ magnesium sulphate

25. Which of the following has the lowest freezing point

[UPSEAT 2004]

(a) 0.1 *m* sucrose

(b) 0.1 *m* urea

(c) 0.1 *m* ethanol

(d) 0.1 *m* glucose

26. Which of the following has minimum freezing point

[Pb. PMT 1999]

(a) $0.1M\ K_2Cr_2O_7$

(b) 0.1 M NH_4Cl

(c) 0.1 M $BaSO_4$
(d) 0.1 M $Al_2(SO_4)_3$

27. Which of the following $0.10\,m$ aqueous solution will have the lowest freezing point **[CBSE PMT 1997]**

(a) $Al_2(SO_4)_3$
(b) $C_5H_{10}O_5$
(c) KI
(d) $C_{12}H_{22}O_{11}$

28. For 0.1 M solution, the colligative property will follow the order **[AMU 2000]**

(a) $NaCl > Na_2SO_4 > Na_3PO_4$
(b) $NaCl < Na_2SO_4 < Na_3PO_4$
(c) $NaCl > Na_2SO_4 \approx Na_3PO_4$
(d) $NaCl < Na_2SO_4 = Na_3PO_4$

29. Which of the following will have the lowest vapour pressure

(a) $0.1M\,KCl$ solution
(b) $0.1M$ urea solution
(c) $0.1M\,Na_2SO_4$ solution
(d) $0.1M\,K_4Fe(CN)_6$ solution

Abnormal molecular mass

1. The Van't Hoff factor will be highest for

(a) Sodium chloride
(b) Magnesium chloride
(c) Sodium phosphate
(d) Urea

2. Which of the following salt has the same value of Van't Hoff factor i as that of $K_3[Fe(CN)_6]$

[CBSE PMT 1994; AIIMS 1998]

(a) $Al_2(SO_4)_3$
(b) $NaCl$
(c) Na_2SO_4
(d) $Al(NO_3)_3$

3. When benzoic acid dissolve in benzene, the observed molecular mass is

(a) 244
(b) 61
(c) 366
(d) 122

4. The ratio of the value of any colligative property for KCl solution to that for sugar solution is nearly **[MP PMT 1985]**

(a) 1
(b) 0.5
(c) 2.0
(d) 3

5. Van't Hoff factor of $Ca(NO_3)_2$ is **[CPMT 1997]**

(a) 1
(b) 2
(c) 3
(d) 4

6. Dry air was passed successively through a solution of $5\,gm$ of a solute in $80\,gm$ of water and then through pure water. The loss in weight of solution was $2.50\,gm$ and that of pure solvent $0.04\,gm$. What is the molecular weight of the solute

[MP PMT 1986]

(a) 70.31
(b) 7.143
(c) 714.3
(d) 80

7. The Van't Hoff factor calculated from association data is always...than calculated from dissociation data

[JIPMER 2000]

(a) Less
(b) More
(c) Same
(d) More or less

8. If α is the degree of dissociation of Na_2SO_4, the Vant Hoff's factor (i) used for calculating the molecular mass is

[AIEEE 2005]

(a) $1+\alpha$
(b)
(c) $1+2\alpha$
(d) $1-2\alpha$

9. Van't Hoff factor i

(a) $= \dfrac{\text{Normal molecular mass}}{\text{Observed molecular mass}}$

(b) $= \dfrac{\text{Observed molecular mass}}{\text{Normal molecular mass}}$

(c) Less than one in case of dissociation

(d) More than one in case of association

10. Which of the following compounds corresponds Van't Hoff factor 'i' to be equal to 2 for dilute solution **[NCERT 1978]**

(a) K_2SO_4
(b) $NaHSO_4$
(c) Sugar
(d) $MgSO_4$

11. The Van't Hoff factor i for a 0.2 molal aqueous solution of urea is

(a) 0.2
(b) 0.1
(c) 1.2
(d) 1.0

12. One mole of a solute A is dissolved in a given volume of a solvent. The association of the solute take place according to $nA \rightleftharpoons (A)_n$. The Van't Hoff factor i is expressed as

[MP PMT 1997]

(a) $i = 1 - x$
(b) $i = 1 + \dfrac{x}{n}$
(c) $i = \dfrac{1 - x + \dfrac{x}{n}}{1}$
(d) $i = 1$

13. Acetic acid dissolved in benzene shows a molecular weight of

(a) 60
(b) 120
(c) 180
(d) 240

14. The observed osmotic pressure of a solution of benzoic acid in benzene is less than its expected value because

[CET Pune 1998]

(a) Benzene is a non-polar solvent

(b) Benzoic acid molecules are associated in benzene

(c) Benzoic acid molecules are dissociated in benzene

(d) Benzoic acid is an organic compound

15. The experimental molecular weight of an electrolyte will always be less than its calculated value because the value of Van't Hoff factor "*i*" is **[MP PMT 1993]**

(a) Less than 1 (b) Greater than 1

(c) Equivalent to one (d) Zero

16. The molecular mass of acetic acid dissolved in water is 60 and when dissolved in benzene it is 120.This difference in behaviour of CH_3COOH is because **[AMU 2000]**

(a) Water prevents association of acetic acid

(b) Acetic acid does not fully dissolve in water

(c) Acetic acid fully dissolves in benzene

(d) Acetic acid does not ionize in benzene

17. The correct relationship between the boiling points of very dilute solutions of $AlCl_3(t_1)$ and $CaCl_2(t_2)$, having the same molar concentration is **[CPMT 1983]**

(a) $t_1 = t_2$ (b) $t_1 > t_2$

(c) $t_2 > t_1$ (d) $t_2 \geq t_1$

18. The Van't Hoff factor for sodium phosphate would be

(a) 1 (b) 2

(c) 3 (d) 4

19. The molecular weight of benzoic acid in benzene as determined by depression in freezing point method corresponds to **[IIT 1996]**

(a) Ionization of benzoic acid

(b) Dimerization of benzoic acid

(c) Trimerization of benzoic acid

(d) Solvation of benzoic acid

Critical Thinking

Objective Questions

1. On adding solute to a solvent having vapour pressure 0.80 *atm*, vapour pressure reduces to 0.60 *atm*. Mole fraction of solute is

(a) 0.25 (b) 0.75

(c) 0.50 (d) 0.33

2. A solution containing 30 *gms* of non-volatile solute in exactly 90 *gm* water has a vapour pressure of 21.85 *mm Hg* at 25^oC. Further 18 *gms* of water is then added to the solution. The resulting solution has a vapour pressure of 22.15 *mm Hg* at 25^oC. Calculate the molecular weight of the solute **[UPSEAT 2001]**

(a) 74.2 (b) 75.6

(c) 67.83 (d) 78.7

3. Vapour pressure of a solution of $5g$ of non-electrolyte in $100\,g$ of water at a particular temperature is $2985\ N/m^2$. The vapour pressure of pure water is $3000\,N/m^2$. The molecular weight of the solute is **[IIT Screening 1993]**

(a) 60 (b) 120

(c) 180 (d) 380

4. Azeotropic mixture of *HCl* and water has **[AFMC 1997; JIPMER 2002]**

(a) 84% *HCl* (b) 22.2% *HCl*

(c) 63% *HCl* (d) 20.2% *HCl*

5. The osmotic pressure at 17^oC of an aqueous solution containing 1.75 *g* of sucrose per 150 *ml* solution is

[BHU 2001]

(a) 0.8 *atm* (b) 0.08 *atm*

(c) 8.1 *atm* (d) 9.1 *atm*

6. 1.2 of solution of *NaCl* is isotonic with 7.2 of solution of glucose. Calculate the van't Hoff's factor of *NaCl* solution

[UPSEAT 2001]

(a) 2.36 (b) 1.50

(c) 1.95 (d) 1.00

7. $0.6\,g$ of a solute is dissolved in $0.1\,litre$ of a solvent which develops an osmotic pressure of 1.23 *atm* at 27^oC. The molecular mass of the substance is **[BHU 199**

(a) $149.5\,g\,mole^{-1}$ (b) $120\ g\ mole^{-1}$

(c) $430\ g\,mole^{-1}$ (d) None of these

8. The boiling point of a solution of 0.1050 *gm* of a substance in 15.84 *gram* of ether was found to be 100^oC higher than that of pure ether. What is the molecular weight of the substance [Molecular elevation constant of ether per 100 *g* = 21.6]

(a) 144.50 (b) 143.18

(c) 140.28 (d) 146.66

9. Boiling point of chloroform was raised by 0.323 *K*, when 0.5143 *g* of anthracene was dissolved in 35 *g* of chloroform. Molecular mass of anthracene is (K_b for $CHCl_3$ = 3.9 *kg mol*$^{-1}$) **[UPSEAT 2003]** **[Pb PMT 2000]**

(a) 79.42 *g/mol* (b) 132.32 *g/mol*

(c) 177.42 *g/mol* (d) 242.32 *g/mol*

10. The boiling point of water (100^oC) becomes 100.52^oC, if 3 *grams* of a nonvolatile solute is dissolved in $200\,ml$ of water. The molecular weight of solute is
(K_b for water is $0.6\,K-m$)

(a) $12.2\,g\,mol^{-1}$ (b) $15.4\,g\,mol$

(c) $17.3\,g\,mol^{-1}$ (d) $20.4\,g\,mol$

11. Normal boiling point of water is 373 K (at 760mm). Vapour pressure of water at 298 K is 23 mm. If the enthalpy of evaporation is 40.656 kJ/mole, the boiling point of water at 23 mm pressure will be **[CBSE PMT 1995]**

(a) 250 K (b) 294 K
(c) 51.6 K (d) 12.5 K

12. A 0.2 molal aqueous solution of a weak acid (HX) is 20% ionised. The freezing point of this solution is (Given $K_f = 1.86^{\circ} C/m$ for water) **[IIT 1995]**

(a) $-0.31^{\circ}C$ (b) $-0.45^{\circ}C$
(c) $-0.53^{\circ}C$ (d) $-0.90^{\circ}C$

13. A 0.001 molal solution of $[Pt(NH_3)_4Cl_4]$ in water had a freezing point depression of $0.0054^{\circ}C$. If K_f for water is 1.80, the correct formulation for the above molecule is **[Kerala CET (Med.) 2003]**

(a) $[Pt(NH_3)_4Cl_3]Cl$ (b) $[Pt(NH_3)_4Cl]Cl_2$
(c) $[Pt(NH_3)_4Cl_2]Cl_3$ (d) $[Pt(NH_3)_4Cl_4]$

14. An aqueous solution of a weak monobasic acid containing 0.1 g in 21.7g of water freezes at 272.813 K. If the value of K_f for water is 1.86 K/m, what is the molecular mass of the monobasic acid **[AMU 2002]**

(a) 50 $g/mole$ (b) 46 $g/mole$
(c) 55 $g/mole$ (d) 60 $g/mole$

15. K_f of 1,4-dioxane is 4.9 mol^{-1} for 1000 g. The depression in freezing point for a 0.001 m solution in dioxane is **[DPMT 2001]**

(a) 0.0049 (b) 4.9 + 0.001
(c) 4.9 (d) 0.49

16. How many litres of CO_2 at STP will be formed when $100 ml$ of $0.1 M\, H_2SO_4$ reacts with excess of Na_2SO_3 **[EAMCET 1998]**

(a) 22.4 (b) 2.24
(c) 0.224 (d) 5.6

17. A solution is obtained by dissolving 12 g of urea ($mol.wt.$60) in a $litre$ of water. Another solution is obtained by dissolving 68.4 g of cane sugar ($mol.wt.$ 342) in a $litre$ of water at are the same temperature. The lowering of vapour pressure in the first solution is **[CPMT 2001]**

(a) Same as that of 2nd solution
(b) Nearly one-fifth of the 2nd solution
(c) Double that of 2nd solution
(d) Nearly five times that of 2nd solution

AR Assertion & Reason

For AIIMS Aspirants

Read the assertion and reason carefully to mark the correct option out of the options given below :

(a) *If both assertion and reason are true and the reason is the correct explanation of the assertion.*
(b) *If both assertion and reason are true but reason is not the correct explanation of the assertion.*
(c) *If assertion is true but reason is false.*
(d) *If the assertion and reason both are false.*
(e) *If assertion is false but reason is true.*

1.	Assertion	:	One molal aqueous solution of urea contains $60 g$ of urea in $1 kg$ $(1000\ g)$ water.
	Reason	:	Solution containing one mole of solute in $1000\ g$ solvent is called as one molal solution.
2.	Assertion	:	If 100 cc of $0.1\, N\, HCl$ is mixed with 100 cc of $0.2\, N\, HCl$, the normality of the final solution will be 0.30.
	Reason	:	Normalities of similar solutions like HCl can be added.
3.	Assertion	:	If a liquid solute more volatile than the solvent is added to the solvent, the vapour pressure of the solution may increase i.e., $p_s > p^o$.
	Reason	:	In the presence of a more volatile liquid solute, only the solute will form the vapours and solvent will not.
4.	Assertion	:	Azeotropic mixtures are formed only by non-ideal solutions and they may have boiling points either greater than both the components or less than both the components.
	Reason	:	The composition of the vapour phase is same as that of the liquid phase of an azeotropic mixutre.
5.	Assertion	:	Molecular mass of polymers cannot be calculated using boiling point or freezing point method.
	Reason	:	Polymers solutions do not possess a constant boiling point or freezing point.
6.	Assertion	:	The molecular weight of acetic acid determined by depression in freezing point method in benzene and water was found to be different.
	Reason	:	Water is polar and benzene is non-polar.
7.	Assertion	:	Ca^{++} and K^+ ions are responsible for maintaining proper osmotic pressure balance in the cells of organism.

Reason : Solutions having the same osmotic pressure are called isotonic solutions.

8. Assertion : Reverse osmosis is used in the desalination of sea water.

Reason : When pressure more than osmotic pressure is applied, pure water is squeezed out of the sea water through the membrane.

9. Assertion : Camphor is used as solvent in the determination of molecular masses of naphthalene, anthracene etc.

Reason : Camphor has high molal elevation constant.

10. Assertion : Elevation in boiling point and depression in freezing point are colligative properties.

Reason : All colligative properties are used for the calculaltion of molecular masses.

11. Assertion : An increase in surface area increases the rate of evaporation.

Reason : Stronger the inter-molecular attractive forces, fast is the rate of evaporation at a given temperature. **[AIIMS 2002]**

12. Assertion : The boiling and melting points of amides are higher than corresponding acids.

Reason : It is due to strong intermolecular hydrogen bonding in their molecules. **[AIIMS 2002]**

13. Assertion : The freezing point is the temperature at which solid crystallizers from solution.

Reason : The freezing point depression is the difference between that temperature and freezing point of pure solvent.**[AIIMS**

14. Assertion : On adding $NaCl$ to water its vapour pressure increases.

Reason : Addition of non-volatile solute increases the vapour pressure. **[AIIMS 19**

15. Assertion : Molar heat of vaporisation of water is greater than benzene.

Reason : Molar heat of vaporisation is the amount of heat required to vaporise one mole of liquid at constant temperature. **[AIIMS 1996]**

16. Assertion : Ice melts faster at high altitude.

Reason : At high altitude atmospheric pressure is high. **[AIIMS 1997]**

17. Assertion : Molecular mass of benzoic acid when determined by colligative properties is found high.

Reason : Dimerisation of benzoic acid. **[AIIMS 1998**

18. Assertion : Use of pressure cooker reduces cooking time.

Reason : At higher pressue cooking occurs faster.

[AIIMS 2000]

19. Assertion : CCl_4 and H_2O are immiscible.

Reason : CCl_4 is a polar solvent. **[AIIMS 2002]**

20. Assertion : Isotonic solution do not show the phenomenon of osmosis.

Reason : Isotonic solutions have equal osmotic pressure.

[AIIMS 2002]

21. Assertion : Increasing pressure on pure water decreases its freezing point.

Reason : Density of water is maximum at 273 K.

[AIIMS 2003]

Answers

Solubility

1	d	2	d	3	c	4	b	5	d
6	c								

Method of expressing concentration of solution

1	c	2	d	3	d	4	e	5	b
6	b	7	a	8	d	9	d	10	b
11	a	12	b	13	a	14	a	15	b
16	c	17	b	18	e	19	b	20	b
21	c	22	c	23	c	24	b	25	c
26	d	27	d	28	c	29	a	30	c
31	a	32	c	33	d	34	a	35	d
36	b	37	b	38	b	39	b	40	c
41	c	42	b	43	c	44	c	45	a
46	ac	47	c	48	b	49	a	50	c
51	c	52	b	53	d	54	b	55	b
56	d	57	b	58	b	59	c	60	a
61	d	62	a	63	a	64	b	65	a
66	a	67	c	68	c	69	a	70	d
71	d	72	c	73	c	74	b	75	b
76	c	77	a	78	b	79	c	80	b
81	d	82	b	83	b	84	b	85	d
86	d	87	d	88	e	89	b	90	b
91	a	92	d	93	a	94	c	95	a
96	a	97	c	98	d	99	b	100	d
101	c	102	d	103	d	104	c	105	d
106	b	107	a	108	b	109	d	110	a

111	d	112	b	113	c	114	c	115	b
116	a	117	b	118	c	119	c	120	d
121	b	122	c	123	b	124	a	125	c
126	c	127	c	128	c	129	a	130	b
131	a	132	c	133	c	134	c	135	c
136	c	137	c	138	b	139	a	140	b
141	d	142	c	143	b	144	a		

Colligative properties

1	a	2	c	3	a	4	c	5	c
6	a	7	b	8	a	9	c	10	a
11	ac								

Lowering of vapour pressure

1	a	2	b	3	b	4	d	5	b
6	a	7	a	8	a	9	c	10	b
11	a	12	b	13	b	14	c	15	d
16	a	17	b	18	d	19	b	20	b
21	a	22	a	23	b	24	b	25	b
26	d	27	a	28	c	29	b	30	d
31	c	32	a	33	c	34	a	35	c
36	b	37	c	38	a	39	b	40	b
41	a	42	b	43	d	44	c		

Ideal and Non-ideal solution

1	b	2	d	3	b	4	b	5	d
6	a	7	d	8	d	9	c	10	b
11	a	12	c	13	a	14	a	15	d
16	b	17	d	18	b	19	a	20	d
21	c	22	a	23	d	24	d	25	a
26	b	27	a	28	c	29	a	30	a

Azeotropic mixture

1	d	2	c	3	d	4	a	5	b

Osmosis and Osmotic pressure of the solution

1	c	2	b	3	c	4	a	5	b
6	b	7	c	8	b	9	b	10	a
11	c	12	d	13	b	14	b	15	a
16	b	17	c	18	a	19	d	20	b
21	a	22	a	23	d	24	d	25	a
26	b	27	c	28	b	29	b	30	b
31	a	32	c	33	b	34	d	35	b
36	c	37	c	38	c	39	b	40	d
41	c	42	b	43	c	44	a	45	c
46	c	47	b	48	a	49	a	50	b
51	d	52	d	53	a	54	b	55	d
56	b	57	d	58	a	59	b	60	bcd
61	ac								

Elevation of boiling point of the solvent

1	a	2	b	3	c	4	d	5	b
6	b	7	b	8	b	9	b	10	b
11	b	12	c	13	c	14	b	15	a
16	d	17	c	18	b	19	b	20	a
21	b	22	c	23	b				

Depression of freezing point of the solvent

1	c	2	c	3	a	4	d	5	c
6	a	7	b	8	b	9	b	10	d
11	a	12	b	13	b	14	b	15	b
16	d	17	a	18	c	19	a	20	a
21	a	22	a	23	d	24	c	25	a
26	ad	27	b						

Colligative properties of electrolyte

1	c	2	b	3	d	4	c	5	c
6	a	7	c	8	c	9	a	10	a
11	c	12	c	13	d	14	c	15	a
16	d	17	c	18	b	19	c	20	c
21	b	22	a	23	b	24	c	25	c
26	d	27	a	28	b	29	d		

Abnormal molecular mass

1	c	2	a	3	a	4	c	5	c
6	a	7	a	8	c	9	a	10	d
11	d	12	c	13	b	14	b	15	b
16	b	17	b	18	d	19	b		

Critical Thinking Questions

1	a	2	c	3	c	4	d	5	a
6	c	7	b	8	b	9	c	10	c

11	b	12	b	13	b	14	d	15	a
16	c	17	a						

Assertion & Reason

1	a	2	e	3	c	4	b	5	c
6	a	7	d	8	a	9	c	10	b
11	c	12	a	13	b	14	d	15	b
16	d	17	a	18	a	19	c	20	b
21	c								

Answers and Solutions

Method of expressing concentration of solution

1. (c) $M_1V_1 + M_2V_2 = MV$

2. (d) $M = \frac{w}{m \times V(l)}$; $0.25 = \frac{w}{106 \times 0.25}$; $w = 6.625$ gm

3. (d) $N_1V_1 = N_2V_2$

$2 \times 1 = N_2 \times 6$

$N_2 = 0.33$

4. (e) 5.85 g $NaCl$ = $\frac{5.85}{58.5} mole = 0.1\ mol$

90 g $H_2O = \frac{90}{18} moles = 5\ moles$

mole fraction of $NaCl$ = $\frac{0.1}{5+0.1} \approx 0.0196$.

5. (b) $M = \frac{n}{V(l)} = \frac{0.006}{0.1} = 0.06$

6. (b) $M = \frac{W \times 1000}{mol.mass \times \text{Volume in } ml.} = \frac{9.8 \times 1000}{98 \times 2000} = 0.05\,M$

7. (a) $M = \frac{W}{m.wt.} \times \frac{1000}{\text{Volume in } ml.} = \frac{5 \times 1000}{40 \times 250} = 0.5M$

8. (d) Basicity of H_3PO_3 is 2.

Hence 0.3 M $H_3PO_3 = 0.6\,N$.

9. (d) 2 gm. Hydrogen has maximum number of molecules than others.

11. (a) $M_1V_1 = M_2V_2$

$0.01 \times 19.85 = M_2 \times 20$

$M_2 = 0.009925$; $M = 0.0099$.

12. (b) 1500 cm^3 of 0.1 N HCl have number of gm equivalence

$= \frac{N_1 \times V_1}{1000} = \frac{1500 \times 0.1}{1000} = 0.15$

$\therefore 0.15\ gm.$ equivalent of $NaOH$ $= 0.15 \times 40 = 6\ gm.$

13. (a) $M = \frac{w}{m.wt. \times \text{volume in litre}} = \frac{5.85}{58.5 \times 0.5} = 0.2M$

14. (a) Molecular weight of $C_2H_5OH = 24 + 5 + 16 + 1 = 46$

Molecular mass of $H_2O = 18$

414g of C_2H_5OH has $\frac{414}{46} = 9$ $mole$

18g of H_2O has $= \frac{18}{18} = 1$ $mole$

Mole fraction of water $= \frac{n_1}{n_1 + n_2} = \frac{1}{1+9} = \frac{1}{10} = 0.1$

15. (b) $17\,gm\ NH_3$ = 1 *mole*.

Molecules of $NH_3 = \dfrac{6.02\times10^{23}\times4.25}{17} = 1.5\times10^{23}$

17. (b) $(2.5\times1+3\times0.5) = M_3\times5.5$

or $2.5+1.5 = M_3\times5.5$ or $M_3 = \dfrac{4}{5.5} = 0.73\ M.$

20. (b) Normality of $2.3M\,H_2SO_4 = M\times\text{Valency}$

$= 2.3\times2 = 4.6N$

21. (c) $N_1V_1 = N_2V_2$, $36\times50 = N_2\times100$

$N_2 = \dfrac{36\times50}{100} = 18$; $18N\ H_2SO_4 = 9M\,H_2SO_4$.

22. (c) Molarity

$= \dfrac{w}{m.wt.\times\text{volume in litre}} = \dfrac{171}{342\times1} = 0.5M$.

23. (c) $N_1V_1 + N_2V_2 = NV$

$4x + 10(1-x) = 6\times1$; $-6x = -4$; $x = 0.66$

24. (b) $[H_3O^+] = 2\times0.02 = 0.04M$

$\therefore$ 2 *litre* solution contains 0.08 mole of H_3O^+.

25. (c) $\because$ 10 *litre* of urea solution contains 240 *gm* of urea

$\therefore$ Active mass $= \dfrac{240}{60\times10} = 0.4$.

26. (d) $NV = N_1V_1 + N_2V_2 + N_3V_3$

or, $1000\,N = 1\times5 + \dfrac{1}{2}\times20 + \dfrac{1}{3}\times30$ or $N = \dfrac{1}{40}$.

27. (d) $W = \dfrac{N\times eq.wt.\times V(ml)}{1000} = \dfrac{0.05\times49.04\times100}{1000} = 0.2452$.

29. (a) For HCl $M = N = 0.1$

$N_1V_1 = N_2V_2$; $25\times N_1 = 0.1\times35$

$N_1 = \dfrac{0.1\times35}{25}$; $\therefore M = \dfrac{0.1\times35}{25\times2} = 0.07$.

30. (c) We know that

Molarity $= \dfrac{\text{Number of moles of solute}}{\text{Volume of solution in } litre}$

$\therefore 2.0 = \dfrac{0.5}{\text{Volume of solution in } litre}$

$\therefore$ Volume of solution in *litre*

$= \dfrac{0.5}{2.0} = 0.250\,litre = 250\ ml.$

31. (a) $M = \dfrac{w}{m\times V(l)}$; $0.52 = \dfrac{w}{36.5\times0.15}$; $w = 2.84\ gm$

32. (c) $M = \dfrac{n}{V(l)}$; $0.5 = \dfrac{n}{2}$; $n = 1$

33. (d) $N = \dfrac{W}{M} = \dfrac{828}{46} = 18, n = \dfrac{w}{m} = \dfrac{36}{18} = 2$

$x_{H_2O} = \dfrac{n}{n+N} = \dfrac{2}{2+18} = \dfrac{2}{20} = 0.1$

34. (a) $N = \dfrac{w\times1000}{E\times\text{volume in } ml.}$, $E = \dfrac{98}{3} = 32.6$

$N = \dfrac{4.9\times1000}{32.6\times500} = 0.3N$.

39. (b) Mole fraction of solute $= \dfrac{20}{80} = 0.25$.

40. (c) $N = \dfrac{w\times1000}{m.wt.\times\text{Volume in } ml} = \dfrac{4\times1000}{40\times100} = 1.0\,N$.

41. (c) $M_1V_1 + M_2V_2 = M_3V_3$;

$1.5\times480 + 1.2\times520 = M\times1000$

$M = \dfrac{720+624}{1000} = 1.344\ M$.

44. (c) $m = \dfrac{18\times1000}{180\times500} = 0.2\,m$

45. (a) Molarity $= \dfrac{\%\times10\times d}{GMM} = \dfrac{22\times10\times1.253}{342} = 0.805\,M$.

Normality $= \dfrac{\%\times10\times d}{GEM} = \dfrac{22\times10\times1.253}{342/6} = 4.83\,N$

Molality $= \dfrac{22\times1000}{342(100-22)} = 0.825\,m$

46. (a) 100 *ml.* of 0.30$M = \dfrac{100\times0.3}{1000} = 0.03$ mole of *NaCl*

100 *ml* of 0.40*M* $= \dfrac{100\times0.4}{1000} = 0.04$ mole of *NaCl*

Moles of *NaCl* to be added $= 0.04 - 0.03 = 0.01$ mole

= 0.585 *gm*

47. (c) $N = \dfrac{6\times1000}{40\times100} = 1.5\,N$

It is show highest normality than others.

48. (b) $M = \dfrac{n}{V(l)} \Rightarrow 0.8 = \dfrac{0.1}{V(l)} \Rightarrow V = 125\,ml$.

50. (c) Strength of $H_2SO_4 = 98\times19.8\,g/litre$

$S = eq.wt.\times N$; $N = \dfrac{S}{eq.wt.} = \dfrac{98\times19.8}{49} = 39.6$

51. (c) $W = 1000\ gm$ (H_2O); $n = 1$ *mole*

$N = \dfrac{W}{M} = \dfrac{1000}{18} = 55.55$

$x_{\text{Solute}} = \dfrac{n}{n+N} = \dfrac{1}{1+55.55}$ = 0.018.

53. (d) Normality of acid = molarity × basicity

i.e., 0.2=molarity × 2

$\therefore$ Molarity = 0.2/2 = 0.1

55. (b) Mole fraction of $H_2O = \dfrac{\frac{80}{18}}{\frac{80}{18}+\frac{20}{24}} = \dfrac{68}{77}$.

59. (d) Volume strength $= \dfrac{1.5\times100}{17} = 8.82.$

60. (a) $n=\frac{w}{m}; w=n\times m=0.25\times 98 = 24.5\,gm$

61. (d) Molar concentration $[H_2]=\frac{Mole}{V\text{ in }litre}=\frac{20/2}{5}=2$.

62. (a) Amount of $AgNO_3$ added in 60 *ml* of solution

$=60\times 0.03=1.8\ g$

63. (a) $N=\frac{w}{E\times V(l)}\Rightarrow 0.1=\frac{w}{100\times 0.1}\Rightarrow w=1gm$

64. (b) $N=\frac{w}{E\times V(l)}\Rightarrow\ 0.1=\frac{w}{40\times 0.25}\Rightarrow w=1\,gm$

65. (a) $20\times 0.4=40\times N$ or $N=0.2$ or $M=\frac{0.2}{2}=0.1M$.

69. (a) $M=\frac{w\times 1000}{m.wt.\times\text{Volume in }ml.}=\frac{10.6\times 1000}{106\times 500}=0.2M$.

72. (c) M.eq. of HCl = M.eq. of $CaCO_3$

$N\times 50=\frac{1}{50}\times 1000\ ;\ N=\frac{1\times 1000}{50\times 50}=0.4N$

73. (c) molality $=\frac{18}{180}=0.1\,molal$.

74. (b) Molarity of $H_2SO_4=0.5$

Normality of $H_2SO_4\ (N_1)=0.5\times 2=1$

$N_1V_1=N_2V_2$

$1\times 1=N_2\times 10$ or $N_2=\frac{1}{10}=0.1N.$

76. (c) The density of solution $=1.8\,gm/ml$

Weight of one litre of solution $=1800\ gm$

$\therefore$ Weight of H_2SO_4 in the solution $=\frac{1800\times 90}{100}$ =162*gm*

$\therefore$ Weight of solvent $=1800-1620=180\ gm$

$\therefore$ Molality $=\frac{1620}{98}\times\frac{100}{180}=9.18$

77. (a) Suppose the total volume of water = *x*

$\therefore 100\,cm^3\times 0.5N=x\times 0.1N$

$\therefore x=\frac{100\times 0.5}{0.1}=500\,cm^3$

Therefore the volume of water added

$=\text{Total volume}-100\text{cm}^3=500-100=400\,cm^3$.

78. (b) $M_1V_1=M_2V_2$, $M_2=\frac{0.25\times 25}{500}=0.0125$.

79. (c) % by $wt.=\frac{wt.\text{of the solute }(g)}{wt.\text{ of the solution }g}\times 100$

$=\frac{10}{90+10}\times 100=10$

80. (b) Molality $=\frac{w}{m\times W}\times 1000=\frac{18\times 1000}{180\times 250}=0.4\ m$

81. (d) Molality $(m)=\frac{w\times 1000}{mW}=14.05$.

82. (b) $N_1V_1=N_2V_2$

$10\times 10=0.1(10+V)$

$V=\frac{10\times 10}{0.1}-10=1000-10=990\,ml.$

83. (b) Sum of mole fraction is always 1.

84. (b) An increases in temperature increase the volume of the solution and thus decreases its molarity.

85. (d) 10^3 parts of $CaCO_3$ has number of parts = 10

10^6 parts of $CaCO_3$ has number of parts

$=\frac{10}{10^3}\times 10^6=10{,}000\ ppm$.

86. (d) $X=\frac{n}{n+N}$

$n=\frac{w}{m}=\frac{3.65}{36.5}=0.1,\quad N=\frac{W}{M}=\frac{16.2}{18}=0.9$

$X=\frac{0.1}{0.1+0.9}=0.1.$

87. (d) 10% glucose solution means $10\,g=\frac{10}{180}$ *mole* in 100 cc. *i.e.*, 0.1 *litre*

Hence 1 *mole* will be present in $\frac{0.1\times 180}{10}$ =1.8 *litre*.

88. (e) For methyl alcohol *N* = *M*.

89. (b) Mole fraction of glucose = $\frac{n}{n+N}$

$=\frac{0.01}{0.01+5}=0.00199$

90. (b) Mole of urea $=\frac{6.02\times 10^{20}}{6.02\times 10^{23}}=10^{-3}$ moles

Conc. of solution (in molarity)

91. (a) Gram molecule of SO_2Cl_2 = 135

$n=\frac{w}{m}=\frac{13.5}{135}=0.1$.

92. (d) 1000 *ml* of 1 *N* oxalic solution = 63 *g*

500 *ml* of 0.2 *N* oxalic acid solution

$=\frac{63}{1000}\times 500\times 0.2=6.3\ g$.

93. (a) Mole fraction at $C_6H_6=\frac{\frac{7.8}{78}}{\frac{7.8}{78}+\frac{46}{92}}=\frac{1}{6}$.

94. (c) $X_{H_2O}=\frac{n_{H_2O}}{n_{H_2O}+n_{C_2H_5OH}+n_{CH_3COOH}}$

95. (a) $M_1V_1=M_2V_2$

i.e. $5\times 1=M_2\times 10\Rightarrow M_2=0.5$

Normality of the solution $=\frac{0.5}{2}=0.25.$

96. (a) $M = \frac{w \times 1000}{m \times \text{Volume in } ml.} = \frac{1 \times 1000}{40 \times 250} = 0.1\,M.$

98. (d) $N = \frac{w \times 1000}{eq.wt. \times \text{volume in } ml.} = 0.33\,N$.

99. (b) Mole of $HCl = \frac{1.2046 \times 10^{24}}{6.023 \times 10^{23}} = 2\,mole$

Normality = molarity × basidity or acicity $= 2 \times 1 = 2N$

100. (d) $10\,N$ = Deca - normal , $\frac{1}{10}N$ = Deci-normal.

101. (c) Molarity $= \frac{w \times 1000}{ml \text{ wt.} \times \text{Volume } ml.}$

$= \frac{7.1 \times 1000}{142 \times 100} = 0.5\,M$.

102. (d) $M = \frac{4 \times 10}{40} = 1\,M$.

103. (d) Mole fraction $X = \frac{n}{n+N} = \frac{\frac{6}{60}}{\frac{6}{60} + \frac{180}{18}} = \frac{0.1}{10.1}$.

104. (c) $N = \frac{w \times 1000}{Eq.wt. \times \text{Volume}} = \frac{10 \times 1000}{60 \times 100} = 1.66\,N$.

106. (b) $N = M \times$ bosicity ; $N = 2 \times 2 = 4$.

108. (b) Concentration $= \frac{5 \times 10^6}{10^6}$ = 5 *ppm.*

110. (a) H_3PO_3 is a dibasic acid

N_1V_1 (acid) $= N_2V_2$ (base)

$0.1 \times 2 \times 20 = 0.1 \times 1 \times V_2$

$\therefore V_2 = \frac{0.1 \times 2 \times 20}{0.1 \times 1} = 40\,ml$

111. (d) $H_3PO_4 \rightleftharpoons H^+ + H_2PO_4^-$

$H_2PO_4^- \rightleftharpoons H^+ + HPO_4^{2-}$

$HPO_4^{2-} \rightleftharpoons H^+ + PO_4^{3-}$

Phosphoric acid does not give 1*N* strength.

112. (b) $C_6H_5COOH + NaOH \rightarrow C_6H_5COONa + H_2O$

$\frac{w}{40} = \frac{12.2}{122} = 4\,gms.$

113. (c) (H_2SO_4) N_1V_1 = N_2V_2 (dilute acid)

$N_2 = (10 \times 36)/1000 = 0.36\,N$.

114. (c) $H_2O_2 \rightarrow H_2O + \frac{1}{2}O_2$

1 *M* H_2O_2 solution $= 2N = 34\,gm/litre = 11.2$

So Normality $= \frac{2 \times 10}{11.2} = 1.75$

115. (b) Weight = molarity × *m.wt.*× *v* = $1 \times 132 \times 2 = 264\,gm.$

116. (a) Mole fraction $= \frac{n}{n+N} = \frac{\frac{w}{m}}{\frac{w}{m} + \frac{W}{M}} = \frac{\frac{1}{2}}{\frac{1}{2} + \frac{8}{32}} = 0.667$.

118. (c) 98% H_2SO_4 means 98*g* H_2SO_4 in 100*g* solution.

$\frac{100}{1.84}cc = 54.3cc$; $98g\ H_2SO_4 = 1\,mol$

Hence molarity $= \frac{1}{54.3} \times 1000 = 18.4\,M$

120. (d) $3CaCl_2 + 2Na_3PO_4 \rightarrow Ca_3(PO_4)_2 + 6NaCl$

$\therefore$ Mole of $Na_3PO_4 = 3$ mole of $CaCl_2 = 1$ *mole* $Ca_3(PO_4)_2$

$\therefore$ 0.2 mole of $Na_3PO_4 = 0.3$ mole of $CaCl_2$ = 0.1 mole of $Ca_3(PO_4)_2$.

121. (b) $\frac{X}{X + \frac{1000}{78}} = 0.2$

122. (c) $C = \frac{6}{60} = 0.1$ *molar.*

123. (b) Molar solution of sulphuric acid is equal to 2*N* because it is show dibasic nature.

124. (a) $N = \frac{w \times 1000}{eq.wt. \times \text{volume in ml.}}$ $eq.wt. = \frac{106}{2} = 53$

$w = \frac{0.5 \times 53 \times 500}{1000} = 13.25$.

125. (c) Molar concentration = $\frac{5.85 \times 1000}{58.5 \times 200} = 0.5\,Molar$.

126. (c) $M = \frac{w \times 1000}{m.wt. \times V \text{ in } ml} = \frac{75.5 \times 1000}{56 \times 540} = 2.50\ M$

129. (a) $N_1V_1 = N_2V_2$

$10 \times 10 = 0.1$ × Volume of new solution

Volume of water = 1000 – 10 = 990 *ml.*

130. (b) $W = \frac{M \times m.wt. \times V}{1000} = \frac{0.1 \times 98 \times 400}{1000} = 3.92\ g$.

131. (a) Molarity of pure water $= \frac{1000}{18} = 55.6\,M$.

132. (c) $M = \frac{N}{2} = \frac{0.2}{2} = 0.1\,M$

133. (c) Moles of water $= \frac{180}{18} = 10\,mole$.

134. (c) Mole fraction of $CO_2 = \frac{n_{CO_2}}{n_{CO_2} + n_{N_2}} = \frac{\frac{44}{44}}{\frac{44}{44} + \frac{14}{28}} = \frac{2}{3}$.

136. (c) $M = \frac{w}{m \times V(l)} \Rightarrow 0.1 = \frac{w \times 4}{40 \times 1} \Rightarrow w = 1gm$

137. (c) $M = \frac{w \times 1\,litre}{m.wt. \times \text{Volume } litre} = \frac{4 \times 1}{40 \times 0.1} = 1\,M$.

138. (b) Number of moles = $\frac{w_1}{m_1} + \frac{w_2}{m_2} = \frac{90}{18} + \frac{300}{60} = 10$

139. (a) The number of moles of solute dissolved in 1000 *gm* of the solvent is called molal solution.

140. (b) $w = \frac{0.1 \times 100 \times 392}{1000} = 3.92\,g$

141. (d) $\frac{18}{180\times 1}=\frac{1}{10}=0.1$ molal.

142. (c) $M=\frac{n}{V(l)}\Rightarrow 3=\frac{n}{1}\Rightarrow n=3$ moles.

143. (b) The unit of molality is mole per kilogram.

144. (a) 0.2 water + 0.8 ethanol; $X_A=$ mole fraction of water,

$X_B=$ mole fraction of ethanol

$X_A=\frac{N_1}{N_1+N_2}$, $X_B=\frac{N_2}{N_2+N_1}$

$\therefore$ Mole fraction of water = 0.2 and ethanol = 0.8.

Colligative properties

3. (a) Osmotic pressure is colligative property.

5. (c) Vapour pressure is not colligative property.

Lowering of vapour pressure

1. (a) $\frac{P^0-Ps}{P^0}=\frac{w\times M}{m\ W}=143-\frac{0.5\times 154}{65\times 158}\times 143$

$=143-1.03=141.97\,mm$.

4. (d) $\frac{P^0-P_s}{P^0}=\frac{\frac{w}{m}}{\frac{w}{m}+\frac{W}{M}}$ or $0.00713=\frac{71.5/m}{\frac{71.5}{m}+\frac{1000}{18}}$

$m=180$

5. (b) HgI_2 although insoluble in water but shows complex formation with KI and freezing point is decreases.

6. (a) For solutions containing non-volatile solutes, the Raoult's law may be stated as at a given temperature, the vapour pressure of a solution containing non-volatile solute is directly proportional to the mole fraction of the solvent.

7. (a) Vapour pressure $\propto\frac{1}{\text{Boiling point}}$

When vapour pressure decreases then *b.pt.* increases.

9. (c) Methanol has low boiling point than H_2O

Lower is boiling point of solvent more is vapour pressure.

11. (a) Sucrose will give minimum value of ΔP .

$\Delta P=P^0-P_s$

$P_s=P^0-\Delta P$ is maximum.

12. (b) The relative lowering of the vapour pressure of dilute solution is equal to the mole fraction of the solute molecule present in the solution.

13. (b) Acetone solution has vapour pressure less than pure water.

15. (d) $P_T=P_p^0x_p+P_h^0x_h=440\times\frac{1}{5}+120\times\frac{4}{5}$

$=88+96=184$; $P_p^0x_p=y_pP_T$; $\frac{88}{184}=y_p$

$y_p=0.478$

16. (a) $P_B=P_B^oX_B$; $\therefore P_B=\frac{\frac{78}{78}}{\frac{78}{78}+\frac{46}{92}}\times 75$; $\therefore P_B$ = 50 torr

17. (b) Given molecular mass of sucrose = 342

Moles of sucrose $=\frac{100}{342}=0.292$ *mole*

Moles of water $N=\frac{1000}{18}=55.5$ *moles* and

Vapour pressure of pure water $P^0=23.8$ *mm Hg*

According to Raoult's law

$\frac{\Delta P}{P^0}=\frac{n}{n+N}\Rightarrow\frac{\Delta P}{23.8}=\frac{0.292}{0.292+55.5}$

$\Delta P=\frac{23.8\times 0.292}{55.792}=0.125$ *mm Hg.*

18. (d) According to Raoult's law, the relative lowering in vapour pressure of a dilute solution is equal to mole fraction of the solute present in the solution.

21. (a) When vapour pressure of solvent decreases, then the boiling point of solvent increases.

25. (b) According to Raoult's Law

$\frac{P^0-P_s}{P^0}=x_B$ (Mole fraction of solute)

$x_B=\frac{0.8-0.6}{0.8}=0.25$.

26. (d) $\frac{P^0-P_s}{P^0}=\text{molality}\times(1-\alpha+x\alpha+y\alpha)$ the value of P^0-P_s is maximum for $BaCl_2$.

27. (a) $\frac{P^0-Ps}{P^0}=\frac{18\times 18}{180\times 90}=0.02$.

30. (d) $P_T=P_P^0X_P+P_Q^0X_Q$; $P_T=80\times\frac{3}{5}+60\times\frac{2}{5}$

$P_T=48+24=72$ *torr* .

31. (c) $\frac{P^0-P_s}{P^0}=\frac{\frac{w}{m}}{\frac{w}{m}+\frac{W}{M}}$ $\because\frac{W}{M}>\frac{w}{m}$ $\Rightarrow\frac{640-600}{640}$

$=\frac{w}{m}\times\frac{M}{W}\Rightarrow\frac{40}{640}=\frac{2.175\times 78}{m\times 39.08}$; $m=\frac{2.175\times 78}{39.08}\times\frac{640}{40}$

$m=69.45$.

33. (c) The lower is boiling point more is vapour pressure; boiling point order, $HCl<HBr<HI<HF$

35. (c) $\frac{P^0-P_s}{P^0}=\frac{n}{N}\Rightarrow\frac{P^0-P_s}{P^0}=\frac{1}{9.9}\Rightarrow 9.9P^0-9.9P_s=P^0$

$8.9P^0=9.9P_s\Rightarrow P_s=\frac{8.9}{9.9}P^0\approx 0.90P^0$

38. (a) 1000 *ml* of CH_3OH requires methanol = 32 *g*.

150 *ml* of 2 M CH_3OH requires methanol

$$= \frac{32}{1000} \times 150 \times 2 = 9.6\,g\,.$$

39. (b) $\therefore P^0 - P_s = P^0 \times \text{mole fraction solute}$

$10 = P^0 \times 0.2\ ;\ 20 = P^0 \times n \Rightarrow n = 0.4 \ \therefore\ N = 0.6\,.$

40. (b) According to the Raoult's law for the non-volatile solute the relative lowering of vapour pressure of a solution containing a non-volatile is equal to the mole fraction of the solute.

43. (d) Relationship between mole fraction of a component in the vapour phase and total vapour pressure of an ideal solution.

$$y_A = \frac{P_A}{P_{total}} = \frac{x_A.P_A^0}{x_A.P_A^0 + x_B.P_B^0}$$

$$= \frac{1 \times 1}{1 \times 1 + 2 \times 2} = \frac{1}{1+4} = \frac{1}{5} = 0.2$$

44. (c) Lowering in weight of solution $\propto$ solution pressure

Lowering in weight of solvent $\propto$ $P^0 - P_s$

($\because$ p^0 = vapour pressure of pure solvent)

$$\frac{p^0 - p_s}{p_s} = \frac{\text{Lowering in weight of solvent}}{\text{Lowering in weight of solution}}$$

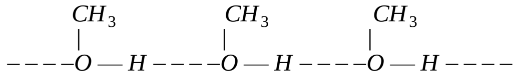
$$\frac{p^0 - p_s}{p_s} = \frac{w \times M}{m \times W}$$

$$\frac{0.05}{2.5} = \frac{10 \times 18}{90 \times m} \Rightarrow m = \frac{2 \times 2.5}{0.05} = \frac{2 \times 250}{5} = 100$$

Ideal and Non-ideal solution

1. (b) In solution showing positive type of deviation the partial pressure of each component of solution is greater than the vapour pressure as expected according to Raoult's law.

In solution of methanol & benzene methanol molecules are held together due to hydrogen bonding as shown below.



$$----\overset{\overset{CH_3}{|}}{O}—H----\overset{\overset{CH_3}{|}}{O}—H----\overset{\overset{CH_3}{|}}{O}—H----$$

On adding benzene, the benzene molecules get in between the molecule of methanol thus breaking the hydrogen bonds. As the resulting solution has weak intermolecular attraction, the escaping tendency of alcohol & benzene molecule from the solution increases. Consequently the vapour pressure of the solution is greater than the vapour pressure as expected from Raoult's law.

3. (b) Chloroform & acetone form a non-ideal solution, in which $A.....B$ type interaction are more than $A......A$ & $B......B$ type interaction due to H-bonding. Hence, the solution shows, negative deviation from Raoult's Law *i.e.,*

$\Delta V_{mix} = -ve$; $\Delta H_{mix} = -ve$

$\therefore$ total volume of solution = less than (30 + 50 *ml*)

or $< 80\,ml$

4. (b) H_2O and C_4H_9OH do not form ideal solution because there is hydrogen bonding between H_2O and C_4H_9OH.

6. (a) Aromatic compound generally separated by fractional distillation. *e.g.* Benzene + Toluene.

7. (d) C_2H_5I and C_2H_5OH do not form ideal solution.

19. (a) For the ideal solution ΔH_{mix} and $\Delta V_{\text{mix}} = 0$.

25. (a) For the ideal solution ΔS_{mix} is not equal to zero.

Azeotropic mixture

1. (d) Azeotropic mixture is constant boiling mixture, it is not possible to separate the components of azeotropic mixture by boiling.

3. (d) Azeotropic mixture is a mixture of two liquids which boils at on particular temperature like a pure liquid and distils over in the same composition.

Osmosis and Osmotic pressure of the solution

1. (c) $\pi = CRT = \frac{3 \times 1000}{180 \times 60} \times 0.0821 \times 288 = 6.56\,atm\,.$

2. (b) Isotonic solution = $\frac{w_1}{m_1 V_1} = \frac{w_2}{m_2 V_2}$

$$= \frac{w_1}{342 \times 1} = \frac{6}{60 \times 1} = \frac{342 \times 6}{60} = 34.2\,.$$

3. (c) $\pi = CRT\ ,\ C = \frac{\pi}{RT} = \frac{0.0821}{0.821 \times 300} = 0.33 \times 10^{-2}\,.$

4. (a) $\pi = \frac{w}{m} \times RT = \frac{0.1}{1} \times 0.0821 \times 273$

5. (b) $\pi = \frac{n}{V} RT \Rightarrow M_P = \left(\frac{m}{V}\right) \frac{RT}{\pi}$

6. (b) $C = \frac{5}{342} \times \frac{1}{100} \times 1000 = \frac{50}{342}\ mol/l$

$$\pi = \frac{50}{342} \times 0.082 \times 423 = 5.07\,atm$$

7. (c) $P = \frac{w}{mv} R.T$ since *wvT* are constant thus $P \propto \frac{1}{m}$

$P_2 > P_1 > P_3\,.$

8. (b) In the osmosis solvent molecule move from lower concentration to higher concentration.

10. (a) Osmosis occur from dilute solution to concentrate solution. Therefore solution A is less concentrated than B.

11. (c) Molar concentration of cane sugar $= \frac{5}{342} \times \frac{1000}{100} = \frac{50}{342}$

Molar concentration of $X = \frac{1}{m}\times\frac{1000}{100} = \frac{10}{m}$

$\frac{10}{m} = \frac{50}{342}$ or $m = 68.4$.

12. (d) Osmotic pressure method is especially suitable for the determination of molecular masses of macromolecules such as protein & polymer because for these substances the value of other colligative properties such as elevation in boiling point or depression in freezing point are too small to be measured on the other hand osmotic pressure of such substances are measurable.

13. (b) $\pi = CRT$; $C = \frac{\pi}{RT} = \frac{7.8}{\cdot 082\times 310} = 0\cdot 31\, mol/litre$

14. (b) $\pi = CRT$

$\pi = \frac{w\times R\times T}{mV} = \frac{68.4\times 0.0821\times 273}{342}$ = 4.92 *atm*

16. (b) $\pi = \frac{n}{V}RT = \frac{m/MRT}{V}$

$\frac{600}{760} = \frac{20\times 0.0821\times 288\times 1000}{500\times M}$; $M = 1200$

17. (c) $\pi = \frac{1.66+2.46}{2} = 2.06\, atm$

19. (d) Copper ferrocyanide *ppt.* acts as a semipermeable membrane.

20. (b) Osmotic pressure = CRT where C = 1 m

$\pi = CRT = 1\times 0.0821\times 300 = 24.6\, atm$

23. (d) $P = CRT$ or $\frac{P}{C} = RT$

24. (d) $\pi = CRT$ or $\pi = \left(\frac{P^0 - P_s}{P^0}\right)\times\frac{dRT}{M}$

31. (a) Isotonic solutions are those which have same concentration.

32. (c) $\pi = CRT = 0.2\times 0.0821\times 293 = 4.81$ *atm*.

35. (b) Equal osmotic pressure only applicable of non-electrolytes solution at low concentration.

38. (c) As soon as the solute molecules increases the osmotic pressure of solution increase.

41. (c) Living cells shrinks in hypertonic solution (plasmolysis) while bursts in hypotonic solution (endosmosis). There is no. effect when living cells are kept in isotonic solution.

43. (c) $\pi V = nRT$

$\pi = \frac{w}{m}\frac{RT}{V} = \frac{10}{342}\times\frac{0.821\times(273+69)}{0.1}$ = 8.21 *atm.*

45. (c) KNO_3 dissociates completely while CH_3COOH dissociates to a small extent. Hence, $P_1 > P_2$.

47. (b) $\pi V = nRT$

$\frac{500\,V_1}{105.3V_2} = \frac{nR\times 283}{nR\times 298}$; $\frac{V_1}{V_2} = \frac{1}{5}$ so $V_2 = 5V_1$

48. (a) There is no net movement of the solvent through the semipermeable membrane between two solution of equal concentration.

50. (b) $\pi V = \frac{w}{m}RT$

$\therefore\ 6\times 10^{-4}\times 1 = \frac{4}{m}\times 0.0821\times 300$; $m = 1.64\times 10^5$.

52. (d) According to the dialysis process molecular weight increases but sensitivity decreases.

55. (d) $\pi\propto T$; if T is doubled π is also doubled.

56. (b) Osmosis reaction are takes place in increases the volume.

58. (a) For two non-electrolytic solution if isotonic, $C_1 = C_2$

$\therefore\ \frac{8.6}{60\times 1} = \frac{5\times 1000}{m.wt.\times 100}$ $\therefore\ m = 348.9$

59. (b) Both urea and glucose are non-electrolytes but *NaCl* being electrolyte ionises.

Elevation of boiling point of the solvent

1. (a) $K_b = \frac{M_1RT_0^2}{1000\ \Delta H_V} = \frac{18\times 1.987\times (373)^2}{1000\times 9700} = 0.513^oC$

2. (b) $\Delta T_b = imk_b = 0.52\times 1\times 2 = 1.04$.

$\therefore\ T_b = 100 + 1.04 = 101.04^oC$.

3. (c) $K_b = \frac{\Delta T_b}{m} = \frac{0.1\times 100}{\frac{1.8}{180}\times 1000} = 1K/m$.

4. (d) $m = \frac{K_b\times w\times 1000}{\Delta T_b\times W} = \frac{2.16\times 0.15\times 1000}{0.216\times 15}$ = 100.

5. (b) Due to higher pressure inside the boiling point elevated.

6. (b) Dissolution of a non-volatile solute raises the boiling pt. of a liquid.

7. (b) As we know that

Boiling point $\propto \frac{1}{\text{vapour pressure of liquid}}$

Hence, on decreasing vapour pressure, boiling point will increase.

8. (b) $\Delta T_b = \frac{100\times K_b\times w}{m\times W}$ $\therefore\ 0.52 = \frac{100\times 5.2\times 6}{m\times 100}$

$m = \frac{100\times 5.2\times 6}{0.52\times 100} = 60$.

10. (b) Elevation in a boiling point is a colligative property as it depends upon the number of particles.

$\Delta T_b\propto n$

For sucrose, n = 1, ΔT_b = 0.1°C

For *NaCl*, n = 2, ΔT_b = 0.2°C

11. (b) $\Delta T_b = K_b\times m$ or $K_b = \Delta T_b/m$

12. (c) $\Delta T_b = K_b\times m = 0.513\times\left(\frac{0.1}{200}\times 1000\right)$

$= 0.2565\ ^oC$, $T_b = 100.256\ ^oC$

15. (a) $\Delta T_b = i.K_b.m$

$CuCl_2 \longrightarrow Cu^{2+} + 2Cl^-$

1 0 0

$(1-\alpha)$ α 2α

$i = 1 + 2\alpha$

Assuming 100% ionization

So, $i = 3$

$\Delta T_b = 3 \times 0.52 \times 0.1 = 0.156 \approx 0.16$

16. (d) $\Delta T_b = \dfrac{K_b \times w \times 1000}{m \times W}$

$m = \dfrac{K_b \times w \times 1000}{\Delta T_b \times W} = \dfrac{2.53 \times 10 \times 1000}{1 \times 100} = 253\,g$.

18. (b) Common salt is non-volatile and rises the b.pt.

19. (b) In the process of evaporation, high energy molecules leave the surface of liquid, hence average kinetic energy and consequently the temperature of liquid falls.

20. (a) The boiling occurs at lowers temperature if atmospheric pressure is lower than 76*cm Hg*.

23. (b) $BaCl_2$ furnishes more ions than KCl and thus shows higher boiling point $T_1 > T_2$.

Depression of freezing point of the solvent

1. (c) $\Delta T_f = K_f \times \text{molality} = 1.86 \times 0.05 = 0.093\ ^\circ C$

Thus freezing point = 0 – 0.093 = -0.093^oC.

2. (c) $\Delta T_f = \dfrac{100 \times K \times w}{m \times W}$ $\therefore 0.186 = \dfrac{100 \times 18.6 \times w}{60 \times 500}$

$w = 3g$

3. (a) Camphor has the maximum value of $K_f (= 39.7)$.

4. (d) The extent of depression in freezing point varies with the number of solute particles for a fixed solvent only and it is a characteristics feature of the nature of solvent also. So for two different solvents the extent of depression may vary even if number of solute particles be dissolved.

6. (a) Molar mass $= \dfrac{K_f \times 1000 \times w}{\Delta T_f \times W} = \dfrac{1.86 \times 1000 \times 1.25}{20 \times 1.1}$

$= 105.68 = 105.7$.

7. (b) $HBr \rightleftharpoons H^+ + Br^-$

$(1-\alpha)$ α α

Total = 1 + α $\therefore\ i = 1 + \alpha = 1 + 0.9 = 1.9$

$\Delta T_f = iK_f \times m = 1.9 \times 1.86 \times \dfrac{8.1}{81} \times \dfrac{1000}{100} = 3.53^oC$

$T_f = -3.53^oC$.

8. (b) $\Delta T_f = K_f \times m = 1.86 \times 0.1 = 0.186$.

9. (b) Freezing point is lowered on addition of solute in it..

10. (d) $\Delta T_b = 0.18$; $\Delta T_b = mK_b$

$\dfrac{0.18}{\Delta T_f} = \dfrac{mK_b}{m\,K_f}$; $\dfrac{0.18 \times 1.86}{0.512} = \Delta T_f$; $\Delta T_f = 0.653$

$T^0 - T_s = 0.653$; $T^0 - T_s = 0.653$; $T_s = 0 - 0.653^oC$.

11. (a) $\Delta T_f = 1.86 \times \left(\dfrac{342}{342}\right) = 1.86^o$; $\therefore\ T_f = -1.86^oC$.

12. (b) $\Delta T_b = K_b \times m$ *i.e.* $0.52 = 0.52 \times m$

$\Delta T_f = K_f \times m = 1.86 \times 1 = 1.86$; $T_f = -1.86^oC$.

13. (b) For $NaCl$ $i = 2$

$\Delta T_f = 2K_f m = 2 \times 1.86 \times 1 = 3.72$

$T_s = T - \Delta T_f = 0 - 3.72 = -3.72^\circ C$

15. (b) $\Delta T_f = K_f \times m \Rightarrow 0.186 = 1.86 \times m$

So $m = 0.1$, Put the value of m in $\Delta T_b = K_b \times m$

$\Delta T_b = 0.521 \times (0.1) = 0.0521$

17. (a) Dissolution of a non-volatile solute lowers the freezing pt. of the solution H_2O.

20. (a) By using, $m = \dfrac{K_f \times 1000 \times w}{\Delta T_f \times W_{\text{Solvent}}\ (gm)} = \dfrac{5.12 \times 1000 \times 1}{0.40 \times 50}$

$= 256\ gm / mol$

Hence, molecular mass of the solute $= 256\ gm\,mol^{-1}$

21. (a) $m = \dfrac{K_f \times w \times 1000}{\Delta T_f \times W} = \dfrac{5.12 \times 0.440 \times 1000}{0.567 \times 22.2} = 178.9$

22. (a) $KBr = K^+ + Br^- = 2$ ions

$BaCl_2 = Ba^{2+} + 2Cl^- = 3$ inos

$Al_2(SO_4)_3 = 2Al^{3+} + 3SO_4^{2-} = 5$ ions

$\therefore$ urea is not ionise hence it is shows highest freezing point.

23. (d) $NaCl \rightarrow Na^+ + Cl^- = 2$ ions

$K_2SO_4 \rightarrow 2K^+ + SO_4^{2-} = 3$ ions

K_2SO_4 give maximum ion in solution so it shows maximum depression in freezing point.

24. (c) $\Delta T_f = \dfrac{K_f \times 1000 \times w}{m \times W} = -0.216^oC$

25. (a) $\Delta T_f = \dfrac{1000 \times 1.86 \times 17}{46 \times 1000} = 0.69^oC$

$T_f = 0 - 0.69 = -0.69^oC$

26. (ad) The depression of freezing point is less than that of pure solvent and only solvent molecules solidify at the freezing point.

27. (b) $K_f = \dfrac{RT_f^2}{1000 \times L_f}$, $R = 8.314\ JK^{-1}mol^{-1}$

$T_f = 273 + 16.6 = 289.6K$; $L_f = 180.75\ Jg^{-1}$

$$K_f = \frac{8.314 \times 289.6 \times 289.6}{1000 \times 180.75}$$

Colligative properties of electrolyte

1. (c) $(NH_4)_3PO_4$ gives maximum ion. Hence, its osmotic pressure is maximum.

2. (b) $BaCl_2$ gives maximum ion hence it is shows lowest vapour pressure.

3. (d) Na_3PO_4 consist of maximum ions hence it show lowest vapour pressure.

$Na_3PO_4 \rightarrow 3Na^+ + PO_4^{3-} = 4$ ion.

4. (c) Vapour pressure of a solvent is lowered by the presence of solute in it. Lowering in vapour pressure is a colligative property *i.e.,* it depends on the no. of particles present in the solution. $Cu(NO_3)_2$ give the maximum no. of ions. (*i.e.,* 3) so it causes the greatest lowering in vapour pressure of water.

5. (c) Na_2SO_4 have more osmotic pressure than $NaCl$ solution because Na_2SO_4 gives 3 ions.

6. (a) $NaCl$ gives maximum ion hence it will show highest osmotic pressure.

8. (c) $BaCl_2 \Rightarrow Ba^{2+} + 2Cl^- = 3$ ion

$NaCl \Rightarrow Na^+ + Cl^- = 2$ ion

Glucose ⇒ No ionisation

$\therefore\ BaCl_2 > NaCl >$ Glucose

9. (a) $Al_2(SO_4)_3$ gives maximum osmotic pressure because it is gives 5 ion.

10. (a) Highest osmotic pressure is given by solution which produce maximum number of ions i.e. $CaCl_2$.

11. (c) $BaCl_2$ gives maximum ion. Hence, its shows highest boiling point.

12. (c) $BaCl_2$ gives maximum ion. Hence, its boiling point is maximum.

13. (d) $CaCl_2$ gives maximum ion hence it shows highest boiling point.

14. (c) Elevation in boiling point is a colligative property which depends upon the number of solute particles. Greater the number of solute particle in a solution higher the extent of elevation in boiling point.

$Na_2SO_4 \rightarrow 2Na^+ + SO_4^{2-}$

15. (a) $NaCl$ contain highest boiling point than other's compound.

16. (d) $\underset{\text{Boiling po int decreasing order} \rightarrow}{KCl > C_6H_5OH > C_6H_{12}O_6}$

Potassium chloride is ionic compound and phenol is formed phenoxide ion hence it is shows greater boiling point then glucose.

17. (c) $Al_2(SO_4)_3$ gives maximum ion hence it will show highest boiling point.

18. (b) $NaCl$ is a more ionic compare to $BaCl_2$, glucose and urea solution.

19. (c) Urea = 1 ; Common salt = 1 ; $Na_2SO_4 = 3$

Ratio = 1 : 2 : 3

20. (c) $CaCl_2$ gives maximum ion hence it has minimum freezing point.

21. (b) $NaCl$ gives maximum ion hence it shows lowest freezing point

23. (b) Lesser the number of particles in solution. Lesser the depression in freezing point, *i.e.* higher the freezing point.

24. (c) $BaCl_2$ gives maximum ion hence it shows maximum depression in freezing point.

26. (d) We know that lowering of freezing point is a colligative property which is directly proportional to the number of particles formed by one mole of compound therefore 0.1*M* $Al_2(SO_4)_3$ solution will have minimum freezing point.

27. (a) $Al_2(SO_4)_3$ gives maximum ion hence its gives lowest freezing point.

28. (b) Colligative property in decreasing order

$Na_3PO_4 > Na_2SO_4 > NaCl$

$Na_3PO_4 \rightarrow 3Na^+ + PO_4^{3-} = 4$

$Na_2SO_4 \rightarrow 2Na^+ + SO_4^{2-} = 3$

$NaCl \rightarrow Na^+ + Cl^- = 2$

29. (d) $K_4[Fe(CN)_6]$ gives maximum ion. Hence it have lowest vapour pressure.

Abnormal Molecular Mass

1. (c) Na_3PO_4 gives maximum four ion it is show highest Vant's haff factor.

2. (a) $K_4[Fe(CN)_6]$ dissociates as $4K^+ + [Fe(CN)_6]^{4-}$, thus 1 molecule dissociates into five particles in the similar way $Al_2(SO_4)_3$ also gives five particles per molecule.

3. (a) Benzoic acid in benzene undergoes association through intermolecular hydrogen bonding.

4. (c) vont's Hoff factor $(i) = \frac{\text{experiment al C.P.}}{\text{Calculated C.P.}}$

$= 1 - \alpha + x\alpha + y\alpha,$ for *KCl* it is = 2 and for sugar it is equal to 1.

5. (c) $Ca(NO_3)_2 \rightarrow Ca^{2+} + 2NO_3^-$ it gives three ions hence the Van't Hoff factor = 3.

6. (a) $m = \frac{5 \times 18 \times 2.5}{0.04 \times 80} = 70.31$

8. (c)

	Na_2SO_4	⇌ $2Na^+$	+ SO_4^{2-}
Mol. before diss.	1	0	0
Mol. after diss	$1-\alpha$	2α	1α

$$i = \frac{\text{Exp.C.P.}}{\text{Normal C.P.}} = 1 - \alpha + 2\alpha + \alpha = 1 + 2\alpha$$

10. (d) $MgSO_4$ dissociates to give 2 ions.

11. (d) Urea does not give ion in the solution.

13. (b) Molecular weight of $CH_3COOH = 60$

Hence the molecular weight of acetic acid in benzene $= 2 \times 60 = 120$.

17. (b) $AlCl_3$ furnishes more ions than $CaCl_2$ and thus shows higher boiling point *i.e.* $t_1 > t_2$.

18. (d) $Na_3PO_4 = 3Na^+ + PO_3^{3-}$.

19. (b) Benzoic acid dimerises due to strong hydrogen bonding.

Critical Thinking Questions

1. (a) $\frac{P^o - P_s}{P^o} = \frac{n}{n+N}$; $P^o = 0.80,\ P_s = 0.60$

$\therefore \frac{n}{n+N} = \frac{0.2}{0.8} = 0.25$.

2. (c) We have,

$\frac{p^0 - 21.85}{21.85} = \frac{30 \times 18}{90 \times m}$, for I case .....(i)

wt. of solvent $= 90 + 18 = 108\,gm$

$\frac{p^0 - 22.15}{22.15} = \frac{30 \times 18}{108 \times m}$, for II case .....(ii)

By eq. (1) $p_m^0 - 21.85m = 21.85 \times 6 = 131.1$

By eq. (2) $p_m^0 - 22.15m = 22.15 \times 5 = 110.75$

$0.30m = 20.35$

$m = \frac{20.35}{0.30} = 67.83$

3. (c) $\frac{P^o - P_s}{P^o} = \frac{\frac{W_2}{M_2}}{\frac{W_1}{M_1}} = \frac{3000 - 2985}{3000} = \frac{\frac{5}{M_2}}{\frac{100}{18}}$ or $M_2 = 180$

4. (d) It is known that azeotropic mixture of HCl and water 20.2% HCl .

5. (a) $\pi = CRT = \frac{n}{V}RT = \frac{\frac{1.75}{342}}{\frac{150}{1000}} \times 0.0821 \times 290$

$= 0.8095 \approx 0.81\,atm$.

6. (c) Vant hoff factor of *NaCl* about 1.95 because it will be ionise into two ions.

$NaCl \rightleftharpoons Na^+ + Cl^-$

7. (b) $m = \frac{wRT}{PV} = \frac{0.6 \times 0.082 \times 300}{1.23 \times 0.1} = 120$

8. (b) $m = \frac{K_b \times w \times 1000}{\Delta T_b \times W} = 143.18$

9. (c) Here: $\Delta T_b = 0.323\,K$

$w = 0.5143\,g$ weight of Anthracene.

$W = 35\,g$ weight of chloroform

$K_b =$ Molal elevation constant $(3.9\ K - Kg/mol)$

$m = \frac{K_b \times w \times 1000}{W \times \Delta T_b} = \frac{3.9 \times 0.5143 \times 1000}{0.323 \times 35}$

$= 177.42\,g/mol$

10. (c) First boiling point of water = $100^o C$

Final boiling point of water = 100.52^o

$w = 3g$, $W = 200\ g$, $K_b = 0.6\,kg^{-1}$

$\Delta T_b = 100.52 - 100 = 0.52^o C$

$m = \frac{K_b \times w \times 1000}{\Delta T_b \times W}$

$= \frac{0.6 \times 3 \times 1000}{0.52 \times 200} = \frac{1800}{104} = 17.3 gmol^{-1}$.

11. (b) Applying clausius clapeyron equation

$\log \frac{P_2}{P_1} = \frac{\Delta H_V}{2.303R}\left[\frac{T_2 - T_1}{T_1 \times T_2}\right]$

$\log \frac{760}{23} = \frac{40656}{2.303 \times 8.314}\left[\frac{373 - T_1}{373T}\right]$

This gives $T_1 = 294.4K$.

12. (b) $\Delta T_f = \text{molality} \times K_f \times (1+\alpha)$

$\alpha = 0.2$, Molality = 0.2, $K_f = 1.86$

$\Delta T_f = 0.2 \times 1.2 \times 1.86 = 0.4464^o$

Freezing point = $-0.45^o C$.

13. (b) $\Delta T_f = imk_f$; $0.0054 = i \times 1.8 \times 0.001$

$i = 3$ so it is $[Pt(NH_3)_4Cl]Cl_2$.

14. (d) $m = \frac{K_f \times w \times 1000}{\Delta T_f \times W} = 60\ g/mole$.

15. (a) $\Delta T = K_f \times \text{Molality} = 4.9 \times 0.001 = 0.0049\,K$

16. (c) $\underset{}{Na_2CO_3} + \underset{98\,gm\,(2mole)}{H_2SO_4} \rightarrow \underset{1mole}{Na_2SO_4} + \underset{1mole}{CO_2}HO$

$0.02 = \frac{0.02 \times 22.4}{2} = 0.224$.

17. (a) We know that in the first solution number of the moles of urea $= \frac{\text{Mass of urea}}{m.wt.\ \text{of urea}} \times \frac{1}{\text{V}} = \frac{12}{60} \times \frac{1}{1} = 0.2$ and

In second solution the number of moles of cane sugar $= \frac{\text{Mass of cane sugar}}{m.wt.\ \text{of cane sugar}} = \frac{68.4}{342} \times \frac{1}{1} = 0.2$.

Assertion & Reason

1. (a) Molecular weight of urea (NH_2CONH_2)

$= 14 + 2 + 12 + 16 + 14 + 2 = 60$

Number of moles $= \frac{\text{Weight}}{\text{molecular weight}} = \frac{60}{60} = 1$

2. (e) If 100 *cc* of $0.1\,N\,HCl$ is mixed with 100 *cc* of $0.2N\,HCl$, the normality of the final solution will be 0.15.

$N_1V_1 + N_2V_2 = N_3V_3$ *i.e.,* $0.1 \times 100 + 0.2 \times 100$

$= N_3 \times 200$ or $N_3 = \frac{0.3 \times 100}{200} = 0.15$

3. (c) Both the solute and solvent will form the vapour but vapour phase will become richer in the more volatile component.

4. (b) Non-ideal solutions with positive deviation i.e., having more vapour pressure than expected, boil at lower temperature while those with negative deviation boil at higher temperature than those of the components.

5. (c) The polymer solutions possess very little elevation in boiling point or depression in freezing point.

6. (a) Depression in freezing point is a colligative property which depends upon the number of particles. The number of particles are different in case of benzene and water that is why molecular weight of acetic acid determined by depression in freezing point method is also different.

7. (d) Sodium ion, Na^+ and potassium ion, K^+ are responsible for maintaining proper osmotic pressure balance inside and outside of the cells of organisms.

8. (a) If a pressure larger than the osmotic pressure is applied to the solution side, the pure solvent flows out of the solution through semi-permeable membrane and this phenomenon is called as reverse osmosis.

9. (c) Camphor has high molal depression constant.

10. (b) Elevation in boiling point and depression in freezing point are colligative properties because both depend only on the number of particles (ions or molecules) of the solute in a definite amount of the solvent but not on the nature of the solute.

12. (a) The boiling point and melting point are higher due to presence of the intermolecular hydrogen bonding.

14. (d) If a non-volatile solute is added to water its vapour pressure always decreases. Therefore, both assertion and reason are false.

15. (b) We know that heat of vaporisation of water at 100^oC is $40.6kJ$ and that of benzene is $31kJ$ at 80^oC. The amount of heat required to vaporise one mole of liquid at constant temperautre is known as heat of vapourisation therefore, both assertion and reason are true but reason is nat the correct explanation of assertion.

16. (d) See melts slowly at high altitude because melting is favoured at a high pressure at high altitude the atmospheric pressure is low and so ice melts slowly.

17. (a) Colligative properties are the properties of solutions containing non volatile solute. It is correct that malecular mass of benzoic acid when determined by colligative properties is found abnormally high. This is because dimerisation of benzoic takes place in solution resulting high molecular mass. Therefore, assertion and reason are true and reason is correct explanation.

18. (a) It is fact that use of pressure cooker reduces cooking time because at higher pressure over the liquid due to cooker lid, the liquid boils at higher temperature and cooking occurs faster.

19. (c) The assertion that CCl_4 & H_2O are immiscible is true because CCl_4 is non-polar liquid while water is polar hence assertion is true and reason is false.

20. (b) It is true that isotonic solution doesn't show the phenomenon of osmosis. Isotonic solution are those solution which have same osmotic pressure. Here both assertion and reason are true but reason is not correct explanation.

Solution and Colligative properties

SET Self Evaluation Test - 4

1. The $2N$ aqueous solution of H_2SO_4 contains

(a) 49 gm of H_2SO_4 per litre of solution

(b) 4.9 gm of H_2SO_4 per litre of solution

(c) 98 gm of H_2SO_4 per litre of solution

(d) 9.8 gm of H_2SO_4 per litre of solution

2. The amount of $KMnO_4$ required to prepare 100 *ml* of $0.1N$ solution in alkaline medium is **[CPMT 1986]**

(a) 1.58 gm (b) 3.16 gm

(c) 0.52 gm (d) 0.31 gm

3. What weight of hydrated oxalic acid should be added for complete neutralisation of $100 ml$ of $0.2\,N - NaOH$ solution ? **[MP PMT 1997]**

(a) $0.45\,g$ (b) $0.90\,g$

(c) $1.08\,g$ (d) $1.26\,g$

4. A $500\,g$ tooth paste sample has $0.2g$ fluoride concentration. What is the concentration of F in terms of *ppm* level **[AIIMS 1992]**

(a) 250 (b) 200

(c) 400 (d) 1000

5. To $5.85\,gm$ of $NaCl$ one kg of water is added to prepare of solution. What is the strength of $NaCl$ in this solution (mol. wt. of $NaCl = 58.5$) **[CPMT 1990; DPMT 1987]**

(a) 0.1 Normal (b) 0.1 Molal

(c) 0.1 Molar (d) 0.1 Formal

6. The degree of dissociation of $Ca(NO_3)_2$ in a dilute aqueous solution containing 14*g* of the salt per 200*g* of water 100^oC is 70 percent. If the vapour pressure of water at 100^oC is 760 *cm*. Calculate the vapour pressure of the solution **[UPSEAT 2000]**

(a) 746.3 *mm* of *Hg* (b) 757.5 *mm* of *Hg*

(c) 740.9 *mm* of *Hg* (d) 750 *mm* of *Hg*

7. The vapour pressure of pure benzene at a certain temperature is 200 *mm Hg*. At the same temperature the vapour pressure of a solution containing 2*g* of non-volatile non-electrolyte solid in 78*g* of benzene is 195 *mm Hg*. What is the molecular weight of solid **[UPSEAT 2001]**

(a) 50 (b) 70

(c) 85 (d) 80

8. Which one of the following non-ideal solutions shows the negative deviation

(a) $CH_3COCH_3 + CS_2$ (b) $C_6H_6 + CH_3COCH_3$

(c) $CCl_4 + CHCl_3$ (d) $CH_3COCH_3 + CHCl_3$

9. The O.P. of equimolar solution of Urea, $BaCl_2$ and $AlCl_3$, will be in the order **[DCE 2000]**

(a) $AlCl_3 > BaCl_2 >$ Urea

(b) $BaCl_2 > AlCl_3 >$ Urea

(c) Urea $> BaCl_2 > AlCl_3$

(d) $BaCl_2 >$ Urea $> AlCl_3$

10. The osmotic pressure of a 5% solution of cane sugar at 150^oC is (mol. wt. of cane sugar = 342)

[CPMT 1986; Manipal MEE 1995]

(a) 4 atm (b) 3.4 atm

(c) 5.07 atm (d) 2.45 atm

11. Which one of the following pairs of solutions can we expect to be isotonic at the same temperature **[NCERT 1**

(a) $0.1M$ urea and $0.1M\,NaCl$

(b) $0.1M$ urea and $0.2M\,MgCl_2$

(c) $0.1M\,NaCl$ and $0.1M\,Na_2SO_4$

(d) $0.1M\,Ca(NO_3)_2$ and $0.1M\,Na_2SO_4$

12. Which of the following would have the highest osmotic pressure (assume that all salts are 90% dissociated)

[NCERT 1982]

(a) Decimolar aluminium sulphate

(b) Decimolar barium chloride

(c) Decimolar sodium sulphate

(d) A solution obtained by mixing equal of (b) and (c) and filtering

13. Which solution will have the highest boiling point

[NCERT 1981]

(a) 1% solution of glucose in water

(b) 1% solution of sodium chloride in water

(c) 1% solution of zinc sulphate in water

(d) 1% solution of urea in water

14. The boiling point of a solution of 0.11 *gm* of a substance in 15 *gm* of ether was found to be $0.1^o C$ higher than that of the pure ether. The molecular weight of the substance will be $(K_b = 2.16)$ **[MP PET 2002]**

(a) 148   (b) 158

(c) 168   (d) 178

15. The boiling point of benzene is 353.23 *K*. When 1.80 *gm* of a nonvolatile solute was dissolved in 90 *gm* of benzene, the boiling point is raised to 354.11 *K*. the molar mass of the solute is

[K_b for benzene = 2.53 K mol^{-1}] **[DPMT 2004]**

(a) $5.8\ g\,mol^{-1}$

(b) $0.58\ g\,mol^{-1}$

(c) $58\ g\,mol^{-1}$

(d) $0.88\ g\,mol^{-1}$

16. The boiling point of 0.1 molal aqueous solution of urea is $100.18^o C$ at 1 atm. The molal elevation constant of water is

(a) 1.8   (b) 0.18

(c) 18   (d) 18.6

17. The freezing point of a solution containing 4.8 *g* of a compound in 60 *g* of benzene is 4.48. What is the molar mass of the compound $(K_f = 5.1 km^{-1})$, (freezing point of benzene = $5.5^o C$)

(a) 100   (b) 200

(c) 300   (d) 400

18. When 0.01 mole of sugar is dissolved in $100\,g$ of a solvent, the depression in freezing point is 0.40^o. When 0.03 mole of glucose is dissolved in $50\,g$ of the same solvent, the depression in freezing point will be

(a) 0.60^o (b) 0.80^o

(c) 1.60^o (d) 2.40^o

19. The freezing point of equimolal aqueous solution will be highest for **[IIT 1990; DCE 2001]**

(a) $C_6H_5NH_3^+Cl^-$ (aniline hydrochloride)

(b) $Ca(NO_3)_2$

(c) $La(NO_3)_3$

(d) $C_6H_{12}O_6$ (glucose)

20. The Van't Hoff factor of the compound $K_3Fe(CN)_6$ is

(a) 1   (b) 2

(c) 3   (d) 4

AS Answers and Solutions

(SET -4)

1. (c) Wt. of H_2SO_4 per litre $= N \times \text{eq. mass} = 2 \times 49 = 98g$.

2. (a) In alkaline medium $KMnO_4$ act as oxidant as follows.

$$2KMnO_4 + 2KOH \rightarrow 2K_2MnO_4 + H_2O + (O)$$

Hence its $eq.wt. = m.wt. = 158$

Now, Normality $= \dfrac{\text{Mass}}{\text{Eq. mass}} \times \dfrac{1}{V_{(L)}}$

$$\text{mass } = 0.1 \times 158 \times \frac{100}{1000} g = 1.58\ g.$$

3. (d) For complete neutralization equivalent of oxalic acid = equivalent of $NaOH$ =

$$\frac{w}{eq.wt} = \frac{NV}{1000} \quad \therefore \frac{w}{63} = \frac{0.2 \times 100}{1000} \Rightarrow w = 1.26\ gm\ .$$

4. (c) F^- ions in $PPm = \dfrac{0.2}{500} \times 10^6 = 400$

5. (b) 5.85 g $NaCl$ = 0.1 mol as it present in 1 kg of water ; molality $= \dfrac{wt.}{m\,wt. \times l} = \dfrac{5.85}{58.5 \times 1} = 0.1 molal$

6. (a)

7. (d) $\dfrac{P^o - P_s}{P^o} = \dfrac{n}{n+N}; \dfrac{P^o - P_s}{P^o} = \dfrac{w \times M}{m \times W} = 80$

8. (d) $CH_3COCH_3 + CHCl_3$ is non ideal solution which shown negative deviation.

9. (a) The particle come of $AlCl_3$ solution will be maximum due to ionisation less in $BaCl_2$ and minimum in urea

$$AlCl_3 \rightarrow Al^{3+} + 3Cl^- = 4$$

$$BaCl_2 \rightarrow Ba^{2+} + 2Cl^- = 3$$

More the number of particles in solution more is the osmotic pressure a colligative properties.

10. (c) $\pi = \dfrac{5 \times 0.0821 \times 1000 \times 423}{342 \times 100} = 5.07\ atm$.

11. (d) Osmotic pressure is a coligative properties equimolar solution of $Ca(NO_3)_2$ and Na_2SO_4 will produce same number of solute particles.

$$CaNO_3 \rightleftharpoons Ca^{2+} + 2NO_3^-$$

$$Na_2(SO_4) \rightleftharpoons 2Na^+ + SO_4^{2-}$$

12. (a) $Al_2(SO_4)_3$ Deci-molar gives maximum ion. Hence, its osmotic pressure is maximum. ***

13. (b) $NaCl$ and $ZnSO_4$ gives 2 ions but $NaCl$ is more ionic than $ZnSO_4$.

14. (b) $m = \dfrac{K_b \times w \times 1000}{\Delta T_b \times W}$

$K_b = 2.16,\ w = 0.11,\ W = 15g,\ \Delta T_b = 0.1$

$$m = \frac{2.16 \times 0.11 \times 1000}{0.1 \times 15} = 158.40 \simeq 158\ .$$

15. (c) The elevation (ΔT_b) in the boiling point

$= 354.11K - 353.23K = 0.88K$

Substituting these values in expression

$$M_{\text{Solute}} = \frac{K_b \times 1000 \times w}{\Delta T_b \times W}$$

Where, $w =$ weight of solute, $W =$ weight of solvent

$$M_{\text{solute}} = \frac{2.53 \times 1.8 \times 1000}{0.88 \times 90} = 58\ gm\,mol^{-1}$$

Hence, molar mass of the solute $= 58\ gm\,mol^{-1}$

16. (a) $K_b = \dfrac{0.18}{0.1} = 1.8$

17. (d) $m = \dfrac{K_f \times 1000 \times w}{W \times \Delta T_f} = \dfrac{5.1 \times 1000 \times 4.8}{60 \times 1.02} = 400$.

18. (d) $\Delta T_f = mk_f$

$$0.40 = \frac{0.01 \times 1000}{100} \times k_f \Rightarrow k_f = 4$$

again $\Delta T_f = mk_f$

$$= \frac{0.03 \times 1000}{50} \times 4$$

$= 2.4$

19. (d) $La(NO_3)_3$ will furnish four ions and thus will develop more lowering in freezing point whereas glucose gives only one particle and thus minimum lowering in freezing point.

20. (d) $K_3[Fe(CN)_6] \rightarrow 3K^+ + [Fe(CN)_6]^{3-}$.