2

Solutions

Multiple Choice Questions (MCQs)

Q. 1 Which of the following units is useful in relating concentration of solution with its vapour pressure?

(a) Mole fraction
(b) Parts per million
(c) Mass percentage
(d) Molality

Ans. *(a)* According to Henry's law partial pressure of gas in the solution is proportional to the mole fraction of gas in the solution.

$$p = K_H x$$

where, K_H = Henry's constant

Hence, (a) mole fraction is the correct choice.

Q. 2 On dissolving sugar in water at room temperature solution feels cool to touch. Under which of the following cases dissolution of sugar will be most rapid?

(a) Sugar crystals in cold water
(b) Sugar crystals in hot water
(c) Powdered sugar in cold water
(d) Powdered sugar in hot water

Thinking Process

Use the concept of solubility and effect of temperature on solubility to answer this question.

Ans. *(d)* Dissolution of sugar in water will be most rapid when powdered sugar is dissolved in hot water because powder form can easily insert in the vacancies of liquid particles.

Further dissolution of sugar in water is an endothermic process. Hence, high temperature will favour the dissolution of sugar in water.

Q. 3 At equilibrium the rate of dissolution of a solid solute in a volatile liquid solvent is ....

(a) less than the rate of crystallisation
(b) greater than the rate of crystallisation
(c) equal to the rate of crystallisation
(d) zero

Ans. *(c)* At equilibrium the rate of dissolution of solid in a volatile liquid solvent is equal to the rate of crystallisation.

Q. 4 A beaker contains a solution of substance 'A'. Precipitation of substance 'A' takes place when small amount of 'A' is added to the solution. The solution is ....

(a) saturated
(b) supersaturated
(c) unsaturated
(d) concentrated

Thinking Process

This problem includes concept of saturated, unsaturated, supersaturated and concentrated solution.

Ans. *(b)* When solute is added to the solution three cases may arise

(i) It dissolves into solution then solution is unsaturated.
(ii) It does not dissolve in the solution then solution is known as saturated.
(iii) When solute get precipitated solution is known as supersaturated solution.

Q. 5 Maximum amount of a solid solute that can be dissolved in a specified amount of a given liquid solvent does not depend upon ....

(a) temperature
(b) nature of solute
(c) pressure
(d) nature of solvent

Ans. *(c)* Maximum amount of solid that can be dissolved in a specified amount of a given solvent does not depend upon pressure. This is because solid and liquid are highly incompressible and practically remain unaffected by change in pressure.

Q. 6 Low concentration of oxygen in the blood and tissues of people living at high altitude is due to ....

(a) low temperature
(b) low atmospheric pressure
(c) high atmospheric pressure
(d) Both low temperature and high atmospheric pressure

Ans. *(b)* Low concentration of oxygen in the blood and tissues of people living at high altitude is due to low atmospheric pressure. Because at high altitude, the partial pressure of oxygen is less than at the ground level. This decreased atmospheric pressure causes release of oxygen from blood.

Q. 7 Considering the formation, breaking and strength of hydrogen bond, predict which of the following mixtures will show a positive deviation from Raoult's law?

(a) Methanol and acetone
(b) Chloroform and acetone
(c) Nitric acid and water
(d) Phenol and aniline

Ans. *(a)* In pure methanol, molecules are hydrogen bonded. On adding acetone, its molecules get in between the host molecules and break some of the hydrogen bonds between them.

Therefore, the intermolecular attractive forces between the solute-solvent molecules are weaker than those between the solute-solute and solvent-solvent molecules.

On the other hand, other three remaining options will show negative deviation from Raoult's law where the intermolecular attractive forces between the solute-solvent molecules are stronger than those between the solute-solute and solvent-solvent molecules.

Q. 8 Colligative properties depend on ....

(a) the nature of the solute particles dissolved in solution
(b) the number of solute particles in solution
(c) the physical properties of the solute particles dissolved in solution
(d) the nature of solvent particles

Ans. ***(b)*** Colligative properties depend upon number of solute particles in solution irrespective of their nature. Colligative property is used to determine the molecular mass of particle.

Q. 9 Which of the following aqueous solutions should have the highest boiling point?

(a) 1.0 M $NaOH$ (b) 1.0 M Na_2SO_4
(c) 1.0 M NH_4NO_3 (d) 1.0 M KNO_3

Thinking Process

This process includes concept of van't Hoff factor and boiling point. Calculate van't Hoff factor then correlate it with boiling point of solution.

Ans. ***(b)*** As we know greater the value of van't Hoff factor higher will be the elevation in boiling point and hence higher will be the boiling point of solution.

Solution	van't Hoff factor (*i*)
1.0 M $NaOH$	2
1.0 M Na_2SO_4	3
1.0 M NH_4NO_3	2
1.0 M KNO_3	2

Hence, 1.0 M Na_2SO_4 has highest value of boiling point.

Q. 10 The unit of ebullioscopic constant is

(a) K kg mol^{-1} or K $(molality)^{-1}$ (b) mol kg K^{-1} or K^{-1} (molality)
(c) kg mol^{-1} K^{-1} or K^{-1} $(molality)^{-1}$ (d) K mol kg^{-1} or K (molality)

Thinking Process

Write the formula of ebullioscopic constant then put the values of their unit and then calculate unit of ebullioscopic constant.

Ans. ***(a)*** As we know from elevation in boiling point that

$$\Delta T_b = K_b m$$

$$K_b = \frac{\Delta T_b}{m}$$

$$\text{Unit of } K_b = \frac{\text{unit of } \Delta T_b}{\text{unit of } m} = \frac{\text{K}}{\text{molality}}$$

$$= \frac{\text{K}}{\text{mol kg}^{-1}} = \text{K mol}^{-1}\text{ kg}$$

Q. 11 In comparison to a 0.01 M solution of glucose, the depression in freezing point of a 0.01 M $MgCl_2$ solution is ....

(a) the same (b) about twice
(c) about three times (d) about six times

Thinking Process

Calculate value of van't Hoff factor then correlate it with colligative property of given solution.

Ans. ***(c)*** As we know depression in freezing point is directly related to van't Hoff factor (*i*) according to which greater the value of *i* greater will be the depression in freezing point.

Solution	*i*
0.01 M glucose	1
0.01 M $MgCl_2$	3

Hence, depression in freezing point of glucose is about 3 times of glucose.

Q.12 An unripe mango placed in a concentrated salt solution to prepare pickle shrivels because ....

(a) it gains water due to osmosis
(b) it loses water due to reverse osmosis
(c) it gains water due to reverse osmosis
(d) it loses water due to osmosis

Ans. ***(d)*** When an unripe mango is placed in a concentrated salt solution to prepare pickle then mango loose water due to osmosis and get shrivel.

Q. 13 At a given temperature, osmotic pressure of a concentrated solution of a substance ....

(a) is higher than that of a dilute solution
(b) is lower than that of a dilute solution
(c) is same as that of a dilute solution
(d) cannot be compared with osmotic pressure of dilute solution

Ans. ***(a)*** According to definition of osmotic pressure we know that $\pi = CRT$. For concentrated solution C has higher value than dilute solution.

Hence, as concentration of solution increases osmotic pressure will also increase.

Q. 14 Which of the following statements is false?

(a) Two different solutions of sucrose of same molality prepared in different solvents will have the same depression in freezing point.

(b) The osmotic pressure of a solution is given by the equation $\pi = CRT$ (where, C is the molarity of the solution)

(c) Decreasing order of osmotic pressure for 0.01 M aqueous solutions of barium chloride, potassium chloride, acetic acid and sucrose is

$$BaCl_2 > KCl > CH_3COOH > \text{sucrose}$$

(d) According to Raoult's law, the vapour pressure exerted by a volatile component of a solution is directly proportional to its mole fraction in the solution

Ans. ***(a)*** According to definition of depression in freezing point

$$\Delta T_f = K_f m$$

where, K_f = freezing point depression constant, value of K_f depends upon nature of solvent. This is why although the solution have same molality two different solutions of sucrose of same molality prepared in different solvents will have different depression in freezing point.

Q. 15 The values of van't Hoff factors for KCl, NaCl and K_2SO_4 respectively are ....

(a) 2, 2 and 2 (b) 2, 2 and 3 (c) 1, 1 and 2 (d) 1, 1 and 1

Ans. *(b)* Number of total ions present in the solution is known as van't Hoff factors (*i*).

Substances	van't Hoff factor (*i*)
For KCl	2
For NaCl	2
For K_2SO_4	3

Hence, correct choice is (b).

Q. 16 Which of the following statements is false?

(a) Units of atmospheric pressure and osmotic pressure are the same

(b) In reverse osmosis, solvent molecules move through a semipermeable membrane from a region of lower concentration of solute to a region of higher concentration

(c) The value of molal depression constant depends on nature of solvent

(d) Relative lowering of vapour pressure, is a dimensionless quantity

Ans. *(b)* In reverse osmosis, solvent molecules move through a semipermeable membrane from a region of higher concentration of solute to lower concentration.

Q. 17 Value of Henry's constant K_H ....

(a) increases with increase in temperature

(b) decreases with increase in temperature

(c) remains constant

(d) first increases then decreases

Ans. *(a)* Value of Henry's constant (K_H) increases with increase in temperature representing the decrease in solubility.

Q. 18 The value of Henry's constant, K_H is ....

(a) greater for gases with higher solubility

(b) greater for gases with lower solubility

(c) constant for all gases

(d) not related to the solubility of gases

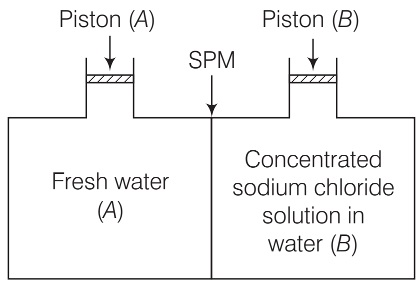
Ans. *(b)* According to Henry's law

$$p \propto x$$

$$\Rightarrow \quad p = K_H x$$

As value of K_H rises solubility of gases decreases.

Q. 19 Consider the figure and mark the correct option.



(a) Water will move from side (A) to side (B) if a pressure lower osmotic pressure is applied on piston (B)
(b) Water will move from side (B) to side (A) if a pressure greater than osmotic pressure is applied on piston (B)
(c) Water will move from side (B) to side (A) if a pressure equal to osmotic pressure is applied on piston (B)
(d) Water will move from side (A) to side (B) if pressure equal to osmotic pressure is applied on piston (A)

Ans. *(b)* We know that, if a pressure higher than the osmotic pressure is applied on the solution. the solvent will flow from the solution into the pure solvent through the semi-permeable membrane. This process is called reverse osmosis.

Thus, in this case, water will move from side (B) to side (A) if a pressure greater than osmotic pressure is applied on piston (B).

Q. 20 We have three aqueous solutions of NaCl labelled as 'A', 'B' and 'C' with concentrations 0.1 M, 0.01 M and 0.001 M, respectively. The value of van't Hoff factor for these solutions will be in the order ....

(a) $i_A < i_B < i_C$ (b) $i_A > i_B > i_C$ (c) $i_A = i_B = i_C$ (d) $i_A < i_B > i_C$

Ans. *(b)* van't Hoff factor is the measurement of total number of ions present in the solution. Therefore, greater the concentration of solution greater will be its van't Hoff factor.

	Concentration NaCl	
A	0.1 M	On moving top to bottom
B	0.01 M	◆ Concentration decreases
C	0.001 M	◆ Van't Hoff factor(i) decreases

Q. 21 On the basis of information given below mark the correct option.
Information

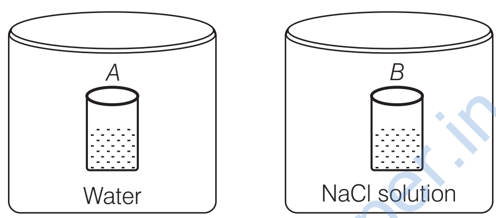
(i) In bromoethane and chloroethane mixture intermolecular interactions of A—A and B—B type are nearly same as A—B type interactions.
(ii) In ethanol and acetone mixture A—A or B—B type intermolecular interactions are stronger than A—B type interactions.
(iii) In chloroform and acetone mixture A—A or B—B type intermolecular interactions are weaker than A—B type interactions.

(a) Solution (ii) and (iii) will follow Raoult's law
(b) Solution (i) will follow Raoult's law
(c) Solution (ii) will show negative deviation from Raoult's law
(d) Solution (iii) will show positive deviation from Raoult's law

Ans. *(b)* For an ideal solution, the *A*—*A* or *B*—*B* type intermolecular interaction is near by equal to *A*—*B* type interaction. Here, a mixture of bromoethane and chloroethane is an example of ideal solution.

On the other hand chloroform and acetone mixture is an example of non-ideal solution having negative deviation. So, (*A*—*A*) or (*B*—*B*) interaction must be stronger than *A*—*B* interaction. While ethanol-acetone mixture shows positive deviation due to weaker *A*—*B* interaction in comparison to *A*—*A* or *A*—*B* interaction.

Q. 22 Two beakers of capacity 500 mL were taken. One of these beakers, labelled as "A", was filled with 400 mL water whereas the beaker labelled "B' was filled with 400 mL of 2M solution of NaCl. At the same temperature both the beakers were placed in closed containers of same material and same capacity as shown in figure.



At a given temperature, which of the following statement is correct about the vapour pressure of pure water and that of NaCl solution?

(a) Vapour pressure in container (*A*) is more than that in container *(B)*

(b) Vapour pressure in container (*A*) is less than that in container *(B)*

(c) Vapour pressure is equal in both the containers

(d) Vapour pressure in container *(B)* is twice the vapour pressure in container *(A)*

Ans. *(a)* When salt is added to water to make the solution the vapour pressure of solution get decreases. This is due to decrease in surface covered by solvent molecule which lead to decrease in number of solvent molecule escaping from the surface corresponding to pure solvent.

Hence, vapour pressure also get reduces.

Q. 23 If two liquids A and B form minimum boiling azeotrope at some specific composition then

(a) *A*—*B* interactions are stronger than those between *A*—*A* or *B*—*B*

(b) vapour pressure of solution increases because more number of molecules of liquids *A* and *B* can escape from the solution

(c) vapour pressure of solution decreases because less number of molecules of only one of the liquids escape from the solution

(d) *A*—*B* interactions are weaker than those between *A*—*A* or *B*—*B*

Ans. *(a)* If two liquids *A* and *B* form minimum boiling azeotrope at some specific composition then *A*—*B* interactions are weaker than those of *A*—*A* and *B*—*B*. It is due to the fact that in case of positive deviation, we get minimum boiling azeotropes whereas in case of negative deviation we get maximum boiling azeotropes.

Q. 24 4 L of 0.02 M aqueous solution of NaCl was diluted by adding 1 L of water. The molality of the resultant solution is ....

(a) 0.004 (b) 0.008 (c) 0.012 (d) 0.016

Thinking Process

To calculate the strength of solution when it is diluted by adding solvent. Write all the given values M_1, V_1, M_2 and V_2. Then calculate required parameter using formula, $M_1V_1 = M_2V_2$

where, V_1 = *volume of solution before dilution*
V_2 = *volume of solution after dilution*
M_1 = *strength of solution before dilution*
M_2 = *strength of solution after dilution*

Ans. *(d)* Given, $M_1 = 0.02\text{M}$, $V_1 = 4\text{L}$, $M_2 = ?$, $V_2 = 4\text{L} + 1\text{L} = 5\text{L}$

As we know,
$$M_1V_1 = M_2V_2$$
$$0.02 \times 4\text{L} = M_2 \times 5\text{L}$$
$$M_2 = \frac{0.08}{5} = 0.016\,\text{M}$$

Q. 25 On the basis of information given below mark the correct option.

Information On adding acetone to methanol some of the hydrogen bonds between methanol molecules break.

(a) At specific composition methanol-acetone mixture will form minimum boiling azeotrope and will show positive deviation from Raoult's law
(b) At specific composition methanol-acetone mixture will form maximum boiling azeotrope and will show positive deviation from Raoult's law
(c) At specific composition methanol-acetone mixture will form minimum boiling azeotrope and will show negative deviation from Raoult's law
(d) At specific composition methanol-acetone mixture will form maximum boiling azeotrope and will show negative deviation from Raoult's law

Ans. *(a)* At specific composition methanol- acetone mixture will form minimum boiling azeotrope and will show positive deviation. This is due to weaker A—B interaction than A—A or B—B interaction. *i.e.*, A—B < A—A and B—B

Q. 26 K_H value for Ar(g), CO_2 (g), HCHO (g) and CH_4(g) are 40.39, 1.67, 1.83×10^{-5} and 0.413 respectively.

Arrange these gases in the order of their increasing solubility.

(a) HCHO < CH_4 < CO_2 < Ar (b) HCHO < CO_2 < CH_4 < Ar
(c) Ar < CO_2 < CH_4 < HCHO (d) Ar < CH_4 < CO_2 < HCHO

Thinking Process

Higher the value of K_H at a given pressure, the lower is the solubility of the gas in the liquid.

Ans. *(c)* Value of K_H depends upon nature of gases dissolved in water.

Gas	Temperature (K)	K_H/k bar
Ar	298 K	40.3
CO_2	298 K	1.67
CH_4	298 K	0.413
HCHO	298 K	1.83×10^{-5}

Hence, correct order is Ar < CO_2 < CH_4 < HCHO and correct choice is (c).

Multiple Choice Questions (More Than One Options)

Q. 27 Which of the following factor(s)affect the solubility of a gaseous solute in the fixed volume of liquid solvent?

(i) Nature of solute (ii) Temperature

(iii) Pressure

(a) (i) and (iii) at constant T (b) (i) and (ii) at constant p

(c) (ii) and (iii) (d) Only (iii)

Ans. ***(a, b)***

Solubility of gaseous solute in the fixed volume of liquid solvent always depends upon nature of solute but it depends upon pressure at constant temperature and depends upon temperature at constant pressure.

Hence, (a) and (b) both are correct.

Q. 28 Intermolecular forces between two benzene molecules are nearly of same strength as those between two toluene molecules. For a mixture of benzene and toluene, which of the following are not true?

(a) $\Delta_{mix} H$ = zero

(b) $\Delta_{mix} V$ = zero

(c) These will form minimum boiling azeotrope

(d) These will not form ideal solution

Ans. ***(c, d)***

The solution which follows Raoult's law is known as ideal solution. For an ideal solution intermolecular forces between two benzene molecules are nearly of same strength as those between two toluene molecules. For an ideal solution

$$\Delta V_{mix} = 0 \text{ and } \Delta H_{mix} = 0$$

Thus, the mixture of benzene and toluene is an example of ideal solution. Option (c) is incorrect as minimum boiling azeotropes are formed by non-ideal solution.

Q. 29 Relative lowering of vapour pressure is a colligative property because ....

(a) it depends on the concentration of a non-electrolyte solute in solution and does not depend on the nature of the solute molecules

(b) it depends on number of particles of electrolyte solute in solution and does not depend on the nature of the solute particles

(c) it depends on the concentration of a non-electrolyte solute in solution as well as on the nature of the solute molecules

(d) it depends on the concentration of an electrolyte or non-electrolyte solute in solution as well as on the nature of solute molecules

Ans. ***(a, b)***

Relative lowering of vapour pressure is a colligative property because

(i) It does not depend upon nature of solute.

(ii) It depends upon number of solute particles.

(iii) It depends upon concentration of non-electrolyte solution.

Hence, (a) and (b) are correct.

Q. 30 van't Hoff factor (i) is given by the expression

(a) $i = \dfrac{\text{normal molar mass}}{\text{abnormal molar mass}}$ (b) $i = \dfrac{\text{abnormal molar mass}}{\text{normal molar mass}}$

(c) $i = \dfrac{\text{observed colligative property}}{\text{calculated colligative property}}$ (d) $i = \dfrac{\text{calculated colligative property}}{\text{observed colligative property}}$

Ans. ***(a, c)***

van't Hoff factor (i) is a measure of extent of association or dissociation of solute particles which can be calculated as

$$i = \frac{\text{normal molar mass}}{\text{abnormal molar mass}}$$
$$= \frac{\text{observed colligative property}}{\text{calculated colligative property}}$$

Q. 31 Isotonic solutions must have the same ....

(a) solute   (b) density

(c) elevation in boiling point   (d) depression in freezing point

Ans. ***(c, d)***

Isotonic solutions have same osmotic pressure and same concentration. Elevation in boiling point and depression in freezing point are the colligative properties. These two colligative properties depend upon concentration.

As the molar concentration is same for isotonic solutions, so elevation in boiling point and depression in freezing point of isotonic solutions must be same.

Q. 32 Which of the following binary mixtures will have same composition in liquid and vapour phase?

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

(c) Water-ethanol   (d) *n*-hexane— *n*-heptane

Ans. ***(b, c)***

Mixtures having same composition in liquid and vapour phase are known as azeotropes. Azeotropes boils at same temperature.

Here, water-nitric acid and water-ethanol mixtures are non-ideal solution. Hence, water-nitric acid and water-ethanol are examples of azeotropes.

While benzene-toluene and *n*-hexane—*n* -heptane are examples of ideal solution.

Q. 33 In isotonic solutions ....

(a) solute and solvent both are same

(b) osmotic pressure is same

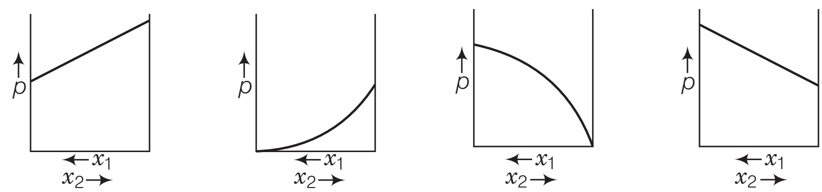
(c) solute and solvent may or may not be same

(d) solute is always same solvent may be different

Ans. ***(b, c)***

The two solutions having same osmotic pressure are known as isotonic solutions. The solute and solvent particles may or may not be same but osmotic pressure must be same.

Q. 34 For a binary ideal liquid solution, the variation in total vapour pressure versus composition of solution is given by which of the curves?



Ans. ***(a,d)***

Depending on the vapour pressures of the pure components 1 and 2, total vapour pressure over the solution decreases or increases with the increase of the mole fraction of component 1.

Q. 35 Colligative properties are observed when ....

(a) a non-volatile solid is dissolved in a volatile liquid
(b) a non-volatile liquid is dissolved in another volatile liquid
(c) a gas is dissolved in non-volatile liquid
(d) a volatile liquid is dissolved in another volatile liquid

Ans. ***(a, b)***

When any of one component of binary mixture either solvent or solute is volatile it causes deviation from ideal behaviour and vapour pressure of solution which causes change in colligative property.

Hence, (a) and (b) are correct.

Short Answer Type Questions

Q. 36 Components of a binary mixture of two liquids A and B were being separated by distillation. After some time separation of components stopped and composition of vapour phase became same as that of liquid phase. Both the components started coming in the distillate. Explain why this happened?

Ans. Both the components are appearing in the distillate and composition of liquid and vapour is same. This shows that liquids have formed azeotropic mixture and boils at constant temperature hence cannot be separated at this stage by distillation or fractional distillation.

Solution having azeotropic nature show large positive or negative deviation from Raoult's law depending upon intermolecular interaction.

Q. 37 Explain why on addition of 1 mole of NaCl to 1 L of water, the boiling point of water increases, while addition of 1 mole of methyl alcohol to 1 L of water decreases its boiling point.

Ans. NaCl is a non-volatile solute. So, its addition to water lowers the vapour pressure of the water. Hence, boiling point of water (solution) increases. Whereas methyl alcohol is more volatile than water.

So, its addition to water increases the total vapour pressure over the solution. It results in the decrease of boiling point.

Q. 38 Explain the solubility rule "like dissolves like" in terms of intermolecular forces that exist in solutions.

Ans. If the intermolecular interactions are similar in both constituents, *i.e.*, solute and solvent then solute dissolves in the solvent. *e.g.*, polar solutes dissolve in polar solvents and non-polar solutes in non-polar solvents.

Thus, the statement 'like dissolves like' proves to be true. *e.g.,* organic compounds dissolve in non-polar organic solvent while polar inorganic compounds (salts) dissolve in polar solvent (water).

Q. 39 Concentration terms such as mass percentage, ppm, mole fraction and molality are independent of temperature, however molarity is a function of temperature. Explain.

Thinking Process

To solve this problem notice the role of temperature in component of concentration term such as volume, mass, number of moles etc.

Ans. Molarity is defined as the number of moles of solute dissolved per litre of a solution. Since, volume depends on temperature and changes with change in temperature, the molarity will also change with change in temperature.

On the other hand, mass does not change with change in temperature, so other concentration terms given in the question also do not do so. Thus, temperature has no effect on the mass but it has significant effect on volume.

Q. 40 What is the significance of Henry's law constant K_H?

Ans. According to Henry's law $p \propto x \Rightarrow p = K_H x$

Higher the value of Henry's law constant K_H, the lower is the solubility of the gas in a liquid. Thus, the solubility of a gas in the given liquid can be increased by increasing pressure.

Q. 41 Why are aquatic species more comfortable in cold water in comparision to warm water?

Ans. Aquatic species are more comfortable in cold water due to the presence of more oxygen. Solubility of oxygen in water increases with decrease in temperature as solubility of a gas in given liquid decreases with increase in temperature.

Q. 42 (a) Explain the following phenomena with the help of Henry's law.

(i) Painful condition known as bends.

(ii) Feeling of weakness and discomfort in breathing at high altitude.

(b) Why soda water bottle kept at room temperature fizzes on opening?

Ans. (a) (i) Henry's law represents a relation between solubility of gases in liquid and pressure. Scuba drivers when comes towards surface, the pressure gradually decreases. This reduce pressure releases the dissolve gas present in blood and leads to formation of bubbles of nitrogen in the blood.

This creates a painful condition by blocking capillaries known as blends.

(ii) At high altitude atmospheric pressure is low as compared to surface which causes difficulty in breathing. On that condition we feel weakness and discomfort.

(b) Soda water bottle kept at room temperature fizzes on opening due to different pressure inside and outside the bottle. When the bottle is opened to air, the partial pressure of CO_2 above the solution decreases. As a result, solubility decreases and hence CO_2 bubbles out.

Q. 43 Why is the vapour pressure of an aqueous solution of glucose lower than that of water?

Ans. In pure liquid, the entire surface of liquid is occupied by the molecules of water. When a non-volatile solute, *e.g.*, glucose is dissolved in water, the fraction of surface covered by the solvent molecules gets reduced because some positions are occupied by glucose molecules.

So, number of solvent molecules escaping from the surface is reduced. That is why vapour pressure of aqueous solution of glucose is reduced.

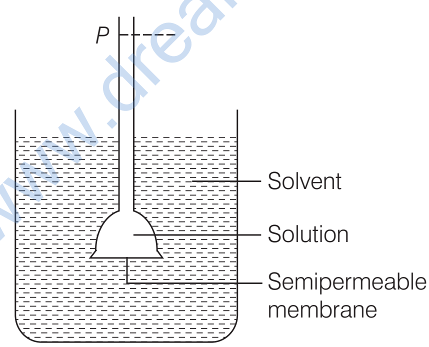
Q. 44 How does sprinkling of salt help in clearing the snow covered roads in hilly areas? Explain the phenomenon involved in the process.

Ans. When salt is spread over snow covered roads, snow starts melting from the surface because depression of freezing point of water takes place due to addition of salt. It helps in clearing of roads.

Hence, the phenomena is depression in freezing point which helps in clearing the snow covered roads in hilly areas.

Q. 45 What is "semipermeable membrane"?

Ans. Continuous sheets or films (natural or synthetic) which contain a network of submicroscopic holes or pores through which small solvent molecules (water etc.) can pass, but solute molecules of bigger size cannot pass are called semipermeable membrane. *e.g.,* cellophane membrane.



Q. 46 Give an example of a material used for making semipermeable membrane for carrying out reverse osmosis.

Ans. Since pressure required for the reverse osmosis is very high, so, a suitable material is used for making semipermeable membrane. It is generally cellulose acetate placed over suitable support.

Matching The Columns

Q. 47 Match the items given in Column I and Column II.

Column I		Column II	
A.	Saturated solution	1.	Solution having same osmotic pressure at a given temperature as that of given solution.
B.	Binary solution	2.	A solution whose osmotic pressure is less than that of another.
C.	Isotonic solution	3.	Solution with two components.
D.	Hypotonic solution	4.	A solution which contains maximum amount of solute that can be dissolved in a given amount of solvent at a given temperature.
E.	Solid solution	5.	A solution whose osmotic pressure is more than that of another.
F.	Hypertonic solution	6.	A solution in solid phase.

Ans. **A.** → (4) **B.** → (3) **C.** → (1) **D.** → (2) **E.** → (6) **F.** → (5)

A. **Saturated solution** A solution which contains maximum amounts of solute that can be dissolved in a given amount of solvent at a given temperature.

B. **Binary solution** A solution with two components is known as binary solution.

C. **Isotonic solution** A solution having same osmotic pressure at a given temperature as that of given solution is known as isotonic solution.

D. **Hypotonic solution** A solution whose osmotic pressure is less than another is known as hypotonic solution.

E. **Solid solution** A solution in solid phase is known as solid solution.

F. **Hypertonic solution** A solution whose osmotic pressure is greater than that of another is known as hypertonic solution.

Q. 48 Match the items given in Column I with the type of solutions given in Column II.

Column I		Column II	
A.	Soda water	1.	A solution of gas in solid
B.	Sugar solution	2.	A solution of gas in gas
C.	German silver	3.	A solution of solid in liquid
D.	Air	4.	A solution of solid in solid
E.	Hydrogen gas in palladium	5.	A solution of gas in liquid
		6.	A solution of liquid in solid

Ans. **A.** → (5) **B.** → (3) **C.** → (4) **D.** → (2) **E.** → (1)

A. **Soda water** A solution of gas in liquid. *e.g.*, CO_2 in soft drinks.

B. **Sugar solution** A solution of solid in liquid in which sugar particles (soild) are dissolved in water (liquid).

C. **German silver** German silver is an alloy which is a solid solution of solid in solid. It is an alloy of Cu, Zn and Ni.

D. **Air** A solution of gas in gas. Air is a mixture of various gases.

E. **Hydrogen gas in palladium** is an example of solution of gas in solid. This is used as an reducing agent.

Q. 49 Match the laws given in Column I with expressions given in Column II.

Column I	Column II
A. Raoult's law	1. $\Delta T_f = K_f m$
B. Henry's law	2. $\pi = CRT$
C. Elevation of boiling point	3. $p = x_1 p_1^\circ + x_2 p_2^\circ$
D. Depression in freezing point	4. $\Delta T_b = K_b m$
E. Osmotic pressure	5. $p = K_H \cdot x$

Ans. **A.** → (3) **B.** → (5) **C.** → (1) **D.** → (1) **E.** → (2)

A. **Raoult's law** Mathematical representation of Raoult's law

$$p = x_1 p_1^\circ + x_2 p_2^\circ$$

B. **Henry's law** $p = K_H \cdot x$

C. **Elevation of boiling point** Mathematical representation, $\Delta T_b = K_b \cdot m$

D. **Depression in freezing point** Mathematical representation, $\Delta T_f = K_f \cdot m$

E. **Osmotic pressure** Mathematical representation, $\pi = CRT$.

Q. 50 Match the terms given in Column I with expressions given in Column II.

Column I	Column II
A. Mass percentage	1. $\frac{\text{Number of moles of the solute component}}{\text{Volume of solution in litres}}$
B. Volume percentage	2. $\frac{\text{Number of moles of a component}}{\text{Total number of moles of all the components}}$
C. Mole fraction	3. $\frac{\text{Volume of the solute component in solution}}{\text{Total volume of solution}} \times 100$
D. Molality	4. $\frac{\text{Mass of the solute component in solution}}{\text{Total mass of the solution}} \times 100$
E. Molarity	5. $\frac{\text{Number of moles of the solute components}}{\text{Mass of solvent in kilograms}}$

Ans. **A.** → (4) **B.** → (3) **C.** → (2) **D.** → (5) **E.** → (1)

Column I (Concentration terms)	Column II (Mathematical formula)
A. Mass percentage	$\frac{\text{Mass of the solute component in solution}}{\text{Total mass of the solution}} \times 100$
B. Volume percentage	$\frac{\text{Volume of the solute component in solution}}{\text{Total volume of solution}} \times 100$
C. Mole fraction	$\frac{\text{Number of moles of a component}}{\text{Total number of moles of all the components}}$
D. Molality	$\frac{\text{Number of moles of the solute components}}{\text{Mass of solvent in kilograms}}$
E. Molarity	$\frac{\text{Number of moles of the solute component}}{\text{Volume of solution in litres}}$

Assertion and Reason

In the following questions a statement of assertion (A) followed by a statement of reason (R) is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.
(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.
(c) Assertion is correct statement but reason is wrong statement.
(d) Assertion and reason both are incorrect statements.
(e) Assertion is wrong statement but reason is correct statement.

Q. 51 Assertion (A) Molarity of a solution in liquid state changes with temperature.

Reason (R) The volume of a solution changes with change in temperature.

Ans. ***(a)*** Assertion and reason both are correct statements and reason is the correct explanation of assertion.

Volume of solutions is a function of temperature which varies with temperature. Hence, molarity of solution in liquid state changes with temperature.

$$\text{Molarity} = \frac{\text{moles of solute}}{\text{volume of solution in litre}}$$

Q. 52 Assertion (A) When methyl alcohol is added to water, boiling point of water increases.

Reason (R) When a volatile solute is added to a volatile solvent elevation in boiling point is observed.

Ans. ***(d)*** Assertion is wrong statement but reason is correct statement.

When methyl alcohol is added to water, boiling point of water decreases because when a volatile solute is added to a volatile solvent elevation in boiling point is observed.

Q. 53 Assertion (A) When NaCl is added to water a depression in freezing point is observed.

Reason (R) The lowering of vapour pressure of a solution causes depression in the freezing point.

Ans. ***(a)*** Assertion and reason both are correct and reason is correct explanation of assertion. When NaCl is added to water a depression in freezing point is observed. This is due to lowering of vapour pressure of a solution. Lowering of vapour pressure is observed due to intermolecular interaction of solvent-solute particles.

Q. 54 Assertion (A) When a solution is separated from the pure solvent by a semipermeable membrane, the solvent molecules pass through it from pure solvent side to the solution side.

Reason (R) Diffusion of solvent occurs from a region of high concentration solution to a region of low concentration solution.

Ans. *(b)* Assertion and reason both are correct statements but reason is not the correct explanation of assertion.

When a solution is separated from the pure solvent by a semipermeable membrane, the solvent molecules pass through it from pure solvent side to the solution side. Solvent molecules always flow from lower concentration to higher concentration of solution.

Long Answer Type Questions

Q. 55 Define the following modes of expressing the concentration of a solution? Which of these modes are independent of temperature and why?

(a) w/w (mass percentage)
(b) V/V (volume percentage)
(c) w/V (mass by volume percentage)
(d) ppm (parts per million)
(e) χ (mole fraction)
(f) M (molarity)
(g) m (molality)

Ans. (a) ***w/w*** (mass percentage) Mass percentage of a component of a solution can be expressed as

$$\text{Mass \% of component} = \frac{\text{mass of component in the solution}}{\text{total mass of solution}} \times 100$$

Thus, the percentage by mass means the mass of the solute in grams present in 100g of the solution.

(b) ***V/V*** (volume percentage) is defined as

$$\text{Volume percentage} = \frac{\text{volume of the component}}{\text{total volume of solution}} \times 100$$

Thus, volume percentage means the volume of the liquid solute in cm^3 present in 100 cm^3 of the solution.

(c) ***w/V*** (mass by volume percentage) = mass of solute dissolved in 100 mL of solution.

(d) **ppm** (parts per million) This parametre is used to express the concentration of very dilute solution.

$$\text{ppm} = \frac{\text{number of parts of component}}{\text{total number of parts of all component of solution}} \times 10^6$$

(e) χ (mole fraction) Mole fraction is an unitless quantity used to determine extent of any particular component present in total solution.

$$\chi = \frac{\text{number of moles of the component}}{\text{total number of moles of all components}}$$

(f) ***M*** (molarity) Number of moles of solute dissolved in per litre of solution is known as molarity.

$$M = \frac{\text{number of moles of solute}}{\text{volume of solution in litre}}$$

(g) *m* (Molality) Molality of any solution can be defined as number of moles of solute dissolved in per kg of solvent.

$$m = \frac{\text{number of moles of solute}}{\text{mass of solvent in kg}}$$

Q. 56 Using Raoult's law explain how the total vapour pressure over the solution is related to mole fraction of components in the following solutions.

(a) $CHCl_3$ (l) and CH_2Cl_2 (l) (b) NaCl(s) and H_2O (l)

Ans. According to Raoult's law for any solution the partial vapour pressure of each volatile component in the solution is directly proportional to its mole fraction.

$$p_1 = p_1^\circ x_1$$

(a) $CHCl_3$ (l) and CH_2Cl_2 (l) both are volatile components.

Hence, for a binary solution in which both components are volatile liquids, the total pressure will be $p = p_1 + p_2 = x_1 p_1^\circ + x_2 p_2^\circ$

$$= x_1 p_1^\circ + (1 - x_1)\, p_2^\circ = (p_1^\circ - p_2^\circ)\, x_1 + p_2^\circ$$

where, p = total vapour pressure

p_1 = partial vapour pressure of component 1

p_2 = partial vapour pressure of component 2

(b) NaCl (s) and $H_2O(l)$ both are non-volatile components.

Hence, for a solution containing non-volatile solute, the Raoult's law is applicable only to vaporisable component and total vapour pressure can be written as

$$p = p_1 = x_1 p_1^\circ$$

Q. 57 Explain the terms ideal and non-ideal solutions in the light of forces of interactions operating between molecules in liquid solutions.

Ans. The solutions which obey Raoult's law over the entire range of concentration are known as ideal solutions. For an ideal solution $\Delta V_{mix} = O$ and $\Delta V_{mix} = O$. The ideal behaviour of the solutions can be explained by considering two components *A* and *B*.

In pure components, the intermolecular attractive interactions will be of *A*—*A* type and *B*—*B* type, whereas in the binary solutions in addition to these two, *A*—*B* type of interaction will also be present. If *A*—*A* and *B*—*B* intermolecular forces are nearly equal to those between *A*—*B*, this leads to the formation of ideal solution *e.g.,* solution of *n*-hexane and *n*-heptane.

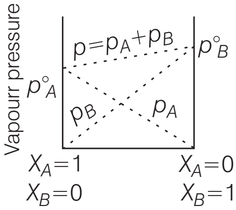
When a solution does not obey-Raoult's law over the entire range of concentration, then it is called non-ideal solution. The vapour pressure of such a solution is either higher or lower, than that predicted by Raoult's law.

If it is higher, the solution exhibits positive deviation and if it is lower it exhibits negative deviation from Raoult's law. In case of positive deviation, *A*—*B* interactions are weaker than those between *A*—*A* or *B*—*B*. *i.e.,* the attractive forces between solute solvent molecules are weaker than those between solute-solute and solvent-solvent molecules *e.g.,* mixture of ethanol and acetone.

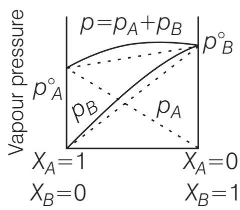
For such solutions $\Delta H_{\text{mixing}} = +$ ve and $\Delta V_{\text{mixing}} = +$ ve

On the other hand, in case of negative deviation the intermolecular attractive forces between *A*—*A* and *B*—*B* are weaker than those between *A*—*B* molecules. Thus, the escaping tendency of *A* and *B* types of molecules from the solution becomes less than from the pure liquids *i.e.,* mixture of chloroform and acetone.

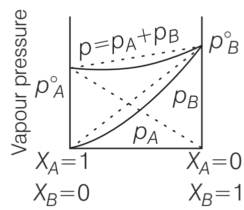
For such solution $\Delta H_{mix} = -$ ve and $\Delta V_{mix} = -$ ve



Graph for ideal solution



Graph showing +ve deviation



Graph showing −ve deviation

Q. 58 Why is it not possible to obtain pure ethanol by fractional distillation? What general name is given to binary mixtures which show deviation from Raoult's law and whose components cannot be separated by fractional distillation. How many types of such mixtures are there?

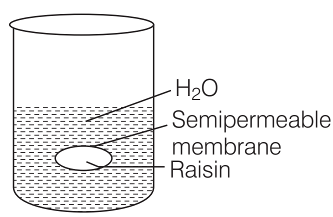
Ans. The solution or mixture having same composition in liquid as well as in vapour phase and boils at a constant temperature is known as azeotropes. Due to constant composition it can't be separated by fractional distillation. *There are two types of azeotropes*

(i) **Minimum boiling azeotropes** Solutions which show large positive deviation from Raoult's law form minimum boiling azeotropes at a specific composition. *e.g.,* ethanol —water mixture

(ii) **Maximum boiling azeotropes** Solutions which show large negative deviation from Raoult's law form maximum boiling azeotropes. *e.g.,* solution having composition 68% HNO_3 and 32% water by mass.

Q. 59 When kept in water, raisin swells in size. Name and explain the phenomenon involved with the help of a diagram. Give three applications of the phenomenon.

Ans. This phenomenon is called endo osmosis, *i.e.*, movement of water inside the raisin and shown with the help of diagram as



The process of osmosis is of immense biological as well as industrial important. *It is evident from the following examples.*

(i) Movement of water from soil into plant roots and subsequently into upper portion of the plant is partly due to osmosis.

(ii) Preservation of meat against bacterial action by addition of salt.

(iii) Preservation of fruits against bacterial action by adding sugar. Bacterium in canned fruit loses water through the process of osmosis and become inactive.

(iv) Reverse-osmosis is used in desalination of water.

Q. 60 Discuss biological and industrial applications of osmosis.

Ans. (i) In animals, water moves into different parts of the body under the effect of the process of osmosis.

(ii) Stretching of leaves, flower, etc., is also controlled by osmosis.

(iii) Osmosis helps in rapid growth of the plants and germination of seeds.

(iv) Different movements of plants such as opening and closing of flowers etc, are controlled by osmosis.

Q. 61 **How can you remove the hard calcium carbonate layer of the egg without damaging its semipermeable membrane? Can this egg be inserted into a bottle with a narrow neck without distorting its shape? Explain the process involved.**

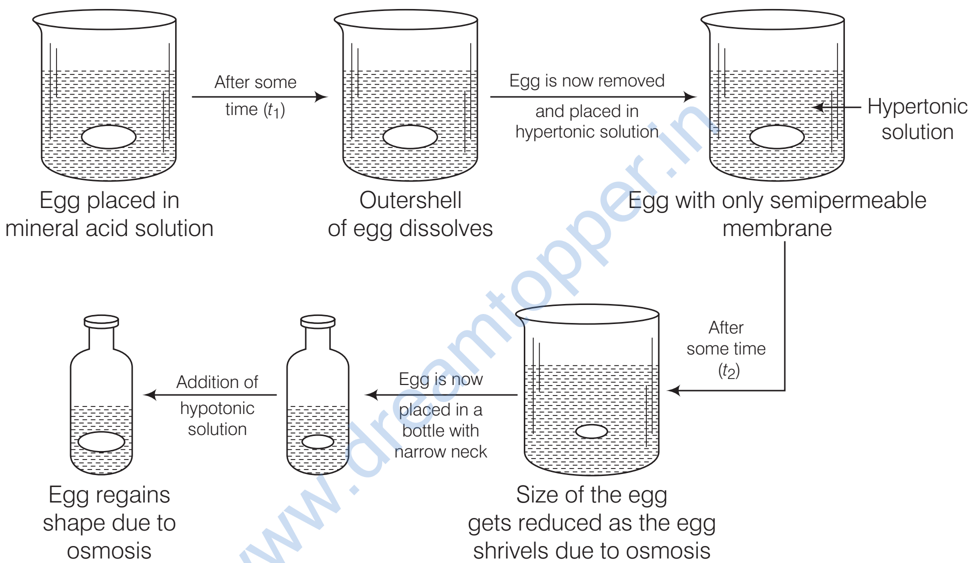
Thinking Process

The question can be answered using the concept of solubility, osmosis, reverse-osmosis, hypertonic solution and hypotonic solution.

Ans. When egg is placed in mineral acid solution outershell of egg dissolves.

Egg is now removed and placed in hypertonic solution. Size of egg get reduced and egg shrivels due to osmosis. Egg is now placed in a bottle with narrow neck. Finally on adding hypotonic solution egg regain its shape due to osmosis.

Diagramatically it can be represented as



Q. 62 **Why is the mass determined by measuring a colligative property in case of some solutes abnormal? Discuss it with the help of van't Hoff factor.**

Ans. Certain compounds when dissolved in suitable solvents either dissociate or associate. *e.g.*, ethanoic acid dimerises in benzene due to H-bonding, while in water, it dissociates and forms ions.

As a result the number of chemical species in solution increases or decreases as compared to the number of chemical species of solute added to form the solution.

Since, the magnitude of colligative property depends on the number of solute particles, it is expected that the molar mass determined on the basis of colligative properties will either higher or lower than the expected value or the normal value and is called abnormal molar mass.

In order to account for the extent of dissociation or association of molecules in solution, van't Hoff introduced a factor, i, known as the van't Hoff factor.

$$i = \frac{\text{expected molar mass}}{\text{abnormal molar mass}} = \frac{\text{observed colligative property}}{\text{calculated colligative property}}$$

$$= \frac{\text{total number of moles of particles after association or dissociation}}{\text{total number of moles of particles before association or dissociation}}$$