CHAPTER

02

Solutions

A Quick Recapitulation of the Chapter

1. A homogeneous mixture of two or more substances, i.e. a one phase system, is called a **solution**. The component of solution which is present in large excess is called **solvent**, while the other (which is present in relatively smaller quantity) is called the **solute**.
2. The various expressions for the **concentration of solutions** can be summarised as given below.

   (i) (a) Mass % of solute $= \frac{W_B}{W_A + W_B} \times 100$

   (b) Parts per million (ppm) $= \frac{W_B}{W_A + W_B} \times 10^6$

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

   $= \frac{W_B}{M_B \times V} \text{ mol L}^{-1}$

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

   $= \frac{W_B}{M_B \times W_A} \text{ mol kg}^{-1}$

   The terms involved in the formulae are:

   M_A = molar mass of solvent M_B = molar mass of solute
   W_A = mass of solvent W_B = mass of solute
   V = volume of solution
3. The maximum amount of a solute that can be dissolved in a given amount of solvent at a given temperature is termed as **solubility** at that temperature.
4. **Henry's law** states that at constant temperature, the solubility of a gas in a liquid is directly proportional to the pressure of the gas.

   Mathematically, the partial pressure (p) of a gas in vapour phase is proportional to the mole fraction of the gas.

   $$p = K_H x$$

   K_H = Henry's law constant
5. Higher the value of K_H at a given pressure, the lower is the solubility of the gas in the liquid.
6. The **vapour pressure of a solvent** is defined as the pressure exerted by the vapours of solvent, when they are in dynamic equilibrium with its liquid at a particular temperature. It depends upon the nature of the liquid, temperature and purity of the liquid.
7. **Raoult's law for *a* volatile solute** states that for any solution, the partial vapour pressure of each volatile component in the solution is directly proportional to its mole fraction.

   $$p \propto x \text{ or } p = p^\circ x$$
8. **According to Dalton's law of partial pressures**, the total pressure (p) over the solution phase in the container will be the sum of the partial pressures of the components of the solution and is given as

   $$p = p_A + p_B = p_A^\circ x_A + p_B^\circ x_B$$

   p_A = partial vapour pressure of component A
   p_A° = vapour pressure of pure component A
   p_B = partial vapour pressure of component B
   p_B° = vapour pressure of pure component B
   p = total vapour pressure of solvent
   x_A and x_B = mole fractions of components A and B respectively.
9. The **mole fractions** of A and B in the vapour phase y_A and y_B can be determined as

   $$y_A = \frac{p_A}{p} = \frac{x_A p^\circ{}_A}{x_A p^\circ{}_A + x_B p^\circ{}_B}$$

   Similarly, $y_B = \frac{p_B}{p} = \frac{x_B p^\circ{}_B}{x_A p^\circ{}_A + x_B p^\circ{}_B}$

10. **Ideal solution** is one which obeys Raoult's law for all range of concentrations and temperatures.
For such solution, $\Delta H_{\text{mix}} = 0$ and $\Delta V_{\text{mix}} = 0$
In ideal solutions, solvent-solvent and solute-solute interactions are almost of same type as that of solvent-solute interactions.
11. **Non-ideal solution** is one which does not obey Raoult's law for all concentrations and temperatures.
For such solution, $\Delta H_{\text{mix}} \neq 0$ and $\Delta V_{\text{mix}} \neq 0$
12. The non-ideal solutions show two types of deviations from the ideal behaviour.
    (i) **Non-ideal solutions showing positive deviations** (new interactions are weaker than those in the pure component) $\Delta V_{\text{mix}} > 0$ and $\Delta H_{\text{mix}} > 0$,
    e.g. acetone + carbon disulphide
    (ii) **Non-ideal solutions showing negative deviations** (new interactions are stronger than those in the pure component)
    $\Delta V_{\text{mix}} < 0$ and $\Delta H_{\text{mix}} < 0$, e.g. acetone + chloroform
13. **Colligative properties** depend only on the number of solute particles present in the solution irrespective of their nature relative to the total number of particles present in the solution.
    (i) **Relative lowering of vapour pressure**
    $$\frac{p^\circ_A - p_A}{p^\circ_A} = x_B = \frac{n_B}{n_A + n_B} = \frac{n_B}{n_A} = \frac{W_B}{M_B} \times \frac{M_A}{W_A}$$
    [for very dilute solution $n_B << n_A$]
    (ii) **Elevation in boiling point**, $\Delta T_b = K_b \times m$
    $$\Delta T_b = \frac{K_b \times W_B \times 1000}{M_B \times W_A}$$
    $$\Delta T_b = T_b - T^\circ_b$$
    (iii) **Depression in freezing point**, $\Delta T_f = K_f \times m$
    $$\Delta T_f = \frac{K_f \times W_B \times 1000}{M_B \times W_A}; \Delta T_f = T^\circ_f - T_f$$
    (iv) **Osmotic pressure** $(\pi) = CRT = \frac{n_B RT}{V} = \frac{W_B \times R \times T}{M_B \times V}$
    where, C = concentration (molarity)
14. **Isotonic solutions** exert same osmotic pressure as they have same molar concentrations.
15. **van't Hoff factor** (i)
$$i = \frac{\text{normal molecular mass}}{\text{observed molecular mass}}$$
or $$i = \frac{\text{observed colligative property}}{\text{calculated colligative property}}$$
or $$i = \frac{\text{total number of moles of particles after dissociation}}{\text{number of moles of particles before dissociation}}$$
For dissociation, $i > 1$, while for association, $i < 1$
16. Colligative properties and van't Hoff factor,
    (i) $\frac{p^\circ_A - p_A}{p^\circ_A} = i\, x_B$ (ii) $\Delta T_b = iK_B m$
    (iii) $\Delta T_f = iK_f m$ (iv) $\pi V = iCRT$

[Objective Questions Based on NCERT Text]

Topic 1
Introduction, Types and Concentration of Solutions

1. Which of the following statements is not correct about homogeneous mixtures?
(a) These have uniform composition throughout the mixture
(b) These show same physical properties throughout the mixture
(c) These have same chemical properties throughout the mixture
(d) These always contain a solute and a solvent

2. Solvent is the component of a solution
(a) which is present in large excess
(b) which is responsible for the chemical properties of solution
(c) which determines the physical state of solution
(d) Both (a) and (c)

3. Consider the solution of ethanol. In it
(a) ethanol is dissolved in water
(b) the components are in same phase
(c) ethanol is present in excess
(d) Both (a) and (b)

4. Which of the following is not an example of a solution?
(a) Air (b) Brass (c) Amalgam (d) Benzene in water

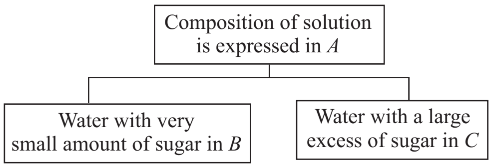
5. Identify the phase of solute and solvent among the options are given below, for a solution as amalgam of mercury with sodium.

	Solute	**Solvent**
(a)	Solid	Liquid
(b)	Solid	Solid
(c)	Liquid	Solid
(d)	Solid	Gas

6. Which of the following is the correct example of solid solution in which the solute is in gas phase?
(a) Copper dissolved in gold (b) Camphor in nitrogen gas
(c) Hydrogen in palladium (d) All of these

7. Which of the following is true about the liquid solution?
(a) Solution may contain one or more than one volatile components
(b) The solute may or may not be volatile
(c) Generally the liquid solvent is volatile
(d) All of the above

8.



Here *A, B C* can be respectively,
(a) unsaturated, saturated, supersaturated
(b) concentration, solute, solvent
(c) concentration, concentrated, dilute
(d) concentration, dilute, concentrated

9. 18 g of sucrose is dissolved in 162 g of water. Calculate the mass percentage of solution.
(a) 18 % (b) 10% (c) 20% (d) 15%

10. 25.3 g of sodium carbonate, Na_2CO_3 is dissolved in enough water to make 250 mL of solution. If sodium carbonate dissociates completely, molar concentration of sodium ion, Na^+ and carbonate ions, CO_3^{2-} respectively are (Molar mass of $Na_2CO_3 = 106\ mol^{-1}$) **(CBSE AIPMT 2012)**
(a) 0.477 M and 0.477 M
(b) 0.955 M and 1.910 M
(c) 1.910 M and 0.955 M
(d) 1.90 M and 1.910 M

11. How many gram of concentrated nitric acid solution should be used to prepare 250 mL of 2.0 M HNO_3? The concentrated acid is 70% HNO_3. **(NEET 2013)**
(a) 45.0 g conc. HNO_3
(b) 90.0 g conc. HNO_3
(c) 70.0 g conc. HNO_3
(d) 50.0 g conc. HNO_3

12. 29.2% (*w*/*W*) HCl stock solution has density of 1.25 g mL^{-1}. The molecular weight of HCl is 36.5 mol^{-1}. The volume (mL) of stock solution required to prepare a 200 mL solution 0.4 M HCl is **(IIT JEE 2012)**
(a) 5.0 mL (b) 6.0 mL
(c) 8.0 mL (d) 15.0 mL

13. A 5.2 molal aqueous solution of methyl alcohol, CH_3OH is supplied. What is the mole fraction of methyl alcohol in the solution? **(AIEEE 2011)**
(a) 1.100 (b) 0.090
(c) 0.086 (d) 0.050

14. 184 g ethyl alcohol is mixed with 72 g of water. The ratio of mole fraction of alcohol to water is
(a) 3 : 4 (b) 1 : 2 (c) 1 : 4 (d) 1 : 1

15. Mole fraction of a solute in benzene is 0.2. The molality of solute is
(a) 3.2 (b) 2 (c) 4 (d) 3.57

16. What is the mole fraction of the solute in a 1m aqueous solution? **(NEET 2016)**
(a) 0.177 (b) 1.770 (c) 0.0354 (d) 0.0177

17. What is the molarity of K^+ in aqueous solution that contains 17.4 ppm of K_2SO_4 (molar mass = $174\ g\ mol^{-1}$) ?
(a) 2×10^{-2} M (b) 2×10^{-3} M
(c) 4×10^{-4}M (d) 2×10^{-4}M

18. The molarity of H_2SO_4 solution, which has a density 1.84 g/cc at 35°C and contains 98% by weight is
(a) 1.84 M (b) 18.4 M (c) 20.6 M (d) 24.5 M

19. The molarity of a solution obtained by mixing 750 mL of 0.5 M HCl with 250 mL of 2M HCl will be **(JEE Main 2013)**
(a) 0.875 M (b) 1.00 M
(c) 1.75 M (d) 0.0975 M

20. 6.02×10^{20} molecules of urea are present in 100 mL of its solution. The concentration of solution is **(NEET 2013)**
(a) 0.02 M (b) 0.01 M (c) 0.001 M (d) 0.1 M

21. The molality of a urea solution in which 0.0100 g of urea, $[(NH_2)_2CO]$ is added to 0.3000 dm^3 of water at STP is **(AIEEE 2011)**
(a) 0.555 m (b) 5.55×10^{-4} m
(c) 33.3 m (d) 3.33×10^{-2} m

22. If mole fraction of a solute in 1kg benzene is 0.2 then molality of solute is **(NEET 2016)**
(a) 3.2 (b) 2 (c) 4 (d) 3.6

23. If two bottles *A* and *B* contain 1 M and 1 m aqueous solution of sulphuric acid respectively,
(a) *A* is more concentrated than *B*
(b) *B* is more concentrated than *A*
(c) Concentration of *A* is equal to concentration of *B*
(d) it is not possible to compare the concentration

24. Concentration terms which are independent of temperature is/are
(a) mole fraction and molality
(b) mole fraction and molarity
(c) only normality
(d) only molarity

Topic 2
Solubility and Henry's Law

25. Which of the following is the incorrect statement about solubility?
(a) It depends upon the nature of solute and solvent
(b) It always increases with increase in pressure
(c) It shows the maximum amount of solute present in a definite amount of solvent.
(d) It depends upon temperature and pressure

26. In case of which type of solution concentration of solute shows its solubility?
(a) Saturated solution
(b) Unsaturated solution
(c) Supersaturated solution
(d) None of these

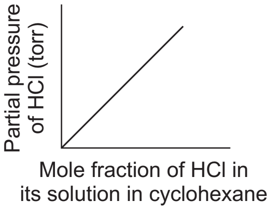
27. Select the incorrect statement.
(a) Dissolution and crystallisation are opposite processes
(b) When dissolution and crystallisation occur with same rate, a saturated solution is obtained
(c) When rate of dissolution = rate of crystallisation, no more solute can be added to it
(d) In saturated solution, the solution is in dynamic equilibrium with dissolved solute

28. What happens to the solubility of substance with rise in temperature, if the dissolution process is endothermic?
(a) Increases
(b) Decreases
(c) Increases or decreases, depending upon the nature of substance
(d) No effect of temperature on solubility

29. 15 g of sucrose is dissolved in 50 mL of water and some pressure is applied on the surface of solution formed. It will result in
(a) increased solubility
(b) decreased solubility
(c) slight increase in solubility
(d) No effect on solubility

30. Which of the following statements is true about Henry's law?
(a) The solubility of solid in a liquid is directly proportional to the partial pressure of the solid present above the surface of liquid or solution
(b) The solubility of a gas in a liquid is directly proportional to the partial pressure of the gas present above the surface of liquid or solution
(c) The solubility of a liquid in gas is directly proportional to the partial pressure of liquid present above the surface of gas
(d) The solubility of a gas in solid is directly proportional to the partial pressure of gas present above the surface of solid

31. In the graph given below, what does the slope of the line represent?



(a) Partial pressure of the gas in vapour phase (p)
(b) Mole fraction of gas in the solution (χ)
(c) Henry's law constant (K_H)
(d) All of the above

32. The value of Henry's law constant for argon (Ar), carbon dioxide (CO_2), methane (CH_4) and formaldehyde (HCHO) are respectively 40.3 K bar, 1.67 K bar, 0.413 K bar and 1.83×10^{-5} K bar at 298 K. The correct order of their solubility is
(a) $Ar < CH_4 < CO_2 < HCHO$
(b) $HCHO < CH_4 < CO_2 < Ar$
(c) $Ar < CO_2 < CH_4 < HCHO$
(d) $Ar < CO_2 < HCHO < CH_4$

33. Calculate the concentration of nitrogen present in the water. Assuming that the temperature is 25°C, total pressure is 1 atm and mole fraction of nitrogen is 0.78. $[K_H$ for nitrogen $= 8.42 \times 10^{-7}$ M/mmHg$]$

(a) 4.99 M
(b) 4.99×10^{-2} M
(c) 4.99×10^{-4} M
(d) None of the above

34. Ratio of O_2 and N_2 in the air is $1:4$. Find out the ratio of their solubilities in terms of mole fractions of O_2 and N_2 dissolved in water at atmospheric pressure and room temperature.

$$\begin{bmatrix} K_H\ (O_2) = 3.30 \times 10^7 \text{ torr} \\ K_H\ (N_2) = 6.60 \times 10^7 \text{ torr} \end{bmatrix}$$

(a) $1:2$
(b) $2:1$
(c) $1:1$
(d) None of these

35. The solubility of N_2 in water at 300 K and 500 torr partial pressure, is 0.01g L^{-1}. The solubility in (g L^{-1}) at 750 torr partial pressure is **(JEE Main 2016)**

(a) 0.02
(b) 0.015
(c) 0.0075
(d) 0.005

36. Soft drinks and soda water bottles are sealed under high pressure

(a) to increase their taste
(b) to increase the solubility of CO_2
(c) to decrease temperature of the gas dissolved
(d) All of the above

37. Which of the following statements is not true?

(a) Pressure is higher under water than at the surface of a sea
(b) Low surface pressure is responsible for the formation of bends in the body of scuba divers
(c) Bends are actually the bubbles of nitrogen in the blood
(d) Due to high pressure, solubility of atmospheric gases in the blood decreases

38. Which of the following statements is true about bends?

(a) Capillaries are blocked and it create medical condition known as bends
(b) These are painful and dangerous to life
(c) These are bubbles of helium in the blood
(d) Both (a) and (b) are true

39. Anoxia is a condition, generally seen in climbers because of

(a) high concentration of oxygen at high altitudes
(b) high concentration of air at high altitudes
(c) high partial pressure of oxygen at high altitudes
(d) low partial pressure of oxygen at high altitudes

40. What is the composition of gases in the tanks used by the scuba divers?

(a) 11.7% helium 32.1% nitrogen 56.2% oxygen
(b) 11.7% helium 56.2% nitrogen 32.1% oxygen
(c) 56.2% helium 11.7% nitrogen 32.1% oxygen
(d) 56.2% helium 32.1% nitrogen 11.7% oxygen

Topic 3

Vapour Pressure and Raoult's Law

41. Which of the following is not the characteristic of solutions of liquids and solids in liquid?

(a) These may contain one or more than one volatile components
(b) Generally, the liquid solvent is volatile
(c) The solute may or may not be volatile
(d) Both solute and solvent are non-volatile

42. When a binary solution of two volatile liquids is taken in a closed vessel, then

(a) in the closed vessel, both the components would evaporate and an equilibrium would be established between vapour phase and liquid phase
(b) in the closed vessel, both the components would evaporate but equilibrium would not be established between vapour phase and liquid phase
(c) in the closed vessel, none of components would evaporate and no equilibrium would be established between vapour phase and liquid phase
(d) None of the above

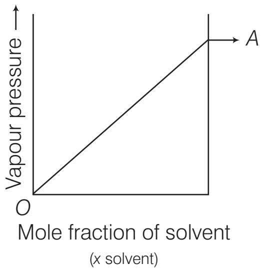
43. p_A and p_B are the vapour pressure of pure liquid components A and B respectively of an ideal binary solution. If x_A represents the mole fraction of component A, the total pressure of the solution will be **(CBSE AIPMT 2012)**

(a) $p_A + x_A\ (p_B - p_A)$
(b) $p_A + x_A\ (p_A - p_B)$
(c) $p_B + x_A\ (p_B - p_A)$
(d) $p_B + x_A\ (p_A - p_B)$

44. The total pressure (p_{total}) over the solution phase in the container will be the sum of the partial pressures of the components of the solution. This statement to belongs

(a) Raoult's law
(b) Henry's law
(c) Dalton's law of partial pressures
(d) All of the above

45. What does A point signifies in the figure given below?



(a) Vapour pressure of solute
(b) Vapour pressure of pure solvent
(c) Vapour pressure of solution
(d) None of the above

46. One component of a solution follows Raoult's law over the entire range $0 \le x_1 \le 1$. The second component must follow Raoult's law in the range when x_2 is
(a) close to zero
(b) close to 1
(c) $0 \le x_2 \le 0.5$
(d) $0 \le x_2 \le 1$

47. 18 g of glucose ($C_6H_{12}O_6$) is added to 178.2 g water. The vapour pressure of water (in torr) for this aqueous solution is **(JEE Main 2016)**
(a) 76.0 (b) 752.4
(c) 759.0 (d) 7.6

48. Vapour pressure of pure A is 70 mm of Hg at 25°C. It forms an ideal solution with 'B' in which mole fraction of A is 0.8. If the vapour pressure of the solution is 84 mm of Hg at 25°C, the vapour pressure of pure B at 25°C is
(a) 56 mm
(b) 70 mm
(c) 140 mm
(d) 28 mm

49. At 40°C, the vapour pressure of pure liquids, benzene and toluene, are 160 mmHg and 60 mmHg respectively. At the same temperature, the vapour pressure of an equimolar solution of the two liquids, assuming the ideal solution should be
(a) 140 mmHg
(b) 110 mmHg
(c) 220 mmHg
(d) 100 mmHg

50. If two substances A and B have $p^\circ_A : p^\circ_B = 1:2$ and mole fraction in solution $= 1:2$ then mole fraction of A in vapours is
(a) 0.33 (b) 0.25
(c) 0.52 (d) 0.2

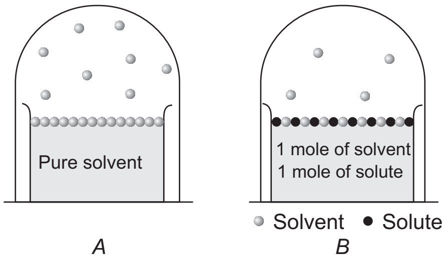
51. At 300 K two pure liquids A and B have 150 mm Hg and 100 mmHg vapour pressures, respectively. In an equimolar liquid mixture of A and B, the mole fraction of B in the vapour mixture at this temperature is
(a) 0.6 (b) 0.5
(c) 0.8 (d) 0.4

52. Vapour pressure of chloroform ($CHCl_3$) and dichloromethane (CH_2Cl_2) at 25° C are 200 mm of Hg and 41.5 mm of Hg respectively. Vapour pressure of the solution obtained by mixing 25.5 g of $CHCl_3$ and 40 g of CH_2Cl_2 at the same temperature will be

(Molecular mass of $CHCl_3 = 119.5$ u and molecular mass of $CH_2Cl_2 = 85$ u) **(CBSE AIPMT 2012)**
(a) 173.9 mm Hg (b) 615.0 mm Hg
(c) 347.9 mm Hg (d) 90.63 mm Hg

53. Raoult's law becomes a special case of Henry's law when
(a) $K_H = p_1^\circ$ (b) $K_H > p_1^\circ$
(c) $K_H < p_1^\circ$ (d) $K_H \ge p_1^\circ$

54. Interpret the correct statement for the following figure.



(a) Vapour pressure of the solution in beaker A is more than in the beaker B
(b) Vapour pressure of the solution in beaker A is less than in the beaker B
(c) Vapour pressure of the solution in both the beakers is same
(d) None of the above

55. Decrease in the vapour pressure of the solvent depends on
(a) nature of non-volatile solute
(b) quantity of non-volatile solute
(c) nature of solution
(d) quantity of solution

Topic 4
Ideal and Non-ideal Solutions

56. For a dilute solution containing 2.5 g of a non-volatile non-electrolyte solute in 100 g of water, the elevation in boiling point at 1 atm pressure is 2°C.
Assuming concentration of solute is much lower than the concentration of solvent, the vapour pressure (mm of Hg) of the solution is
(take $K_b = 0.76 \text{ K kg mol}^{-1}$) **(AIEEE 2012)**

(a) 724 (b) 740 (c) 736 (d) 718

57. Which one of the following is not correct for an ideal solution?

(a) It must obey Raoult's law (b) $\Delta H = 0$
(c) $\Delta V = 0$ (d) $\Delta H = \Delta V \neq 0$

58. Which of the following statements is/are true for an ideal solution?

(a) No heat is absorbed or evolved when the components are mixed
(b) Volume of solution = sum of volume of two component
(c) Intermolecular attraction forces between *A*—*A* and *B*—*B* types are equal to *A*—*B* type
(d) All of the above

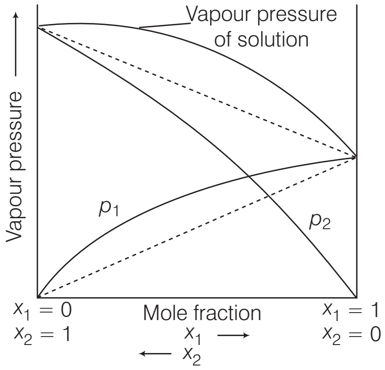
59. Solution of bromoethane and chloroethane

(a) obeys Raoult's law over the entire range of concentration
(b) is a non-ideal solution
(c) has $\Delta_{\text{mix}}V \neq 0$
(d) All of the above

60. True statement about non-ideal solutions is

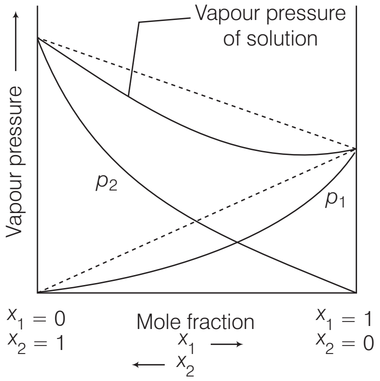
(a) donot obey Raoult's law over entire range of concentration
(b) $A—A$ or $B—B$ type interactions $>A—B$ type interactions
(c) $A—A$ or $B—B$ type interactions $< A—B$ type interactions
(d) All of the above

61. What does the following figure represent?



(a) Non-ideal solution
(b) Positive deviation from Raoult's law
(c) Negative deviation from Raoult's law
(d) Only (a) and (b)

62. Which of the following statements is/are true for the diagram?



(a) The escaping tendency of molecule decreases for each component
(b) Vapour pressure of the solution decreases
(c) Solution shows negative deviation from Raoult's law
(d) All of the above

63. The solution formed by adding carbon disulphide to acetone, shows positive deviation from Raoult's law. It is because

(a) the dipolar interactions between solute-solvent molecules are stronger than the respective interactions among the solute-solute and solvent-solvent molecules
(b) All the dipolar interactions among solute-solvent, solute-solute and solvent-solvent are same
(c) the dipolar interactions between solute-solvent molecules are weaker than the respective interactions among the solute-solute and solvent-solvent molecules
(d) Only solute-solvent interactions are involved in the reaction

64. Which of the following statements about the composition of the vapour over an ideal 1:1 molar mixture of benzene and toluene is correct ?

Assume that the temperature is constant at 25°C. (Given, vapour pressure data at 25°C, benzene = 12.8 kPa and toluene = 3.85 kPa)

(CBSE AIPMT 2012)

(a) The vapour will contain a higher percentage of toluene
(b) The vapour will contain equal amounts of benzene and toluene
(c) Not enough information is given to make a prediction
(d) The vapour will contain a higher percentage of benzene

65. Select the incorrect statement.

(a) Solution of chloroform and acetone shows negative deviation from Raoult's law

(b) Solution of ethanol and acetone shows positive deviation from Raoult's law

(c) In case of solution of phenol A and aniline B, $A—A$ and $B—B$ interactions are stronger than $A—B$ (i.e. phenol and aniline) interactions

(d) Azeotropes are constant boiling mixtures, which are separated by azeotropic distillation.

66. Arrange the following in the increasing order of their solubility in *n*-octane based on solute-solvent interactions.

(a) KCl < CH_3CN < CH_3OH < cyclohexane

(b) KCl < cyclohexane < CH_3OH < CH_3CN

(c) KCl < CH_3OH < CH_3CN < cyclohexane

(d) KCl < cyclohexane < CH_3CN< CH_3CN

67. The solution which show large positive deviation from Raoult's law form

(a) maximum boiling azeotrope at a specific composition

(b) maximum freezing azeotrope at a specific composition

(c) minimum boiling azeotrope at a specific composition

(d) minimum freezing azeotrope at a specific composition

68. Among the following, the azeotropic mixture is

(a) $CCl_4 + CHCl_3$

(b) $C_6H_{14} + C_7H_{16}$

(c) $C_2H_5Br + C_2H_5Cl$

(d) chlorobenzene + bromobenzene

69. Which of the following azeotropic solutions has the boiling point less than the boiling point of its constituents molecules?

(a) $CHCl_3$ and CH_3COCH_3

(b) CS_2 and CH_3COCH_3

(c) CH_3CH_2OH and CH_3COCH_3

(d) CH_3CHO and CS_2

70. The solution that forms maximum boiling azeotrope is

(a) carbon disulphide – acetone

(b) benzene – toluene

(c) acetone – chloroform

(d) *n*-hexane – *n*-heptane

71. Solution of azeotropic nitric acid mixture contain

(a) 32% HNO_3, 68% H_2O by mass

(b) 68% HNO_3, 32% H_2O by mass

(c) 50% HNO_3, 50% H_2O by mass

(d) 30% H_2O, 70% HNO_3 by mass

Topic 5

Colligative Properties

72. An aqueous solution is 1.00 molal in KI. Which change will cause the vapour pressure of the solution to increase? **(CBSE AIPMT 2011)**

(a) Addition of water (b) Addition of NaCl

(c) Addition of Na_2SO_4 (d) Addition of 1.00 molal KI

73. If p° and p_s are vapour pressures of the solvent and solution respectively, n_1 and n_2 are the mole fractions of solvent and solute respectively, then

(a) $p_s = p^\circ n_1$ (b) $p_s = p^\circ n_2$

(c) $p^\circ = p_s n_2$ (d) $p_s = p^\circ \left(\frac{n_1}{n_2}\right)$

74. The vapour pressure of acetone at 20°C is 185 torr. When 1.2 g of a non-volatile substance was dissolved in 100 g of acetone at 20°C, its vapour pressure was 183 torr. The molar mass (g mol^{-1}) of the substance is **(JEE Main 2015)**

(a) 32 (b) 64 (c) 128 (d) 488

75. Lowering of vapour pressure of an aqueous solution of a non-volatile, non-electrolyte 1M aqueous solution at 100°C is

(a) 14.12 torr (b) 312 torr (c) 13.45 torr (d) 352 torr

76. The vapour pressure lowering caused by the addition of 100 g of sucrose (molecular mass = 342 g mol^{-1}) to 1000 g of water, if the vapour pressure of water at 25°C is 23.8 mm of Hg is

(a) 0.12 mm Hg

(b) 0.125 mm Hg

(c) 1.15 mm Hg

(d) 1.25 mm Hg

77. If at certain temperature, the vapour pressure of pure water is 25 mm of Hg and that of a very dilute aqueous urea solution is 24.5 mm of Hg, the molality of solution is

(a) 0.02 (b) 1.2

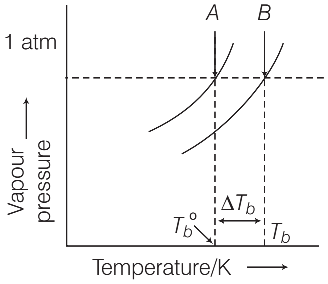
(c) 1.11 (d) 0.08

78. Vapour pressure of pure benzene is 119 torr and that of toluene is 37.0 torr at the same temperature. Mole fraction of toluene in vapour phase which is in equilibrium with 8 solution of benzene and toluene having a mole fraction of toluene 0.50, will be **(JEE Main 2013)**

(a) 0.137 (b) 0.237

(c) 0.435 (d) 0.205

79. What does point *A* and *B* represent in the following diagram?



Point *A*	Point *B*
(a) Boiling point of solvent	Boiling point of solution
(b) Boiling point of solution	Boiling point of solvent
(c) Boiling point of solute	Boiling point of solvent
(d) Boiling point of solvent	Boiling point of solute

80. When concentration of a salt solution is increased,

(a) boiling point increases, while vapour pressure decreases
(b) boiling point decreases, while vapour pressure increases
(c) freezing point decreases, while vapour pressure increases
(d) freezing point increases, while vapour pressure decreases

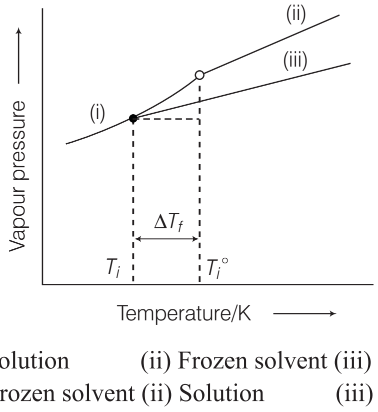
81. If the elevation in boiling point of a solution of 10 g of solute (molecular weight = 100) in 100 g of water is ΔT_b, the ebullioscopic constant of water is

(a) 10
(b) $100\,T_b$
(c) ΔT_b
(d) $\dfrac{\Delta T_b}{10}$

82. To observe an elevation of boiling point is 0.05°C, the amount of a solute (molecular weight = 100) to be added to 100 g of water ($K_b = 0.5$) is

(a) 2 g
(b) 0.05 g
(c) 1 g
(d) 0.75 g

83. Identify (i), (ii) and (iii) in the following diagram.



(a) (i) Solution (ii) Frozen solvent (iii) Liquid solvent
(b) (i) Frozen solvent (ii) Solution (iii) Liquid solvent
(c) (i) Frozen solvent (ii) Liquid solvent (iii) Solution
(d) (i) Solution (ii) Liquid solvent (iii) Frozen solvent

84. During the depression of freezing point experiment an equilibrium is established between the molecules of

(a) liquid solvent and solid solvent
(b) liquid solute and solid solvent
(c) liquid solute and solid solute
(d) liquid solvent and solid solute

85. What happens to freezing point of benzene when naphthalene is added?

(a) Increases
(b) Decreases
(c) Remains unchanged
(d) First decreases and then increases

86. Ethylene glycol is used as an antifreeze in a cold climate. Mass of ethylene glycol which should be added to 4 kg of water to prevent it from freezing at -6°C will be (K_f for water = 1.86 K kg mol^{-1} and molar mass of ethylene glycol = 62 g mol^{-1}) **(AIEEE 2011)**

(a) 804.32 g
(b) 204.30 g
(c) 400.00 g
(d) 304.60 g

87. How many grams of methyl alcohol should be added to 10 L tank of water to prevent its freezing at 268 K? **(JEE Main 2013)**

(a) 880.07 g
(b) 899.04 g
(c) 886.02 g
(d) 868.06 g

88. Dissolution of 1.5 g of a non-volatile solute (molecular weight = 60) in 250 g of a solvent reduces its freezing point by 0.01°C. Find at the molal depression constant of the solvent.

(a) 0.01
(b) 0.001
(c) 0.0001
(d) 0.1

89. A 5% solution (by mass) of cane sugar in water has freezing point = 271 K and freezing point of pure water is 273.15 K. The freezing point of a 5% solution (by mass) of glucose in water is

(a) 271 K
(b) 273.15 K
(c) 269.07 K
(d) 277.23 K

90. K_f for water is 1.86 K kg mol^{-1}. If your automobile radiator holds 1.0 kg of water, how many grams of ethylene glycol ($C_2H_6O_2$) must you add to get the freezing point of the solution lowered to -2.8°C? **(AIEEE 2012)**

(a) 72 g
(b) 93 g
(c) 39 g
(d) 27 g

91. The order of boiling points of four equimolar aqueous solutions is $C < B < A < D$. The correct order of their freezing points is

(a) $D < C < B < A$
(b) $D > C < B < A$
(c) $D < B > A < C$
(d) $D > A > B > C$

92. The difference between the boiling point and freezing point of an aqueous solution containing sucrose (molecuar weight $= 342\ \text{g mol}^{-1}$) in 100 g of water is 105.0°C. If K_f and K_b of water are 1.86 and 0.51 K kg mol^{-1} respectively, the weight of sucrose in the solution is about

(a) 34.2 g (b) 342 g (c) 7.2 g (d) 72 g

93. The correct statement about semipermeable membrane is

(a) it appears as a continuous sheet or film but actually it is porous
(b) Only small solute molecules can pass through it
(c) it is always natural, i.e. of animal or vegetable origin
(d) All of the above

94. Osmosis is the process of movement of solvent particles

(a) from the solution of higher concentration to the solution of lower concentration
(b) from the solution of lower concentration to the solution of higher concentration
(c) from the pure solvent to the solution
(d) Both (b) and (c)

95. Select the correct statement.

(a) Osmotic pressure is the excess pressure applied on solution side to stop osmosis
(b) Osmotic pressure is directly proportional to the molarity of solution at a given temperature
(c) Osmotic pressure is related to molar mass of the solute by the relation, $\pi = \dfrac{w_2 RT}{M_2 \cdot V}$
(d) All the above are correct statements

96. At a given temperature, osmotic pressure of the concentrated solution of a substance

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

97. 0.1 M NaCl and 0.005 M $BaCl_2$ solutions are separated by a semipermeable membrane in a container. For this system, choose the correct answer.

(a) There is no movement of any solution across the membrane
(b) Water flows from $BaCl_2$ solution to NaCl solution
(c) Water flows from NaCl solution to $BaCl_2$ solution
(d) Osmotic pressure of 0.1 M NaCl is lower than that of $BaCl_2$ (assume complete dissociation)

98. The osmotic pressure of 0.2 molar solution of urea at 27°C ($R = 0.082$ L atm $\text{mol}^{-1}\ \text{K}^{-1}$) is

(a) 4.92 atm (b) 1 atm (c) 0.2 atm (d) 27 atm

99. The temperature at which 10% aqueous solution (w/V) of glucose exhibits the osmotic pressure of 16.4 atm, is ($R = 0.082\ \text{dm}^3\ \text{atm K}^{-1}\text{mol}^{-1}$)

(a) 200 K (b) 180 K
(c) 90 K (d) 360 K

100. 1.26 g of the protein is present in the aqueous solution of 200 cm^3. Calculate the molar mass of the protein, if the osmotic pressure of such solution is 2.57×10^{-3} bar at 300 K.

(a) 61000 g mol^{-1}
(b) 60304 g mol^{-1}
(c) 60000 g mol^{-1}
(d) 61009 g mol^{-1}

101. 6 g of a compound exerts the same osmotic pressure as that of 0.05 M glucose solution. Find out the molecular formula of the compound if empirical formula of non-electrolyte is CH_2O.

(a) $C_2H_4O_2$ (b) $C_3H_6O_3$
(c) $C_5H_{10}O_5$ (d) $C_4H_8O_4$

102. Osmotic pressure method is used to determine molar mass of protein, macromolecules like polymers, biomolecules etc., because

(a) osmotic pressure is measured at room temperature
(b) osmotic pressure depends upon molality
(c) these are very big molecules and have poor solubility
(d) All of the above

103. Osmotic pressure present in the fluid inside the blood cell is equivalent to

(a) 0.9% (*m/V*) NaCl solution
(b) less than 0.9% (*m/V*) NaCl solution
(c) more than 0.9 % (*m/V*) NaCl solution
(d) 0.9% (*m/V*) Na_2SO_4 solution

104. A 6% solution of urea is isotonic with

(a) 0.05 M solution of glucose
(b) 6% solution of glucose
(c) 25% solution of glucose
(d) 1 M solution of glucose

105. Solutions *A*, *B*, *C* and *D* are respectively 0.1 M glucose, 0.05 M NaCl, 0.05 M $BaCl_2$ and 0.1 M $AlCl_3$. Which one of the following pairs is isotonic?

(a) *A* and *B* (b) *B* and C
(c) *A* and *D* (d) *A* and *C*

106. Reverse osmosis is a process,

(a) in which applied pressure to the solution side, is larger than the osmotic pressure
(b) in which solvent moves from solution of higher concentration to solution of lower concentration
(c) which is used for desalination of sea water
(d) All of the above

Topic 6

van't Hoff Factor and Modified Colligative Properties

107. The van't Hoff factor (i) for a compound which undergoes dissociation in one solvent and association in other solvent is respectively **(CBSE AIPMT 2011)**

(a) greater than one and greater than one
(b) less than one and greater than one
(c) less than one and less than one
(d) greater than one and less than one

108. Which of the following will have same value of van't Hoff factor as that of $Al_2(SO_4)_3$?

(a) BCl_3 (b) $AlCl_3$
(c) $Al(OH)_3$ (d) $K_4[Fe(CN)_6]$

109. A molecule M associates in a given solvent according to the equation $M \rightleftharpoons (M)_n$. For a certain concentration of M, the van't Hoff factor was found to be 0.9 and the fraction of associated molecules was 0.2. The value of n is **(AIEEE 2012)**

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

110. The degree of dissociation (α) if a weak electrolyte, A_xB_y is related to van't Hoff factor (i) by the expression **(AIEEE 2011)**

(a) $\alpha = \dfrac{i-1}{(x+y-1)}$ (b) $\alpha = \dfrac{i-1}{x+y+1}$
(c) $\alpha = \dfrac{x+y-1}{i-1}$ (d) $\alpha = \dfrac{x+y+1}{i-1}$

111. Of the following 0.10 m aqueous solutions, which one will exhibit the largest freezing point depression? **(CBSE AIPMT 2011)**

(a) KCl (b) $C_6H_{12}O_6$ (c) $Al_2(SO_4)_3$ (d) K_2SO_4

112. Arrange the following aqueous solutions in the order of their increasing boiling points.

I. 10^{-2} M NaCl II. 10^{-3} M $MgCl_2$
III. 10^{-4} M Urea IV. 10^{-4} M NaCl

(a) I < II < IV < III (b) III < IV < II < I
(c) II < I < III < IV (d) IV < III < I = II

113. 58.5 g of NaCl and 180 g of glucose were separately dissolved in 1000 mL of water. Identify the correct statement regarding the elevation of boiling point (bp) of the resulting solution.

(a) NaCl solution will show higher elevation of boiling point
(b) glucose solution will show higher elevation of boiling point
(c) both the solutions will show equal elevation of boiling point
(d) the boiling point elevation will be shown by none of the solutions

114. Which of the following has least freezing point?

(a) 1% sucrose (b) 1% NaCl
(c) 1% $CaCl_2$ (d) 1% glucose

115. Which of the following would exert maximum osmotic pressure?

(a) Decinormal aluminium sulphate
(b) Decinormal barium chloride
(c) Decinormal sodium chloride
(d) A solution obtained by mixing equal volumes of (b) and (c)

116. The van't Hoff factor of $BaCl_2$ at 0.01 M concentration is 1.98. The percentage of dissociation of $BaCl_2$ at this concentration is

(a) 49 (b) 69 (c) 89 (d) 98

117. Compound A undergoes tetramerisation in the given solvent. The van't Hoff factor is

(a) 2.0 (b) 0.5
(c) 0.25 (d) 0.125

118. The elevation in boiling point of a solution is 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 $K_b = 0.52\ \text{Km}^{-1}$).

(a) 0.16°C (b) 0.05°C (c) 0.1°C (d) 0.2°C

119. KBr is 80% dissociated in aqueous solution of 0.5 m concentration. (Given, K_f for water = 1.86 K kg mol^{-1}). The solution freezes at

(a) 271.326 K (b) 272 K
(c) 270.5 K (d) 268.5 K

120. What is the freezing point of a solution containing 8.1 g HBr in 100 g of water. Assuming the acid to be 90% ionised? (K_f for water = 1.86 K kg mol^{-1})

(a) 3.534°C (b) – 3.53°C (c) 0°C (d) – 0.35°C

121. The freezing point depression constant for water is $-1.86°\text{C molal}^{-1}$. If 5.00 g Na_2SO_4 is dissolved in 45.0 g of H_2O, the freezing point is changed by $-3.82°$C. Calculate the van't Hoff factor for Na_2SO_4. **(CBSE AIPMT 2011)**

(a) 0.381 (b) 2.05 (c) 2.63 (d) 3.11

122. A solution of 1.25 g of P in 50 g of water lowers the freezing point of water by 0.3°C. Molar mass of P is 94. $K_{f(\text{water})} = 1.86$ K kg mol^{-1}. The degree of association of P in water is

(a) 80% (b) 60%
(c) 65% (d) 75%

123. 0.01 M solution of KCl and $BaCl_2$ are prepared in water. The freezing point of KCl is found to be −2°C. What is the freezing point of $BaCl_2$ to be completely ionised?

(a) −3°C (b) +3°C (c) −2°C (d) −4°C

124. On adding 1 g arsenic to 80 g benzene, the freezing point of benzene is lowered by 0.19°C. The formula of arsenic is ($K_f = 5.08$ K kg mol^{-1}).

(a) As (b) As_2
(c) As_3 (d) As_4

125. Pure benzene freezes at 5.3°C. A solution of 0.223 g of phenylacetic acid ($C_6H_5CH_2COOH$) in 4.4 g of benzene ($K_f = 5.12$ K kg mol^{-1}) freezes at 4.47°C. From this observation, one can conclude that

(a) phenylacetic acid exists as such in benzene
(b) phenylacetic acid undergoes partial ionisation in benzene
(c) phenylacetic acid undergoes complete ionisation in benzene
(d) phenylacetic acid dimerises in benzene

126. The molar mass of the solute, sodium hydroxide obtained from the measurement of the osmotic pressure of its aqueous solution at 27°C is 25 g mol^{-1}. Therefore, its ionisation percentage in this solution is

(a) 75 (b) 60
(c) 80 (d) 70

127. 1.2% NaCl solution is isotonic with 7.2% glucose solution. What will be the van't Hoff factor '*i*' for NaCl?

(a) 0.5 (b) 1
(c) 2 (d) 6

128. 1×10^{-3} m solution of $Pt(NH_3)_2Cl_4$ in H_2O shows depression in freezing point by 0.0054°C. The ionisable Cl^- ions will be (Given, $K_f (H_2O) = 1.860$ K kg mol^{-1})

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

129. Find out the osmotic pressure of 0.1M monobasic acid, if pH = 2.0 at 25°C.

(a) 2.69 atm (b) 26.9 atm
(c) 0.269 atm (d) None of these

Special Format Questions

I. More Than One Correct Option

130. Which of the following statements are correct?

(a) Sugar solution is a homogeneous mixture
(b) Air is not a true solution
(c) Amalgam is an example of liquid solution
(d) 10% glucose solution contains 90 g water

131. 10% (*m*/*m*) aqueous potassium iodide has a density of 1.202 g mL^{-1}. The true statements about this solution are

(a) this solution contains 100 g of water
(b) molarity of this solution is 2.90
(c) molality of this solution is 0.67
(d) mole fraction of KI in this solution is 0.0118

132. Select the incorrect statements about solubility.

(a) It depends upon the nature of solute but not of solvent
(b) Ethanol being a polar ionic molecule is soluble in water
(c) Oxygen dissolves only to a smaller extent in water
(d) Solubility of gases in water varies inversely with the value of K_H

133. The correct statement about the mixture of phenol and aniline are

(a) A—A and B—B interactions are weaker than A—B interactions
(b) it forms a maximum boiling azeotrope
(c) $\Delta H_{mix} > 0$
(d) volume of mixture is lesser than zero

134. The examples of minimum boiling azeotropes are

(a) ethanol + acetone
(b) carbon disulphide + acetone
(c) ethanol + water
(d) water + HNO_3

135. The correct relations showing Raoult's law are

(a) $\frac{p^\circ - p}{p^\circ}$ = mole fraction of solute

(b) $\frac{p^\circ - p}{p} = \frac{\text{moles of solute}}{\text{moles of solvent}}$

(c) $\frac{p^\circ - p}{p^\circ} = \frac{\text{moles of solvent}}{\text{moles of solute}}$

(d) For very dilute solution, $\frac{p^\circ - p}{p^\circ} = \frac{\text{moles of solvent}}{\text{moles of solute}}$

136. Select the correct statements.

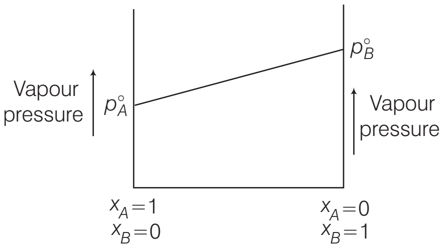
(a) A liquid always boils, when its vapour pressure becomes equal to 1 atm

(b) Elevation in boiling point is shown by the difference of boiling point of solution and boiling point of pure solvent

(c) Ebullioscopic constant has the units K kg mol^{-1}

(d) K_b is same for the solvent of salt solution and sugar solution

137. The following is a graph plotted between the vapour pressure of two volatile liquids against their respective mole fractions.



Which of the following options are correct?

(a) When $x_A = 1$ and $x_B = 0$ then $p = p_A^\circ$

(b) When $x_B = 1$ and $x_A = 0$ then $p = p_B^\circ$

(c) When $x_A = 1$ and $x_B = 0$ then $p = p_B^\circ$

(d) When $x_B = 1$ and $x_A = 0$ then $p = p_A^\circ$

138. Mark the correct options for the freezing point of a substance.

(a) Solid phase is in dynamic equilibrium with liquid phase

(b) Lowering of vapour pressure of solution causes lowering of freezing point as compared to pure solvent

(c) A solution will freeze, when its vapour pressure equals to the vapour pressure of pure solid solvent

(d) Depression constant $= \dfrac{RM_1T_b^2}{1000 \times \Delta_{vap}H}$

139. Consider the following aqueous solutions and assume 100% ionisation in electrolytes

I. 0.1 M urea

II. 0.04 M $Al_2(SO_4)_3$

III. 0.05 M $CaCl_2$

IV. 0.005 M NaCl

The incorrect statements regarding the above solution are

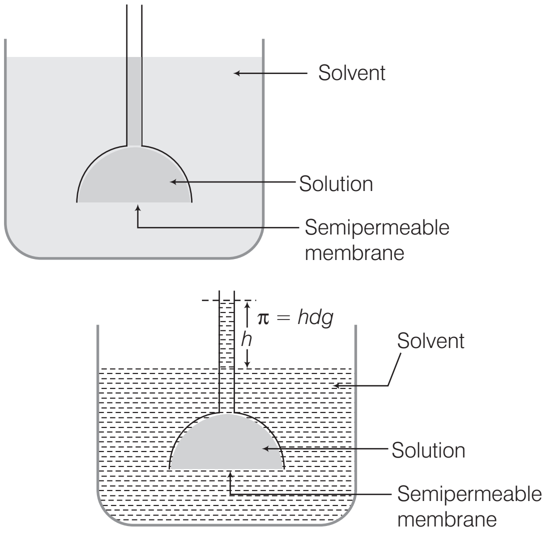
(a) freezing point will be lowest for solution I

(b) freezing point will be highest for solution IV

(c) boiling point will be highest for solution IV

(d) vapour pressure will be highest for solution II

140.



After 10 min

Mark the incorrect informations derived from the diagram.

(a) Solute molecule passes through the semipermeable membrane from pure solvent to the solution

(b) The level of solution increases due to osmosis

(c) Solvent molecules flow through membrane from solution to pure solvent

(d) Solvent molecules flow from pure solvent to solution

141. Which of the following statements are false?

(a) In reverse osmosis, the direction of osmosis can be reversed if pressure larger than osmotic pressure is applied to the solvent side

(b) In reverse osmosis, pure solvent flows out of solvent through semipermeable membrane

(c) In reverse osmosis, only a few polymer membranes are available for reverse osmosis

(d) In osmosis solvent molecules move from the solution of lower concentration to the solution of higher concentration

II. Statement Based Questions

142. Which of the following statements are true?

I. In a binary mixture, mole fraction of A is,

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

II. For solution containing (i) number of components,

$$\chi_i = \frac{n_i}{\Sigma n_i}$$

III. Sum of mole fractions of all the components of a solution is one.

Select the correct option with true statements.

(a) Both I and II
(b) Both II and III
(c) Both III and I
(d) I, II and III

143. Which of the following statements is/are true?

I. Different gases have different K_H values at the same temperature.

II. K_H is a function of the nature of the gas.

Choose the correct option.

(a) Only I (b) Only II (c) Both I and II (d) None of these

144. $p_{total} = x_1 p_1^\circ + x_2 p_2^\circ = p_1^\circ + (p_2^\circ - p_1^\circ) x_2$

Following conclusions can be derived from the above equation.

I. Total vapour pressure of the solution is related to the mole fraction of any one component.

II. Total vapour pressure of the solution varies exponentially with the mole fraction of component 2.

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

Select the correct conclusions derived from the given equation.

(a) Both I and II (b) Both II and III
(c) Both I and III (d) I, II and III

145. Which of the following statements is/are correct for K_f?

I. K_f depends upon the nature of solvent.

II. K_f is known as freezing point depression constant/molal depression constant.

III. K_f is known as cryoscopic constant.

Select the correct conclusion derived from the equation.

(a) Only I (b) Only II (c) Both I and II (d) All are correct

146. Information

I. Semipermeable membrane contains network of submacroscopic holes or pores.

II. Semipermeable membrane appears to be continuous sheets or films.

III. Solvent molecules cannot pass through the holes of semipermeable membrane but solute molecules can pass.

On the basis of the information given above select the correct option.

(a) Only I (b) Only II (c) Only III (d) I, II and III

147. Which of the following statements are true about osmotic pressure?

I. Flow of solvent from solution across a semipermeable membrane can be stopped, if some extra pressure is applied on solution.

II. It is the pressure that stops the flow of solvent towards solution.

III. It is the pressure that allow flows of solvent across the semipermeable membrane.

(a) Both I and II (b) Both II and III
(c) Both I and III (d) I, II and III

148. Consider the following statements about osmotic pressure method of molar mass determination.

I. Molarity of the solution is used instead of molality.

II. Magnitude of osmotic pressure is very large even for dilute solutions.

III. Molar mass of biomolecules can be determined as they are not stable at higher temperatures.

IV. Determine the molar mass of polymer as they have poor solubility.

Which of the above statements are responsible for advantage of osmotic pressure for determination of molar mass over the other colligative properties?

(a) Both I and II (b) Both III and IV
(c) I, II, III and IV (d) None of these

III. Assertion-Reason Type Questions

■ **Directions** (Q. Nos.149-162) *In the following questions, an Assertion* (A) *is followed by a corresponding Reason* (R). *Use the following keys to choose the appropriate answer.*

(a) Both A and R are correct, R is the correct explanation of A.
(b) Both A and R are correct, R is not the correct explanation of A.
(c) A is correct, R is incorrect.
(d) A is incorrect, R is correct.

149. Assertion (A) 1M aqueous solution of glucose contains 180 g of glucose in 1 kg water.

Reason (R) Solution containing one mole of solute in 1000 g of solvent is called one molal solution.

150. Assertion (A) 1.575 g $H_2C_2O_4 \cdot 2H_2O$ in 250 mL solution makes it 0.1 N.

Reason (R) $H_2C_2O_4 \cdot 2H_2O$ is a dihydrate organic acid.

151. Assertion (A) Pressure does not have any significant effect on solubility of solids in liquids.

Reason (R) Solids and liquids are highly incompressible and remain unaffected by change in pressure.

152. Assertion (A) Polar solute dissolves in polar solvents and non-polar solute dissolves in non-polar solvents.

Reason (R) Like dissolves like.

153. Assertion (A) When scuba divers come towards surface, their capillaries get blocked which is painful and dangerous to life.

Reason (R) There occurred release of dissolved gases as the pressure decreases and leads to the formation of bubbles of nitrogen in the blood.

154. Assertion (A) Ethanol and acetone show positive deviation from Raoult's law.

Reason (R) Pure ethanol molecule show hydrogen bond and on adding acetone hydrogen bond between ethanol molecules breaks.

155. Assertion (A) When non-volatile solute is added to solvent, the vapour pressure of the solution decreases.

Reason (R) As number of solvent molecules escaping from the surface is reduced, the vapour pressure of the solution is also reduced.

156. Assertion (A) Melting point of a substance is used for testing the purity of the substance.

Reason (R) There is no other method to determine the purity of substance.

157. Assertion (A) Freezing point of solvent is more than that of solution.

Reason (R) When non-volatile solid is added to the solvent, its vapour pressure increases and become equal to solid solvent at the lower temperature.

158. Assertion (A) The water pouch of instant cold pack for treating athletic injuries breaks when squeezed and NH_4NO_3 dissolves in water to lower the temperature.

Reason (R) Addition of non-volatile solute into solvent results into depression of freezing point of the solvent.

159. Assertion (A) People taking a lot of salty food experience the puffiness or swelling, called edema.

Reason (R) There is water retention in tissue cells and intercellular spaces because of osmosis.

160. Assertion (A) High blood pressure patients are advised to take the minimum quantity of salt.

Reason (R) From salt Na^+ and Cl^- ion concentration increases in the body fluid which may rupture the blood cells.

161. Assertion (A) Experimentally determined molar mass is always lower than the true value.

Reason (R) Lower molar mass is due to dissociation of solute into ions.

162. Assertion (A) The molecular weight of acetic acid determined by depression in freezing point method in benzene and water was found to be different.

Reason (R) Water is polar and benzene is non-polar.

IV. Matching Type Questions

163. Match the following columns and choose the correct option from the codes given below.

Column I (Solution example)	**Column II** (Type of solution)
A. Chloroform mixed with nitrogen gas	1. Gaseous solution
B. Ethanol dissolved in water	2. Solid solution
C. Amalgam of mercury with sodium	3. Liquid solution

Codes

	A	B	C
(a)	1	2	3
(b)	1	3	2
(c)	2	1	3
(d)	2	3	1

164. Match the following Column I which represent concentration term to the Column II representing their corresponding formulae.

Column I	**Column II**
A. Mass percentage	1. $\frac{\text{Volume of the component}}{\text{Total volume of solution}} \times 100$
B. Volume percentage	2. $\frac{\text{Mass of the component in the solution}}{\text{Total mass of the solution}} \times 100$
C. Molality	3. $\frac{\text{Moles of solute}}{\text{Volume of solvent (in L)}}$
D. Molarity	4. $\frac{\text{Moles of solute}}{\text{Mass of solvent (in kg)}}$

Codes

	A	B	C	D		A	B	C	D
(a)	2	1	4	3	(b)	1	2	3	4
(c)	4	3	2	1	(d)	2	4	1	3

165. Match the following Henry's law constant values for gases in water at 298 K.

Column I	**Column II**
A. Argon	1. 1.83×10^{-5}
B. CO_2	2. 0.413
C. Formaldehyde	3. 40.3
D. Methane	4. 0.611
E. Vinyl chloride	5. 1.67

Codes

	A	B	C	D	E
(a)	3	4	2	1	4
(b)	3	1	5	2	4
(c)	3	5	1	2	4
(d)	3	2	5	1	4

166. Match the terms given in Column I with expression given in Column II. Select an appropriate answer from the codes given below.

Column I	Column II
A. Isotonic solution	1. Salt concentration is less than 0.9% (*m/V*), water will flow into cell and it will swell.
B. Hypertonic solution	2. Salt concentration is more than 0.9% (*m/V*) NaCl, water will flow out of cell and the cell will shrink.
C. Hypotonic solution	3. No osmosis occurs, if solution is separated by semipermeable membrane.

Codes

	A	B	C		A	B	C
(a)	3	1	2	(b)	3	2	1
(c)	1	2	3	(d)	2	1	3

167. Match the following terms given in Column I with the Column II.

Column I	Column II (van't Hoff factor appox.)
A. KCl	1. 0.5
B. Ethanoic acid	2. 2
C. K_2SO_4	3. 3

Codes

	A	B	C		A	B	C
(a)	2	3	1	(b)	1	3	2
(c)	2	1	3	(d)	1	2	3

V. Matrix Matching Type Questions

168. Match the items of Column I with Column II.

Column I (Example of solution)	Column II (Type of solution)
A. Sucrose solution	p. Either solute or solvent is liquid
B. Air	q. Solid solution
C. Brass	r. Homogeneous mixture
D. Amalgam	s. Gaseous solution

Codes

	A	B	C	D		A	B	C	D
(a)	p, r	r, s	q, r	p, q, r	(b)	p, r	q, r	r, s	p, q
(c)	p, q, r	q, r	r, s	p, q, s	(d)	q, r	p, q	p, q, r	r, p

169. Match the items of Column I with Column II.

Column I (Concentrations term)	Column II (Factor on concentration term depends)
A. Molarity	p. Dependent upon temperature
B. Molality	q. Not depend upon volume
C. Mass per cent	r. Depend upon volume of solution
D. Volume per cent	s. Depend upon moles of solute

Codes

	A	B	C	D		A	B	C	D
(a)	p, r	r, s	q, r	p, q ,r	(b)	q, r	q,s	p, r	r, s
(c)	p, r, s	q,s	q	p, r	(d)	p, r	p,r	r, s	p, q, s

170. Match the items of Column I with Column II.

Column I (Intermolecular interaction)	Column II (Example)
A. *A*—*B* > *A*—*A* or *B*—*B* Interaction	p. Hexane and heptane
B. $\Delta V_{mix} = 0$	q. Chloroform and acetone
C. $\Delta V_{mix} < 0$	r. Chlorobenzene and bromobenzene
D. Follows Raoult's law in all conditions of *T* and *p*.	s. Water and nitric acid

Codes

	A	B	C	D		A	B	C	D
(a)	p, r	p, r	r, s	p, q	(b)	q, s	p, r	q, s	p, r
(c)	r, s	p, r	q, r	p, q	(d)	p, q, r	p, q	r, s	p, q

171. Match the items of Column I with Column II.

Column I	Column II
A. Vapour pressure	p. Colligative properties
B. Osmotic pressure	q. Decreases in the presence of solute.
C. Freezing point	r. Varies inversely with molecular mass.
D. Elevation in boiling point	s. Dependent on ebullioscopic constant.

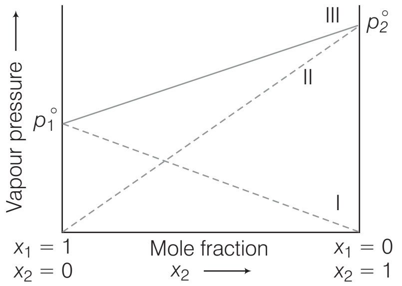
Codes

	A	B	C	D
(a)	p, r	q, r	r, s	p, q
(b)	p	q, r	r, s	p, r
(c)	p, q	p, r	q, s	p, r
(d)	q	p, r	q	p, r,s

VI. Passage Based Questions

■ **Direction** (Q. Nos. 172-174) *These questions are based on the following situation. Choose the correct options from those given below.*

The diagram given below represents the vapour pressure and mole fraction of an ideal solution of component 1 and 2. Answer the following questions.



172. $x_1 = 1$ signifies that

(a) only component 1 is present
(b) only component 2 is present
(c) component 1 and 2 both are present
(d) No component is present

173. What does lines I, II and III indicate?

	I	II	III
(a)	p_1	p_{total}	p_2
(b)	p_2	p_1	p_{total}
(c)	p_1	p_2	p_{total}
(d)	p_1	p_{total}	p_1

174. Which of the following statements is true about the diagram?

(a) Component 1 is more volatile than component 2

(b) Component 1 is less volatile than component 2

(c) Component 1 is equally volatile as component 2

(d) None of the above is true

■ **Direction** (Q. Nos. 175-177) *These questions are based on the following situation. Choose the correct options from those given below.*

"Vapour pressure of chloroform and dichloromethane at 298 K are 200 mm of Hg and 415 mm of Hg respectively".

175. What is the vapour pressure of solution prepared by mixing 25.5 g of $CHCl_3$ and 40 g of CH_2Cl_2 at 298 K?

(a) 347.9 mmHg (b) 300 mmHg

(c) 200 mmHg (d) 147.9 mmHg

176. Calculate the mole fractions of each component in vapour phase.

(a) $y_{CH_2Cl_2} = 0.285$ $y_{CHCl_3} = 0.715$

(b) $y_{CH_2Cl_2} = 0.18$ $y_{CHCl_3} = 0.82$

(c) $y_{CH_2Cl_2} = 0.82$ $y_{CHCl_3} = 0.18$

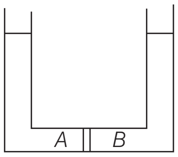
(d) $y_{CH_2Cl_2} = 62.4$ $y_{CHCl_3} = 0.376$

177. Which one of them is more volatile component?

(a) CH_2Cl_2 (b) $CHCl_3$

(c) Both (a) and (b) (d) Not able to determine

■ **Direction** (178-180) *These questions are based on the following situation. Choose the correct options from those given below.*



Compartments *A* and *B* have the following combinations of solution.

	A	B
1.	0.1 M KCl	0.2 M KCl
2.	0.1% (*m*/*V*) NaCl	10% (*m*/*V*) NaCl
3.	18 gL^{-1} glucose	34.2 gL^{-1} sucrose
4.	20% (*m*/*V*) glucose	10% (*m*/*V*) glucose

Answer the following questions on this basis.

178. Which of the above solutions is isotonic?

(a) 1

(b) 2

(c) 3

(d) 4

179. The solutions in which compartment *B* is hypertonic are

(a) 1 and 2

(b) 2 and 3

(c) 3 and 4

(d) 1 and 4

180. Indicate the solution(s) in which compartment *B* will show an increase in volume

(a) 1,2 and 4

(b) 1 and 2

(c) 2 and 3

(d) 3 and 4

NCERT & NCERT Exemplar Questions

NCERT

181. Calculate the mass of urea (NH_2CONH_2) required in making 2.5 kg of 0.25 molal aqueous solution.

(a) 37 g (b) 35 g

(c) 34 g (d) 32 g

182. Calculate the mole fraction of ethylene glycol ($C_2H_6O_2$) in a solution containing 20% of $C_2H_6O_2$ by mass.

(a) 0.068 (b) 0.932

(c) 0.078 (d) 0.010

183. Concentrated nitric acid used in laboratory work is 68% nitric acid by mass in aqueous solution. What should be the molarity of such a sample of the nitric acid, if the density of the solution is 1.504 g mL^{-1}?

(a) 16.23 M (b) 17.00 M

(c) 15.00 M (d) 15.23 M

184. If the solubility product of CuS in 6×10^{-16}, calculate the maximum molarity of CuS in an aqueous solution.

(a) 2.45×10^{-8} mol L^{-1} (b) 2.45×10^{-7} mol L^{-1}

(c) 2.45×10^{-6} mol L^{-1} (d) 2.45×10^{-5} mol L^{-1}

185. 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

186. 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

187. 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

188. Henry's law constant for the solubility of methane in benzene at 298 K is 4.27×10^5 mm Hg. Calculate the solubility of methane in benzene at 298K under 760 mmHg.
(a) 1.78×10^{-3} (b) 1.78×10^{-2}
(c) 1.78×10^{-1} (d) 1.78

189. The air is a mixture of a number of gases. The major components of air are oxygen and nitrogen with approximate proportion of 20% to 79% by volume at 298 K. The water is in equilibrium with air at a pressure of 10 atm. At 298 K, if the Henry's law constants for oxygen and nitrogen are 330×10^7 mm and 6.51×10^7 mm respectively, calculate the composition of these gases in water.
(a) $N_2 = 4.6 \times 10^{-5}$; $O_2 = 9.22 \times 10^{-5}$
(b) $N_2 = 2.3 \times 10^{-5}$; $O_2 = 4.8 \times 10^{-5}$
(c) $N_2 = 9.22 \times 10^{-5}$; $O_2 = 4.6 \times 10^{-5}$
(d) $N_2 = 4.8 \times 10^{-5}$; $O_2 = 2.3 \times 10^{-5}$

190. Benzene and naphthalene form an ideal solution over the entire range of composition. The vapour pressure of pure benzene and naphthalene at 300 K are 50.71 mm Hg and 32.06 mm Hg respectively. Calculate the mole fraction of benzene in vapour phase if 80 g of benzene is mixed with 100 g of naphthalene.
(a) 0.675 (b) 0.325
(c) 42.65 (d) 13.85

191. The boiling point of benzene is 353.23 K. When 1.80 g of a non-volatile solute was dissolved in 90 g of benzene, the boiling point is raised to 354.11 K. Calculate the molar mass of the solute.
(K_b for benzene is 2.53 K kg mol^{-1})
(a) 58 g mol^{-1} (b) 49 g mol^{-1}
(c) 85 g mol^{-1} (d) 94 g mol^{-1}

192. 1.00 g of a non-electrolyte solute is dissolved in 50 g of benzene which lowers the freezing point of benzene by 0.40 K. The freezing point of depression constant of benzene is 5.12 K kg mol^{-1}. Find the molar mass of the solute.
(a) 206 g mol^{-1} (b) 226 g mol^{-1}
(c) 246 g mol^{-1} (d) 256 g mol^{-1}

193. Determine the osmotic pressure of the solution prepared by dissolving 25 mg of K_2SO_4 in 2 L of water at 25°C. (Assuming it is to be completely dissociated)
(a) 5.27×10^{-4} atm (b) 5.27×10^{-3} atm
(c) 5.27×10^{-2} atm (d) 5.27×10^{-1} atm

NCERT Exemplar

194. 4 L of 0.02 M aqueous solution of NaCl was diluted by adding 1 L of water. The molarity of the resultant solution is
(a) 0.004 (b) 0.008 (c) 0.012 (d) 0.016

195. 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

196. On the basis of information given below mark the correct option.
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

197. 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 of between *A*—*A* or *B*—*B*

198. Colligative properties depend on

(a) the nature of the solute particles dissolved in solution

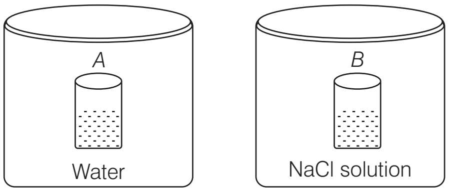
(b) the number of solute particles in solution

(c) the physical properties of the solute particles dissolved in solution

(d) the nature of solvent particles

199. Two beakers of capacity 500 mL were taken. One of these beakers, labelled as *A*, was filled with 400 mL water, whereas the other beaker is labelled as "*B*' was filled with 400 mL of 2 M 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*

200. 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

201. 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

202. 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

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

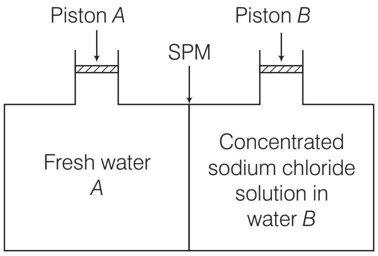
(a) it gains water due to osmosis

(b) it loses water due to reverse osmosis

(c) it gains water due to reverse osmosis

(d) it loses water due to osmosis

204. Consider the figure and mark the correct option.



(a) Water will move from side *A* to side *B*, if a pressure lower than 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*

205. 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 higher concentration of solute to lower concentration of solute

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

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

206. 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

207. 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 points.
- (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

208. 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) $i_A < i_B > i_C$

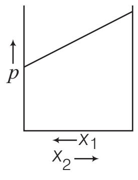
209. Which of the following factors affect the solubility of a gaseous solute in the fixed volume of liquid solvent?

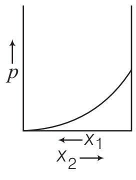
(i) Nature of solute (ii) Temperature
(iii) Pressure

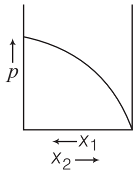
- (a) (i) and (iii) at constant T
- (b) (i) and (ii) at constant p
- (c) Both (ii) and (iii)
- (d) Only (iii)

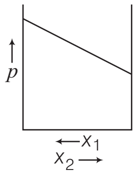
210. Which of the following binary mixtures will have same composition in liquid and vapour phase?
- (a) Benzene-toluene
- (b) Water-nitric acid
- (c) Water-ethanol
- (d) *n*-hexane-*n*-heptane

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

(a)


(b)


(c)


(d)


212. 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) $\Delta_{mix} H = 0$
- (b) $\Delta_{mix} V = 0$
- (c) These will form minimum boiling azeotrope
- (d) These will not form an ideal solution

213. 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

214. 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 electrolytic 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

■ **Directions** (Q.Nos. 215 - 218) *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) Both A and R are correct, R is the correct explanation of A.
- (b) Both A and R are correct, R is not the correct explanation of A.
- (c) A is correct, R is incorrect.
- (d) A is incorrect, R is correct.

215. **Assertion** (A) Molarity of a solution in liquid state changes with temperature.

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

216. **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.

217. **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.

218. **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.

219. 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.

Codes

	A	B	C	D	E	F
(a)	1	3	5	4	2	6
(b)	4	3	1	2	6	5
(c)	5	1	2	3	4	6
(d)	2	1	3	4	6	5

220. 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

Codes

	A	B	C	D	E		A	B	C	D	E
(a)	1	2	4	5	3	(b)	2	3	1	4	5
(c)	5	4	3	1	2	(d)	5	3	4	2	1

221. 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 in 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.	$p = K_H \cdot x$

Codes

	A	B	C	D	E
(a)	3	5	4	1	2
(b)	1	2	3	5	4
(c)	2	3	5	4	1
(d)	5	4	1	2	3

Answers

1.	(d)	**2.**	(d)	**3.**	(d)	**4.**	(d)	**5.**	(c)	**6.**	(c)	**7.**	(d)	**8.**	(b)	**9.**	(b)	**10.**	(c)	**11.**	(a)	**12.**	(c)	**13.**	(c)	**14.**	(d)	**15.**	(d)
16.	(d)	**17.**	(d)	**18.**	(b)	**19.**	(a)	**20.**	(b)	**21.**	(b)	**22.**	(a)	**23.**	(b)	**24.**	(a)	**25.**	(b)	**26.**	(a)	**27.**	(d)	**28.**	(a)	**29.**	(d)	**30.**	(b)
31.	(c)	**32.**	(c)	**33.**	(c)	**34.**	(a)	**35.**	(b)	**36.**	(b)	**37.**	(d)	**38.**	(d)	**39.**	(d)	**40.**	(b)	**41.**	(d)	**42.**	(a)	**43.**	(d)	**44.**	(c)	**45.**	(b)
46.	(d)	**47.**	(b)	**48.**	(c)	**49.**	(b)	**50.**	(d)	**51.**	(d)	**52.**	(d)	**53.**	(a)	**54.**	(a)	**55.**	(b)	**56.**	(a)	**57.**	(d)	**58.**	(d)	**59.**	(a)	**60.**	(d)
61.	(d)	**62.**	(d)	**63.**	(c)	**64.**	(d)	**65.**	(c)	**66.**	(c)	**67.**	(c)	**68.**	(a)	**69.**	(c)	**70.**	(c)	**71.**	(b)	**72.**	(a)	**73.**	(a)	**74.**	(b)	**75.**	(c)
76.	(b)	**77.**	(c)	**78.**	(b)	**79.**	(a)	**80.**	(a)	**81.**	(c)	**82.**	(c)	**83.**	(c)	**84.**	(a)	**85.**	(b)	**86.**	(a)	**87.**	(c)	**88.**	(d)	**89.**	(c)	**90.**	(b)
91.	(c)	**92.**	(d)	**93.**	(a)	**94.**	(d)	**95.**	(d)	**96.**	(a)	**97.**	(b)	**98.**	(a)	**99.**	(d)	**100.**	(b)	**101.**	(d)	**102.**	(a)	**103.**	(a)	**104.**	(d)	**105.**	(a)
106.	(d)	**107.**	(d)	**108.**	(d)	**109.**	(c)	**110.**	(a)	**111.**	(c)	**112.**	(b)	**113.**	(a)	**114.**	(c)	**115.**	(a)	**116.**	(a)	**117.**	(c)	**118.**	(a)	**119.**	(a)	**120.**	(b)
121.	(c)	**122.**	(a)	**123.**	(a)	**124.**	(d)	**125.**	(d)	**126.**	(b)	**127.**	(c)	**128.**	(b)	**129.**	(a)	**130.**	(ad)	**131.**	(cd)	**132.**	(ab)	**133.**	(abd)	**134.**	(abc)	**135.**	(ab)
136.	(bcd)	**137.**	(ab)	**138.**	(abcd)	**139.**	(acd)	**140.**	(ac)	**141.**	(abc)	**142.**	(d)	**143.**	(c)	**144.**	(c)	**145.**	(d)	**146.**	(b)	**147.**	(a)	**148.**	(c)	**149.**	(a)	**150.**	(b)
151.	(a)	**152.**	(a)	**153.**	(a)	**154.**	(a)	**155.**	(a)	**156.**	(c)	**157.**	(c)	**158.**	(a)	**159.**	(a)	**160.**	(a)	**161.**	(d)	**162.**	(a)	**163.**	(b)	**164.**	(a)	**165.**	(c)
166.	(b)	**167.**	(c)	**168.**	(a)	**169.**	(c)	**170.**	(b)	**171.**	(d)	**172.**	(a)	**173.**	(c)	**174.**	(b)	**175.**	(a)	**176.**	(c)	**177.**	(a)	**178.**	(c)	**179.**	(a)	**180.**	(b)
181.	(a)	**182.**	(a)	**183.**	(a)	**184.**	(a)	**185.**	(d)	**186.**	(b)	**187.**	(c)	**188.**	(a)	**189.**	(c)	**190.**	(a)	**191.**	(a)	**192.**	(d)	**193.**	(b)	**194.**	(d)	**195.**	(a)
196.	(b)	**197.**	(bd)	**198.**	(b)	**199.**	(a)	**200.**	(a)	**201.**	(b)	**202.**	(c)	**203.**	(d)	**204.**	(b)	**205.**	(b)	**206.**	(b)	**207.**	(a)	**208.**	(b)	**209.**	(ab)	**210.**	(bc)
211.	(ad)	**212.**	(cd)	**213.**	(ab)	**214.**	(ab)	**215.**	(a)	**216.**	(d)	**217.**	(a)	**218.**	(b)	**219.**	(b)	**220.**	(d)	**221.**	(a)								

Hints & Explanations

1. (*d*) A homogeneous mixture may have two or more than two components, so it may contain more than one solute.

2. (*d*) Generally the solute decides the chemical properties of a solution. Physical state of a solution, however depends upon the solvent.

3. (*d*) In the solution of ethanol, water is in excess. Water and ethanol both exist in liquid phase.

4. (*d*) Solution is a homogeneous mixture of two or more substances. Since, benzene is insoluble in water so mixture of benzene with water is not the example of solution.

5. (*c*) In the amalgam of mercury with sodium, sodium metal is the solvent and mercury (which is a liquid) is solute.

6. (*c*) Solution of hydrogen in palladium is an example of solid solution in which solute is a gas. It is one of the rare examples in which solute is present in larger volume as compared to the solvent.

8. (*b*) In the given chart water is solvent and sugar is solute. In dilute solution, solute is present in very less amount but in concentrated solution, it is present in large amount.

9. (*b*) We know that mass percentage

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

and total mass of solution

$$= \text{mass of sucrose (solute)} + \text{mass of solvent (water)}$$

$$= (18 + 162)\text{g} = 180\,\text{g}$$

$$\therefore \text{ Mass percentage} = \frac{18}{180} \times 100 = 10\%$$

10. (*c*) Molarity of Na_2CO_3 solution $= \dfrac{25.3 \times 1000}{106 \times 250} = 0.955\,\text{M}$

$$\begin{array}{llll} & Na_2CO_3 \longrightarrow & 2Na^+ \; + & CO_3^{2-} \\ \text{Initial conc.} & 0.955 & 0 & 0 \\ \text{After dissociation} & & 2 \times 0.955 & 0.955 \end{array}$$

$$\therefore \quad [Na^+] = 2 \times 0.955\ \text{M} = 1.910\ \text{M}$$

$$[CO_3^{2-}] = 0.955\ \text{M}$$

11. (*a*) Given molarity of solution = 2

$\therefore$ Volume of the solution $= 250\,\text{mL} = \dfrac{250}{1000} = \dfrac{1}{4}\text{L}$

Molar mass of $HNO_3 = 1 + 14 + 3 \times 16 = 63\ \text{g mol}^{-1}$

Molarity

$$= \frac{\text{Weight of } HNO_3}{\text{Molecular mass of } HNO_3 \times \text{volume of solution (in L)}}$$

Weight of HNO_3

$$= \text{molarity} \times \text{molecular mass} \times \text{volume (in L)}$$

$$= 2\,\text{mol/L} \times 63\text{g mol}^{-1} \times \frac{1}{4}\text{L}$$

$$= 31.5\ \text{g}$$

It is weight of 100% HNO_3

But the given acid contains 70% of HNO_3

70% HNO_3 means 70 g HNO_3 is present in 100g solution

$\therefore$ 31.5g HNO_3 will be present in $\dfrac{100}{70} \times 31.5 = 45$ g of solution.

12. (*c*) Mass of HCl in 1.0 mL stock solution

$$= 1.25 \times \frac{29.2}{100} = 0.365\text{g}$$

Mass of HCl required for 200 mL solution of 0.4 M HCl

$$= \frac{200}{1000} \times 0.4 \times 36.5 = 0.08 \times 36.5g$$

$\because$ 0.365 g of HCl is present in 1.0 mL stock solution.

$\therefore$ 0.08×36.5 g HCl will be present in $\dfrac{0.08 \times 36.5}{0.365} = 8.0\,\text{mL}$

13. (*c*) Molality $= \dfrac{\text{Moles of solute}}{\text{Mass of solvent (in kg)}}$

$$= \frac{5.2\text{mol } CH_3OH}{1\text{kg } H_2O} \qquad [1\text{kg} = 1000\text{ g}]$$

$$n_1(CH_3OH) = 5.2,\ n_2(H_2O) = \frac{1000}{18} = 55.56$$

$$\therefore \quad n_1 + n_2 = 5.20 + 55.56 = 60.76\ \text{mol}$$

$$\therefore \quad x_{CH_3OH} = \frac{n_1}{n_1 + n_2} = \frac{5.2}{60.76} = 0.086$$

14. (*d*) Number of moles of $C_2H_5OH = \dfrac{184}{46} = 4;$

$$(M_{C_2H_5OH} = 46\text{ g/mol})$$

Number of moles of $H_2O = \dfrac{72}{18} = 4;$

$$(M_{H_2O} = 18\text{ g/mol})$$

Mole fraction, $x_{C_2H_5OH} = \dfrac{4}{4+4} = \dfrac{4}{8}$

$$x_{H_2O} = \frac{4}{4+4} = \frac{4}{8}$$

$$\Rightarrow \quad \frac{x_{C_2H_5OH}}{x_{H_2O}} = \frac{4/8}{4/8} = \frac{1}{1} = 1:1$$

15. (*d*) Let the solution be *x* molal then moles of benzene present in 1000 g of benzene $= \dfrac{1000}{78} = 12.82$ mol

$\therefore$ Mole fraction of solute $= \dfrac{x}{x + 12.82}$

$$0.2 = \frac{x}{x + 12.82}$$

$$0.2(x + 12.82) = x$$

$$0.2x + 2.564 = x$$

$$2.564 = x - 0.2x = 0.8x$$

$$x = \frac{2.8564}{0.8} = 3.57$$

16. (*d*) Given $m = 1$ $\quad m = \dfrac{1000 \times n}{N \times M}$

$$\therefore \quad 1 = \frac{1000 \times n}{N \times 18} \Rightarrow \frac{n}{N} = \frac{18}{1000}$$

$$\text{or} \quad \frac{n}{n+N} = \frac{18}{1018} = 0.0177$$

17. (*d*) K_2SO_4 is 17.4 ppm, i.e. 10^6 g has 17.4 g K_2SO_4

$$1\text{ L } (10^3\text{ mL}) \text{ has } K_2SO_4 = \frac{17.4 \times 10^3}{10^6} = 0.0174 \text{ g/L}$$

$$= \frac{0.0174}{174} \text{ mol/L}$$

$$\therefore \quad [K_2SO_4] = 1 \times 10^{-4}\text{ M}$$

$$K_2SO_4 \rightleftharpoons 2K^+ + SO_4^{2-}$$

$$\therefore \quad [K^+] = 2 \times 10^{-4}\text{ M}$$

18. (*b*) 98% by mass means 98 g H_2SO_4 is present in 100 g of acid.

$$M = \frac{\text{given mass} \times 1000}{\text{molecular mass} \times V(\text{cc})}$$

Given, mass = 98 g, molecular mass = 98 g

$$V = \frac{\text{mass}}{\text{density}} = \frac{100}{1.84}$$

($\because$ given density of H_2SO_4 is 1.84 g/cc)

Putting the values, $M = \dfrac{98 \times 1000 \times 1.84}{98 \times 100} = 18.4$ M

19. (*a*) $M_f = \dfrac{M_1V_1 + M_2V_2}{V_1 + V_2}$

$$= \frac{750 \times 0.5 + 250 \times 2}{750 + 250} = \frac{875}{1000} = 0.875\text{M}$$

20. (*b*) Given number of molecules of urea = 6.02×10^{20}

$\therefore$ Number of moles = $\dfrac{6.02 \times 10^{20}}{6.02 \times 10^{23}} = 1 \times 10^{-3}$ mol

Volume of the solution = 100 mL = $\dfrac{100}{1000}$ L = 0.1 L

Concentration of urea solution (in mol L^{-1})

$$= \frac{1 \times 10^{-3}}{0.1} = 1 \times 10^{-2} \text{ mol L}^{-1}$$

$$= 0.01 \text{ mol/L or M}$$

21. (*b*) Molality = $\dfrac{\text{Moles of solute}}{\text{Mass of water (in kg)}}$

Moles of urea = $\dfrac{0.010}{60}$ mol

Mass of water at STP

$$(d = 1\text{g/cm}^3 = 1\text{kg/dm}^3) = 0.3\text{ dm}^3 = 0.3\text{ kg}$$

$$\therefore \quad \text{Molality} = \frac{0.010}{60 \times 0.3} = 5.55 \times 10^{-4} \text{ molal}$$

22. (*a*) Let number of moles of solute in solution = x

Moles of benzene in solution = $\dfrac{1000\text{ g}}{78\text{ g mol}^{-1}} = 12.82$ moles

Mole fraction of solute = $\dfrac{x}{x + 12.82} \Rightarrow 0.2 = \dfrac{x}{x + 12.82}$

On solving, $\quad x = 3.2$

$$\therefore \quad \text{Molality } (m) = \frac{\text{Number of moles of solute}}{\text{Mass of solvent (in kg)}} = \frac{3.2}{1} = 3.2$$

23. (*b*) 1 M H_2SO_4 means 1 mole H_2SO_4 in 1000 cc of solution where as, 1 m H_2SO_4 means 1 mole H_2SO_4 in 1000 g of water

Total volume of 1 m solution will be greater than 1000 cc due to extra mole of H_2SO_4. Hence, number of moles per 1000cc will be less than 1 mole. Thus, 1M is less concentrated than 1 m.

24. (*a*) Mole fraction and molality depend only upon weight but not on volume, which is not a function of temperature, so they are independent of temperature.

27. (*d*) In saturated solution, the solution is in dynamic equilibrium with undissolved solute.

29. (*d*) Pressure does not have any significant effect on solubility of solids in liquids. It is so because solids and liquids are highly incompressible and practically remain unaffected by change in pressure.

31. (*c*) On comparing $p = K_H \cdot x$ with equation of straight line *viz*

$y = mx + c$, $m = K_H$ (Here, m = slope of the line).

Thus, Henry's law constaint is represented by the slope of the line.

32. (*c*) Higher the value of Henry's law constant, lower is the solubility of gas in water (or in liquid solvent).

The order of K_H value is:

Ar	CO_2	CH_4	HCHO
40.3	>1.67	> 0.413	$> 1.83 \times 10^{-5}$

Thus, the order of solubility is:

$$\text{Ar} < CO_2 < CH_4 < \text{HCHO}$$

33. (*c*) $p_{N_2} = x_{N_2} \times p_{\text{total}}$ $\quad$ [$\because$ 1 atm = 760 mmHg]

$$p_{N_2} = 0.78 \times 1\text{atm} = 0.78 \times 760 \text{ mm} = 592.8 \text{ mm}$$

Concentration in solution

$$= K_H \times p_{N_2}$$

$$= 8.42 \times 10^{-7}\text{M (mm)}^{-1} \times 592.8 \text{ mm}$$

$$= 4.99 \times 10^{-4}\text{M}$$

34. (*a*) $\quad p_{O_2} = \dfrac{1}{5} \times 1 = 0.2$ bar

$$p_{N_2} = \frac{4}{5} \times 1 = 0.8 \text{ bar}$$

$$p = K_H\, x \text{ (from Henry's law)}$$

$$\therefore \quad \frac{x_{O_2}}{x_{N_2}} = \frac{p_{O_2}}{K_H(O_2)} \times \frac{K_{(H)}(N_2)}{p_{N_2}}$$

$$= \frac{0.2 \times 6.60 \times 10^7}{0.8 \times 3.30 \times 10^7} = \frac{1}{2}$$

$$x_{O_2} : x_{N_2} = 1 : 2$$

35. (*b*) According to Henry's law, $\frac{p_1}{p_2} = \frac{s_1}{s_2}$

[p_1 and p_2 are partial pressures and s_1 and s_2 are solubilities]

$$\frac{500}{750} = \frac{0.01}{s_2} \Rightarrow s_2 = \frac{750 \times 0.01}{500} = 0.015\text{g L}^{-1}$$

37. (*d*) [$\because$ Solubility of gas $\propto p$]

40. (*b*) Air diluted with helium, i.e. a mixture of 11.7% helium, 56.2% nitrogen and 32.1% oxygen, is present in the tanks used by scuba divers for respiration.

43. (*d*) Total pressure, $p_T = p'_A + p'_B$ …(i)

We know that $p'_A = p_A x_A$ and $p'_B = p_B x_B$

Substituting the values of p'_A and p'_B in Eq. (i)

$$p_T = p_A x_A + p_B x_B \quad ..(ii)$$

$[x_A + x_B = 1 \Rightarrow x_A = 1 - x_B \text{ or } x_B = 1 - x_A]$

From Eq. (ii)

$$p_T = p_A x_A + p_B(1 - x_A) = p_A x_A + p_B - p_B x_A$$

$$p_T = p_B + x_A(p_A - p_B)$$

46. (*d*) Ideal solution obeys Raoult's law at every range of concentration. So, the second component must follow, Raoult's law in the range, when x_2 is $0 \le x_2 \le 1$.

47. (*b*) Vapour pressure of water $(p^\circ) = 760$ torr

Number of moles of glucose

$$= \frac{\text{Mass of glucose (in g)}}{\text{Molecular mass of glucose (g mol}^{-1})}$$

$$= \frac{18\text{ g}}{180\text{ g mol}^{-1}} = 0.1\text{ mol}$$

Number of moles of water $= \frac{178.2\text{ g}}{18\text{ g mol}^{-1}} = 9.9$ mol

Total number of moles $= (0.1 + 9.9)$ moles $= 10$ mol

Now, mole fraction of glucose in solution = Change in pressure with respect to initial pressure

$$\frac{\Delta p}{p^\circ} = \frac{0.1}{10}$$

or $\Delta p = 0.01 p^\circ = 0.01 \times 760 = 7.6$ torr

$\because$ Vapour pressure of solution $= (760 - 7.6) = 752.4$ torr.

48. (*c*) Given, $p^\circ_A = 70$ mm Hg

$$x_A = 0.8$$

$\therefore$ $x_B = (1 - 0.8) = 0.2$ and $p = 84$ mmHg

According to Raoult's law,

$$p = p^\circ_A\ x_A + p^\circ_B\ x_B$$

$$84 = 0.8 \times 70 + 0.2 \times p^\circ_B$$

$$p^\circ_B = \frac{28}{0.2} = 140\text{ mm Hg}$$

49. (*b*) For ideal solution, $p_{\text{total}} = p_1{}^\circ x_1 + p_2{}^\circ x_2$

$$= 160 \times \frac{1}{2} + 60 \times \frac{1}{2} = 110\text{ mmHg}$$

50. (*d*) Mole fraction of component A in vapour phase

$$= \frac{\text{Partial pressure of }A}{\text{Total vapour pressure}} = \frac{p_A}{p_A + p_B}$$

but $p_A = p^\circ_A x_A$ and $p_B = p^\circ_B x_B$

$\therefore$ Mole fraction of A in vapour phase $= \frac{p^\circ_A x_A}{p^\circ_A x_A + p^\circ_B x_B}$

Given, $p^\circ_A = 1, x_A = 1, p^\circ_B = 2, x_B = 2$

On substituting the values, we get

Mole fraction of component A in vapour phase

$$= \frac{1 \times 1}{1 \times 1 + 2 \times 2} = \frac{1}{1 + 4} = \frac{1}{5} = 0.2$$

51. (*d*) In equimolar liquid mixture

$$x_A = 0.5, x_B = 0.5$$

So, $p = 0.5 \times 150 + 0.5 \times 100 = 125$

Now, let Y_B be the mole fraction of vapour B then

$$Y_B = \frac{x_B p^\circ_B}{p} = \frac{0.5 \times 100}{125} = 0.4$$

52. (*d*) Number of moles of $CHCl_3$,

$$n_A = \frac{w}{M} = \frac{25.5}{119.5} = 0.213$$

Number of moles of CH_2Cl_2,

$$n_B = \frac{40}{85} = 0.47$$

Mole fraction of $CHCl_3$,

$$x_A = \frac{n_A}{n_A + n_B} = \frac{0.213}{0.683} = 0.31$$

Mole fraction of CH_2Cl_2

$$x_B = 1 - x_A = 1 - 0.31 = 0.69$$

$$p_{\text{total}} = p_A x_A + p_B x_B$$

$$= 200 \times 0.31 + 41.5 \times 0.693$$

$$= 62 + 28.63 = 90.63\text{ mmHg}$$

54. (*a*) Vapour pressure of pure solvent is higher than the vapour pressure of solution, because solute particles occupy some surface sites and hence, less surface is available for evaporation.

56. (*a*) The elevation in boiling point is

$$\Delta T = K_b m; \left[m = \text{molality} = \frac{n_2}{w_1} \times 1000\right]$$

[n_2 = number of moles of solute,
w_1 = weight of solvent in gram]

$$\Rightarrow \quad 2 = 0.76 \times \frac{n_2}{100} \times 1000$$

$$\Rightarrow \quad n_2 = \frac{5}{19}$$

Also, from Raoult's law of lowering of vapour pressure

$$\frac{-\Delta p}{p^\circ} = x_2$$

$$\frac{-\Delta p}{p^\circ} = \frac{n_2}{n_1 + n_2}$$

$$\frac{-\Delta p}{p^\circ} \approx \frac{n_2}{n_1} \qquad [\because n_1 >> n_2]$$

$$\Rightarrow \qquad -\Delta p = 760 \times \frac{5}{19} \times \frac{18}{100}$$

$$= 36 \text{ mm Hg}$$

$$\Rightarrow \qquad p = 760 - 36 = 724 \text{ mm Hg}$$

57. (*d*) For ideal solution, $\Delta H_{\text{mix}} = 0$, $\Delta V_{\text{mix}} = 0$.

58. (*d*) In case of ideal solution, the intermolecular forces of attraction between *A*—*A* and *B*—*B* types are nearly equal to that between *A*—*B* type. Hence,

$\Delta V_{\text{mix}} = 0$, i.e. volume of solution = sum of volumes of two components and $\Delta H_{\text{mix}} = 0$, i.e. no heat is absorbed or evolved.

59. (*a*) Bromoethane and chloroethane form ideal solution.

61. (*d*) The figure shows that $p_{\text{total}} > p_1x_1 + p_2x_2$,

i.e. positive deviation for non-ideal from Raoult's law.

62. (*d*) Figure suggests that escaping tendency of molecules for each component decreases and consequently the vapour pressure decreases resulting in the negative deviation from Raoult's law.

64. (*d*) Since, component having higher vapour pressure will have higher percentage in vapour phase. Benzene has vapour pressure of 12.8 kPa which is greater than that of toluene (3.85 kPa). Therefore, the vapour will contain a higher percentage of benzene.

65. (*c*) In the mixture of phenol and aniline, the intermolecular hydrogen bonding between phenolic proton and lone pair on nitrogen atom of aniline is stronger than the respective intermolecular hydrogen bonding between similar molecules.

66. (*c*) KCl < CH_3OH < CH_3CN < cyclohexane

- (i) Cyclohexane and *n*-octane both are non-polar, so they will mix completely.
- (ii) KCl is an ionic compound, while octane is non-polar organic compound, so KCl will not dissolve in *n*-octane.
- (iii) CH_3OH and CH_3CN both are polar but CH_3CN will dissolve more than CH_3OH in octane because CH_3CN is less polar than CH_3OH.

68. (*a*) Only non-ideal solutions form azeotropic mixtures (constant boiling mixtures). Among the given, only CCl_4 and $CHCl_3$ form non-ideal solution, thus they form azeotropic mixture.

69. (*c*) When the new interaction is weaker than those in the pure constituents, the boiling point of the resultant solution is less than that of the constituents. Such condition is found in case of non-ideal solution showing positive deviation from Raoult's law. Among the given solutions, mixture of CH_3CH_2OH and CH_3COCH_3 is non-ideal and show positive deviation. Hence, it has lesser boiling point or higher vapour pressure, than its constituents.

70. (*c*) Solution which show negative deviation from Raoult's law are also called maximum boiling azeotrope. Hence, acetone chloroform forms maximum boiling azeotrope.

71. (*b*) Nitric acid and water is an example of class of azeotrope. This azeotrope has approximate composition, 68% nitric acid and 32% water by mass with a boiling point of 393.5 K.

72. (*a*) With the addition of water, concentration decreases thus vapour pressure increases.

73. (*a*) From Raoult's law,

$$\frac{p^\circ - p_s}{p^\circ} = n_2 \quad \Rightarrow 1 - \frac{p_s}{p^\circ} = n_2$$

$$\frac{p_s}{p^\circ} = 1 - n_2 = n_1$$

$$p_s = n_1 \times p^\circ$$

74. (*b*) Given, $p^\circ = 185$ torr at 20°C and $p_s = 183$ torr at 20°C

Mass of non-volatile substance, $m = 1.2$ g

Mass of acetone taken = 100 g and M = ?

As, we have $\dfrac{p_o - p_s}{p_s} = \dfrac{n}{N}$

Putting the values, we get,

$$\frac{185 - 183}{183} = \frac{\frac{12}{M}}{\frac{100}{58}}$$

$$\Rightarrow \qquad \frac{2}{183} = \frac{1.2 \times 58}{100 \times M}$$

$$\therefore \qquad M = \frac{183 \times 1.2 \times 58}{2 \times 100} = 63.684 \text{ g} \approx 64 \text{ g mol}^{-1}$$

75. (*c*) 1 M aqueous solution contains 1 mole of solute in 1000 g (55.5 moles) of water.

$$x_B = \frac{1}{1 + 55.5} = \frac{1}{56.5}$$

$$p^\circ = 760 \text{ torr at } 100^\circ\text{C}$$

$$\frac{\Delta p}{p^\circ} = x_B, \Delta p = p^\circ x_B = \frac{760 \times 1}{56.5} = 13.45 \text{ torr}$$

76. (*b*) Number of moles of $C_{12}H_{22}O_{11} = \dfrac{100}{342} = 0.292$ mol,

Number of moles of $H_2O = \dfrac{1000}{18} = 55.5$ mol,

Vapour pressure of pure water, $p^\circ = 23.8$ mm Hg

According to Raoult's law, $\dfrac{\Delta p}{p^\circ} = \dfrac{n}{n+N}$

$$\Rightarrow \qquad \frac{\Delta p}{23.8} = \frac{0.292}{0.292 + 55.5}$$

$$\Delta p = \frac{23.8 \times 0.292}{55.79}$$

$$= 0.125 \text{ mm Hg}$$

77. (*c*) By using the relation, molality $= \dfrac{p^\circ - p_s}{p^\circ} \times \dfrac{1000}{M}$

$$\text{Molality } (m) = \frac{25-24.5}{25} \times \frac{1000}{18} = \frac{0.5}{25} \times \frac{1000}{18} = 1.11$$

∴ Molality of solution = 1.11 m

78. (*b*) From Raoult's law, for ideal solution

$$p = p^\circ_B\, x_B + p^\circ_T\, x_T \quad [B = \text{benzene}, T = \text{toluene}]$$

$$= 119 \times 0.5 + 37 \times 0.5$$

$$= 59.5 + 18.5 \qquad [\because x_B = 1 - x_T]$$

$$= 78 \text{ torr}$$

∴ Mole fraction of toluene in vapour phase

$$(x_T)_V = \frac{p^\circ_T\, x_T}{p} = \frac{18.5}{78} = 0.237$$

79. (*a*) Since, boiling point of a solution is always higher than that of pure solvent and from figure $B > A$. So, B is the boiling point of solution and A is of pure solvent.

80. (*a*) Increase in the concentration of salt solution means more solute (salt) is present and hence, more surface sites are occupied by solute molecules, That's why vapour pressure decreases and a higher temperature is required to boil the solution, i.e. boiling point increases.

81. (*c*) $\Delta T_b = \dfrac{1000 \times K_b \times w}{W \times M}$

$$= \frac{1000 \times K_b \times 10}{100 \times 100}, \Delta T_b = K_b$$

Here, K_b = ebullioscopic constant

82. (*c*) Elevation of boiling point, $\Delta T_b = \dfrac{w \times K_b \times 1000}{M \times W(\text{in gram})}$

(Here, w and W= weights of solute and solvent respectively, M = molecular weight of solute and K_b = constant)

On substituting values, we get

$$0.05 = \frac{w \times 0.5 \times 1000}{100 \times 100}$$

or $$w = \frac{0.05 \times 100 \times 100}{0.5 \times 1000} = 1\text{ g}$$

84. (*a*) Freezing point of a substance is the temperature at which the solid and the liquid forms of the substance are in equilibrium. When freezing starts, liquid solvent is in equilibrium with the solid solvent (and both have the same vapour pressure).

85. (*b*) Freezing point of a pure solvent decreases on addition of solute and hence, a solution of benzene and naphthalene has lower freezing point than the freezing point of pure benzene.

86. (*a*) $\Delta T_f = \dfrac{1000 K_f\, w_1}{m_1 w_2} = 0^\circ - (-6^\circ\text{C}) = 6^\circ\text{C}$

$$\therefore \quad 6 = \frac{1000 \times 1.86 \times w_1}{62 \times 4000}$$

$$\Rightarrow \quad w_1 = 800\text{ g} \approx 804.32\text{ g}$$

87. (*c*) Normal freezing point of water = 273.15K. In order to prevent freezing at 268 K, let the amount of methanol added be x g.

$$\therefore \quad \text{Molality, } m = \frac{x}{32 \times 10} = \frac{x}{320}$$

[∵ Molar mass of CH_3OH = 32g mol^{-1} and volume of H_2O = 10L]

Now, $$\Delta T_f = K_f \cdot m$$

$$(273.15 - 268) = 1.86 \times \frac{x}{320}$$

$$5.15 = 1.86 \times \frac{x}{320} \quad [\because K_f \text{ for water} = 1.86\text{ K kg mol}^{-1}]$$

or $$x = \frac{5.15 \times 320}{1.86} = 886.02\text{ g}$$

88. (*d*) Depression in freezing point, $\Delta T_f = K_f \times m$

where, m = molality

$$= \frac{\text{weight of solute} \times 1000}{\text{molecular weight of solute} \times \text{weight of solvent}}$$

$$= \frac{1.5 \times 1000}{60 \times 250} = 0.1$$

$$\Delta T_f = K_f \times 0.1 \Rightarrow 0.01 = K_f \times 0.1$$

$$\therefore \quad K_f = \frac{0.01}{0.1} = 0.1$$

89. (*c*) $\Delta T_f = K_f \times \dfrac{w}{m} \times \dfrac{1000}{W}$ and $\dfrac{\Delta T_{f_2}}{\Delta T_{f_1}} = \dfrac{m_1}{m_2}$

Here, m_1 (cane sugar, $C_{12}H_{22}O_{11}$) = 342 g mol^{-1}

m_2 (glucose, $C_6H_{12}O_6$) = 180 g mol^{-1}

$$\Delta T_{f_1} = 273.15 - 271 = 2.15\text{ K}$$

$$\frac{\Delta T_{f_2}}{2.15} = \frac{342}{180} \Rightarrow \Delta T_{f_2} = 4.085\text{ K}$$

So, freezing point of glucose in water

$$= 273.15 - 4.085 = 269.07\text{ K}$$

90. (*b*) Coolant glycol ($C_2H_6O_2$) is a non-electrolyte.

$$\Delta T_f = 2.8^\circ$$

$$\Delta T_f = \frac{100 K_f w_1}{m_1 w_2}$$

$$\Rightarrow \quad 2.8 = \frac{1000 \times 1.86 \times w_1}{62 \times 1000}$$

$$\therefore \quad w_1 = 93.33\text{ g} \approx 93\text{ g}$$

91. (*c*) Elevation in boiling point and depression in freezing point, both are the colligative properties, i.e. depend only upon the number of particles present in solution. In other words, as the number of particles increases, boiling point increases but freezing point decreases. Since, the order of boiling point is

$$C < B < A < D.$$

∴ The order of freezing point will be

$$D < A < B < C \text{ or } D < B > A < C$$

92. (*d*) Given, $T_b - T_f = 105.0°\text{C}$

$$\Rightarrow (100 - \Delta T_b) - (0 - \Delta T_f) = 105°\text{C}$$

$$\Delta T_b + \Delta T_f = 5$$

$$\Delta T_b + \Delta T_f = (K_b + K_f) \times m; \ (m = \text{molality})$$

$$\Rightarrow \quad 5 = (1.86 + 0.51) \times \frac{w \times 1000}{342 \times 100}$$

$\therefore$ On solving, $w = 72\text{ g}$

96. (*a*) $\pi \propto C$, so more the concentration, higher is the osmotic pressure.

97. (*b*) The concentration of $BaCl_2$ solution is lower, thus solvent (water) moves from the $BaCl_2$ solution to NaCl solution, when 0.1 M NaCl and 0.005 M $BaCl_2$ solutions are separated by a semipermeable membrane.

98. (*a*) Osmotic pressure, $\pi = CRT$

Here, $C = 0.2\text{ M}$

$$R = 0.082\text{ atm dm}^3\text{ mol}^{-1}\text{ K}^{-1}$$

$$T = (27 + 273)\text{K} = 300\text{ K}$$

$$\pi = 0.2 \times 0.082 \times 300 = 4.92\text{ atm}$$

99. (*d*) We know that osmotic pressure,

$$\pi = CRT = \frac{w \times R \times T}{m \times V}$$

$$16.4 = \frac{10 \times 1000}{180 \times 100} \times 0.082 \times T$$

$$\therefore \quad T = \frac{16.4 \times 180}{0.082 \times 100} = 360\text{ K}$$

100. (*b*) Given, $\pi = 2.57 \times 10^{-3}$ bar, $V = 200\text{ cm}^3 = 0.200\text{ L}$

$$T = 300\text{ K}, R = 0.082\text{ L bar mol}^{-1}\text{ K}^{-1}$$

$$M_2 = \frac{w_2RT}{\pi \times V}$$

$$M_2 = \frac{1.26\text{ g} \times 0.082\text{ L bar K}^{-1}\text{ mol}^{-1} \times 300\text{K}}{2.57 \times 10^{-3}\text{ bar} \times 0.200\text{ L}}$$

$$= 60304\text{ g mol}^{-1}$$

101. (*d*) Osmotic pressure $\propto$ concentration

$\therefore$ Concentration of the compound

= Concentration of the glucose

$$\frac{6}{M} = 0.05$$

$$M = 120$$

Empirical formula (CH_2O) mass $= 12 + 2 + 16 = 30\text{ g mol}^{-1}$

$$n = \frac{\text{molecular mass}}{\text{empirical formula mass}}$$

$$= \frac{120}{30} = 4$$

Molecular formula $= (CH_2O)_n = (CH_2O)_4 = C_4H_8O_4$

103. (*a*) Osmotic pressure associated with the fluid inside the blood cell is equivalent to that of 0.9% (*m*/*V*) sodium chloride solution, called normal saline solution which is safe to inject intravenously.

104. (*d*) When a solution of urea (6%) is isotonic with a solution of glucose

$$\pi_{\text{glucose}} = \pi_{\text{urea}}, C_{\text{glucose}} = C_{\text{urea}}$$

$$\therefore \quad \left(\frac{w_g \times 1000}{m_g \times 100}\right) = \left(\frac{w_u \times 1000}{m_u \times 100}\right)$$

where, w_g = mass of glucose = x g

m_g = molecular mass of glucose = 180 g mol^{-1}

w_u = mass of urea = 6 g

m_u = molecular mass of urea = 60 g mol^{-1}

$$\therefore \quad \frac{x \times 1000}{180 \times 100} = \frac{6 \times 1000}{60 \times 100} \Rightarrow x = 18\text{ g}$$

Thus, 18 g of glucose is present in 100 mL of solution.

In other words, 1 M solution of glucose (18 g in 100 mL) is isotonic with 6% solution of urea.

105. (*a*) Isotonic solutions have same molar concentration of solute particles in solution. Molar concentration of solute particles in solution are 0.1 M in glucose, $2 \times 0.05\text{ M}$ in NaCl, 3×0.05 in $BaCl_2$ and 4×0.1 in $AlCl_3$. Therefore, 0.1 M glucose and 0.05 M NaCl solutions are isotonic.

107. (*d*) In case of dissociation, van't Hoff factor $i > 1$.

In case of association, van't Hoff factor $i < 1$.

109. (*c*) Let the degree of association be α

$$\begin{array}{lcc} & M \rightleftharpoons & (M)_n \\ \text{Initially} & 1 & 0 \\ \text{After time } t & 1 - \alpha & \frac{\alpha}{n} \end{array}$$

$$\text{Total moles after association} = 1 - \alpha + \frac{\alpha}{n} = 1 + \left(\frac{1}{n} - 1\right)\alpha$$

$$i = \frac{\text{moles after association}}{\text{initial moles}}$$

$$= \frac{1 + \left(\frac{1}{n} - 1\right)\alpha}{1}$$

$$\text{or} \quad (i - 1) = \left(\frac{1}{n} - 1\right)\alpha \qquad \text{...(i)}$$

We have, $i = 0.9$ and $\alpha = 0.2$

On putting values of i and α in Eq. (i) we get $n = 2$

110. (*a*) $\underset{(1-\alpha)}{A_xB_y} \rightleftharpoons \underset{x\alpha}{xA^{y+}} + \underset{y\alpha}{yB^{x-}}$

After dissociation x

$$i = n(A_xB_y) + n(A^{y+}) + n(B^{x-})$$

$$= 1 - \alpha + x\alpha + y\alpha$$

$$= 1 + \alpha(x + y - 1)$$

$$\therefore \quad \alpha = \frac{i - 1}{(x + y - 1)}$$

111. (*c*) Freezing point depression (ΔT_f) is a colligative property and depends upon the van't Hoff factor (*i*), i.e. number of ions given by the electrolyte in aqueous solution.

$$\Delta T_f = i \times K_f \times m$$

where, K_f = molal freezing point depression constant

m = molality of the solution

$\because$ K_f amd m are constant

$\therefore$ $\Delta T_f \propto i$

(a) $KCl(aq) \rightleftharpoons K^+(aq) + Cl^-(aq)$ (total ions = 2 thus, $i = 2$)

(b) $C_6H_{12}O_6 \rightleftharpoons$ no ions [$i = 0$]

(c) $Al_2(SO_4)_3(aq) \rightleftharpoons 2Al^{3+} + 3SO_4^{2-}$

(total ions = 5, thus, $i = 5$)

(d) $K_2SO_4(aq) \rightleftharpoons 2K^+ + SO_4^{2-}$ (total ions = 3, thus, $i = 3$)

Hence, $Al_2(SO_4)_3$ will exhibit largest freezing point depression due to the highest value of *i*.

112. (*b*) More the value of *i*, more will be the elevation in boiling point. Again, more dilute solution has low boiling point. Hence, increasing order of boiling points is:

$$\underset{(i=1)}{10^{-4}\,M\ \text{Urea}} < \underset{(i=2)}{10^{-4}\,M\ NaCl} < \underset{(i=3)}{10^{-3}\,M\ MgCl_2} < \underset{(i=2)}{10^{-2}\,M\ NaCl}$$

113. (*a*) Elevation in boiling point, $\Delta T_b = i \times K_b \times m$

$$\text{Molality of NaCl solution} = \frac{n}{w} \times 1000$$

$$= \frac{\frac{58.5}{58.5} \times 1000}{w_{H_2O}} = \frac{1000}{w_{H_2O}}$$

$$\text{Molality of } C_6H_{12}O_6 \text{ solution} = \frac{\frac{180}{180} \times 1000}{w_{H_2O}} = \frac{1000}{w_{H_2O}}$$

Both solutions have same molality but values of *i* i.e. van't Hoff factor for NaCl and glucose are 2 and 1 respectively.

Hence, NaCl will show higher elevation in boiling point.

114. (*c*) Depression in freezing point is a colligative property (i.e. depends only upon the number of particles of solutes). Thus, the compound which produces maximum number of ions will have the least freezing point.

$\because$ Concentration is same

$$\text{Sucrose} \longrightarrow \text{No ions}$$

$$NaCl \longrightarrow \underbrace{Na^+ + Cl^-}_{\text{Two ions}}$$

$$CaCl_2 \longrightarrow \underbrace{Ca^{2+} + 2Cl^-}_{\text{Three ions}}$$

$$\text{Glucose} \longrightarrow \text{No ions}$$

Thus, 1% $CaCl_2$ will have the least freezing point.

115. (*a*) $Al_2(SO_4)_3$ produces maximum number of ions so, it will have highest osmotic pressure.

116. (*a*)

$$\begin{array}{llll} & BaCl_2 & \rightleftharpoons Ba^{2+} & + 2Cl^- \\ \text{Initial} & 0.01\ M & 0 & 0 \\ \text{At equil.} & (0.01 - x)\ M & x\ M & 2x\ M \end{array}$$

$$i = \frac{(0.01 - x) + x + 2x}{0.01} = \frac{0.01 + 2x}{0.01} = 1.98$$

$\Rightarrow$ $x = 0.0049$

$$\text{Percentage of } \alpha = \frac{x}{0.01} \times 100 = \frac{0.0049 \times 100}{0.01} = 49\%$$

117. (*c*) $\underset{1-\alpha}{4A} \rightleftharpoons \underset{\alpha/4}{A_4}$

$$i = \frac{1 - \alpha + \frac{\alpha}{4}}{1} = 1 - \frac{3}{4}\alpha$$

α = degree of association = 1, i.e. 100% association

$$i = 1 - \frac{3}{4} = 0.25$$

118. (*a*) $CuCl_2$ is an electrolyte, which ionises in solution as follows

$$\begin{array}{llll} & CuCl_2 & \rightleftharpoons Cu^{2+} & + 2Cl^- \\ \text{At } t = 0 & 1\ \text{mol} & 0 & 0 \\ \text{After ionisation} & (1 - \alpha)\ \text{mol} & \alpha\ \text{mol} & 2\alpha\ \text{mol} \end{array}$$

Thus, number of particles after ionisation

$$= 1 - \alpha + \alpha + 2\alpha = 1 + 2\alpha$$

$\therefore$ van't Hoff factor

$$(i) = \frac{\text{number of particles after ionisation}}{\text{number of particles before ionisation}}$$

or $(i) = \dfrac{1 + 2\alpha}{1}$ (on 100% ionisation $\alpha = 1$)

$$= \frac{1 + 2 \times 1}{1} = 3$$

The elevation in boiling point (when colligative property is abnormal)

$$\Delta T_b = i \times K_b \times m$$

m = molality of solution

Molality of $CuCl_2$ solution

$$= \frac{\frac{\text{Weight of } CuCl_2 \text{ (in gram)}}{\text{molecular weight of } CuCl_2}}{\text{Weight of water (solvent) in kg}}$$

$$= \frac{\frac{13.44}{134.4}}{1} = 0.1\,m$$

Thus, $\Delta T_b = 3 \times 0.52 \times 0.1 = 0.156 = 0.16°\,C$

119. (*a*) $\Delta T_f = i \times K_f \times$ molality

Here, degree of dissociation = 80%

$$KBr \rightleftharpoons K^+ + Br^-$$

$$\because \quad i = \frac{1 - \alpha + n\alpha}{1};\ i = \frac{1 - 0.8 + 2 \times 0.8}{1} = 1.8$$

$\therefore$ $\Delta T_f = 1.8 \times 1.86 \times 0.5 \Rightarrow \Delta T_f = 1.674\ K$

$\Delta T_f = T°_f - T_f \qquad \Rightarrow 1.674 = 273 - T_f$

$T_f = 273 - 1.674 \qquad \Rightarrow \quad T_f = 271.326\ K$

120. (*b*) $\Delta T_f = i \times K_f \times m;$

$$\underset{1-\alpha}{\text{HBr}} \longrightarrow \underset{\alpha}{\text{H}^+} + \underset{\alpha}{\text{Br}^-}$$

Total ions $= 1-\alpha+\alpha+\alpha = 1+\alpha$

$\therefore \qquad i = 1+\alpha$

Given, $\qquad K_f = 1.86\,\text{K kg mol}^{-1}$

Mass of HBr $= 8.1\,\text{g}$

Mass of $H_2O = 100\,\text{g}$

(α) = degree of ionisation = 90%

$$\text{molality}(m) = \frac{\text{mass of solute/ molecular weight of solute}}{\text{mass of solvent (in kg)}}$$

$$m(\text{molality}) = \frac{8.1/81}{100/1000}$$

$$i = 1+\alpha = 1+\frac{90}{100} = 1.9$$

$$\Delta T_f = i \times K_f \times m$$

$$= 1.9 \times 1.86 \times \frac{8.1/81}{100/1000} = 3.534°\,\text{C}$$

ΔT_f (depression in freezing point)

= freezing point of water − freezing point of solution

$3.534 = 0 -$ freezing point of solution

$\therefore$ Freezing point of solution $= -3.534°\,\text{C}$

121. (*c*) Using, $\Delta T_f = i \times K_f \times m$

$$i = \frac{\Delta T_f \times w_A}{K_f \times n_B \times 1000} = \frac{3.82 \times 45}{1.86 \times \left(\frac{5}{142}\right) \times 1000} = 2.63$$

122. (*a*) **Step I** Calculation of van't Hoff factor for *P*

$$\Delta T_f = i \times K_f \times m = i \times K_f \times \frac{w_2 \times 1000}{w_1 \times M_2}$$

$$0.3 = i \times 1.86 \times \frac{1.25 \times 1000}{50 \times 94}$$

$$\Rightarrow \qquad i = \frac{0.3 \times 50 \times 94}{1.86 \times 1.25 \times 1000} = 0.6064$$

Step II Calculation of degree of association of *P*

Degree of association, α

$$= \frac{i-1}{\frac{1}{n}-1} = \frac{0.6064-1}{\frac{1}{2}-1} = \frac{-0.3936}{-0.5}$$

$$= 0.7872 = 78.72\% \approx 80\%$$

123. (*a*) *i* for KCl = 2, *i* for $BaCl_2 = 3$

$$\because \qquad \Delta T_f \propto i; \frac{\Delta T_f(\text{KCl})}{\Delta T_f(\text{BaCl}_2)} = \frac{2}{3}$$

$$\therefore \qquad \Delta T_f(\text{BaCl}_2) = \frac{3}{2} \times 2 = 3°\,\text{C}$$

$\therefore$ Freezing point of KCl $= -3°\,\text{C}$

124. (*d*) $\Delta T_f = \dfrac{1000 K_f w}{mW}$

$\Delta T_f = 0.19°\,\text{C}$; $K_f = 5.08\,\text{K kg mol}^{-1}$, $w = 1$ g; $W = 80\,\text{g}$

$$m = \frac{1000 K_f w}{\Delta T_f W} = \frac{1000 \times 5.08 \times 1}{0.19 \times 80} = 334.21$$

Atomic weight of As = 74.92

Hence, number of atoms $= \dfrac{334.21}{74.92} \approx 4$

Hence, the formula of arsenic is As_4.

125. (*d*) Depression in freezing point, $\Delta T_f = K_f m$

(where, *m* = molality)

$$= 5.12 \times \frac{0.223 \times 1000}{4.4 \times 136}$$

[$\because$ mol. w.t. of phenylacetic acid = 136]

$$= 5.12 \times 0.372 = 1.91°\,\text{C}$$

$\therefore$ Theoretical $\Delta T_f = 1.91$

Actual $\Delta T_f = 5.3°\,\text{C} - 4.47°\,\text{C} = 0.83°\,\text{C}$

$$\therefore \qquad i = \frac{0.83}{1.91} = 0.43$$

$$\because \qquad i < 1$$

$\therefore$ Association will take place.

Thus, it can be said that phenylacetic acid dimerises in benzene.

126. (*b*) In case of ionisation of binary electrolyte

Abnormal molecular mass $= \dfrac{M_{\text{normal}}}{1+\alpha}$

Abnormal molecular mass $= 25\text{g mol}^{-1}$

So, $25 = \dfrac{40}{1+\alpha} \Rightarrow \alpha = 0.6$

Ionisation percentage $= 0.6 \times 100 = 60\%$

127. (*c*) For NaCl, $\quad \pi_1 V_1 = i \times n_1 RT$

$$\pi_1 \times \frac{100}{1000} = \frac{1.2}{58.5} \times 0.0821 \times T \times i \qquad \ldots\text{(i)}$$

For glucose, $\pi_2 V = n_2 RT$

$$\pi_2 \times \frac{100}{1000} = \frac{7.2}{180} \times 0.0821 \times T \qquad \ldots\text{(ii)}$$

($\because$ for glucose $i = 1$)

$\because$ NaCl and glucose solutions are isotonic.

$$\therefore \qquad \pi_1 = \pi_2$$

$$\Rightarrow \qquad i = \frac{7.2}{180} \times \frac{58.5}{1.2} = 1.95 \approx 2$$

128. (*b*) $\Delta T_f = iK_f m \Rightarrow 0.0054 = i \times 1.86 \times 0.001$

$$i = \frac{5.4}{1.86} \approx 3$$

$$[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]\text{Cl}_2 \rightleftharpoons [\text{Pt}(\text{NH}_3)_2\text{Cl}_2]^{2+} + 2\text{Cl}^-$$

So, ionisable Cl^- ions are 2.

129. (*a*)

$$\begin{array}{ccccc} HA & \rightleftharpoons & H^+ & + & A^- \\ C & & 0 & & 0 \\ C(1-\alpha) & & C\alpha & & C\alpha \end{array}$$

$$[H^+] = C\alpha$$

$$[H^+] = 10^{-2} \qquad [\because \text{pH} = 2]$$

$$C\alpha = 10^{-2}$$

$$\alpha = \frac{10^{-2}}{0.1} = 0.1$$

Total number of moles after dissociation

$$= C - C\alpha + C\alpha + C\alpha = C(1+\alpha)$$

$$\text{van't Hoff factor} = \frac{C(1+\alpha)}{C} = 1 + \alpha = 1 + 0.1 = 1.1$$

$$\pi = iCRT = 1.1 \times 0.1 \times 0.0821 \times 298$$

$$= 2.69 \text{ atm}$$

130. (*a,d*) Sugar solution and air both are homogeneous mixture and hence, are the examples of true solution. Amalgam is the example of solid solution. 10% glucose solution means 10 g of glucose is present in 90 g of water to form 100 g of solution.

131. (*c,d*) 10% solution of KI contains, 10g of KI in 90 g (or 0.09 kg)of water.

Molar mass of KI $= (39+127)\text{ g mol}^{-1} = 166\text{ g mol}^{-1}$

$$\therefore \text{Molality of solution} = \frac{\text{Number of moles of KI}}{\text{Mass of water (in kg)}}$$

$$= \frac{(10\text{ g}/166\text{ g mol}^{-1})}{0.09\text{kg}}$$

$$= 0.67 \text{mol kg}^{-1}$$

$$\text{Further, molarity } (M) = \frac{\text{Moles of KI}}{\text{Volume of solution (in L)}}$$

$$= \frac{(10\text{g}/166\text{ g mol}^{-1}) \times 1000}{100\text{g}/1.202\text{ g mL}^{-1}}$$

$$= \frac{10/166 \times 1000}{83.19}$$

$$[\because \text{Volume} = \text{Mass/density} = 100/1.202 = 83.19 \text{ mL}]$$

$$= 0.72 \text{ mol L}^{-1} = 0.72\text{M}$$

$$\text{Number of moles of KI} = \frac{10\text{ g}}{166\text{ g mol}^{-1}} = 0.06 \text{ mol}$$

$$\text{Number of moles of water} = \frac{90\text{ g}}{18\text{ g mol}^{-1}} = 5 \text{ mol}$$

$$\text{Mole fraction of KI} = \frac{n_{KI}}{n_{KI} + n_{H_2O}}$$

$$= \frac{0.06}{5+0.06} = \frac{0.06}{5.06} = 0.01186$$

132. (*a,b*) Solubility depends upon the nature of solute as well as solvent. Ethanol is a covalent molecule but due to the formation of H-bonding with water, it is soluble in it. Other given statements are true.

133. (*a,b,d*) In the mixture of phenol and aniline, the intermolecular hydrogen bonding between phenolic proton and lone pair on N-atom of aniline is stronger than the respective intermolecular hydrogen bonding between two same molecules. Thus, their mixture shows negative deviation from Raoult's law.

For such mixtures, $\Delta H_{\text{mix}} < 0$ and $\Delta V_{\text{mix}} < 0$

It forms a maximum boiling azeotrope.

134. (*a,b,c*) Mixtures of ethanol and acetone, carbon disulphide and acetone, ethanol and water show positive deviation from Raoult's law and thus, form minimum boiling azeotrope.

135. (*a, b*) According to Raoult's law,

Relative lowering in vapour pressure = Mole fraction of solute

$$\frac{p^\circ - p}{p^\circ} = x_2 \Rightarrow \frac{p^\circ - p}{p^\circ} = \frac{n_2}{n_1 + n_2}$$

or $$\frac{p^\circ}{p^\circ - p} = \frac{n_1 + n_2}{n_2}$$

or $$\frac{p^\circ}{p^\circ - p} = 1 + \frac{n_1}{n_2}$$

$$\frac{p^\circ}{p^\circ - p} - 1 = \frac{n_1}{n_2} \Rightarrow \frac{p}{p^\circ - p} = \frac{n_1}{n_2}$$

or $$\frac{p^\circ - p}{p} = \frac{n_2}{n_1}$$

136. (*b, c, d*) A liquid boils when its vapour pressure becomes equal to atmospheric pressure.

138. (*a, b,c,d*) All the given statements are true.

139. (*a, c,d*) According to colligative properties, freezing point will be highest for solution IV due to lower concentration of NaCl.

140. (*a, c*) Solute molecules can never pass through the semipermeable membrane, only solvent molecules can do that. They move from the solution of lower concentration or from pure solvent to solution of higher concentration.

141. (*a,b,c*) In reverse osmosis, the direction of osmosis can be reversed if a pressure larger than the osmotic pressure is applied to the solution side.

142. (*d*) All the given statements are true.

143. (*c*) K_H is a function of nature of gas and is different for different gases at a given temperature.

144. (*c*) $p_{\text{total}} = x_1 p_1^\circ + x_2 p_2^\circ = (1 - x_2)p_1^\circ + x_2 p_2^\circ$

$$= p_1^\circ + (p_2^\circ - p_1^\circ)x_2$$

Following conclusions can be drawn from the above equation.

(i) Total vapour pressure over the solution can be related to the mole fraction of any one component.

(ii) Total vapour pressure over the solution varies linearly with the mole fraction of component 2.

(iii) Depending upon the vapour pressure of the pure components 1 and 2, total vapour pressure of the solution decreases or increases with the increase of mole fraction of component 1.

145. (*d*) The proportionality constant K_f depends on the nature of solvent and is known as freezing point depression constant or molal depression constant or cryoscopic constant. Unit of K_f is K kg mol^{-1}.

$$M_2 = \frac{K_f \times w_2 \times 1000}{\Delta T_f \times w_1}$$

where w_2 gram of solute having molar mass as M_2 is present in w_1 gram of solvent.

146. (*b*) Semipermeable membranes appear to be continuous sheet or films yet they contain network of submicroscopic holes or pores, through which small solvent molecules, like water can pass through these holes the passage of bigger molecules like solute is hindered.

147. (*a*) The flow of solvent from its side to solution across a semipermeable membrane can be stopped, if some extra pressure is applied on the solution. This pressure that just stops the flow of solvent is called osmotic pressure of the solution.

148. (*c*) The osmotic pressure method has the advantage over other methods as the pressure measurement is around the room temperature and the molality of the solution is used instead of molarity. As compared to other colligative properties, its magnitude is large even for very dilute solutions. This technique of osmotic pressure for determination of molar mass of solutes is particularly useful for biomolecules as they are generally not stable at higher temperature and polymers having poor solubility.

149. (*a*) $\text{Molality } (m) = \dfrac{\text{Number of moles of solute}}{\text{Weight of solvent(in kg)}}$

Number of moles of solute = 1

Weight of solvent = 1kg

Then, molality = 1, i.e. one molal glucose ($C_6H_{12}O_6$),

Molecular weight = 180

$\text{Number of moles} = \dfrac{180}{180} = 1$

Weight of water = 1kg

Hence, molality of the solution in one.

150. (*b*) $w = \dfrac{ENV}{1000}$

$$\Rightarrow N = \frac{1.575 \times 1000}{63 \times 250} \qquad [\because E \text{ of } H_2C_2O_4 \cdot 2H_2O = \frac{126}{2} = 63]$$

$= 0.1$ N

$H_2C_2O_4 \cdot 2H_2O$ is an organic acid which contains 2 molecules of water of crystallisation.

151. (*a*) Solids and liquids are highly incompressible and practically remain unaffected by change in pressure. That is why pressure does not have any significant effect on solubility of solids in liquids.

152. (*a*) Polar solutes dissolves in polar solvents and non-polar solutes in non-polar solvents. In general, a solute dissolves in a solvent, if the intermolecular interactions are similar in the two or we may say like dissolves like.

153. (*a*) When the divers come towards the surface, pressure gradually decreases. This releases the dissolved gases and leads to the formation of bubbles of nitrogen in the blood.

154. (*a*) Ethanol molecules shows hydrogen bonding. On adding acetone, its molecules get in between the host molecule and break some of hydrogen bonds between them. Due to weakening of interaction the mixture of ethanol and acetone shows the positive deviation from Raoult's law.

155. (*a*) In solution, the surface has both solute and solvent molecules, thereby the fraction of the surface covered by the solvent molecules get reduced. Consequently, the number of solvent molecules escaping from the surface is reduced, thus vapour pressure of the solution is also reduced.

156. (*c*) A pure component has sharp melting point. If any impurity is present, it lowers the melting point of the substance. Other methods like chromatography etc., can also be used to check the purity of substances.

157. (*c*) At the freezing point, the solid phase of a substance is in dynamic equilibrium with its liquid phase. A solution will freeze, when its vapour pressure becomes equals to the vapour pressure of the pure solid solvent.

When non-volatile solid is added to the solvent, its vapour pressure decreases and becomes equal to solid solvent at lower temperature.
Freezing point of the solvent is more than that of solution.

158. (*a*) The water pouch of instant cold pack for treating athletic injuries breaks when squeezed and NH_4NO_3 dissolves in water to lower the temperature. This is because addition of non-volatile solute into solvent results into depression of freezing point of the solvent.

159. (*a*) People taking a lot of salt or salty food experience water retention in tissue cells and intercellular spaces because of osmosis. The resulting puffiness or swelling is called edema.

160. (*a*) High blood pressure patients are advised not to have salt because Na^+ and Cl^- ion enter into body fluid by raising the concentration of solute which may rupture the blood cells.

161. (*d*) When there is dissociation of solute into ions, the experimentally determined molar mass is lower than the true value.

162. (*a*) In benzene, acetic acid dimerises but in water it does not. This is because benzene is non-polar, whereas water is polar. The number of particles become different in both the solvents.

Depression in freezing point is a colligative property, i.e. depends upon the number of particles in solution. Hence, molecular mass determined by depression in freezing point method comes out to be different.

163. (*b*) A $\rightarrow$ 1, B $\rightarrow$ 3, C $\rightarrow$ 2

164. (*a*) A $\rightarrow$ 2, B $\rightarrow$ 1, C $\rightarrow$ 4, D $\rightarrow$ 3.

165. (*c*) A $\rightarrow$ 3, B $\rightarrow$ 5, C $\rightarrow$ 1, D $\rightarrow$ 2, E $\rightarrow$ 4

166. (*b*) A $\rightarrow$ 3, B $\rightarrow$ 2, C $\rightarrow$ 1

167. (*c*) A $\rightarrow$ 2, B $\rightarrow$ 1, C $\rightarrow$ 3

KCl and K_2SO_4 being ionic, completely to give 2 and 5 ions respectively. Ethanoic acid only partially ionises, sold has. $i \approx 0.5$.

168. (*a*) A $\rightarrow$ p,r; B $\rightarrow$ r,s; C $\rightarrow$ q,r; D $\rightarrow$ p, q,r

All the given substances are homogeneous mixtures. Sucrose solution contains sucrose and water. Air is a mixture of different gases. Brass and amalgam are solid solutions.

169. (*c*) A $\rightarrow$ p,r,s; B $\rightarrow$ q,s; C $\rightarrow$ q; D $\rightarrow$ p,r

$$\text{Mass per cent} = \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 100$$

$$\text{Volume per cent} = \frac{\text{Volume of solute}}{\text{Volume of solution}} \times 100$$

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

$$\text{Molality} = \frac{\text{Moles of solute}}{\text{Weight of solvent (in kg)}}$$

Among these, only molarity and volume per cent depend upon temperature as these are the function of volume and volume varies with temperature.

170. (*b*) A $\rightarrow$ q,s; B $\rightarrow$ p,r; C $\rightarrow$ q,s; D $\rightarrow$ p,r

Hexane and heptane; chlorobenzene and bromobenzene are the mixtures that form ideal solutions, i.e. they follow Raoult's law in all conditions of T and p.

For such solutions.

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

Mixture of chloroform with acetone and water with nitric acid show negative deviation from Raoult's law. So for these pairs

$$A\text{—}B > A\text{—}A \text{ or } B\text{—}B \text{ interaction}$$

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

171. (*d*) A $\rightarrow$ q, B $\rightarrow$ p,r, C $\rightarrow$ q, D $\rightarrow$ p, r, s

Osmotic pressure and elevation in boiling point are the colligative properties.

Vapour pressure and freezing point decrease in the presence of solute.

$$\pi = CRT$$

or
$$\pi = \frac{n}{m} RT$$

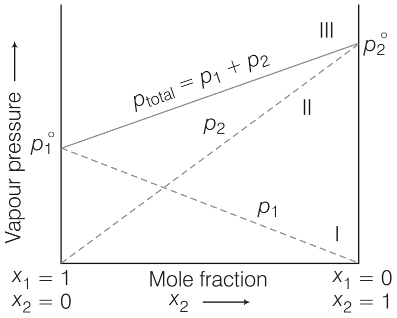
i.e. osmotic pressure varies inversely with molecular mass.

Elevation in boiling point, $\Delta T_b = K_b \cdot m$

where, $K_b =$ ebullioscopic constant

172. (*a*) $x_1 = 1$ signifies that only component 1 is present.

173. (*c*) These lines (I and II) pass through the points for which x_1 and x_2 are equal to unity. The plot (line III) of p_{total} *versus* x_2 is linear.



The plot of vapour pressure and mole fraction of an ideal solution at constant temperature i.e. the dashed lines I and II represent the partial pressure of the components. The total vapour pressure is given by line marked III.

174. (*b*) The minimum value of p_{total} is p_1° and maximum value is p_2°, assuming that component 1 is less volatile than component 2, i.e. $p_1^\circ < p_2^\circ$.

175. (*a*)
$$\begin{aligned}
\text{Molar mass of } CH_2Cl_2 &= 12 \times 1 + 1 \times 2 + 35.5 \times 2 \\
&= 85 \text{ g mol}^{-1} \\
\text{Molar mass of } CHCl_3 &= 12 \times 1 + 1 \times 1 + 35.5 \times 3 \\
&= 119.5 \text{ g mol}^{-1} \\
\text{Moles of } CHCl_3 &= \frac{25.5}{119.5} = 0.213 \text{ mol} \\
\text{Moles of } CH_2Cl_2 &= \frac{40 \text{ g}}{85 \text{ g mol}^{-1}} = 0.47 \text{ mol} \\
\text{Total number of moles} &= 0.47 + 0.213 = 0.683 \text{ mol} \\
x_{CH_2Cl_2} &= \frac{0.47 \text{ mol}}{0.683 \text{ mol}} = 0.688 \\
x_{CHCl_3} &= 1.00 - 0.688 = 0.312
\end{aligned}$$

Using equation,
$$\begin{aligned}
p_{\text{total}} &= p_1^\circ + (p_2^\circ - p_1^\circ) x_2 \\
&= 200 + (415 - 200) \times 0.688 \\
&= 200 + 147.9 \\
&= 347.9 \text{ mm Hg}
\end{aligned}$$

176. (*c*) Using the relation $y_1 = \dfrac{p_1}{p_{\text{total}}}$, we can calculate the mole fractions of the components in the gas phase (y_i).

$$\begin{aligned}
p_{CH_2Cl_2} &= 0.688 \times 415 \text{ mm Hg} = 285.5 \text{ mm Hg} \\
p_{CHCl_3} &= 0.312 \times 200 \text{ mm Hg} = 62.4 \text{ mm Hg} \\
y_{CH_2Cl_2} &= 285.5 \text{ mm Hg} / 347.9 \text{ mm Hg} = 0.82 \\
y_{CHCl_3} &= 62.4 \text{ mmHg} / 347.9 \text{ mm Hg} = 0.18
\end{aligned}$$

177. (*a*) CH_2Cl_2 is more volatile component than $CHCl_3$, [$p^\circ_{CH_2Cl_2} = 415$ mm Hg and $p^\circ_{CHCl_3} = 200$ mmHg] and the vapour phase is also richer in CH_2Cl_2 [$y_{CH_2Cl_2} = 0.82$ and $y_{CHCl_3} = 0.18$].

178. (*c*) Isotonic solutions have same molarity.

Molarity of 18 g glucose $= \frac{18}{180} / \frac{1000}{1000} = 0.1$

Molarity of 34.2 g sucrose $= \frac{34.2}{342} / \frac{1000}{1000} = 0.1$

Thus, 18 gL^{-1} glucose solution is isotonic with 34.2 gL^{-1} solution of sucrose.

179. (*a*) For solutions 1 and 2 the concentration in compartment *B* is higher than in *A*.

180. (*b*) In hypertonic solution, osmotic pressure is higher, therefore volume rise is higher in compartment *B*.

181. (*a*) Mass of solvent = 1000 g

Molar mass of urea (NH_2CONH_2) = 60 g mol^{-1}

0.25 mole of urea $= 0.25 \times 60 = 15$ g

Total mass of solution $= (1000 + 15)$g $= 1.015$ kg

$\because$ 1.015 kg of solution contain urea = 15 g

$\therefore$ 2.5 kg of solution will contain urea $= \frac{15}{1.015} \times 2.5 = 37$ g

182. (*a*) Assume that we have 100 g of solution (because percentage composition). Solution will contain 20 g of ethylene glycol and 80 g of water.

$$\text{Molar mass of } C_2H_6O_2 = 12 \times 2 + 6 \times 1 + 16 \times 2 = 62 \text{ g mol}^{-1}$$

$$\text{Moles of } C_2H_6O_2 = \frac{20}{62} = 0.322 \text{ mol}$$

$$\text{Moles of water} = \frac{80 \text{ g}}{18 \text{ g mol}^{-1}} = 4.444 \text{ mol}$$

$$\chi_{\text{glycol}} = \frac{\text{moles of } C_2H_6O_2}{\text{moles of } C_2H_6O_2 + \text{moles of } H_2O} = \frac{0.322 \text{ mol}}{0.322 \text{ mol} + 4.444 \text{ mol}} = 0.068$$

183. (*a*) 68% HNO_3 means

68 g of nitric acid in 100 g solution.

Density of the solution = 1.504 g mL^{-1}

$$\text{Moles of } HNO_3 = \frac{68}{63} = 1.079 \text{ mol}$$

$$[\because HNO_3 = 1 + 14 + 16 \times 3 = 63 \text{ g mol}^{-1}]$$

$$\text{Volume of the solution} = \frac{100}{1.504} = 66.5 \text{ mL} = 0.0665 \text{ L}$$

$$\text{Molarity of the solution} = \frac{1.079}{0.0665} = 16.23 \text{ M}$$

184. (*a*) Maximum molarity of CuS in aqueous solution

= Solubility of CuS in mol L^{-1}

$$CuS \rightleftharpoons \underset{S}{Cu^{2+}} + \underset{S}{S^{2-}}$$

$$K_{sp} = [Cu^{2+}][S^{2-}] = S \times S = S^2$$

$$S^2 = 6 \times 10^{-16},$$

$$S = \sqrt{6 \times 10^{-16}} = 2.45 \times 10^{-8} \text{ mol L}^{-1}$$

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

Further dissolution of sugar in water is an endothermic process (as cooling is produced).

Hence, high temperature will favour the dissolution of sugar in water.

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

(i) If it dissolves into solution then solution will be unsaturated.

(ii) If it does not dissolve in the solution then solution is known as saturated.

(iii) When solute get precipitated, solution is known as supersaturated solution.

187. (*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.

188. (*a*) From Henry's law,

$$p = K_H \times x$$

$$x = \frac{(760 \text{ mm of Hg})}{4.27 \times 10^5 \text{ mm of Hg}} = 178 \times 10^{-5} = 1.78 \times 10^{-3}$$

189. (*c*) $p = x\, p_{\text{total}}$; $p_{O_2} = 10 \times \frac{20}{100} = 2 \text{ atm} = 2 \times 760 \text{ mm}$

$$p_{N_2} = 10 \times \frac{79}{100} = 7.9 \text{ atm} = 7.9 \times 760 \text{ mm}$$

$$x_{O_2} = \frac{p_{O_2}}{K_H} = \frac{2 \times 760 \text{ mm}}{3.3 \times 10^7 \text{ mm}} = 4.6 \times 10^{-5}$$

$$x_{N_2} = \frac{p_{N_2}}{K_H} = \frac{7.9 \times 760 \text{ mm}}{6.51 \times 10^7 \text{ mm}} = 9.22 \times 10^{-5}$$

190. (*a*) $n_{\text{benzene}} = \frac{80 \text{ g}}{78 \text{ g mol}^{-1}} = 1.026 \text{ mol}$

$$n_{\text{naphthalene}} = \frac{100}{128} = 0.781 \text{ mol}$$

$$x_{\text{benzene}} = \frac{1.026}{1.026 + 0.781} = 0.568$$

$$x_{\text{naphthalene}} = 1 - 0.568 = 0.432$$

$$p_{\text{benzene}} = p^{\circ}_{\text{benzene}} \times x_{\text{benzene}} = 50.71 \times 0.568 = 28.80 \text{ mm}$$

$$p_{\text{naphthalene}} = 32.06 \times 0.432 = 13.85 \text{ mm}$$

$$p_{\text{total}} = 28.80 + 13.85 = 42.65 \text{ mm}$$

$$y_{\text{benzene}} \text{ in vapour phase} = \frac{x_{\text{benzene}} \times p^{\circ}_{\text{benzene}}}{p_{\text{total}}} = \frac{0.568 \times 50.71}{42.65} = 0.675$$

191. (*a*) The elevation (ΔT_b) in boiling point

$$= 354.11\text{ K} - 353.23\text{ K} = 0.88\text{ K}$$

$$\Delta T_b = \frac{K_f \times w_2 \times 10^3}{M_2 \times w_1} \text{ and } M_2 = \frac{K_f \times w_2 \times 10^3}{\Delta T_b \times w_1}$$

$$\therefore \quad M_2 = \frac{2.53\text{ K kg mol}^{-1} \times 1.8\text{ g} \times 1000\text{ g kg}^{-1}}{0.88\text{ K} \times 90\text{ g}}$$

$$\approx 58\text{ g mol}^{-1}$$

Therefore, molar mass of the solute, $M_2 = 58\text{ g mol}^{-1}$

192. (*d*) $M_2 = \dfrac{K_f \times w_2 \times 1000}{\Delta T_f \times w_1}$

where, $w_1 \rightarrow$ mass of solvent, $w_2 \rightarrow$ mass of solute and $M_2 \rightarrow$ molar mass of solute.

Substituting the values of various terms involved in equation

$$M_2 = \frac{5.12\text{ K kg mol}^{-1} \times 1.00\text{ g} \times 1000\text{ g kg}^{-1}}{0.40\text{K} \times 50\text{ g}} = 256\text{ g mol}^{-1}$$

Thus, molar mass of the solute $= 256\text{ g mol}^{-1}$

193. (*b*) K_2SO_4 dissolved $= 25\text{ mg} = 0.025\text{ g}$

Volume $= 2$ L; Temperature, $T = 298$ K

Molar mass of $K_2SO_4 = 174\text{ g mol}^{-1}$

K_2SO_4 dissociates into 2 K^+ and SO_4^{2-} ions, so $i = 3$

$$\pi = iCRT$$

$$\pi = i \times \frac{w}{M} \times \frac{RT}{V}$$

$$= 3 \times \frac{0.025}{174} \times \frac{1}{2} \times 0.0821 \times 298$$

$$= 5.27 \times 10^{-3}\text{ atm}$$

194. (*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, $\quad M_1V_1 = M_2V_2$

$$0.02 \times 4\text{L} = M_2 \times 5\text{L}$$

$$M_2 = \frac{0.08}{5} = 0.016\text{ M}$$

195. (*a*) In pure methanol, molecules are hydrogen bonded. On adding acetone, its molecules come 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 of 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 in between the solute-solute and solvent-solvent molecules.

196. (*b*) For an ideal solution, the *A—A* or *B—B* type intermolecular interaction are equal to *A—B* type interactions. Here, a mixture of bromoethane and chloroethane is an example of ideal solution. So it follows Raoult's law.

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

197. (*b,d*) 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* interactions. 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.

Moreover due to weak *A—B* interactions, the molecules of *A*(or *B*) will find it easier to escape and hence, vapour pressure of the solution increases.

198. (*b*) Colligative properties depend upon the number of solute particles present in solution irrespective of their nature.

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

Hence, vapour pressure also gets reduced.

200. (*a*) According to Raoult's law, $p = p^\circ \times x_A$

201. (*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.

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

Solution	van't Hoff factor (*i*)
0.01 M glucose	1
0.01 M $MgCl_2$	3

Hence, depression in freezing point of $MgCl_2$ is about 3 times of glucose.

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

204. (*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 semipermeable 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.

From solvent to solution side, solvent move spontaneously without applying pressure on any side.

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

206. (*b*) Number of total ions present in the solution in case of 100% ionisable substances is known as van't Hoff factor (i).

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

207. (*a*) According to the 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. That is why two different solutions of sucrose of same molality prepared in different solvents will have different depression in freezing point.

208. (*b*) van't Hoff factor is the measurement of total concentration ions present in the solution.

Therefore, greater the concentration of solution, greater will be its van't Hoff factor.

A	0.1 M	On moving top to bottom concentration decreases and van't Hoff factor (i) also decreases.
B	0.01 M	
C	0.001 M	

209. (*a,b*) Solubility of gaseous solute in the fixed volume of liquid solvent always depends upon the nature of solute but also it depends upon pressure at constant temperature and temperature at constant pressure.

210. (*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 mixtures of benzene-toluene and *n*-hexane-*n* -heptane are the examples of ideal solutions.

211. (*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.

212. (*c,d*) Benzene and toluene form ideal solution and for an ideal solution intermolecular forces between two benzene molecules are nearly of same strength as those of between two toluene molecules. For such solutions,

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

Azeotropes are formed only by non-ideal solutions.

213. (*a,b*) When any one of the components of binary mixture either solvent or solute is non-volatile, it causes deviation in vapour pressure of solution which causes change in its colligative properties.

214. (*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.

215. (*a*) $\text{Molarity } (M) = \dfrac{\text{Moles of solute}}{\text{Volume of solution (in L)}}$

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

216. (*d*) When methyl alcohol is added to water, boiling point of water decreases because when a volatile solute is added to a volatile solvent depression in boiling point is observed.

217. (*a*) When NaCl is added to water, a depression in freezing point is observed. This is due to lowering of vapour pressure of the solution. Lowering of vapour pressure is observed because some surface is occupied by solute (non-volatile) molecules.

218. (*b*) 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. This process is called osmosis. However, in case of diffusion, solvent always move from a region of high concentration solution to a region of low concentration solution.

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

220. (*d*) 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 (solid) 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.

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