SOLUTIONS

IMPORTANT FORMULAE

In the formulae given below, A represents solvent and B represents solute, also

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 d = Density of solution

GEM = Gram Equivalent Mass GMM = Gram Molecular Mass

1. Mass percentage $(w/w) = \dfrac{W_B}{W_A + W_B} \times 100$

Volume percentage $(V/V) = \dfrac{V_B}{V_A + V_B} \times 100$

Mass by volume percentage $\left(\dfrac{w}{V}\right) = \dfrac{W_B \times 100}{V\text{ (mL)}}$

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

2. Mole fraction of A, $x_A = \dfrac{n_A}{n_A + n_B}$

Mole fraction of B, $x_B = \dfrac{n_B}{n_A + n_B}$

$$x_A + x_B = 1$$

3. Molarity $(M) = \dfrac{\text{Moles of solute}}{\text{Volume of solution in litre}} = \dfrac{n_B}{V\text{ (in L)}} = \dfrac{W_B}{M_B \times V\text{ (in L)}}$

4. Molality $(m) = \dfrac{\text{Moles of solute}}{\text{Mass of solvent in kg}} = \dfrac{n_B}{W_A\text{(in kg)}}$ or $m = \dfrac{W_B \times 1000}{M_B \times W_A\text{ (in g)}}$

5. Normality $(N) = \dfrac{\text{Gram equivalents of solute}}{\text{Volume of solution in litre}} = \dfrac{W_B}{GEM\text{ of solute} \times V\text{ (in L)}}$

6. Relationship between Molarity and Normality

The normality (N) and molarity (M) of a solution are related as follows:

Normality × Equivalent mass (solute) = Molarity × Molar mass (solute)

7. Relationship between Molarity and Normality with Mass percentage (p)

If p is the mass percentage and d is the density of the solution then

$$\text{Molarity} = \frac{p \times d \times 10}{\text{Molecular mass (solute)}};$$

$$\text{Normality} = \frac{p \times d \times 10}{\text{Equivalent mass (solute)}}$$

8. **Relationship between Molarity (M) and Molality (m)**

$$m = \frac{1000 \times M}{(1000 \times d) - (M \times GMM_B)}$$

9. **Relationship between Molality (m) and Mole fraction of solute (x_B)**

$$x_B = \frac{m \times GMM_A}{1000 + m \times GMM_A}$$

Also, $$m = \frac{1000 x_B}{x_A \times GMM_A}$$

10. **Dilution formula:** If the solution of some substance is diluted by adding solvent from volume V_1 to volume V_2, then

$$M_1V_1 = M_2V_2$$

Similarly, $$N_1V_1 = N_2V_2$$

11. **Molarity of a mixture:** If V_1 mL of a solution of molarity M_1 is mixed with another solution of same substance with volume V_2 and molarity M_2 then molarity of the resulting mixture of solution (M) can be obtained as:

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

12. **Relationship between molarity (M) and mole fraction of solute (x_B)**

$$x_B = \frac{M \times GMM_A}{M(GMM_A - GMM_B) + 1000d}$$

Also, $$M = \frac{1000 \times d \times x_B}{x_A \times GMM_A + x_B \times GMM_B}$$

13. **Raoult's law for volatile solute**

$$p_A = p_A^{\circ} x_A \quad \text{and} \quad p_B = p_B^{\circ} x_B$$

where p_A and p_B are partial vapour pressures of component 'A' and component 'B' in the solution. p_A° and p_B° are vapour pressures of pure components 'A' and 'B' respectively.

Total vapour pressure, $p = p_A + p_B = p_A^{\circ} x_A + p_B^{\circ} x_B$

14. **Raoult's law for non-volatile solute**

$$\frac{p_A^{o} - p}{p_A^{o}} = x_B = \frac{n_B}{n_A + n_B} = \frac{n_B}{n_A} = \frac{W_B}{M_B} \times \frac{M_A}{W_A}$$ (For a dilute solution $n_B << n_A$).

$$M_B = \left(\frac{p_A^{o}}{p_A^{o} - p_A}\right)\frac{W_B \times M_A}{W_A}$$

where x_B is mole fraction of solute and $\frac{p_A^{o} - p_A}{p_A^{o}}$ is relative lowering of vapour pressure.

15. **Elevation in boiling point:**

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

$$\Delta T_b = \frac{K_b \times W_B \times 1000}{M_B \times W_A}$$

or, $$M_B = \frac{K_b \times W_B \times 1000}{\Delta T_b \times W_A}$$

where, $$\Delta T_b = T_b - T_b^{\circ}$$

16. Depression in freezing point:

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

$$\Delta T_f = \frac{K_f \times W_B \times 1000}{M_B \times W_A}$$

or,
$$M_B = \frac{K_f \times W_B \times 1000}{\Delta T_f \times W_A}$$

17. Osmotic pressure (π)

$$\pi V = n_B RT$$

$$\pi V = \frac{W_B}{M_B} \times R \times T, \quad M_B = \frac{W_B \times R \times T}{\pi \times V}$$

$$\pi = \frac{n_B}{V} \times R \times T \quad \text{or} \quad \pi = CRT \text{ where '}C\text{' is molarity.}$$

Osmotic pressure is related to the relative lowering of vapour pressure, elevation in boiling point and depression in freezing points according to the following relations:

$$\pi = \left(\frac{p_A^o - p_A}{p_A^o}\right) \times \frac{d \times R \times T}{M_B}$$

$$\pi = \frac{\Delta T_b \times d \times R \times T}{1000 \times K_b}$$

$$\pi = \frac{\Delta T_f \times d \times R \times T}{1000 \times K_f}$$

where d is the density of solution at temperature 'T'.

18. Molal elevation constant, $K_b = \dfrac{R \times M_A \times (T_b^o)^2}{1000 \times \Delta_{vap} H}$

19. Molal depression constant, $K_f = \dfrac{R \times M_A \times (T_f^o)^2}{1000 \times \Delta_{fus} H}$

MULTIPLE CHOICE QUESTIONS

Choose and write the correct option in the following questions.

1. A solution of amalgam of mercury with sodium contains

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

2. One kilogram of sea water sample contains 6 mg of dissolved O_2. The concentration of O_2 in ppm in the sample is

(*a*) 0.06 (*b*) 60 (*c*) 6 (*d*) 0.6

3. Mole fraction of the solute in a 1.0 molal aqueous solution is:

(*a*) 0.1770 (*b*) 0.0177 (*c*) 0.0344 (*d*) 1.7700

4. At what concentration does the solution of ethylene glycol used as an antifreeze?

(*a*) 35% volume by volume (*b*) 35% mass by volume
(*c*) 35% mass by mass (*d*) 35 ppm

5. 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? *[NCERT Exemplar]*

(*a*) Sugar crystals in cold water. (*b*) Sugar crystals in hot water.

(*c*) Powdered sugar in cold water. (*d*) Powdered sugar in hot water.

6. At equilibrium the rate of dissolution of a solid solute in a volatile liquid solvent is _________. *[NCERT Exemplar]*

(*a*) less than the rate of crystallisation (*b*) greater than the rate of crystallisation

(*c*) equal to the rate of crystallisation (*d*) zero

7. The value of Henry's constant K_H is ____________. *[NCERT Exemplar]*

(*a*) greater for gases with higher solubility. (*b*) greater for gases with lower solubility.

(*c*) constant for all gases. (*d*) not related to the solubility of gases.

8. Low concentration of oxygen in the blood and tissues of people living at high altitude is due to __________. *[NCERT Exemplar]*

(*a*) low temperature

(*b*) low atmospheric pressure

(*c*) high atmospheric pressure

(*d*) both low temperature and high atmospheric pressure

9. 50 mL of an aqueous solution of glucose $C_6H_{12}O_6$ (Molar mass : 180 g/mol) contains 6.02×10^{22} molecules. The concentration of the solution will be *[CBSE 2020 (56/2/1)]*

(*a*) 0.1 M (*b*) 0.2 M (*c*) 1.0 M (*d*) 2.0 M

10. A solution of chloroform in diethylether

(*a*) obeys Raoult's law. (*b*) shows a positive deviation from Raoult's law.

(*c*) shows a negative deviation from Raoult's law. (*d*) behaves like a near ideal solution.

11. Considering the formation, breaking and strength of hydrogen bond, predict which of the following mixtures will show a positive deviation from Raoult's law? *[NCERT Exemplar]*

(*a*) Methanol and acetone. (*b*) Chloroform and acetone.

(*c*) Nitric acid and water. (*d*) Phenol and aniline.

12. The system that forms maximum boiling azeotropes is:

(*a*) ethyl alcohol-water (*b*) benzene-toluene

(*c*) acetone-chloroform (*d*) carbon disulphide-acetone

13. At a given temperature, osmotic pressure of a concentrated solution of a substance ____________. *[NCERT Exemplar]*

(*a*) is higher than that of a dilute solution.

(*b*) is lower than that of a dilute solution.

(*c*) is same as that of a dilute solution.

(*d*) cannot be compared with osmotic pressure of dilute solution.

14. An unripe mango placed in a concentrated salt solution to prepare pickle, shrivels because ____________. *[NCERT Exemplar]*

(*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.

15. If we place the blood cells in a solution containing less than 0.9% (m/V) sodium chloride. They would swell. This is because

(*a*) the solution is hypotonic (*b*) the solution is isotonic

(*c*) the solution is hypertonic (*d*) none of these

16. Which of the following colligative property is used to calculate the molar mass of biomolecules?

(*a*) Relative lowering of vapour pressure (*b*) Elevation in boiling point

(*c*) Depression in freezing point (*d*) Osmotic pressure

17. Which of the following statements is false? **[*NCERT Exemplar*]**

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

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

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

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

18. Molal elevation constant is calculated from the enthalpy of vapourisation ($\Delta_{vap}H$) and boiling point of the pure solvent ($T°$) using the relation:

(*a*) $K_b = \dfrac{M_A RT^{\circ 2}}{1000\,\Delta_{vap}H}$ (*b*) $K_b = \dfrac{1000\,RT^2}{M_A \Delta_{vap}H}$ (*c*) $K_b = \dfrac{\Delta_{vap}H}{1000\,M_A RT^{\circ 2}}$ (*d*) $K_b = \dfrac{1000\,M_A T^{\circ 2}}{\Delta_{vap}HR}$

19. Which of the following statements is false? **[*NCERT Exemplar*]**

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

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

(*c*) Decreasing order of osmotic pressure for 0.01 M aqueous solutions of barium chloride, potassium chloride, acetic acid and sucrose is $BaCl_2 > KCl > CH_3COOH >$ 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.

20. When KCl is dissolved in water, the

(*a*) boiling point of the solution decreases

(*b*) boiling point of the solution increases

(*c*) boiling point of the solution remains unchanged

(*d*) none of the above

21. Compared to Puri, the vapour pressure of water at Delhi is

(*a*) equal (*b*) more (*c*) less (*d*) none of these

22. A sample of hard water was found to contain 40 mg of $MgSO_4$ in 10 kg of sample. The ppm of $MgSO_4$ in the sample will be

(*a*) 2 ppm (*b*) 4 ppm (*c*) 8 ppm (*d*) 15 ppm

23. If the molarity of a solution of sulphuric acid is 1.35 M, then its molality will be (The density of the acid solution is 1.02 g cm^{-3})

(*a*) 3.43 m (*b*) 1.80 m (*c*) 1.52 m (*d*) 2.39 m

24. If Molarity of dilute solution is doubled, the value of molal depression constant (K_f) will be

(*a*) halved (*b*) tripled (*c*) unchanged (*d*) doubled

25. When dry grapes or raisins are placed in water, they swell due to

(*a*) osmosis (*b*) diffusion (*c*) surface tension (*d*) absorption

26. The mixture that forms minimum boiling azeotrope is

(*a*) Methanol-acetic acid (*b*) Chloroform-benzene

(*c*) Water-nitric acid (*d*) *n*-hexane-acetone

27. When an egg is placed in concentrated solution of sodium chloride, it shrinks due to

(*a*) exosmosis (*b*) endosmosis (*c*) diffusion (*d*) surface tension

28. When a non-volatile solute in dissolved in water

(*a*) The boiling point increases (*b*) The vapour pressure decreases

(*c*) The freezing point decreases (*d*) All of the above

29. Which of the following concentration term is not affected by the temperature?

(*a*) Molarity (*b*) Normality (*c*) Molality (*d*) $\frac{w}{v}$%

30. Which of the following is affected by the temperature?

(*a*) Molarity (*b*) Normality (*c*) $\frac{w}{v}$% (*d*) All of the above

31. The solubility of a solid in liquid does not depend upon

(*a*) nature of solute and solvent (*b*) temperature

(*c*) pressure (*d*) all of the above

32. If 5.85 g of NaCl is dissolved in 90 g of water, then the mole-fraction of solute is

(*a*) 0.1 (*b*) 0.2 (*c*) 0.01 (*d*) 0.0196

33. Boiling point of water in a pressure cooker is

(*a*) below 100°C (*b*) above 100°C (*c*) equal to 100°C (*d*) none of the above

34. The molarity of water is

(*a*) 18 (*b*) 55.5 (*c*) 80 (*d*) 49.9

35. Which one of the following is a colligative property?

(*a*) The half life of a radioactive element (*b*) The conductance of solution

(*c*) The surface tension of solution (*d*) The osmotic pressure of solution

36. The relative lowering of vapour pressure is equal to the mole fraction of solute. The law is known as

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

(*c*) Ostwald's dilution law (*d*) Van't Hoff law

37. Isotonic solutions have the same

(*a*) viscosity (*b*) molar concentration (*c*) boiling point (*d*) density

38. If 18 g glucose is present in 1000 g of a solvent, the solution will be

(*a*) 1 molar (*b*) 0.1 molar (*c*) 0.5 molal (*d*) 0.1 molal

39. At constant temperature, the osmotic pressure of a solution is

(*a*) directly proportional to the concentration.

(*b*) inversely proportional to the concentration.

(*c*) directly proportional to the square of the concentration.

(*d*) independent of concentration.

40. When a non-volatile solute is dissolved in a pure solvent

(*a*) freezing point of the solution is decreased.

(*b*) freezing point of the solution is increased.

(*c*) boiling point of the solution is decreased.

(*d*) Both (*a*) and (*c*).

41. Which one of the following is not a colligative property?

(*a*) Relative lowering of vapour pressure (*b*) Osmotic pressure

(*c*) Elevation of boiling point (*d*) None of these

42. Osmotic pressure of a sugar solution at 24°C is 2.5 atm. The concentration of the solution in moles/litre is

(*a*) 10.25 (*b*) 1.025 (*c*) 1025 (*d*) 0.1025

43. Elevation of boiling point was 0.52°C when 6 g of a compound X was dissolved in 100 g of water. Molecular weight of X is (K_b = 0.52 Km^{-1}.)

(*a*) 120 kg/mol (*b*) 60 kg/mol (*c*) 180 kg/mol (*d*) 342 kg/mol

44. Number of moles of the solution per litre of the solution is

(*a*) molality (*b*) molarity (*c*) normality (*d*) formality

45. The boiling point of a solution containing a non-volatile solute is

(*a*) depressed (*b*) elevated (*c*) remain unchanged (*d*) none of these

46. An aqueous solution of methanol in water has vapour pressure

(*a*) equal to that of water (*b*) equal to that of methanol
(*c*) more than that of water (*d*) less than that of water

47. 5 mL N HCl, 20 mL N/2H_2SO_4 and 30 mL $\frac{N}{3}$ HNO_3 are mixed together and the volume is made to one litre. The normality of the resulting solution is

(*a*) N/5 (*b*) N/10 (*c*) N/20 (*d*) N/40

48. 500 mL of an aqueous solution of glucose contains 6×10^{22} molecules. The concentration of the solution is

(*a*) 0.1 M (*b*) 0.2 M (*c*) 1.0 M (*d*) 2.0 M

49. If NaCl is added to ice, then the melting point of ice will

(*a*) increase (*b*) decrease
(*c*) remains unchanged (*d*) first increase then decrease

50. A solution is a

(*a*) heterogeneous mixture (*b*) homogeneous mixture
(*c*) colloidal sol (*d*) gel

51. An ideal solution is the one which obeys

(*a*) Raoult's law (*b*) Henry's law (*c*) Both (*a*) and (*b*) (*d*) None of these

52. Real solution shows deviation from Raoult's law

(*a*) positive (*b*) negative (*c*) both (*a*) and (*b*) (*d*) none of these

53. If RBC is placed in 0.91% NaCl solution then it will

(*a*) shrink (*b*) swell
(*c*) neither shrink nor swell (*d*) either shrink or swell

54. Chlorobenzene-bromobenzene system is an example of

(*a*) ideal solution (*b*) non-ideal solution with positive deviation
(*c*) non-ideal solution with negative deviation (*d*) none of these

55. The number of moles of each of the following in 20 g will be

(*i*) $C_6H_{12}O_6$ (*ii*) CH_3OH (*iii*) CH_3COOH

(*a*) 0·111, 0·333, 0·625 (*b*) 0·333, 0·625, 0·111 (*c*) 0·111, 0·625, 0·333 (*d*) 0·625, 0·333, 0·111

56. Increase of temperature of an aqueous solution will cause

(*a*) decrease in molality (*b*) decrease in molarity
(*c*) decrease in mole fraction (*d*) decrease in % (w/W)

57. In cold countries, glycol is added to water in car radiators during winter. It results in

(*a*) lowering in boiling point. (*b*) reducing the viscosity.
(*c*) reducing the specific heat. (*d*) lowering in freezing point.

58. The concentration of a cane-sugar solution which is isotonic with 0.86% solution of urea (mol. wt. = 60 g/mol) is

(*a*) 4.9% (*b*) 3% (*c*) 5.8% (*d*) 8.4%

59. Partial pressure of a solution component is directly proportional to its mole fraction. This statement is known as

(*a*) Henry's law (*b*) Raoult's law (*c*) Distribution law (*d*) Ostwald's dilution law

60. At high altitude, the boiling point of water is lower because

(*a*) atmospheric pressure is low (*b*) temperature is low
(*c*) atmospheric pressure is high (*d*) none of these

61. For an aqueous solution, freezing point is –0.186°C. Elevation of the boiling point of the same solution is (K_f = 1.86°C mol^{-1} kg and K_b = 0.512°C mol^{-1} kg)

(*a*) 0.186°C (*b*) 0.0512°C (*c*) 1.86°C (*d*) 5.12°C

62. In a mixture of A and B, components show negative deviation when

(*a*) A–B interaction is stronger than A–A and B–B interaction

(*b*) A–B interaction is weaker than A–A and B–B interaction

(*c*) $\Delta V_{mix} > 0, \Delta S_{mix} > 0$

(*d*) $\Delta V_{mix} = 0, \Delta S_{mix} > 0$

63. 25ml of a solution of barium hydroxide on titration with a 0.1molar solution of hydrochloric acid gave a titre value of 35ml. The molarity of barium hydroxide solution will be

(*a*) 0.07 (*b*) 0.14 (*c*) 0.28 (*d*) 0.35

64. If liquids A and B form an ideal solution, the

(*a*) enthalpy of mixing is zero

(*b*) entropy of mixing is zero

(*c*) free energy of mixing is zero

(*d*) free energy as well as the entropy of mixing is zero.

65. Which one of the following statements is false?

(*a*) Raoult's law states that the vapour pressure of a component over a solution is proportional to its mole fraction.

(*b*) The osmotic pressure (π) of a solution is given by the equation π = MRT, where M is the molarity of the solution.

(*c*) The correct order of osmotic pressure for 0.01 M aqueous solution of each compound is $BaCl_2 > KCl > CH_3COOH >$ sucrose.

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

66. Equimolar solutions in the same solvent will have

(*a*) different boiling and different freezing points.

(*b*) same boiling and same freezing points.

(*c*) same freezing point but different boiling point.

(*d*) same boiling point but different freezing point.

67. The glucose solution to be injected into the blood stream and the blood itself should have the same.

(*a*) viscocity (*b*) vapour pressure (*c*) molarity (*d*) osmotic pressure

68. The most commonly used artificial semi-permeable membrane is chemically

(*a*) potassium ferrocyanide (*b*) copper sulphate

(*c*) copper ferricyanide (*d*) copper ferrocyanide

69. A mixture of ethyl alcohol and propyl alcohol has a vapour pressure of 290 mm Hg at 300 K. The vapour pressure of propyl alcohol is 200 mm Hg. If the mole fraction of ethyl alcohol is 0.6, its vapour pressure (in mm Hg) at the same temperature will be

(*a*) 360 (*b*) 350 (*c*) 300 (*d*) 700

70. At 80° C, the vapour pressure of pure liquid A is 520 mm Hg and that of pure liquid B is 1000 mm Hg. If a mixture solution of A and B boils at 80° C and 1 atm pressure, the amount of A in the mixture is

(*a*) 52 mol percent (*b*) 34 mol percent (*c*) 48 mol percent (*d*) 50 mol percent

71. The vapour pressure of water at 20°C is 17.5mm Hg. If 18 g of glucose ($C_6H_{12}O_6$) is added to 178.2 g of water at 20°C, the vapour pressure of the resulting solution will be

(*a*) 0.175 mm Hg (*b*) 17.325 mm Hg (*c*) 0.157 mm Hg (*d*) 16.83 mm Hg

72. A 5.2 molal aqueous solution of methyl alcohol, CH_3OH, is supplied. The mole fraction of methyl alcohol in the solution will be

(*a*) 0.100 (*b*) 0.190 (*c*) 0.086 (*d*) 0.050

73. Camphor is often used in molecular mass determination of naphthalene by Rast method because

(*a*) it is readily available
(*b*) it has a very high cryoscopic constant
(*c*) it is volatile
(*d*) it is solvent for organic substances

74. A solution of urea (mol. mass 56 g mol^{-1}) boils at 100.18°C at the atmospheric pressure. If K_f and K_b for water are 1.86 and 0.512 K kg mol^{-1} respectively, the above solution will freeze at

(*a*) 0.654°C (*b*) – 0.654°C (*c*) 6.54°C (*d*) – 6.54°C

75. The vapour pressure of two liquids P and Q are 80 and 60 torr, respectively. The total vapour pressure of solution obtained by mixing 3 mole of P and 2 mol of Q would be

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

76. A solution containing 10 g per dm^3 of urea (molecular mass = 60 g mol^{-1}) is isotonic with a 5% solution of a non-volatile solute. The molecular mass of the non-volatile solute is

(*a*) 200 g mol^{-1} (*b*) 250 g mol^{-1} (*c*) 300 g mol^{-1} (*d*) 350 g mol^{-1}

77. 1.00 g of a non-electrolyte solute (molar mass 250 g mol^{-1}) was dissolved in 51.2 g of benzene. If the freezing point depression constant, K_f of benzene is 5.12 K kg mol^{-1}, the freezing point of benzene will be lowered by

(*a*) 0.2 K (*b*) 0.4 K (*c*) 0.3 K (*d*) 0.5 K

78. A solution of acetone in ethanol

(*a*) obeys Raoult's law.
(*b*) shows a negative deviation from Raoult's law.
(*c*) shows a positive deviation from Raoult's law.
(*d*) behaves like a near ideal solution.

79. The factor $\frac{\Delta T_b}{K_b}$ represents

(*a*) molality (*b*) normality (*c*) formality (*d*) molarity

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

(*a*) shows negative deviation from Raoult's law
(*b*) shows no deviation from Raoult's law
(*c*) shows positive deviation from Raoult's law
(*d*) is saturated

81. During osmosis, flow of water through a semipermeable membrane is

(*a*) from solution having lower concentration only
(*b*) from solution having higher concentration only
(*c*) from both sides of semipermeable membrane with equal flow rates
(*d*) from both sides of semipermeable membrane with unequal flow rates.

82. If 0.1 M solution of glucose and 0.1 M solution of urea are placed on two sides of the semipermeable membrane to equal heights, then it will be correct to say that

(*a*) there will be no net movement across the membrane.
(*b*) glucose will flow towards urea solution.
(*c*) urea will flow towards glucose solution.
(*d*) water will flow from urea solution to glucose.

83. The relationship between osmotic pressure at 273 K when 10 g glucose (π_1), 10 g urea (π_2), and 10 g sucrose (π_3) are dissolved in 250 mL of water is

(*a*) $\pi_2 > \pi_1 > \pi_3$ (*b*) $\pi_2 > \pi_3 > \pi_1$ (*c*) $\pi_1 > \pi_2 > \pi_3$ (*d*) $\pi_3 > \pi_1 > \pi_2$

84. 200 mL of an aqueous solution of a protein contains 1.26 g of protein. The osmotic pressure of this solution at 300 K is found to be 2.57 × 10^{-3} bar. The molar mass of protein will be (R = 0.083 L bar mol^{-1}K^{-1})

(*a*) 51022 g mol^{-1} (*b*) 122041 g mol^{-1} (*c*) 31011 g mol^{-1} (*d*) 61039 g mol^{-1}

85. The number of grams of dibasic acid (mol. weight 200) should be present in 100 mL of the aqueous solution to give strength of 0.1 N is

(*a*) 10 g (*b*) 2 g (*c*) 1 g (*d*) 20 g

86. The boiling point of water (100°C) becomes 100.52°C, if 3 g of a non-volatile solute is dissolved in 200 g of water. The molecular weight of solute is (K_b for water = 0.6 K/m)

(*a*) 17.31 g mol^{-1} (*b*) 15.42 mol^{-1} (*c*) 12.20 g mol^{-1} (*d*) 20.46 g mol^{-1}

87. Boiling point of benzene is 353.23 K. When 1.8 g of non-volatile solute is dissolved in 90 g of benzene, boiling point is raised to 354.11 K. If K_b (benzene) is 2.53 K kg mol^{-1}, then the molecular mass of non-volatile substance is

(*a*) 58 g mol^{-1} (*b*) 120 g mol^{-1} (*c*) 116 g mol^{-1} (*d*) 60 g mol^{-1}

88. Vapour pressure of benzene at 30°C is 121.8 mm of Hg. When 15 g of a non-volatile solute is dissolved in 250 g of benzene. its vapour pressure is decreased to 120.2 mm of Hg. The molecular weight of the solute is

(*a*) 35.67 g (*b*) 354.8 g (*c*) 432.8 g (*d*) 502.7 g

89. The vapour pressure of CCl_4 at 25°C is 143 mm Hg. If 0.5 g of a non-volatile solute (mol. weight = 65 g mol^{-1}) is dissolved in 100 mL CCl_4, the vapour pressure of the solution will be (Density of CCl_4 = 1.58 g cm^{-3})

(*a*) 19934 mm Hg (*b*) 143.99 mm Hg (*c*) 141.93 mm Hg (*d*) 94.39 mm Hg

90. The vapour pressure of a solvent is decreased by 10 mm of mercury when a non-volatile solute was added to the solvent. The mole fraction of the solute in the solution is 0.2. If the decrease in the vapour pressure is to be 20 mm of mercury then the mole fraction of the solvent will be

(*a*) 0.4 (*b*) 0.6 (*c*) 0.8 (*d*) 0.2

91. The osmotic pressure of a solution containing 0.3 mol of solute per litre at 273 K is

(*a*) $\frac{0.3}{1} \times \frac{273}{0.0821}$ atm (*b*) $0.3 \times 2 \times 0.0821 \times 273$ atm

(*c*) $\frac{0.3}{1} \times 0.0821 \times 273$ atm (*d*) $\frac{1}{0.3} \times 0.0821 \times 273$ atm

92. If 1.0 molal aqueous solution of a substance boils at 100.55 °C ; then it freezes at approximately (K_b = 0.51 °C kg mol^{-1} and K_b = 1.86 °C kg mol^{-1})

(*a*) 272 K (*b*) 271 K (*c*) 375 K (*d*) 274 K

93. The mole fraction of solute in its one molal aqueous solution will be

(*a*) 0.108 (*b*) 0.018 (*c*) 0.008 (*d*) None of these

94. The mole-fraction of solute in an aqueous solution of a substances having strength 4.5 m?

(*a*) 0.75 (*b*) 0.075 (*c*) 0.45 (*d*) 0.045

95. An aqueous solution of 1.00 molal in KI. Which change will cause the vapour pressure of the solution to increase?

(*a*) Addition of NaCl (*b*) Addition of Na_2SO_4

(*c*) Addition of 1.00 molal KI (*d*) Addition of water

96. A solution of sucrose (molar mass = 342 g mol^{-1}) has been prepared by dissolving 68.5 g of sucrose in 1000 g of water. The freezing point of the solution obtained will be (K_f for water = 1.86°C kg mol^{-1})

(*a*) – 0.372 °C (*b*) – 0.520 °C (*c*) + 0.372 °C (*d*) – 0.570 °C

97. p_A and p_B are the vapour pressure of pure liquid components, *A* and *B*, respectively of an ideal binary solution. If χ_A represents the mole fraction of component A, the total pressure of the solution will be

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

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

(*a*) 173.91 mm Hg (*b*) 615.08 mm Hg (*c*) 90.64 mm Hg (*d*) 285.52 mm Hg

99. The number of grams of concentrated nitric acid that should be used to prepare 250 mL of 2.0M HNO_3 solution is (Given concentrated acid is 70% HNO_3)?

(*a*) 70.0 g conc. HNO_3 (*b*) 54.0 g conc. HNO_3 (*c*) 45.0 g conc. HNO_3 (*d*) 90.0 g conc. HNO_3

100. Which of the following is not satisfied by an ideal solution?

(*a*) $\Delta_{mix} V = 0$ (*b*) $\Delta_{mix} V \neq 0$

(*c*) Obeyance to Raoult's Law (*d*) $\Delta_{mix} H = 0$

101. Which of the following mixture will form maximum boiling azeotrope?

(*a*) conc. HNO_3 and water (*b*) Acetone and benzene

(*c*) Ethyl alcohol and water (*d*) Acetone and CS_2

102. Molal depression constant for water is 1.86 °C/m. The freezing point of a 0.05 molal solution of a non-electrolyte in water is

(*a*) –1.86° C (*b*) –0.93° C (*c*) –0.093° C (*d*) 0.93° C

103. The Henry's law is applicable only when

(*a*) the gas undergoes association or dissociation in the solution.

(*b*) the gas undergoes any chemical change.

(*c*) the pressure of the gas is not too high and temperature is not too low.

(*d*) All of the above

104. The vapour pressure of a liquid in a closed vessel depends upon

(*a*) surface area of the vessel. (*b*) amount of liquid.

(*c*) temperature. (*d*) none of the above.

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

(*a*) Water — hydrochloric acid (*b*) Benzene — methanol

(*c*) Water — nitric acid (*d*) Acetone — chloroform

106. A 5.25% solution of a substance is isotonic with a 1.5% solution of urea (molar mass = 60 g mol^{-1}) in the same solvent. If the densities of both the solutions are assumed to be equal to 1.0 gcm^{-3}, molar mass of the substance will be

(*a*) 210.0 g mol^{-1} (*b*) 90.0 g mol^{-1} (*c*) 115.0 g mol^{-1} (*d*) 105.0 g mol^{-1}

107. A solution has a 1:4 mole ratio of pentane to hexane. The vapour pressures of the pure hydrocarbons at 20°C are 440 mm Hg for pentane and 120 mm Hg for hexane. The mole fraction of pentane in the vapour phase is

(*a*) 0.200 (*b*) 0.549 (*c*) 0.786 (*d*) 0.478

Answers

1. (*c*)	**2.** (*c*)	**3.** (*b*)	**4.** (*a*)	**5.** (*d*)	**6.** (*c*)	**7.** (*b*)	**8.** (*b*)
9. (*d*)	**10.** (*c*)	**11.** (*a*)	**12.** (*d*)	**13.** (*a*)	**14.** (*d*)	**15.** (*a*)	**16.** (*d*)
17. (*b*)	**18.** (*a*)	**19.** (*a*)	**20.** (*b*)	**21.** (*c*)	**22.** (*b*)	**23.** (*c*)	**24.** (*c*)
25. (*a*)	**26.** (*d*)	**27.** (*a*)	**28.** (*d*)	**29.** (*c*)	**30.** (*d*)	**31.** (*c*)	**32.** (*d*)
33. (*b*)	**34.** (*b*)	**35.** (*d*)	**36.** (*b*)	**37.** (*b*)	**38.** (*d*)	**39.** (*a*)	**40.** (*a*)
41. (*d*)	**42.** (*d*)	**43.** (*b*)	**44.** (*b*)	**45.** (*b*)	**46.** (*c*)	**47.** (*d*)	**48.** (*b*)
49. (*b*)	**50.** (*b*)	**51.** (*a*)	**52.** (*c*)	**53.** (*c*)	**54.** (*a*)	**55.** (*c*)	**56.** (*b*)
57. (*d*)	**58.** (*a*)	**59.** (*b*)	**60.** (*b*)	**61.** (*b*)	**62.** (*a*)	**63.** (*a*)	**64.** (*a*)
65. (*d*)	**66.** (*b*)	**67.** (*d*)	**68.** (*d*)	**69.** (*b*)	**70.** (*d*)	**71.** (*a*)	**72.** (*c*)
73. (*b*)	**74.** (*d*)	**75.** (*a*)	**76.** (*c*)	**77.** (*b*)	**78.** (*c*)	**79.** (*a*)	**80.** (*c*)

81. (*d*)	**82.** (*a*)	**83.** (*a*)	**84.** (*d*)	**85.** (*c*)	**86.** (*a*)	**87.** (*a*)	**88.** (*b*)
89. (*c*)	**90.** (*b*)	**91.** (*c*)	**92.** (*b*)	**93.** (*b*)	**94.** (*b*)	**95.** (*d*)	**96.** (*a*)
97. (*d*)	**98.** (*c*)	**99.** (*c*)	**100.** (*b*)	**101.** (*a*)	**102.** (*c*)	**103.** (*c*)	**104.** (*c*)
105. (*b*)	**106.** (*a*)	**107.** (*d*)					

CASE-BASED QUESTIONS

1. Read the passage given below and answer the following questions:

When a solution does not obey Raoult's law over entire range of concentration, then it is called non-ideal solution. The vapour pressure of such solution is either higher or lower than that predicted by Raoult's law. If it is higher, the solution exhibits positive deviation and if it is lower, it exhibits negative deviation from Raoult's law. The cause of these deviations lie in the nature of interactions at the molecular level. In case of positive deviation from Raoult's law, A–B interactions are weaker than those between A—A or B—B, *i.e.*, the intermolecular attractive forces between the solute-solvent molecules are weaker than those between the solute-solute and solvent-solvent molecules. This means that in such solutions, the molecules of A(or B) will find it easier to escape than in pure state. This will increase the vapour pressure resulting in positive deviation. In case of negative deviations from Raoult's law, the intermolecular attractive forces between A—A and B—B are weaker than those between A–B and leads to decrease in vapour pressure resulting in negative deviations.

In these questions (Q. No (i) to (iv)), a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

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

(*i*) **Assertion (A) :** A solution formed by adding carbon disulphide to acetone shows positive deviation from Raoult's law.

Reason (R) : The dipolar interactions between solute-solvent molecules are stronger than the respective interactions among the solute-solute and solvent-solvent molecules.

(*ii*) **Assertion (A) :** A mixture of phenol and aniline shows positive deviation from Raoult's law.

Reason (R) : The intermolecular H-bonding between phenolic proton and lone pair on nitrogen atom of aniline is stronger than the respective intermolecular H-bonding between similar molecules.

OR

Assertion (A) : The vapour pressure increases in positive deviation from Raoult's law.

Reason (R) : The intermolecular attractive forces between the solute-solvent molecules are weaker than those between the solute-solute and solvent-solvent molecules.

(*iii*) **Assertion (A) :** A solution of *n*-hexane and *n*-heptane is an ideal solution.

Reason (R) : The intermolecular attractive forces between the solvent-solvent and solute-solute are nearly equal to those between solute-solvent.

(*iv*) **Assertion (A) :** If on mixing two liquids, the solution becomes hot, it suggests that it shows a negative deviation from Raoult's law.

Reason (R) : Solutions which exhibit negative deviation from Raoult's law are accompanied by decrease in volume.

Answers

(*i*) (*c*) (*ii*) (*d*) **OR** (*a*) (*iii*) (*a*) (*iv*) (*b*)

2. Read the passage given below and answer the following questions:

Some liquids on mixing, form azeotropes which are binary mixtures having the same composition in liquid and vapour phase and boil at a constant temperature. In such cases, it is not possible to separate the components by fractional distillation. There are two types of azeotropes, minimum boiling azeotrope and maximum boiling azeotrope. The solutions which show a large positive deviation from Raoult's law form minimum boiling azeotrope at a specific composition while the solutions that show large negative deviation from Raoult's law form maximum boiling azeotrope at specific composition.

In these questions (Q. No (i) to (iv)), a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

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

(*i*) **Assertion (A) :** A mixture of 68% nitric acid and 32% water by mass form minimum boiling azeotrope.

Reason (R) : The solution which show a large positive deviation from Raoult's law form minimum boiling azeotrope.

(*ii*) **Assertion (A) :** 95% by volume ethanol-water mixture is maximum boiling azeotrope.

Reason (R) : The solution that show large negative deviation from Raoult's law form maximum boiling azeotrope.

(*iii*) **Assertion (A) :** Pure ethanol cannot be obtained from rectified spirit (approx 95% by volume of ethanol) even by fractional distillation.

Reason (R) : Rectified spirit (approx 95% by volume of ethanol) is an azeotrope, *i.e.*, a constant boiling mixture.

(*iv*) **Assertion (A) :** In maximum boiling azeotropes, the boiling point of azeotrope is higher than that of either of the pure components.

Reason (R) : Boiling point of a liquid is the temperature at which its vapour pressure becomes equal to external pressure.

OR

Assertion (A) : Non-ideal solutions always form azeotropes.

Reason (R) : Boiling point of an azeotrope may be higher or lower than boiling points of both components.

Answers

(*i*) (*d*) (*ii*) (*d*) (*iii*) (*a*) (*iv*) (*b*) **OR** (*d*)

3. Read the given passage and answer the questions that follow. *[CBSE Question Bank]*

Boiling point or freezing point of liquid solution would be affected by the dissolved solids in the liquid phase. A soluble solid in solution has the effect of raising its boiling point and depressing its freezing point. The addition of non-volatile substances to a solvent decreases the vapour pressure and the added solute particles affect the formation of pure solvent crystals. According to many researches the decrease in freezing point directly correlated to the concentration of solutes dissolved in the solvent. This phenomenon is expressed as freezing point depression and it is useful for several applications such as freeze concentration of liquid food and to find the molar mass of an unknown solute in the solution. Freeze concentration is a high quality liquid food concentration method where water is removed by forming ice crystals. This is done by cooling the liquid food below the freezing point of the solution. The freezing point depression is referred as a colligative property and it is proportional to the molar concentration of the solution (m), along with vapour pressure lowering, boiling point elevation, and osmotic pressure. These are physical characteristics of solutions that depend only on the identity of the solvent and the concentration of the solute. The characters are not depending on the solute's identity.

(Jayawardena, J. A. E. C., Vanniarachchi, M. P. G., & Wansapala, M. A. J. (2017). Freezing point depression of different Sucrose solutions and coconut water.)

The following questions are multiple choice questions. Choose the most appropriate answer:

(*i*) When a non volatile solid is added to pure water it will:

(*a*) boil above 100°C and freeze above 0°C (*b*) boil below 100°C and freeze above 0°C

(*c*) boil above 100°C and freeze below 0°C (*d*) boil below 100°C and freeze below 0°C

(*ii*) Colligative properties are:

(*a*) dependent only on the concentration of the solute and independent of the solvent's and solute's identity.

(*b*) dependent only on the identity of the solute and the concentration of the solute and independent of the solvent's identity.

(*c*) dependent on the identity of the solvent and solute and thus on the concentration of the solute.

(*d*) dependent only on the identity of the solvent and the concentration of the solute and independent of the solute's identity.

(*iii*) Assume three samples of juices A, B and C have glucose as the only sugar present in them. The concentration of sample A, B and C are 0.1 M, 0.5 M and 0.2 M respectively. Freezing point will be highest for the fruit juice:

(*a*) A (*b*) B

(*c*) C (*d*) All have same freezing point

(*iv*) Identify which of the following is a colligative property:

(*a*) freezing point (*b*) boiling point (*c*) osmotic pressure (*d*) all of the above

Answers

(*i*) (*c*) (*ii*) (*d*) (*iii*) (*a*) (*iv*) (*c*)

ASSERTION-REASON QUESTIONS

In the following questions, a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

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

1. **Assertion (A) :** Molarity of a solution in liquid state changes with temperature.
   Reason (R) : The volume of a solution changes with change in temperature.
2. **Assertion (A) :** The solubility of a gas in a liquid increases with increase of pressure.
   Reason (R) : The solubility of a gas in a liquid is directly proportional to the pressure of the gas.
3. **Assertion (A) :** Raoult's law is a special case of Henry's law.
   Reason (R) : Higher the value of K_H at a given pressure, the lower is the solubility of the gas in the liquid.
4. **Assertion (A) :** Non-ideal solutions always form azeotropes.
   Reason (R) : Boiling point of an azeotrope may be higher or lower than boiling points of both components.
5. **Assertion (A) :** If more volatile liquid is added to another liquid, vapour pressure of solution will be greater than that of pure solvent.
   Reason (R) : Vapour pressure of solution is entirely due to solvent molecules.
6. **Assertion (A) :** The vapour pressure of a liquid decreases if some non-volatile solute is dissolved in it.
   Reason (R) : The relative lowering of vapour pressure of a solution containing a non-volatile solute is equal to the mole fraction of the solute in the solution.
7. **Assertion (A) :** The boiling point of pure solvent is always higher than the boiling point of solution.
   Reason (R) : The vapour pressure of the solvent decreases in the presence of non-volatile solute.
8. **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.
9. **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.
10. **Assertion (A) :** Lowering of vapour pressure is directly proportional to osmotic pressure of the solution.
    Reason (R) : Osmotic pressure is a colligative property.
11. **Assertion (A) :** Molecular mass of polymers cannot be calculated using boiling point or freezing point method.
    Reason (R) : Polymers solutions do not possess a constant boiling point or freezing point.

12. **Assertion (A)** : The boiling point of 0.1 M urea solution is less than that of 0.1 M KCl solution.

Reason (R) : Elevation of boiling point is directly proportional to the number of species present in the solution.

13. **Assertion (A)** : Osmotic pressure is a colligative property. ***[CBSE 2020 (56/3/1)]***

Reason (R) : Osmotic pressure is directly proportional to molarity.

14. **Assertion (A)** : Non-ideal solutions form azeotropic mixture. ***[CBSE 2020 (56/3/3)]***

Reason (R) : Maximum boiling azeotropes are formed by a solution showing negative deviation.

15. **Assertion (A)** : Elevation in boiling point is a colligative property. ***[CBSE 2020 (56/5/1)]***

Reason (R) : Elevation in boiling point is directly proportional to molarity.

16. **Assertion (A)** : An ideal solution obeys Henry's law. ***[CBSE 2020 (56/5/3)]***

Reason (R) : In an ideal solution, solute-solute as well as solvent-solvent interactions are similar to solute-solvent interaction.

Answers

1. (*a*)	**2.** (*a*)	**3.** (*b*)	**4.** (*d*)	**5.** (*c*)	**6.** (*b*)	**7.** (*d*)	**8.** (*a*)
9. (*b*)	**10.** (*b*)	**11.** (*c*)	**12.** (*a*)	**13.** (*a*)	**14.** (*b*)	**15.** (*c*)	**16.** (*d*)

HINTS/SOLUTIONS OF SELECTED MCQS

1. (*c*) Amalgam of mercury with sodium is an example of solid solution in which mercury (liquid) is solute and sodium (solid) is a solvent.

2. (*c*) 1 ppm = 10^6 mg

1 kg water = 10^6 mg:

10^6 mg water contains 6 mg O_2

$\therefore$ Concentration of O_2 is 6 ppm.

3. (*b*) 1 molal aqueous solution means 1 mole of solute is dissolved in 1 kg of water

$\Rightarrow$ No. of moles of solute =1 mole

No. of Moles of water $= \frac{1000}{18}$

$= 55.55$ moles

$\therefore$ Total no. of moles $=1+55.55=56.55$ moles

Now, we know

$$\text{Mole fraction of solute} = \frac{\text{Moles of solute}}{\text{Total moles in solution}}$$

$$\Rightarrow \text{Mole fraction in solute} = \frac{1}{56.55} = 0.0177$$

20. (*b*) When a non-volatile solute like KCl is added to a solvent (water), the vapour pressure of the solution decreases. So, the solution needs to be heated to a higher temperature in order to equalise with the atmospheric pressure compensating the lowering of vapour pressure compensating the lowering of vapour pressure in order to boil. Therefore, the boiling point of the solution increases.

21. (*c*) The vapour pressure of water at Delhi will be less as compared to the Puri district due to presence of more non-volatile impurities in Delhi.

22. (*b*) $\frac{\text{ppm of solute}}{10^6} = \frac{\text{Weight of solute}}{\text{Weight of solution}}$

$\frac{\text{ppm of } MgSO_4}{10^6} = \frac{40 \text{ mg}}{10 \text{ kg}}$

$\text{ppm of } MgSO_4 = \frac{40 \times 10^{-3} \text{ g}}{10 \times 10^3 \text{ g}} \times 10^6 = 4 \text{ ppm}$

23. (*c*) Let the solution be 1 litre or 1000 cm^3.

$\therefore$ Number of moles of H_2SO_4 = 1.35

Weight of solution = 1000 × 1.02 = 1020 g

Weight of sulphuric acid = 1.35 × 98 = 132.3 g

Weight of water = 1020 – 132.3 = 887.7 g

Molality of $H_2SO_4 = \frac{1.35}{887.7} \times 1000 = 1.52 \text{ m}$

24. (*c*) Molal depression constant (K_f) is independent of the concentration term, *i.e.*, molarity and therefore on doubling the value of molarity of dilute solution, the value of K_f remains unchanged.

25. (*a*) When dried grapes or raisins are placed in water, the water from the surrounding enters into the raisins and therefore the raisins swell up. The phenomenon involved is called osmosis.

26. (*d*) The non-ideal solutions which shows a large positive deviations from Raoult's law forms minimum boiling azeotrope at a specific composition, *e.g.*, *n*-hexane-acetone. The other three given options are examples of negative deviation from Raoult's law.

27. (*a*) When egg is placed in a saline solution (hypertonic solution), exosmosis occurs and the egg shrinks due to loss of water to the surrounding environment.

28. (*d*) Non-volatile solutes lowers the vapour pressure of a solvent which in turn increases the boiling point of the solution and decreases the freezing point of the solution.

29. (*c*) Molality is not affected by change in temperature because it depends on the mass of solvent which do not change with temperature.

30. (*d*) Both molality and mole fraction are not affected by change in temperature. While molarity, normality and w/v % all are affected by temperature as they depend on the volume of the solution.

31. (*c*) Pressure has no effect at all on solubility of solute is solid or liquid. However, pressure is an important factor affecting the solubility of gas in liquids.

32. (*d*) $n_{NaCl} = \frac{m_{NaCl}}{M_{NaCl}}$, where m = Mass, M = Molecular mass

$= \frac{5.85}{58.5} = 0.1 \text{ mol}$

$n_{H_2O} = \frac{m_{H_2O}}{M_{H_2O}} = \frac{90}{18} = 5 \text{ moles}$

$\chi = \frac{0.1}{0.1 + 5} = 0.0196$

33. (*b*) A pressure cooker contains the steam, which increases the pressure in the pot. They have a regulator which sets the pressure at about 10 - 15 PSI higher than the standard pressure. This increases the boiling point, so the boiling liquid and the steam are hotter than they would be at normal atmospheric pressure.

34. (*b*) Molarity of pure water means the number of moles of H_2O per litre of water. Since, the density of water is 1 g/L, the mass of 1 L or 1000 mL of water will be 1000 g. Thus, the number of moles of H_2O in 1000 g will be

$$n_{H_2O} = \frac{\text{Mass of } H_2O}{\text{Molar mass of } H_2O} = \frac{1000\text{ g}}{18} = 55.5\text{ mol}$$

As these moles are present in 1L of H_2O, we say that molarity of H_2O is 55.5 M.

35. (*d*) Colligative properties of solutions are properties that depend upon the number of solute particles (molecules or ions), but not upon the identity of the solute. Colligative properties include vapour pressure lowering, boiling point elevation, freezing point depression, and osmotic pressure.

36. (*b*) Raoult's law states that the partial pressure of each component of an ideal mixture of liquid is equal to the vapour pressure of the pure component multiplied by its mole fraction in the mixture. On adding non-volatile solute to the volatile, the vapour pressure of the solution decreases. Mathematically, it can be represented as

$$P_A = P_A^{\circ} x_A \quad \text{or} \quad \frac{P_A^{\circ} - P}{P_A^{\circ}} = x_B = \frac{n_B}{n_A + n_B}$$

37. (*b*) Two solutions are said to be isotonic when they exert the same osmotic pressure because they have the same molar concentration.

38. (*d*) Mass of Glucose = 18 g

Molar mass of glucose = 180 g/mol

$$\because \quad \text{Molality} = \frac{\text{Moles of solute}}{\text{Mass of solvent (in g)}} \times 1000$$

$$\text{Molality} = \frac{18}{180} \times \frac{1000}{1000} = \frac{1}{10} = 0.1\text{ molal}$$

39. (*a*) Osmotic pressure is a colligative property.

Mathematically,

$$\text{Osmotic pressure } (\pi) = \frac{n}{V} RT$$

$$\frac{n}{V} = C\text{(concentration)}$$

$$\pi = CRT$$

If R and T is constant, then, $\pi \propto C$

40. (*a*) Non-volatile solutes lowers the vapour pressure of a solvent. This results in decrease in the freezing point of a solution. As only at lower temperature, the vapour pressure of solution will be equal to that of the solute.

41. (*d*) Colligative properties of solutions are properties that depend upon the number of solute particles (molecules or ions), but not upon the nature of the solute. Colligative properties includes vapour pressure lowering, boiling point elevation, freezing point depression, and osmotic pressure.

42. (*d*) Given, $\pi = 2.5$ atm, $T = 24 + 273 = 297$ K

$R = 0.0821$ litre atm K^{-1} mol^{-1}

$$\because \quad \pi = CRT$$

$$\therefore \quad C = \frac{\pi}{RT} = \frac{2.5}{0.0821 \times 297}$$

$$= 0.1025 \text{ moles/litre}$$

43. (*b*) $\because \ \Delta T_b = K_b m$

$$\Rightarrow \quad 0.52 = \frac{0.52 \times 6 \times 1000}{100 \times M}$$

$$M = \frac{0.52 \times 6 \times 1000}{0.52 \times 100}$$

$$= 60 \text{ kg/mol}$$

44. (*b*) Molarity (*M*) indicates the number of moles of solute per litre of solution (moles/Litre) and is one of the most common units used to measure the concentration of a solution.

45. (*b*) The boiling point of a substance is the temperature at which the vapour pressure of the substance become equal to the atmospheric pressure. Thus, the boiling point of a solution containing a non-volatile solute is higher than that of the pure solvent . This effect is called boiling point elevation.

46. (*c*) The vapour pressure of an aqueous methanol solution is more than that of water but less than that of methanol. This is because the solute-solvent interaction in case of methanol and water is more (due to formation of greater hydrogen bonding) as compared to methanol but less than that of water due to more extensive hydrogen bonding in case of water.

47. (*d*) $(NV)_{resulting} = N_1V_1 + N_2V_2 + N_3V_3$

$$N \times 1000 = 1 \times 5 + \frac{1}{2} \times 20 + \frac{1}{3} \times 30$$

$$N = \frac{1}{40}$$

48. (*b*) As we know that, 6.022×10^{23} molecules = 1 mole

So, 6.022×10^{22} molecules= 0.1 moles

$$\therefore \ \text{Molarity} = \frac{\text{Number of moles of solute}}{\text{Volume of soluton in litre}} = \frac{0.1 \times 1000}{500} = 0.2 \text{ M}$$

49. (*b*) When a non-volatile solute like NaCl is added to ice, the vapour pressure will decreases as a result, the melting point of ice will decrease.

50. (*b*) A solution is a homogeneous mixture of two or more pure substances, the relative ratio of which can be changed within certain limits.

51. (*a*) A solution is called an ideal solution if it obeys Raoult's law over a wide range of concentration and at a particular specified temperature.

52. (*c*) Real solution shows either positive or negative deviation from Raoult's law.

53. (*c*) A 0.91% NaCl solution is isotonic with human red blood corpuscles (RBC). Therefore, in this solution, RBC will neither shrink nor swell.

54. (*a*) Chlorobenzene-bromobenzene is an example of ideal solution. Here, A—A and B—B interactions are same as that of A—B interactions.

55. (*c*) $\because$ Number of moles $= \dfrac{\text{Moles of solute}}{\text{Molar mass}}$

$$\Rightarrow \quad n_{C_6H_{12}O_6} = \frac{20}{180} = \frac{1}{9} = 0.111$$

$$\Rightarrow \quad n_{CH_3OH} = \frac{20}{32} = 0.625$$

$$\Rightarrow \quad n_{CH_3COOH} = \frac{20}{60} = 0.333$$

56. (*b*) An increase in temperature increases the volume of the solution and thus, decreases its molarity.

The other given concentration terms, do not depend on temperature.

57. (*d*) Addition of glycol lowers the freezing point of water in the radiator so that the cold winter temperatures wouldn't burst the lines and therefore, glycol-water mixture is used as antifreeze in radiators of cars.

58. (*a*) Molar concentration of cane sugar $= \dfrac{w_{\text{cane sugar}}}{342 \times 100} \times 1000$ ...(*i*)

Molar concentration of urea $= \dfrac{w_{\text{urea}}}{60 \times 100} \times 1000$ ...(*ii*)

On equating equation (*i*) and (*ii*), we get

$$\frac{w_{\text{cane sugar}}}{342} = \frac{0.86}{60}$$

$$w_{\text{cane sugar}} = \frac{0.86}{60} \times 342$$

$$\frac{4.9 \text{ moles}}{100 \text{ mL}} = 4.9\%$$

59. (*b*) According to the Raoult's law, the partial pressure of each component of an ideal mixture of liquids is equal to the vapour pressure of the pure component multiplied by its mole fraction in the mixture. Mathematically, it can be expressed as

$$p_A = p_A^{\text{o}} \times x_A$$

or $\quad p_B = p_B^{\text{o}} \times x_B$

60. (*b*) High altitudes have lower atmospheric pressure. As you get higher up into the atmosphere the air pressure gets lower. Therefore, boiling point of water will generally be at lower temperature.

61. (*b*) $\Delta T_b = K_b m$

$\Delta T_f = K_f m$

$$\frac{\Delta T_b}{\Delta T_f} = \frac{K_b}{K_f} = \frac{0.512}{1.86} \qquad (\because \text{The solution is same})$$

$$\Delta T_b = \frac{0.512 \times 0.186}{1.86} = 0.0512°\text{C}$$

62. (*a*) In a mixture of A and B, components show negative deviation as $\Delta H_{\text{mix}} = -\text{ve}$ and $\Delta V_{\text{mix}} = -\text{ve}$

This can be explained as

If the force of attraction between molecules of A and B in the solution are stronger than that of between A–A and B–B, then the tendency of escaping of molecules AB from the solution becomes less than that of pure liquids.

The total pressure of the solution will be lower than the corresponding vapour pressure of ideal solution of the same component A and B. This type of solution shows negative deviation from Raoult's law.

63. (*a*) $Ba(OH)_2 + 2HCl \longrightarrow BaCl_2 + 2H_2O$

According to the given balanced equation,

$$\frac{M_1 V_1}{n_1} = \frac{M_2 V_2}{n_2}$$

where M_1, M_2, V_1 and V_2 are the molarity and volume of $Ba(OH)_2$ and HCl respectively

$n_1 = 1$ [For $Ba(OH)_2$]

$n_2 = 2$ [For HCl]

$$\frac{M_1 \times 25}{1} = \frac{0.1 \times 35}{2}$$

$$M_1 = \frac{0.1 \times 35}{25 \times 2}$$

$$= 0.07 \text{ molar}$$

64. (*a*) For ideal solutions, $\Delta H_{mix} = 0$, neither heat is evolved nor absorbed during dissolution.

65. (*d*) Two sucrose solutions of the same molality prepared in different solvents will have different freezing point depression. This is because the molal depression in freezing point constant K_b is different for different solvents.

The freezing point depression ⇒ $\Delta T_f = K_b \times m$

Here, m is the molality of sucrose solution.

66. (*b*) Boiling point and freezing point depends upon K_b (molal elevation constant) and K_f (molal depression constant) of the solvent. Thus, equimolar solution (of the non-electrolyte) will have same boiling point and also same freezing point.

$\Delta T_f = K_f \times$ molality

$\Delta T_b = K_b \times$ molality

67. (*d*) The glucose solution should have the same osmotic pressure as that of the blood stream and the blood; otherwise the blood vessels would either shrink or burst depending upon the concentration of glucose.

68. (*d*) The most commonly used semipermeable membrane in laboratory is prepared by depositing copper ferrocyanide in porous walls of a battery pot or unglazed porcelain.

69. (*b*) According to Raoult's law

$$P = p^\circ_A \cdot \chi_A + p^\circ_B \cdot \chi_B$$
$$290 = 200 \times 0.4 + p^\circ_B \,.\, 0.6$$
$$p^\circ_B = 350 \text{ mm}$$

70. (*d*) Let the amount of A in the mixture is χ_A and B be the χ_B

$$P = p^\circ_A \cdot \chi_A + p^\circ_B \cdot \chi_B$$
$$760 = 520\, \chi_A \times 1000\,(1 - \chi_A)$$
$$480\, \chi_A = 240$$
$$\chi_A = \frac{1}{2} \text{ or } 50 \text{ mol\%}$$

(1 atm=760 mm Hg)

71. (*a*) According to Raoult's law,

In a solution containing non-volatile solute. The relative lowering of vapour pressure of solution is directly proportional to its mole fraction.

$$P_{\text{solution}} = p^\circ \times \chi_{\text{solvent}}$$

Let A be the solute and B the solvent

$$\therefore \quad \chi_B = \frac{n_B}{n_A + n_B} = \frac{178.2/18}{18/180 + 178.2/18}$$

$$\chi_B = \frac{9.9}{9.94} = 0.99$$

$$\frac{17.5 - p_s}{17.5} = 0.99$$

Or, $\quad 17.5 - p_s = 17.32$

⇒ $\quad p_s - 0.175$ mm Hg.

72. (*c*) A 5.2 molal aqueous solution of methyl alcohol means 5.2 moles of methyl alcohol is present in 1000 g of water.

$\therefore$ Mole fraction $= \dfrac{n}{n + N}$ (n = moles of methyl alcohol, N = moles of water)

$$= \frac{5.2}{5.2 + \frac{1000}{18}} = 0.086$$

73. (*b*) Camphor has a large K_f value and therefore, it will cause large depression in the melting point of a solution with very small amount of naphthalene.

74. (*d*)

$$\Delta T_f = K_f\, m$$
$$\Delta T_b = K_b\, m$$

$\Rightarrow$
$$\frac{\Delta T_f}{\Delta T_b} = \frac{K_f}{K_b}$$

$$\Delta T_b = 100.18 - 100$$
$$= 0.18°\text{C}$$

So,
$$\frac{\Delta T_f}{0.18} = \frac{1.86}{0.512}$$
$$\Delta T_f = 0.6539$$

or
$$\Delta T_f = \Delta T_f = T_f^{\text{o}} - T_f = 0°\text{C} - 0.654$$
$$T_{f\,urea} = -0.654°\text{C}$$

75. (*a*) By Raoult's law,

$$P_T = p_P^{\text{o}}\chi_P + p_Q^{\text{o}}\chi_Q$$
$$P_T = 80 \times \frac{3}{5} + 60 \times \frac{2}{5}$$
$$= 48 + 24$$
$$= 72 \text{ torr}$$

76. (*c*) 5% solution of non-volatile solute means 5 g of solute present in 100 mL of solution. For isotonic solution,

$$\pi_{\text{urea}} = \pi_{\text{non-volatile solute}}$$
$$C_{\text{urea}}RT = C_{\text{non-volatile solute}} \times R \times T$$
$$\frac{n_{\text{urea}}}{V}RT = \frac{n_{\text{non-volatile solute}}}{V}RT$$
$$\frac{w_{\text{urea}}}{M_{\text{urea}} \times V}RT = \frac{w_{\text{non-volatile solute}} \times RT}{M_{\text{non-volatile solute}} \times V}$$
$$\frac{10}{60 \times 1000} = \frac{5}{\text{M} \times 100}$$
$$M = \frac{5 \times 60 \times 1000}{10 \times 100}$$
$$= 300 \text{ g mol}^{-1}$$

77. (*b*)

$$\Delta T_f = K_f \text{ m}$$
$$= K_f \frac{w_{\text{solute}} \times 1000}{W_{\text{solvent}} \times M_{\text{solute}}}$$
$$= \frac{5.12 \times 1000 \times 1}{51.2 \times 250}$$
$$= \frac{100}{250} = 0.4 \text{ K}$$

78. (*c*) In case of pure ethanol, the molecules are held together by hydrogen bond. On adding acetone, the molecules of acetone gets in between the host molecules causing breaking of hydrogen bonds. Thus, A–B interaction < A–A or B–B interaction. Therefore, it shows positive deviation from Raoult's law.

79. (*a*) For dilute solution, it has been found that the molal elevation of boiling point is directly proportional to the molal concentration of the solute in the solution. Thus,

$$\Delta T_b \propto m \quad \text{or} \quad \Delta T_b = K_b \times m$$

$$\Rightarrow \quad \frac{\Delta T_b}{K_b} = m \text{ (molality)}$$

80. (*c*) The azeotropic mixture showing positive deviation from Raoult's law has higher vapour pressure or lower boiling point $\left(\because \text{V.P.} \propto \frac{1}{\text{B.P.}}\right)$ than either of the two liquids.

81. (*d*) Osmosis is the phenomenon of flow of pure solvent from the solvent to the solution or from a less concentrated solution to a more concentrated solution through a semipermeable membrane. Common semipermeable membranes are permeable to certain solute particles also. Infact, there is no perfect semipermeable membrane. Therefore we can say that flow of water through a semipermeable membrane takes place both sides with unequal rates.

82. (*a*) There will be no net movement of the solvent through the semipermeable membrane between two solutions of equal concentration.

83. (*a*)

$$n_1 \text{ (for glucose)} = \frac{10}{180} = 0.05$$

$$n_2 \text{ (for urea)} = \frac{10}{60} = 0.16$$

$$n_3 \text{ (for sucrose)} = \frac{10}{342} = 0.03$$

$\because \quad \pi V = nRT$

So, $\therefore \quad \pi \propto n$

So, $\pi_2 > \pi_1 > \pi_3$

84. (*d*)

$$\pi V = n\text{RT}$$

or

$$\pi V = \frac{w}{M}\text{RT}$$

$$M = \frac{w \times \text{R} \times \text{T}}{\pi \times V}$$

$$= \frac{1.26 \times 0.083 \times 300}{2.57 \times 10^{-3} \times 0.2}$$

$$= 61039 \text{ g mol}^{-1}$$

85. (*c*)

$$\text{Normality } (N) = \frac{\text{Weight of solute in g} \times 1000}{\text{Eq. weight of solute} \times \text{Volume of solute in mL}}$$

$$\therefore \quad w = \frac{N \times \text{Eq. weight} \times V}{1000} \quad \text{[For dibasic acid, Z = 2]}$$

$$= \frac{0.1 \times 200 \times 100}{1000 \times 2}$$

$$= 1 \text{ g}$$

86. (*a*)

$$\Delta T_b = K_b\, m$$

$$T_b - T_b^\circ = K_b \times m$$

$$100.52 - 100.00 = \frac{0.6 \times 3 \times 1000}{M \times 200}$$

$$= \frac{1800}{104}$$

$$= 17.31 \text{ g mol}^{-1}$$

87. (*a*)

$$T_b^\circ = 353.23 \text{ K}, W_B = 1.8 \text{ g}$$

$$W_A = 90 \text{ g}, T_b = 354.11 \text{ K}$$

$$K_B = 2.53 \text{ K kg mol}^{-1}$$

$$\Delta T_b = T_b - T_b^\circ = 354.11 - 353.23$$

$$= 0.88 \text{ K}$$

$$M_B = \frac{W_B \times K_B \times 1000}{\Delta T_B \times W_A} = \frac{1.8 \times 2.53 \times 1000}{0.88 \times 90}$$

$$= 57.5 = 58 \text{ g mol}^{-1}$$

88. (*b*) We know that

$$\frac{p^\circ - p}{p^\circ} = \frac{w/m}{w/m + W/M}$$

$$\frac{121.8 - 120.2}{121.8} = \frac{15/m}{15/m + \frac{250}{78}}$$

$$m = 354.8 \text{ g}$$

89. (*c*)

$$\frac{p^\circ - p}{p^\circ} = \frac{w/m}{W/M}$$

$$\frac{143 - p}{143} = \frac{0.5 \times 154}{65 \times 158}$$

$$\frac{143 - p}{143} = .01$$

$$143 - p = 1.694$$

$$p = 143 - 1.694$$

$$= 141.93 \text{ mm Hg}$$

90. (*b*) $\chi_1 = 0.2$

As we know that,

$$\frac{p^\circ - p}{p^\circ} = \chi_1$$

$$\frac{10}{p^\circ} = 0.2$$

$$p^\circ = 50 \text{ mm Hg}$$

Again, when

$$p^\circ - p = 20 \text{ mm Hg}$$

then,

$$\frac{20}{50} = \chi_1$$

$$\chi_1 = 0.4$$

So,

$$\chi_2 = 1 - 0.4$$

$$= 0.6$$

91. (*c*) The osmotic pressure of the solution is expressed as

$$\pi = CRT, \text{ or, } \pi = \frac{n}{V}RT$$

$$\pi = \frac{0.3 \text{ mol}}{1 \text{ L}} \times 0.0821 \text{ L atm K}^{-1} \text{ mol}^{-1} \times 273 \text{ K}$$

92. (*b*)

$$\frac{\Delta T_f}{\Delta T_b} = \frac{K_f}{K_b}$$

$\therefore$

$$\Delta T_f = \frac{K_f}{K_b} \times \Delta T_b$$

$$= \frac{1.86}{0.51} \times 0.55$$

$$= 2 \text{ K}$$

$\therefore$

$$T_f = 273 - 2$$

$$= 271 \text{ K}$$

93. (*b*)
$$\chi_A = \frac{n_A}{n_A + n_B}$$
$$n_A = 1, \quad n_B = \frac{1000}{18} = 55.55$$
$$\chi_A = \frac{1}{1+55.55} = \frac{1}{56.55} = 0.018$$

94. (*b*) 4.5 m means 4.5 moles of solute in 1000 g of solvent (H_2O)
$$\chi = \frac{m}{55.5 + m}$$
$$\chi = \frac{4.5}{55.5 + 4.5}$$
$$= 0.075$$

95. (*d*) Addition of water to an aqueous solution of KI decreases the concentration of the solution thereby increasing the vapour pressure. In the other three options, the electrolytes will undergo ionisation that leads to lowering of vapour pressure.

96. (*a*) We know, $\Delta T_f = K_f\, m$

Here, $m = \frac{68.5 \times 1000}{342 \times 1000}$
$$\Delta T_f = 0.2003 \times 1.86$$
$$= 0.3725° \text{ C}$$
$$T_f = 0°\text{C} - 0.3725°\text{C}$$
$$= -\ 0.3725° \text{ C}$$

97. (*d*) According to Raoult's law,
$$p = \chi_A.P_A + \chi_B.p_B \qquad ...(i)$$
for Binary solutions,
$$\chi_A + \chi_B = 1$$
$$\chi_B = 1 - \chi_A \qquad ...(ii)$$
Putting value of χ_B from equation (*ii*) into equation (*i*), we get
$$p = \chi_A\, p_A + (1 - \chi_A)\, p_B$$
$$= \chi_A\, p_A + p_B - \chi_A\, p_B$$
$$p = p_B + \chi_A\, (p_A - p_B)$$

98. (*c*)
$$\text{Moles of } CHCl_3 - \frac{25.5}{119.5} = 0.213$$
$$\text{Moles of } CH_2Cl_2 = \frac{40}{85} = 0.31$$
$$\chi_{CHCl_3} = \frac{0.213}{0.213 + 0.470} = 0.31$$
$$\chi_{CH_2Cl_2} = \frac{0.470}{0.213 + 0.470} = 0.69$$
$$P_T = p^o_{CHCl_3}\chi_{CHCl_3} + p^o_{CH_2Cl_2}\chi_{CH_2Cl_2}$$
$$= 200 \times 0.31 + 41.5 \times 0.69$$
$$= 62 + 28.64$$
$$= 90.64 \text{ mm Hg}$$

99. (*c*)

$$\text{Molarity} = \frac{W \times 1000}{M_W \times V_{solu}(\text{mL})}$$

$$\Rightarrow \quad 2 = \frac{W}{63} \times \frac{1000}{250}$$

$$W = \frac{63}{2}\text{g}$$

$$\text{Mass of acid} \times \frac{70}{100} = \frac{63}{2}$$

$$\text{Mass of acid} = 45 \text{ g}$$

100. (*b*) An ideal solution has the following condition:

- Volume change (ΔV) of mixing should be zero.
- Enthalpy change (ΔH) of mixing should be zero.
- Obey's Raoult's law at every range of concentration.

101. (*a*) The non-ideal solutions that show large negative deviation from Raoult's law forms maximum boiling azeotrope at a specific composition, *e.g.*, a mixture of conc. HNO_3 and H_2O. The other three given options are example of positive deviation from Raoult's law.

102. (*c*)

$$\Delta T_f = K_f \text{m}$$
$$= 1.86 \times 0.05$$
$$= 0.093°\text{C}$$
$$T_f^\circ = 0°\text{C}$$

so, $$\Delta T_f = T_f^\circ - T_f$$

or $$T_f = T_f^\circ - \Delta T_f$$
$$= 0°\text{C} - 0.093°\text{C}$$
$$= -0.093°\text{C}$$

103. (*c*) The Henry's law is applicable only when

(*i*) The gas should not undergo any chemical change.

(*ii*) The gas should not undergo any dissociation or association in the solution.

(*iii*) The pressure of the gas is not too high and temperature is not too low.

104. (*c*) The vapour pressure of a liquid increases with increase in temperature. This is because, with increase in temperature, the K.E. of the molecules increases and therefore large number of molecules will be available for escaping from the surface of the liquid.

It is independent of surface area and volume of the container.

105. (*b*) Benzene - methanol shows a positive deviation from Raoult's law.

When benzene is added in pure methanol, the molecules come in between the methanol molecules thus breaking up hydrogen bonds. Therefore, in benzene - methanol mixture the intermolecular forces of attractions are weaker than those in pure liquids.

Consequently, the boiling point of the mixture is decreased and the vapour pressure of the solution is increased.

106. (*a*) Isotonic solution have same osmotic pressure.

$$\pi_1 = C_1RT, \pi_2 = C_2RT$$

$\Rightarrow$ $$\pi_1 = \pi_2$$

Or, $$C_1RT = C_2RT$$

$$\frac{n_1}{V}RT = \frac{n_2}{V}RT$$

$$\frac{1.5}{60} = \frac{n_2}{M}$$

$$\frac{1.5}{60} = \frac{5.25}{M}$$

$$M = \frac{5.25 \times 60}{1.5} = 210 \text{ g mol}^{-1}$$

107. (*d*)

$$\frac{n_{\text{pentane}}}{n_{\text{hexane}}} = \frac{1}{4}$$

So,

$$\chi_{\text{pentane}} = \frac{1}{5}$$

$$\chi_{\text{Hexane}} = \frac{4}{5}$$

$$P_{\text{Total}} = p^{\text{o}}_{\text{pentane}} \times \chi_{\text{pentane}} + p^{\text{o}}_{\text{Hexane}} \times \chi_{\text{Hexane}}$$

$$= 440 \times \frac{1}{5} + 120 \times \frac{4}{5} = 184 \text{ mm of Hg}$$

By Raoult's law

Now $p_{\text{pentane}} = p^{\text{o}}_{\text{pentane}} \times \chi_{\text{pentane}}$ ...(*i*)

χ_{pentane} is mole fraction of pentane in solution.

By Dalton's law

$$p_{\text{pentane}} = P_T \times \chi'_{\text{pentane}} \quad \text{...(ii)}$$

χ'_{pentane} is mole fraction of pentane in vapour phase.

From (*i*) and (*ii*), we get

$$p^{\text{o}}_{\text{pentane}} \times \chi_{\text{pentane}} = P_T \times \chi'_{\text{pentane}}$$

$$\chi'_{\text{pentane}} = \frac{p^{\text{o}}_{\text{pentane}} \times \chi_{\text{pentane}}}{P_T}$$

$$= \frac{440 \times \frac{1}{5}}{184}$$

$$= \frac{88}{184} = 0.478$$