Chapter 1

Solutions

1. WAYS TO EXPRESS CONCENTRATION OF SOLUTIONS

Objective Qs [1 mark]

1. Which of the following is an example of a solid solution?
   (a) Sea water
   (b) Sugar solution
   (c) Smoke
   (d) 22 carat gold

   [CBSE SQP Term-1 2021]

   Question No. 2 and 3 consist of two statements Assertion (A) and Reason (R). Answer these questions selecting the appropriate option given below:

   (a) Both (A) and (R) are true and (R) is the correct explanation of (A).

   (b) Both (A) and (R) are true but (R) is not the correct explanation of (A).

   (c) (A) is true but (R) is false.

   (d) (A) is false but (R) is true.

2. Assertion (A): Molarity of a solution changes with temperature.

   Reason (R): Molarity is a colligative property.

   [CBSE SQP Term-1 2021]

3. Assertion (A): Molality of a solution changes with temperature.

   Reason (R): Volume of a solution changes with temperature.

   [Delhi Gov. SQP Term-1 2021]

Very Short & Short Qs 1 - 3 marks

4. Define the following term: Molality (m)

   [CBSE 2017, 14]

5. Define the following term:

Mole fraction

[CBSE 2014]

6. (A) What do you understand by a binary aqueous solution?

   (B) Define the following term: Molarity (M)

   [CBSE 2014]

7. Differentiate between molarity and molality of a solution. How can we change molality value of a solution into molarity value?

   [CBSE 2014]

8. Calculate the molarity of $9.8\%(w/w)$ solution of $\mathrm{H}_2 SO_4$ if the density of the solution is $1.02 \mathrm{~g} \mathrm{~mL}^{-1}$.

   (Molar mass of $\mathrm{H}_2 \mathrm{SO}_4$ is $98 \mathrm{~g} \mathrm{~mol}^{-1}$)

   [CBSE 2014]

9. A solution of glucose (molar mass $=180 \mathrm{~g} \mathrm{~mol}^{-1}$) in water is labelled as 10% (by mass). What would be the molality and molarity of the solution?

   (Density of solution $=1.2 \mathrm{~g} \mathrm{~mL}^{-1}$).

   [CBSE 2014]

2. SOLUBILITY AND VAPOUR PRESSURE

Objective Qs [1 mark]

10. Solubility of gases in liquids decreases with rise in temperature because dissolution is an: (a) endothermic and reversible process

    (b) exothermic and reversible process

    (c) endothermic and irreversible process

    (d) exothermic and irreversible process.

    [CBSE SQP Term-1 2021]

11. On mixing $20 \mathrm{~mL}$ of acetone with $30 \mathrm{~mL}$ of chloroform, the total volume of the solution is:
    (a) $<50 \mathrm{~mL}$
    (b) $=50 \mathrm{~mL}$

(c) > 50 mL
(d) $= 10$ mL

[CBSE Term-1 2021]

12. An azeotropic solution of two liquids has a boiling point lower than either of the two when it:

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

(b) shows a negative deviation from Raoult's law.

(c) shows no deviation from Raoult's law.

(d) is saturated.

[CBSE Term-1 2021]

13. Which one of the following pairs will form an ideal solution?

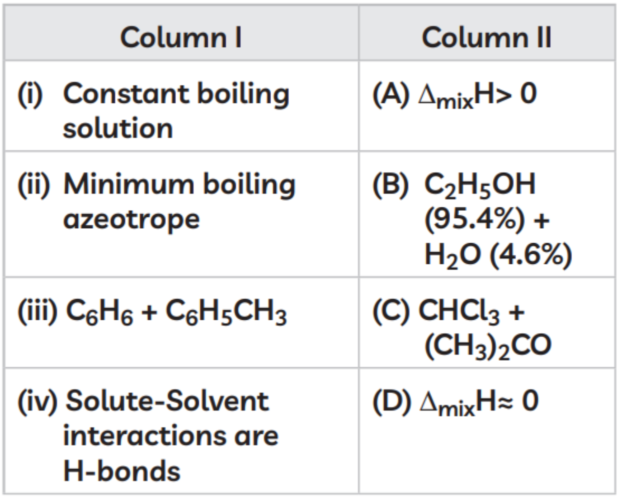
(a) Chloroform and acetone

(b) Ethanol and acetone

(c) n-hexane and n-heptane

(d) Phenol and aniline [CBSE Term-1 2021]

14. Match the following:



Column I	Column II
(i) Constant boiling solution	(A) $\Delta_{mix}H > 0$
(ii) Minimum boiling azeotrope	(B) C_2H_5OH (95.4%) + H_2O (4.6%)
(iii) $C_6H_6 + C_6H_5CH_3$	(C) $CHCl_3 + (CH_3)_2CO$
(iv) Solute-Solvent interactions are H-bonds	(D) $\Delta_{mix}H \approx 0$

Which of the following is the best matched options?

(a) (i) - (B), (ii) - (A), (iii) - (D), (iv) - (C)

(b) (i) - (C), (ii) - (B), (iii) - (D), (iv) - (A)

(c) (i) - (B), (ii) - (A), (iii) - (D), (v) - (C)

(d) (i) - (B), (ii) - (D), (iii) - (A), (v) - (C)

[CBSE Term-1 2021]

15. An unknown gas ' X ' is dissolved in water at 2.5 bar pressure and has mole fraction 0.04 in solution. The mole fraction of ' X ' gas when the pressure of gas is doubled at the same temperature is:
(a) 0.08
(b) 0.04
(c) 0.02
(d) 0.92

[CBSE Term-1 2021]

16. Which of the following formula represents Raoult's law for a solution containing nonvolatile solute?

(a) $\mathrm{P}_{\text{solute}} = \mathrm{P}_{\text{solute}}^{\circ} \cdot \mathrm{X}_{\text{solute}}$

(b) $P = K_H \cdot X$

(c) $\mathrm{P}_{\text{Total}} = P_{\text{Solvent}}$

(d) $\mathrm{P}_{\text{solute}} = \mathrm{P}_{\text{solvent}}^{\circ} \cdot \mathrm{X}_{\text{solvent}}$

[CBSE Term-1 2021]

Very Short & Short Qs [1 -3 marks]

17. (A) What type of deviation from Raoult's Law is expected when phenol and aniline are mixed with each other? What change in the net volume of the mixture is expected? Graphically represent the deviation.

(B) The vapour pressure of pure water at a certain temperature is 23.80 mmHg. If 1 mole of a non-volatile non-electrolytic solute is dissolved in 100 g water, Calculate the resultant vapour pressure of the solution.

[CBSE SQP 2023]

18. The vapour pressure of pure liquid X and pure liquid Y at $25^{\circ}\mathrm{C}$ are 120 mmHg and 160 mm Hg respectively. If equal moles of X and Y are mixed to form an ideal solution, calculate the vapour pressure of the solution.

[CBSE 2023]

19. Answer the following questions:

(A) State Henry's law and explain why are the tanks used by scuba divers filled with air diluted with helium (11.7% helium, 56.2% nitrogen and 32.1% oxygen)?

(B) Assume that argon exerts a partial pressure of 6 bar. Calculate the solubility of argon gas in water. (Given: Henry's Law constant for Argon dissolved in water, $\mathrm{K}_{\mathrm{H}} = 40\mathrm{kbar}$)

[CBSE SQP 2022]

20. State Raoult's law for the solution containing volatile components. What is the similarity between Raoult's law and Henry's law?

[CBSE 2020]

21. State Henry's law. Calculate the solubility of $\mathrm{CO_2}$ in water at $298\ \mathrm{K}$ under $760\mathrm{mmHg}$.

$(\mathrm{K_H}$ for $\mathrm{CO_2}$ in water at $298\ \mathrm{K}$ is 1.25×10^6 mmHg)

[CBSE 2020]

22. Identify which liquid will have a higher vapour pressure at $90^\circ\mathrm{C}$ if the boiling points of two liquids A and B are $140^\circ\mathrm{C}$ and $180^\circ\mathrm{C}$, respectively.

[CBSE 2020]

23. What happens when acetone is added to pure ethanol?

[CBSE 2020]

24. Give reasons for the following:

(A) Aquatic species are more comfortable in cold water than in warm water.

(B) At higher altitudes people suffer from anoxia resulting in inability to think.

[CBSE 2019]

25. Write two differences between ideal solutions and non-ideal solutions.

[CBSE 2019, 17]

26. What type of azeotropic mixture will be formed by a solution of acetone and chloroform? Justify on the basis of strength of intermolecular interactions that develop in the solution.

[CBSE 2019]

27. Give reason for the following.

Aquatic animals are more comfortable in cold water than in warm water. [CBSE 2018]

28. "The main application of Henry's law in respiratory physiology is to predict how gases will dissolve in the alveoli and bloodstream during gas exchange. The partial pressure of oxygen is greater in alveolar air than in deoxygenated blood, so oxygen has a high tendency to dissolve into deoxygenated blood."

State Henry's law about partial pressure of a gas in a mixture.

[CBSE 2017]

29. In non-ideal solution, what type of deviation shows the formation of maximum boiling azeotropes?

[CBSE 2016]

30. Gas (A) is more soluble in water than gas (B) at the same temperature. Which one of the two gases will have the higher value of K_H (Henry's constant) and why? [CBSE 2016]

31. What is meant by positive deviations from Raoult's law? Give an example. What is the sign of $\Delta_{mix} H$ for positive deviation?

    [CBSE 2015]

32. Define azeotropes. What type of azeotrope is formed by positive deviation from Raoult's law? Give an example.

    [CBSE 2015]

33. Define Raoult's law.

    [CBSE 2014]

34. Define the following terms: Azeotropes

    [CBSE 2014]

35. What type of deviation is shown by a mixture of ethanol and acetone? Give reason.

    [CBSE 2014]

3. COLLIGATIVE PROPERTIES

Objective Qs [1 mark]

36. An azeotropic mixture of two liquids will have a boiling point lower than either of the two liquids when it:

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

    (b) forms an ideal solution

    (c) shows a positive deviation from Raoult's law

    (d) is saturated

    [CBSE 2023]

37. In which of the following cases blood cells will shrink?

    (a) When placed in water containing more than 0.9% (mass/ volume) NaCl solution.

    (b) When placed in water containing less than 0.9% (mass /volume) NaCl solution.

(c) When placed in water containing 0.9% (mass/volume) NaCl solution.

(d) When placed in distilled water.

[CBSE SQP Term-1 2021]

38. How much ethyl alcohol must be added to 1 litre of water so that the solution will freeze at $-14^\circ \mathrm{C}$? (K_f for water $= 1.86^\circ \mathrm{C/mol}$)
(a) 7.5 mol
(b) 8.5 mol
(c) 9.5 mol
(d) 10.5 mol

[CBSE SQP Term-1 2021]

39. A 5% solution of cane sugar (molar mass $= 342$) is isotonic with 1% solution of a substance X. The molar mass of X is:
(a) $171.2 \mathrm{~g~mol}^{-1}$
(b) $68.4 \mathrm{~g~mol}^{-1}$
(c) $34.2 \mathrm{~g~mol}^{-1}$
(d) $136.2 \mathrm{~g~mol}^{-1}$

[Delhi Gov. SQP Term-1 2021]

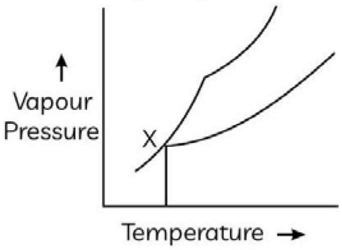
40. The boiling point of a 0.2 m solution of a non-electrolyte in water is (K_b for water = $0.52 \mathrm{~K~kg~mol}^{-1}$):
(a) $100^\circ \mathrm{C}$
(b) $100.52^\circ \mathrm{C}$
(c) $100.104^\circ \mathrm{C}$
(d) $100.26^\circ \mathrm{C}$

[CBSE Term-1 2021]

41. The osmotic pressure of a solution containing 0.3 mol of solute per litre at Temperature T is:
(a) $0.3\mathrm{RT}$
(b) $0.03RT$
(c) $0.003RT$
(d) $3\mathrm{RT}$

[Delhi Gov. SQP Term-1 2021]

42. In the following diagram point, ' X ' represents:



(a) Boiling point of solution

(b) Freezing point of solvent

(c) Boiling point of solvent

(d) Freezing point of solution

[CBSE Term-1 2021]

43. Water retention or puffiness due to high salt intake occurs due to:

(a) diffusion

(b) vapour pressure difference

(c) osmosis

(d) reverse osmosis

[CBSE SQP Term-1 2021]

In the following question (Q. No. 44-46) a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Both (A) and (R) are true and (R) is the correct explanation of (A).

(b) Both (A) and (R) are true and (R) is not the correct explanation of (A).

(c) (A) is true but (R) is false.

(d) (A) is false but (R) is true.

44. Assertion (A): Elevation in boiling point is a colligative property.

Reason (R): The lowering of vapour pressure of solution causes elevation in boiling point.

[CBSE 2023]

45. Assertion (A): Osmotic pressure is a colligative property.

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

[CBSE 2023]

46. Assertion (A): Cryoscopic constant depends on nature of solvent.

Reason (R): Cryoscopic constant is a universal constant.

[CBSE SQP Term-1 2021]

Case Based Qs [4 - 5 marks]

Read the following passages and answer the questions that follow:

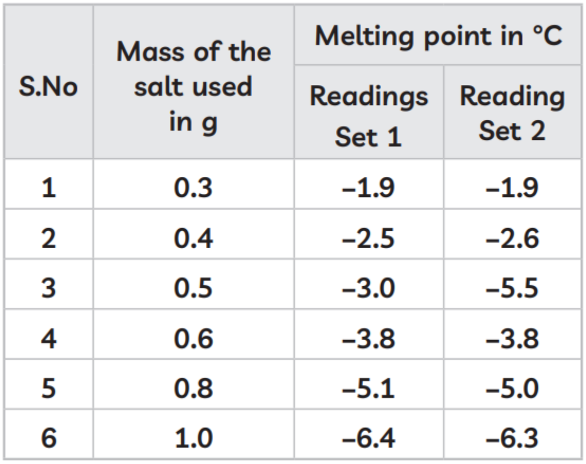
47. Henna is investigating the melting point of different salt solutions.

She makes a salt solution using 10 mL of water with a known mass of NaCl salt.

She puts the salt solution into a freezer and leaves it to freeze.

She takes the frozen salt solution out of the freezer and measures the temperature when the frozen salt solution melts.

She repeats each experiment.



S.No	Mass of the salt used in g	Melting point in °C	
		Readings Set 1	Reading Set 2
1	0.3	–1.9	–1.9
2	0.4	–2.5	–2.6
3	0.5	–3.0	–5.5
4	0.6	–3.8	–3.8
5	0.8	–5.1	–5.0
6	1.0	–6.4	–6.3

Assuming the melting point of pure water as 0°C, answer the following questions:

(A) One temperature in the second set of results does not fit the pattern. Which temperature is that? Justify your answer.

(B) Why did Henna collect two sets of results?

(C) In place of NaCl, if Henna had used glucose, what would have been the melting point of the solution with 0.6 g glucose in it?

OR

(C) What is the predicted melting point if 1.2 g of salt is added to 10ml of water? Justify your answer.

[CBSE SQP 2022]

48. 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 vapor 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 vapor 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.

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

(a) boil above $100^{\circ}\mathrm{C}$ and freeze above $0^{\circ}\mathrm{C}$

(b) boil below $100^{\circ}\mathrm{C}$ and freeze above $0^{\circ}\mathrm{C}$

(c) boil above $100^{\circ}\mathrm{C}$ and freeze below $0^{\circ}\mathrm{C}$

(d) boil below $100^{\circ}\mathrm{C}$ and freeze below $0^{\circ}\mathrm{C}$

(B) 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 not 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.

(C) 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 $0.1\mathrm{M}, 0.5\mathrm{M}$ and $0.2\mathrm{M}$ respectively. Freezing point will be highest for the fruit juice:

(a) A

(b) B

(c) C

(d) All have same freezing point

(D) Elevation of boiling point is inversely proportional to: (a) molal elevation constant (K_b)

(b) molality (m)

(c) molar mass of solute (M)

(d) weight of solute (W)

[CBSE Term-1 2021]

\section*{

Very Short & Short Qs	1 -3 marks

Very Short & Short Qs [1 – 3 marks]

49. (A) What is the effect of temperature on the solubility of glucose in water?

(B) Ibrahim collected a $10 \mathrm{~mL}$ each of fresh water and ocean water. He observed that one sample labeled " P " froze at $0^{\circ} \mathrm{C}$ while the other " Q " at $-1.3^{\circ} \mathrm{C}$. Ibrahim forgot which of the two, "P" or "Q" was ocean water. Help him identify which container contains ocean water, giving rationalization for your answer.

[CBSE SQP 2023]

50. When 19.5 g of $\mathrm{F}-\mathrm{CH}_{2}-\mathrm{COOH}$ (Molar mass $=78 \mathrm{~g} \mathrm{~mol}^{-1}$), is dissolved in $500 \mathrm{~g}$ of water, the depression in freezing point is observed to be $1^{\circ} \mathrm{C}$. Calculate the degree of dissociation of $\mathrm{F}-\mathrm{CH}_{2}-\mathrm{COOH}$.

[Given: K_{f} for water $=1.86 \mathrm{~K} \mathrm{~kg} \mathrm{~mol}^{-1}$]

[CBSE 2023]

51. Calculate the mass of ascorbic acid (Molar mass $=176 \mathrm{~g} \mathrm{~mol}^{-1}$) to be dissolved in 75 g of acetic acid, to lower its freezing point by $1.5^{\circ} \mathrm{C}$. $\left(K_{f}=3.9 \mathrm{~K} \mathrm{~kg} \mathrm{~mol}^{-1}\right)$

[CBSE 2020]

52. For a 5% solution of urea (Molar mass $=60 \mathrm{~g} / \mathrm{mol}$), calculate the osmotic pressure at $300 \mathrm{~K}$. $[\mathrm{R}=0.0821 \mathrm{~L} \text{ atm } \mathrm{K}^{-1} \mathrm{~mol}^{-1}]$

[CBSE 2020]

53. What happens when a pressure greater than the osmotic pressure is applied on the solution side separated from solvent by a semipermeable membrane?

[CBSE 2020]

54. Define the following term: Osmotic pressure

[CBSE 2017]

55. Define the following term: Colligative properties

[CBSE 2017]

56. A 10% solution (by mass) of sucrose in water has freezing point of 269.15 K. Calculate the freezing point of 10% glucose in water if freezing point of pure water is 273.15 K.

(Given: molar mass of sucrose $= 342$ g mol^{-1}, molar mass of glucose $= 180$ g mol^{-1})

[CBSE 2017]

57. Calculate the boiling point elevation for a solution prepared by adding 10 g of CaCl_2 to 200 g of water. (K_b for water $= 0.512$ K kg mol^{-1}, Molar mass of $\mathrm{CaCl}_2 = 111$ g mol^{-1})

[CBSE 2017, 14]

58. Blood cells are isotonic with 0.9% sodium chloride solution. What happens if we place blood cells in a solution containing:

(A) 1.2% sodium chloride solution?

(B) 0.4% sodium chloride solution?

[CBSE 2016]

59. Derive the relationship between relative lowering of vapour pressure and molar mass of the solute.

[CBSE 2015]

60. Calculate the mass of compound (molar mass $= 256$ g mol^{-1}) to be dissolved in 75 g of benzene to lower its freezing point by 0.48 K $\left(K_f = 5.12 \text{ K kg mol}^{-1}\right)$.

[CBSE 2014]

61. A solution containing 15 g urea (molar mass $= 60$ g mol^{-1}) per litre of solution in water has the same osmotic pressure (isotonic) as a solution of glucose (molar mass $= 180$ g mol^{-1}) in water. Calculate the mass of glucose present in one litre of its solution.

[CBSE 2014]

62. How is the vapour pressure of a solvent affected when a non-volatile solute is dissolved in it?

[CBSE 2014]

63. What are isotonic solutions?

[CBSE 2014]

64. Define the following term: Molal elevation constant (K_b)

[CBSE 2014]

4. ABNORMAL MOLECULAR MASS

Objective Qs [1 mark]

65. $0.5\mathrm{M}$ aqueous solution of glucose is isotonic with:

(a) $0.5\mathrm{MKCl}$ solution

(b) $0.5\mathrm{MCaCl}_2$ solution

(c) $0.5\mathrm{M}$ urea solution

(d) $1\mathrm{M}$ solution of sucrose

[Delhi Gov. SQP Term-1 2021]

66. Which pair of solutions is isotonic at same temperature?

(a) $0.1\mathrm{M}$ urea and $0.1\mathrm{MNaCl}$

(b) $0.1\mathrm{MNaCl}$ and $0.1\mathrm{MNa}_2\mathrm{SO}_4$

(c) $0.1\mathrm{M}$ urea and $0.2\mathrm{MMgCl}_2$

(d) $0.1\mathrm{MNa}_2\mathrm{SO}_4$ and $0.1\mathrm{MCa}(\mathrm{NO}_3)_2$

[Delhi Gov. SQP Term-1 2021]

Very Short & Short Qs [1 - 3 marks]

67. A 5% solution of $\mathrm{Na}_2\mathrm{SO}_4 \cdot 10\mathrm{H}_2\mathrm{O}(\mathrm{M} \cdot \mathrm{W} = 322\ \mathrm{g})$ is isotonic with 2% solution of nonelectrolytic, non volatile substance X. Find out the molecular weight of X.

[CBSE SQP 2023]

68. Calculate Van't Hoff factor for an aqueous solution of $\mathrm{K}_3[\mathrm{Fe}(\mathrm{CN})_6]$ if the degree of dissociation (α) is 0.852. What will be boiling point of this solution if its concentration is 1 molal? ($K_b = 0.52$ K $\mathrm{kg/mol}$)

[CBSE SQP 2023]

69. The freezing point of a solution containing 5 g of benzoic acid ($M = 122$ g mol^{-1}) in 35 g of benzene is depressed by 2.94 K. What is the percentage association of benzoic acid if it forms a dimer in solution? [K_f for benzene $= 4.9$ K kg mol^{-1}]

70. Define the following term:

Abnormal molar mass

[CBSE 2020]

71. Define the following term:

    Van't Hoff factor

    [CBSE 2017, 12]

72. Calculate the boiling point of solution when 4 g of $\mathrm{MgSO_4}(\mathrm{M}=120 \mathrm{gmol^{-1}})$ was dissolved in 100 g of water, assuming $\mathrm{MgSO_4}$ undergoes complete ionisation. [CBSE 2016]

73. Calculate the freezing point of solution when 1.9 $\mathrm{g_{of}}$ $\mathrm{MgCl_2}(\mathrm{M}=95 \mathrm{~g~mol^{-1}})$ was dissolved in 50 g of water, assuming $\mathrm{MgCl_2}$ undergoes complete ionization. $\left(K_f\right.$ for water $=1.86$ K kg $\left.\mathrm{mol^{-1}}\right)$

    [CBSE 2016]

74. When 2.56 g of sulphur was dissolved in 100 g of $\mathrm{CS_2}$, the freezing point lowered by 0.383 K. Calculate the formula of sulphur (S_x). [K_{f} for $\mathrm{CS_2}=3.83$ K kg $\mathrm{mol^{-1}}$, Atomic mass of sulphur $=32 \mathrm{~g~mol^{-1}}$]

    [CBSE 2016]

75. 3.9 g of benzoic acid dissolved in 49 g of benzen shows a depression in freezing point of 1.62 K. Calculate the Van't Hoff factor and predict the nature of solute (associated or dissociated).

    (Given: Molar mass of benzoic acid $=122 \mathrm{~g~mol^{-1}}$, K_f for benzene $=4.9$ K kg $\mathrm{mol^{-1}}$)

    [CBSE 2015]

76. Calculate the mass of NaCl (molar mass $=58.5 \mathrm{~g~mol^{-1}}$) to be dissolved in $37.2 \mathrm{~g}^2$ of water to lower the freezing point by 2°C assuming that NaCl undergoes complete dissociation.

    $\left(K_f\right.$ for water $=1.86$ K kg $\left.\mathrm{mol^{-1}}\right)$

    [CBSE 2015]

Chapter-1

SOLUTIONS

1. WAYS TO EXPRESS CONCENTRATION OF SOLUTIONS

1. (d) 22 carat gold

   Explanation: Gold is an alloy so it is a solid in solid solution. A solid solution is a uniform mixture of two crystalline solids that share a common crystal lattice. Among the given options, 22 carat gold is an example of solid solutions.

2. (c) (A) is true but (R) is false.

   Explanation: Molarity is a means to express concentration. It is not a physical property. Molarity depends on temperature but molarity is not a colligative property.

3. (d) (A) is false but (R) is true.

   Explanation: Molality $= \frac{\text{Moles of solute}}{\text{Mass of solvent (kg)}}$

   As molality has only mass terms thus it does not depend on temperature.

4. Molality (m) is defined as the number of moles of the solute per kilogram (kg) of the solvent and is expressed as:

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

5. Commonly used symbol for mole fraction is X and subscript used on the right hand side of X denotes the component. It is defined as:

   Mole fraction of a component = Number of moles of the component/Total number of moles of all the components

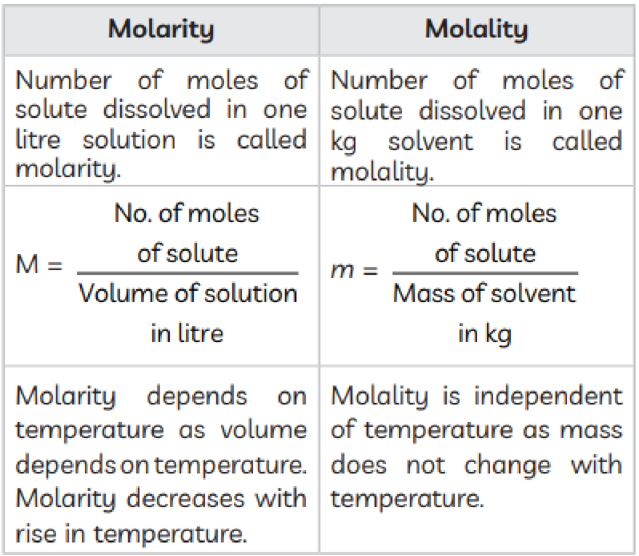
6. (A) Binary solution means solution containing two components solute and solvent as it is aqueous solution hence solvent is water.

   Thus, binary aqueous solution contains solute and water as its components.

   (B) Molarity (M) is defined as number of moles of solute dissolved in one litre (or one cubic decimeter) of solution.

   Molarity $= \frac{\text{Moles of solute}}{\text{Volume of solution in litre}}$

7.



Molarity	Molality
Number of moles of solute dissolved in one litre solution is called molarity.	Number of moles of solute dissolved in one kg solvent is called molality.
$M = \frac{\text{No. of moles of solute}}{\text{Volume of solution in litre}}$	$m = \frac{\text{No. of moles of solute}}{\text{Mass of solvent in kg}}$
Molarity depends on temperature as volume depends on temperature. Molarity decreases with rise in temperature.	Molality is independent of temperature as mass does not change with temperature.

If M_g is the molar mass of solute, d is the densityo of solution then molality (m) of a solutions can be converted to molarity (M) by using the formula

$$M = \frac{1000 \times d}{\left[\left(\frac{1000}{m}\right) + M_g\right]}$$

8. Mass of solute $= 9.8$ g

Mass of solution $= 100$ g

Density of solution $= 1.02 \text{ g mL}^{-1}$

∴ Volume of solution

$$= \frac{\text{Mass of solution}}{\text{Density of solution}}$$
$$= \frac{100 \text{ g}}{1.02 \text{ g mL}^{-1}}$$
$$= 98.039 \text{ mL} = 0.098 \text{ L}$$

Number of moles of solute,

$$n = \frac{9.8}{98} = 0.1 \text{ mol}$$

$$\text{Molarity } = \frac{\text{Number of moles of solute}}{\text{Volume of solution (in L)}}$$
$$= \frac{0.1 \text{ mol}}{0.098 \text{ L}} = 1.02\text{M}$$

9. Given: Mass of solute, $W_2 = 10$ g

Mass of solvent,

$$W_1 = 90 \text{ g}$$

Molar mass of solute,

$$\mathrm{M}_2 = 180 \text{ g mol}^{-1}$$

Density of solution $= 1.2$ g mL^{-1}

(i)

$$\begin{aligned}\text{Molality } &= \frac{W_2 \times 1000}{M_2 \times W_1} \\ &= \frac{10 \times 1000}{180 \times 90} \\ &= 0.62 \text{ m}\end{aligned}$$

(ii) Volume of solution

$$\begin{aligned}&= \frac{\text{mass}}{\text{density}} \\ &= \frac{100 \text{ g}}{1.2 \text{ g mL}^{-1}}\end{aligned}$$

$$\text{Molarity } = \frac{W_2 \times 1000}{M_2 \times V}$$

$$M = \frac{10 \times 1000}{180 \times \frac{100}{1.2}}$$

$$= \frac{10 \times 1000 \times 1.2}{180 \times 100} = 0.67\text{M}$$

2. SOLUBILITY AND VAPOUR PRESSURE

10. (b) exothermic and reversible process

Explanation: Solubility of gases in liquids decreases with rise in temperature. As dissolution is an exothermic and reversible process hence according to Le Chatelier's principle, solubility of gases in liquids decreases with rise in temperature.

11. (a) < 50 mL

Explanation: Acetone and chloroform form a solution showing negative deviation from ideal behaviour due to intermolecular H - bonding between the two. So, volume after mixing decreases.

12. (a) shows a positive deviation from Raoult's law.

    Explanation: Interactions are weaker after mixing the two liquids so vapour pressure increases that decreases the boiling point and forms minimum boiling point azeotrope.

13. (c) n-hexane and n-heptane

    Explanation: n-hexane and n-heptane have almost similar intermolecular forces so interactions after mixing remain same so these form an ideal solution.

14. (a) (i) - (B), (ii) - (A), (iii) - (D), (iv) - (C)

15. (a) 0.08

    Explanation: Mole fraction of gas in the solution is proportional to the partial pressure of the gas.

$$\mathrm{X} \propto \mathrm{P}$$

$$\text{Or} \qquad \frac{\mathrm{X}}{\mathrm{P}} = \text{ Constant}$$

$$\text{Or,} \qquad \frac{\mathrm{X}_1}{\mathrm{P}_1} = \frac{\mathrm{X}_2}{\mathrm{P}_2}$$

Where,

X_1 = Initial mole fraction of gas

P_1 = Partial pressure of gas

X_2 = Final mole fraction of gas

P_2 = Final partial pressure of gas

∵ Here only one gas

∴ Partial pressure of gas = Pressure of gas.

Therefore,

$$\frac{0.04}{2.5} = \frac{x_2}{2 \times (2.5)}$$

$$\Rightarrow \quad x_2 = \frac{0.04 \times 2 \times 2.5}{2.5}$$

$$\Rightarrow \quad x_2 = 0.08$$

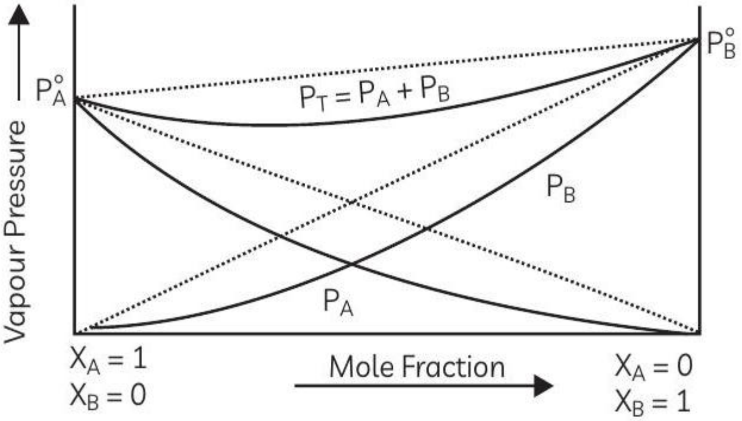
16. (c) $P_{\text{Total}} = P_{\text{Solvent}}$

    Explanation: When a non-volatile solute is added to the volatile liquid, then partial pressure of solution is only due to volatile component.

    So,

$P_{\text{Total}} = P_{\text{Solvent}}$

17. (A) Negative deviation is expected when phenol and aniline are mixed with each other. The net volume of the mixture will decrease, $\Delta V < 0$ due to stronger intermolecular interactions.



P-X Diagram for solutions showing Negative Deviation from Raoult's Law

(B) Relative lowering of vapour pressure

$$= \frac{(P^\circ - P)}{P^\circ} = X_2$$

$$X_2 = \frac{n_2}{n_1}$$

$$n_2 = 0.1$$

$$n_1 = \frac{100}{18}$$

$$X_2 = \frac{0.1}{5.55 + 0.1}$$

$$= \frac{0.1}{5.65} = 0.018$$

$$P^\circ = 23.8 \text{ mmHg}$$

Relative lowering of vapour pressure

$$= \frac{(23.80 - P)}{23.80} = 0.018$$

$$23.80 - P = 0.428$$

$$P = 23.80 - 0.428$$

$$= 23.37 \text{ mmHg}$$

18. $P_X^0 = 120$ mmHg, $P_Y^0 = 160$ mmHg $n_X = n_Y$ (given)

So, Mole fraction of $X(X_X) = \frac{n_x}{n_x + n_y} = \frac{n_x}{2n_x} = \frac{1}{2}$

Mole fraction of $Y(X_Y) = \frac{n_y}{n_x+n_y} = \frac{n_y}{2n_y} = \frac{1}{2}$

According to Raoult's law,

$$\begin{aligned} P_A &= P_A^\circ X_A \\ P_X &= P_X^\circ X_X \text{ and } P_Y = P_Y^o X_Y \\ P_X &= 120 \times \frac{1}{2} \text{ and } P_Y = 160 \times \frac{1}{2} \\ \text{So,} \quad P_X &= 60 \text{ mmHg and } P_Y = 80 \text{ mmHg} \\ P_{\text{Total}} &= P_X + P_Y \\ &= (60 + 80)\text{mmHg} \\ &= 140 \text{ mm Hg} \end{aligned}$$

19. (A) Henry's law: The partial pressure of the gas in vapour phase (P) is proportional to the mole fraction of the gas (X) in the solution. The pressure underwater is high, so the solubility of gases in blood increases. When the diver comes to surface the pressure decreases so does the solubility causing bubbles of nitrogen in blood, to avoid this situation and maintain the same partial pressure of nitrogen underwater too, the dilution is done.

(B) $P = K_H X$

Mole fraction of Argon in water

$$\begin{aligned} X &= \frac{P}{K_H} \\ &= \frac{6}{40 \times 10^3} = 1.5 \times 10^{-4} \end{aligned}$$

20. Raoult's law states that for a solution of volatile liquids, the partial vapour pressure of each component in the solution is directly proportional to its mole fraction.

Thus, if there is a solution of two liquid components (1 and 2), then for component 1:

For components 2:

$$p_1 = p_1^0 \mathrm{X}_1$$

$$p_2 = p_2^0 X_2$$

Here:

$p_1, p_2 =$ Partial vapour pressure of two volatile components (1 and 2) of the solution

$p_1^0, p_2^0 =$ Vapour pressure of pure components (1 and 2)

$X_1, X_2 =$ Mole fractions of the components (1 and 2)

Similarity between Raoult's law and Henry's law:

According to both rules, partial pressure of the volatile component or gas is directly proportional to its mole fraction in the solution.

21. Henry's law: This law states that the partial pressure of the gas in vapour phase is proportional to the mole fraction of the gas in the solution.

i.e.,

$$P \propto X$$
$$X = \text{ mole fraction of gas}$$
$$P = K_H X$$
$$K_H = \text{ Henry's constant}$$

It an also be given in terms of solubility.

$$\text{Solubility } = \frac{P}{K_H}$$

$$\text{For } CO_2\text{; solubility } = \frac{760}{1.25 \times 10^6}$$
$$= 6.08 \times 10^{-4}$$

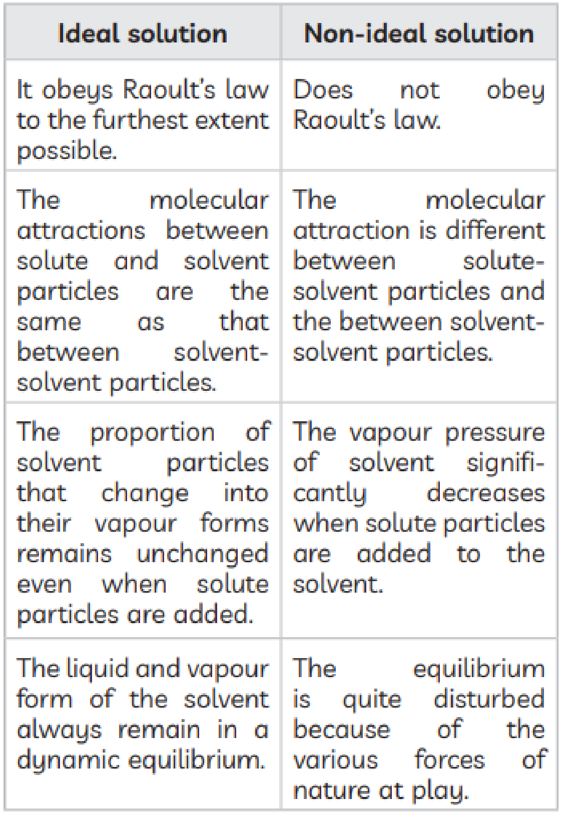
22. Those liquids which have lower boiling point will vapourise first and have higher vapour pressure. Hence, liquid A will have a high vapour pressure.

23. A mixture of ethanol and acetone shows the positive deviation from the Raoult's law. The vapour pressure of such a solution is higher than that predicted by Raoult's law due to weak intermolecular interactions between ethanol and acetone, the solution exhibits positive deviation.

24. (A) Solubility of gases in liquid decreases on increasing the temperature. Hence the availability of dissolved oxygen in water is more at lower temperatures hence; the aquatic animals feel more comfortable at lower temperatures than at the higher temperatures because oxygen is more soluble in cold water or at low temperature.

    (B) At the higher altitudes, the partial pressure of oxygen is less than at the ground level, thus the concentration of the oxygen in the blood decrease in the tissues thus at the higher altitudes people suffer more from anoxia resulting in the inability to think.

25. The difference between ideal and non-ideal solutions are as follows:



Ideal solution	Non-ideal solution
It obeys Raoult's law to the furthest extent possible.	Does not obey Raoult's law.
The molecular attractions between solute and solvent particles are the same as that between solvent-solvent particles.	The molecular attraction is different between solute-solvent particles and the between solvent-solvent particles.
The proportion of solvent particles that change into their vapour forms remains unchanged even when solute particles are added.	The vapour pressure of solvent significantly decreases when solute particles are added to the solvent.
The liquid and vapour form of the solvent always remain in a dynamic equilibrium.	The equilibrium is quite disturbed because of the various forces of nature at play.

(Any two)

26. When mixture of chloroform and acetone are mixed it shows negative deviation from Raoult's law because hydrogen bonding between acetone and chloroform reduces the possibility of molecules of the mixture escaping which leads to a decrease in vapour pressure.

27. Cold water is more comfortable for aquatic species than warm water. This is because a reduction in temperature causes oxygen to become more soluble in water. Cold water has more dissolved oxygen per unit volume than warm water. Hence, aquatic species can breathe easily in cold water but struggle to do so in warm water.

28. The mole fraction of a gas in the solution is directly proportional to the partial pressure of the gas over the solution.

$$\text{i.e.,} \quad P \propto X$$
$$P = K_H . X$$

Where P = partial pressure of the gas

X = mole fraction of the gas

K_H = Henry's law constant

29. Negative deviation from Raoult's law shows the formation of maximum boiling azeotropes.

30. The solubility of a gas in a liquid depends on various factors like temperature, the partial pressure of the gas over the liquid, the nature of the solvent and the nature of the gas. By Henry's law, solubility of a gas is inversely proportional to henry's constant for that gas. So, gas (B) will show a higher K_H value as it is less soluble.

31. Positive deviation from Raoult's law means that the observed vapour pressure is greater than expected value. Example- The mixture of ethanol and acetone shows a positive deviation. Heat absorption occurs when solutions have positive deviation, hence Δ_{mix} H has a positive $(+)$ sign.

32. Azeotropes are binary solution mixtures with same chemical composition in the liquid and vapour phases and have constant boiling points throughout distillation.

    A minimum boiling azeotrope is formed by solution showing a large positive deviation from Raoult's law. Example: An ethanol-water mixture containing approximately 95% ethanol by volume.

33. According to Raoult's law the vapour pressure of volatile component A in a given solution is given by $P_A = P_A^0 X_A$ hence, vapour pressure of A is proportional to the mole fraction of A.

34. Azeotropes are binary mixtures which have the same composition in liquid and vapour phase and boil at a constant temperature.

35. Raoult's law deviates positively in the case of ethanol and acetone mixture. In pure ethanol, molecules are hydrogen bonded. When acetone is added, its molecules bind to the host molecules and break some of the hydrogen bonds between them. Due to weakening of interactions, the solution shows positive deviation from Raoult's law.

3. COLLIGATIVE PROPERTIES

36. (c) shows a positive deviation from Raoult's law

    Explanation: When a solution shows positive deviation from Roult's is law, the intermolecular forces of solute-solvent are weaker than solute and solvent-solvent interactions.

    The vapour pressure of each component is greater than that predicted from Roult's law and the total vapour pressure of the solution is greater than the total vapour pressure of an ideal solution.

    So, an azeotropic mixture of two liquids will have a boiling point lower than either of the two liquids when it shows a positive deviation from Raoult's law.

37. (a) When placed in water containing more than 0.9% (mass/ volume) NaCl solution.

    Explanation: Isotonic solutions are those solutions which have same osmotic pressure at a given temperature.

38. (a) 7.5 mol

    Explanation:

$$\Delta \mathrm{T}_f = \mathrm{K}_f m$$

$$\Delta \mathrm{T}_f = \mathrm{K}_f \times \frac{n_2 \times 1000}{\mathrm{W}_1}$$

$$14 = 1.86 \times \frac{n_2 \times 1000}{1000}$$

$$n_2 = 7.5 \text{ mol}$$

Related Theory

The depression in freezing point can be given as:

$$\Delta T_f = K_f m$$

Where,
$\Delta T_f =$ Change in freezing point
$m =$ molality
$K_f =$ molal freezing point depression constant

39. (b) 68.4 g mol^{-1}

Explanation: 5% solution means 5 g cane sugar in 100 mL solution.

$$M = \frac{5}{342} \times \frac{1000}{100}$$

$$\pi_1 = C_1 RT$$
$$= \frac{5}{342} \times \frac{1000}{100} \times RT$$
$$\pi_2 = C_2 RT$$
$$= \frac{1}{M_X} \times \frac{1000}{100} \times RT$$

As the solution are isotonic, so

$$\pi_1 = \pi_2$$
$$\frac{5}{342} \times \frac{1000}{100} \times RT = \frac{1000}{100} \times RT$$
$$\frac{5}{342} = \frac{1}{M_X}$$
$$M_X = \frac{342}{5} = 68.4 \text{ g mol}^{-1}$$

40. (c) 100.104°C

Explanation: Given: Molality of solution = 0.2 m $\mathrm{K}_b = 0.52$ K kg mol^{-1}

So, 0.2 moles of non-electrolyte solute in 1 kg of water, formula used:

$\Delta T_b = K_b\ m$

$(\Delta T_b =$ Elevation in boiling point)

$= 0.52 \times 0.2$

$\Delta T_b = 0.104°C$

$\Delta T_b = T_b - T_b^\circ$ ($T_b^\circ = 100°C$ for

but water)

So, $T_b = 100° + 0.104°$

$= 100.104°C$

Boiling point of solution, $T_b = 100.104°C$.

41. (a) $0.3RT$

Explanation: As we know,

$$\begin{aligned} \pi V &= nRT \\ \pi \times 1 &= 0.3RT \\ &= 0.3RT \end{aligned}$$

42. (d) Freezing point of solution

Explanation: In presence of a non-volatile solute, vapour pressure of a liquid in solution deceases and so its freezing point also decreases. ' X ' represents depression in freezing point of a liquid in solution.

43. (c) osmosis

Explanation: Water retention or puffiness due to high salt intake occurs due to osmosis. It is a spontaneous process by which a molecule of solvent tends to pass through semipermeable membrane from less concentrated solution into a more concentrated one.

44. (a) Both (A) and (R) are true and (R) is the correct explanation of (A).

Explanation: Elevation in boiling point is a colligative property. It depends on amount of solute present in the solution. So, it is directly proportional to molality.

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

Where, $\Delta T_b =$ Elevation in boiling point and $m =$ molality.

45. (a) Both (A) and (R) are true, and (R) is the correct explanation of the (A).

Explanation: Colligative property depends on the no. of solute particles present in the solution. Osmotic pressure depends upon the no. of particles of solute, i.e., molarity of solute. Hence, osmotic pressure is a colligative property.

46. (c) (A) is true but (R) is false.

Explanation: Cryoscopic constant depends on nature of solvent cryoscopic constant varies with the type of solvent.

47. The melting point of ice is the freezing point of water. We can use the depression in freezing point property in this case.

(A) 3rd reading for 0.5 g there has to be an increase in depression of freezing point and therefore decrease in freezing point so also decrease in melting point when amount of salt is increased but the trend is not followed on this case.

(B) Two sets of reading help to avoid error in data collection and give more objective data.

$$\Delta \mathrm{T}_f(\text{ glucose }) = 1 \times \mathrm{K}_f \times \frac{0.6 \times 1000}{180 \times 10}$$
$$\Delta \mathrm{T}_f(\mathrm{NaCl}) = 2 \times \mathrm{K}_f \times \frac{0.6 \times 1000}{58.5 \times 10}$$
$$3.8 = 2 \times \mathrm{K}_f \times \frac{0.6 \times 1000}{58.5 \times 10}$$

Divide equation 1 by 2

$$\frac{\Delta \mathrm{T}_f(\text{ glucose })}{3.8} = \frac{58.5}{2 \times 180}$$
$$\Delta \mathrm{T}_f(\text{ glucose }) = 0.62$$

Freezing point or Melting point $= -0.62^\circ\mathrm{C}$

OR

Depression in freezing point is directly proportional to molality (mass of solute when the amount of solvent remains same)

0.3 g depression is $1.9^\circ\mathrm{C}$

0.6 g depression is $3.8^\circ\mathrm{C}$

1.2 g depression will be $3.8 \times 2 = 7.6\ ^\circ\mathrm{C}$

48. (A) (c) boil above $100^\circ\mathrm{C}$ and freeze below $0^\circ\mathrm{C}$ Explanation: On addition of a non-volatile solute to pure water, the vapour pressure decreases. This increases the boiling point and decreases the freezing point of water. Therefore, pure water will boil above $100^\circ\mathrm{C}$ and freeze below $0^\circ\mathrm{C}$.

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

Explanation: Colligative properties are those properties which depend only on the concentration (number of particles) of the solute and independent of the solvent's and solute's identity.

(C) (a) A

Explanation: As the concentration of solution increases, the freezing point decreases. So, the highest freezing point will be for the solution which has the lowest concentration of solution. Therefore, the freezing point of fruit juice A, with concentration 0.1M, will be the highest.

(D) (c) molar mass of solute (M)

Explanation: According the formula:

$$\Delta \text{T}_b = \frac{\text{K}_b \times 1000 \times \text{W}_2}{\text{M}_2 \times \text{W}_1}$$

Elevation of boiling point $(\Delta \text{T}_\text{b})$ is inversely proportional to the molar mass of the solute (M_2).

49. (A) Addition of glucose to water is an endothermic reaction. According to Le Chatelier's principle, on increase in temperature, solubility will increase.

    (B) Q is ocean water, due to the presence of salts it freezes at lower temperature (depression in freezing point)

50. $\Delta \text{T}_b = 1^\circ\text{C} = 1\ \text{F}$

    $\text{K}_b = 1.86\ \text{K kg mol}^{-1}$

    Since, $\Delta \text{T}_b = iK_b\ \text{m}$

$$1 = i \times 1.86 \times \frac{19.5 \times 1000}{78 \times 500}$$
$$i = \frac{1 \times 78 \times 500}{1.86 \times 19.5 \times 100}$$
$$i = 1.0753$$

$$\begin{array}{llll} & \text{CH}_2\text{FCOOH} \rightleftharpoons & \text{CH}_2\text{FCOO}^- & + \ \text{H}^- \\ \text{At t} = 0 & \text{C} & \text{O} & \text{O} \\ \text{At t} = \text{teq}^{\text{m}} & \text{C}(1-\alpha) & \text{C}\alpha & \text{C}\alpha \end{array}$$

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

$$i = \frac{C + C\alpha}{C} = \frac{C(1+\alpha)}{C} = 1 + \alpha$$
$$i = 1 + \alpha$$
$$\alpha = i - 1$$
$$\alpha = 1.0753 - 1$$
$$\alpha = 0.0753$$

So, the required degree of dissociation is 0.0753.

51. Given, $\text{M}_2 = 176\ \text{g mol}^{-1}, \Delta \text{T}_f = 1.5^\circ\text{C}, \text{W}_1 = 75\ \text{g},\ \text{K}_f = 3.9\ \text{K kg mol}^{-1},\ \text{W}_2 = ?$

$$\Delta T_f = \frac{K_f \times W_2 \times 1000}{M_2 \times W_1}$$

$$W_2 = \frac{\Delta T_f \times M_2 \times W_1}{K_f \times 1000}$$

$$= \frac{1.5 \times 176 \times 75}{3.9 \times 1000} = 5.077 \text{ g}$$

52. Given, 5% urea solution means 5 g urea is present in 100ml of solution. moles of urea present

$$= \frac{\text{weight given}}{\text{molecular weight of urea}}$$

$$= \frac{5 \text{ g}}{60 \text{ g mol}^{-1}}$$

$$= 0.083$$

Hence, Concentration of urea

$$= \frac{\text{moles of urea } (n)}{\text{volume of solution}} \times 1000$$

$$= \frac{112}{100} \times 1000$$

$$= 0.83$$

Hence, Osmotic pressure

$$= 1 \times \frac{10}{20} \times 0.082 \times 300 \text{ atm}$$

$$= 12.45 \text{ atm.}$$

53. When the external pressure applied becomes more than the osmotic pressure of solution then the solvent molecules from the solution will move towards the solvent compartment through semi permeable membrane. This is called reverse osmosis.

54. The pressure that just stops the flow of solvent is called osmotic pressure of the solution.

55. Colligative properties are the one which depends on the number of moles of the solute particles dissolved in the solution.

56.

$\Delta T_f = K_f \text{ m}$

Here,

$$m = w_2 \times \frac{1000}{M_2} \times M_1$$

$$273.15 - 269.15 = K_f \times 10 \times \frac{1000}{342} \times 90$$

$$\begin{aligned} \mathrm{K}_f &= 12.3 \text{ K kg/mol} \\ &= \mathrm{K}_f m \\ &= 12.3 \times 10 \times \frac{1000}{180} \times 90 \\ &= 7.6 \text{ K} \\ \mathrm{T}_f &= 273.15 - 7.6 \\ &= 266.55 \text{ K} \end{aligned}$$

57. $CaCl_2$ dissociates in aqueous solution.

$$\mathrm{CaCl}_{2(\,s)} \xrightarrow{(\mathrm{aq})} \mathrm{Ca}^{2+}{}_{(aq)} + 2\mathrm{Cl}^-{}_{(aq)}$$

$$i = 3,\ \mathrm{W_B} = 10 \text{ g},\ \mathrm{W_A} = 200 \text{ g} = 0.2,\ \mathrm{K}_b = 0.512 \text{ K kg mol}^{-1}$$

$$\mathrm{M_B} = 110 \text{ g mol}^{-1}$$

$$\Delta \mathrm{T}_b = i \times \mathrm{K}_b \text{ m} = \frac{i \times \mathrm{K}_b \times \mathrm{W_B}}{\mathrm{M_B} \times \mathrm{W_A}}$$

$$\Delta \mathrm{T}_b = \frac{(3) \times (0.512 \text{ Kkgmol}^{-1}) \times (10 \text{ g})}{(110\text{gmol}^{-1}) \times (0.2 \text{ kg})}$$

$$= 0.69 \text{ K}$$

58. (A) The 1.2% sodium chloride solution is hypertonic in nature thus the cell will shrink due to the exosmosis process taking place in the blood cells.

(B) The 0.4% sodium chloride solution is hypotonic in nature thus the cell will swell due to the endosmosis process taking place in the blood cells.

59.

$$\begin{aligned} & \mathrm{P_A} && \propto \mathrm{X_A} \\ \Rightarrow\ & \mathrm{P_A} && = \mathrm{P_A^\circ X_A} \\ \because\ & \mathrm{X_A} + \mathrm{X_B} && = 1 \\ \therefore\ & \mathrm{X_A} && = 1 - \mathrm{X_B} \\ \Rightarrow\ & \mathrm{P_A} && = \mathrm{P_A^\circ}(1 - \mathrm{X_B}) \\ & \frac{\mathrm{P_A}}{\mathrm{P_Å}} && = 1 - \mathrm{X_B} \\ \Rightarrow\ & 1 - \frac{\mathrm{P_A}}{\mathrm{P_Å}} && = \mathrm{X_B} \\ & \frac{\mathrm{P_Å} - \mathrm{P_A}}{\mathrm{P_Å}} && = \mathrm{X_B} \end{aligned}$$

$$\frac{\mathrm{P}_{\mathring{A}} - \mathrm{P}_A}{\mathrm{P}_{\mathring{A}}} = \frac{\frac{\mathrm{W}_B}{M_B}}{\frac{W_A}{M_A} + \frac{W_B}{M_B}} = \frac{\frac{W_B}{M_B}}{\frac{W_A}{M_A}}$$

$$\left[\because \frac{W_B}{M_B} \ll< \frac{W_A}{M_A} \text{ for dilute solution}\right]$$

$$\Rightarrow \frac{P_{\mathring{A}} - P_A}{P_{\mathring{A}}} = \frac{W_B}{M_B} \times \frac{M_A}{W_A}$$

$$\Rightarrow M_B = \frac{W_B \times M_A}{W_A} \times \frac{P_{\mathring{A}}}{P_{\mathring{A}} - P_A}$$

where $P_{\mathring{A}}$ = Vapour pressure of pure 'A' (solvent)

X_A = Mole fraction of ' A '

X_B = Mole fraction of ' B ' (solute)

P_A = Vapour pressure of solution

W_B = Mass of solute

W_A = Mass of solvent

M_B = Molar mass of solute

M_A = Molar mass of solvent

60. Given: $W_2 = ?$, $M_2 = 256 \text{ g mol}^{-1}$, $\Delta T_f = 0.48$ K, $W_1 = 75$ g, $K_f = 5.12 \text{ K kg mol}^{-1}$

$$\Delta T_f = \frac{(3) \times (0.512 \text{ Kkgmol}^{-1}) \times (10 \text{ g})}{(110 \text{gmol}^{-1}) \times (0.2 \text{ kg})}$$

$0.48 \text{ K} = 5.12 \text{ K kg mol}^{-1}$

$$\times \frac{W_2}{75 \times 256} \times 1000$$

$$W_2 = \frac{0.48 \times 75 \times 256}{5.12 \times 1000} \text{ g}$$

$$W_2 = 1.8 \text{ g}$$

61. Given: Mass of Urea,

$$W_B = 15 \text{ g}$$

Molar Mass of Urea

$$M_b = 60 \text{ g}$$

The solution of urea in water is isotonic to that of glucose solution.

$$\begin{aligned} \pi_{\text{Urea}} &= \pi_{\text{Glucose}} \\ \mathrm{C}_{\text{urea}}\,\mathrm{RT} &= \mathrm{C}_{\text{Glucose}}\,\mathrm{RT} \\ \frac{n_{\text{urea}}}{\mathrm{V}}\,\mathrm{RT} &= \frac{n_{\text{Glucose}}}{\mathrm{V}T} \\ \text{So,} \qquad \frac{15}{60} &= \frac{\mathrm{W}_{\text{Glucose}}}{180} \\ \mathrm{W}_{\text{Glucose}} &= \frac{15 \times 18}{60} \\ &= 4.5\ \mathrm{g} \end{aligned}$$

So, 4.5 g of glucose is present in 1 L of solution.

62. When a non-volatile solute is added to a solvent, then the vapour pressure of the solvent decreases because surface area is partly occupied by non-volatile solute molecules. Due to this rate of evaporation decreases.

63. Two solutions having same osmotic pressure at a given temperature are called isotonic solutions.

64. Molal elevation constant can be defined as the elevation in boiling point produced when one mole of solute is dissolved in 1 kg i.e., 1000 g of the solvent. It is also known as the Ebullioscopic constant.

4. ABNORMAL MOLECULAR MASS

65. (c) 0.5M urea solution

Explanation: Isotonic solutions have same osmotic pressure.

$\pi = i$ CRT

$\pi_1 = 1 \times 0.5 \times RT$ for glucose, $i = 1$

$\pi_2 = 2 \times 0.5 \times \mathrm{RT}$ for KCl, $i = 2$

$\pi_3 = 3 \times 0.5 \times \mathrm{RT}$ for $\mathrm{CaCl_2}, i = 3$

$\pi_4 = 0.5 \times 1 \times \mathrm{RT}$ for urea, $i = 1$

$\pi_5 = 1 \times 1 \times \mathrm{RT}$ for sucrose, $i = 1$

$\pi_1 = \pi_4$ hence answer is 0.5 urea solution.

66. (d) $0.1\mathrm{MNa_2}SO_4$ and $0.1\mathrm{MCa(NO_3)_2}$

Explanation: $\mathrm{Na_2}SO_4 \rightarrow 2\mathrm{Na^+} + \mathrm{SO_4^{2-}}$

Concentration $= 0.3\mathrm{M}$

$$\mathrm{Ca(NO_3)_2} \rightarrow \mathrm{Ca^{2+}} + 2\mathrm{NO_3^-}$$

Concentration $= 0.3\text{M}$

Osmotic pressure $\propto$ number of particles.

67.

$$\pi_1 = \pi_2$$
$$\text{iC}_1\text{RT} = \text{C}_2\text{RT}$$
$$\frac{3 \times 5}{322} = \frac{2}{\text{M}}$$
$$\text{M} = \frac{2 \times 322}{3 \times 5}$$
$$\text{M} = 42.9 \text{ g}$$

68. $\text{K}_3[\text{Fe(CN)}_6]$ gives 4 ions in aqueous solution

$$i = 1 + (n-1)\alpha$$
$$i = 1 + (4-1) \times 0.0.852$$
$$i = 3.556$$
$$\Delta\text{T}_\text{b} = i\ \text{K}_\text{b}\text{m} = 3.556 \times 0.52 \times 1$$
$$= 1.85$$
$$\text{T}_\text{b} = 101.85°\text{C}$$

69. Number of moles of benzoic acid $= \frac{5}{122}$

Molality of benzoic acid solution

$$= \frac{5}{122} \times \frac{1000}{35} = 1.17$$

Apply the relation,

$$\Delta\text{T}_f = i\ \text{K}_f\ \text{m}$$

Where i is Vant Hoff factor.

$$2.94 \text{ K} = i \times 4.8\text{Kgmol}^{-1}$$

$$\text{Or}\ \ i = \frac{2.94}{4.9 \times 1.17}\ \times 1.17\text{molkg}^{-1}$$

$$(\text{C}_6\text{H}_5\text{COOH})_2 \rightarrow (\text{C}_6\text{H}_5\text{COOH})_2$$

Total number of moles $= 1 - x(x/2)$

$$= 1 - (x/2)$$

$$i = \frac{1 - \frac{x}{2}}{1}$$

From (i) and (ii), we have

$$1 - \frac{x}{2} = \frac{2.94}{4.9 \times 1.17} = 0.5128$$

$$\text{Or } \frac{x}{2} = 1 - 0.5128 = 0.4872$$

$$\text{Or } x = 0.9744 \text{ or } 97.44\%$$

70. Molar mass that is either lower or higher than the expected or the normal molar mass is known as abnormal molar mass.

71. The Van't Hoff factor is the ratio between the actual concentration of particles produced when the substance is dissolved and the concentration of a substance as calculated from its mass. For most non-electrolytes dissolved in water, the Van't Hoff factor is essentially 1.

72. Apply the relation,

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

For $MgSO_4$, $i = 2$

Molarity of Solution

$$= \frac{4/120}{100} \times 1000$$

$$= \frac{4}{120} \times 10$$

$$= \frac{1}{3}$$

Substituting the values in eq. (i), we have

$$\Delta T_b = 2 \times 0.52 \times \frac{1}{3}$$

$$= 0.347$$

Boiling point of the solution

$$= 100 + 0.347$$

$$= 100.347^\circ C$$

$$= 373.347 \text{ K}$$

73. Given:

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

Mass of solute $= 1.9$ g

Mass of solvent $= 50$ g

Therefore,

Molality of the solution,

$$m = \frac{1.9}{95} \times \frac{1000}{50} = 0.4 \text{ m}$$

Also, $MgCl_2$ undergoes complete ionisation and thereby yielding 3 moles of constituent ions for every mole of $MgCl_2$.

$\therefore i = 3$

Now, depression in freezing point is given as:

$$\begin{aligned} \Delta T_f &= i \, K_f \text{ m} \\ &= 3 \times 1.86 \times 0.4 \\ &= 2.232 \text{ K} \\ T_f &= 273.15 - 2.232 \\ &= 270.918 \text{ K} \end{aligned}$$

Hence, the new freezing point of the solution is 270.92 K.

74. Here, $W_B = 2.56$ g, $W_A = 100$ g, $\Delta T_f = 0.383$ K, $K_f = 3.83$ K kg mol^{-1}

Substitution these values in the expression, we get

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

$$M_B = \frac{3.83 \text{ K kg mol}^{-1} \times 2.56 \times 1000 \text{ g kg}^{-1}}{100 \text{ g} \times 0.383 \text{ K}}$$

Now, molecular mass of $S_x = x \times 32 = 256$

$$x = \frac{256}{32} = 8$$

Therefore, formula of sulphur = S_8.

75.

$$\begin{aligned} \Delta T_f &= i \, K_f \text{ m} \\ \text{m} &= \frac{W_B \times 1000}{M_B \times W_B} \\ \Delta T_f &= \text{ Depression in freezing point} \\ &= 1.62 \\ i &= \text{ Van't Hoff factor} \\ K_f &= \text{ constant } = 4.9 \end{aligned}$$

$$\mathrm{m} = \frac{3.9 \times 1000}{122 \times 49} = 0.65$$

$$i = \frac{\Delta \mathrm{T}_f}{\mathrm{K}_f m}$$

$$= \frac{1.62}{4.9 \times 0.65} = 0.50$$

$$i = 0.50$$

As the value of $i < 1$, the solute is associated.

76. NaCl undergoes complete dissociation as:

$$\mathrm{NaCl} \rightarrow \mathrm{Na}^+ + \mathrm{Cl}^-$$

The Van't Hoff factor, i is given as: Number of particles

$$i = \frac{\text{after dissociation}}{\text{Number of particles}}$$

before diss

$$\Rightarrow \qquad i = \frac{2}{1} = 2$$

The depression in freezing point of a solution is given by:

Given:

$$\Delta \mathrm{T}_f = \mathrm{iK}_f \frac{\mathrm{W_s} \times 1000}{\mathrm{M_s} \times \mathrm{W}}$$

$$\mathrm{K}_f \text{ for water } = 1.86 \mathrm{~K~kg~mol}^{-1}$$

Molar mass of solute, $M_S = 58.5 \mathrm{~g~mol}^{-1}$ Mass of water,

Mass of solute, $\mathrm{W_s} = ?$

$$\mathrm{W} = 37.2 \mathrm{~g}$$

$$\Delta \mathrm{T}_f = 2^\circ\mathrm{C} = 2 \mathrm{~K}$$

Substituting the above values in (i), we get

$$2 = 2 \times 1.86 \times \frac{W_s \times 1000}{58.5 \times 37.2}$$

$$W_s = 1.17 \mathrm{~g}$$

Hence, the required mass of NaCl is 1.17 g.