Solutions

(1) EXPRESSING CONCENTRATION OF SOLUTIONS

- Mass percentage (w/w) $= \dfrac{\text{Mass of a component}}{\text{Mass of solution}} \times 100$

- Volume percentage (v/v) $= \dfrac{\text{Volume of a component}}{\text{Total volume of solution}} \times 100$

- Mass by volume percentage (w/v) $= \dfrac{\text{Mass of solute}}{\text{Volume of solution}} \times 100$

- Parts per million (ppm) $= \dfrac{\text{Mass of solute}}{\text{Mass of solution}} \times 10^6$

- Mole fraction (X) $= \dfrac{\text{Mole of a component}}{\text{Total moles of all components}}$

- Molarity (M) $= \dfrac{\text{Moles of solute}}{\text{Volume of solution (l)}}$

- Molality (m) $= \dfrac{\text{Mass of solute}}{\text{Mass of solvent (kg)}}$

- Solubility of a substance is its maximum amount that can be dissolved in a specified amount of solvent at a specified temperature.

(2) SOLUBILITY OF A SOLID IN A LIQUID

- Significantly affected by temperature change.
- Pressure does not have any significant effect.

(3) SOLUBILITY OF A GAS IN A LIQUID

- Henry's law: $p = K_H x$
- Decreases with increase in temperature.
- Increases with increase in pressure.
- The air tanks of scuba divers are diluted with He to avoid bends.
- To increase the solubility of CO_2 in soft drinks and soda water, the bottle is sealed under high pressure.

(4) RAOULT'S LAW

- For non-volatile solute in volatile solvent
$p_{solution} = p^{\circ}_{solvent} \, x_{solvent}$

- For volatile liquids:
$p_{total} = p_1 + p_2 = p^{\circ}_1 x_1 + p^{\circ}_2 x_2 = p^{\circ}_1 + (p^{\circ}_2 - p^{\circ}_1)x_2$

- Mole fraction of any component in vapour phase:
$y_1 = p_1/p_{total}$

(5) TYPE OF SOLUTIONS

- **Ideal solutions:** A – B interactions are of same magnitude as A – A and B – B interactions. $\Delta V_{mix} = 0$ and $\Delta H_{mix} = 0$
eg.: n-hexane and n-heptane, bromoethane and chloroethane.

- **Non-ideal solutions:** A – B interactions are of different magnitude than A – A and B – B interactions. $\Delta V_{mix} \neq 0$ and $\Delta H_{mix} \neq 0$.

- **(+)ve deviations:** A – B interactions are weaker than A – A and B – B interactions.
  - $\Delta H_{mix} > 0, \Delta V_{mix} > 0, P_{obs} > P_{cal}$
  - eg: acetone + ethanol,

- **(–)ve deviations:** A – B interactions are stronger than A – A and B – B interactions.
  - $\Delta H_{mix} < 0, \Delta V_{mix} < 0, P_{obs} < P_{cal}$
  - eg: nitric acid + water, chloroform + acetone

- **Azeotropes:** constant boiling mixtures whose composition does not change on distillation.

- **Minimum boiling azeotrope:** 95% C_2H_5OH and 5% H_2O by volume

- **Maximum boiling azeotrope:** 68% HNO_3 and 32% H_2O by mass

(6) COLLIGATIVE PROPERTIES

- Relative lowering of vapour pressure : $\dfrac{p^{\circ}_1 - p_1}{p^{\circ}_1} = x_{solute}$

- Elevation in boiling point: $\Delta T_b = T_b - T^0_b = K_b m$
Where, $K_b = \dfrac{R \times M_1 \times T^2_b}{1000 \times \Delta_{vap}H}$

- Depression in freezing point: $\Delta T_f = T^0_f - T_f = K_f m$
Where, $K_f = \dfrac{R \times M_1 \times T^2_f}{1000 \times \Delta_{fus}H}$

- Osmotic pressure: $\pi = CRT = \left(\dfrac{n}{v}\right) RT$

- Osmotic pressure method is widely used to determine molar mass of proteins, polymers.
- Isotonic solution have same osmotic pressure.
- Osmotic pressure associated with the fluid inside the blood cell is equivalent to 0.9% (mass/vol) of NaCl solution.

(7) van't Hoff FACTOR AND ITS SIGNIFICANCE

$i = \dfrac{\text{Observed value of colligative property}}{\text{Calculated value of colligative property}}$

$= \dfrac{\text{Normal molar mass}}{\text{Abnormal molar mass}}$

- For normal solute (i = 1)
- For association, i < 1
- For dissociation, i > 1

(8) MODIFIED COLLIGATIVE PROPERTIES

- $\dfrac{p^{\circ}_1 - p_1}{p^{\circ}_1} = \dfrac{i n_2}{n_1}$
- $\Delta T_b = i K_b m$
- $\Delta T_f = i K_f m$
- $\pi = iCRT$

Sharpen Your Understanding

NCERT Based MCQs

1. Which of the following is a common example of solid solution? [NCERT Pg. 36]

   (1) Chloroform mixed with nitrogen gas

   (2) Glucose dissolved in water

   (3) Solution of hydrogen in palladium

   (4) Camphor in nitrogen gas

2. If a solution is described by 10% glucose in water by mass it means that

   [NCERT Pg. 36]

   (1) 10 g of glucose is present in 90 g of water

   (2) 10 g of glucose is present in 100 g of water

   (3) 10 g of glucose is present in 110 g of water

   (4) 10 g of glucose is present in 100 ml of water

3. The molarity of 20% (mass/mass) aqueous KI solution will be (Density of solution = 1.202 g ml^{-1}) [NCERT Pg. 38]

   (1) 1.87 M   (2) 1.52 M

   (3) 1.21 M   (4) 1.44 M

4. Generally solubility of one substance into another substance depends on

   [NCERT Pg. 39]

   (1) The nature of substances

   (2) Temperature

   (3) Pressure

   (4) All of these

5. Select the incorrect statement among the following. [NCERT Pg. 41]

   (1) Different gases have different K_H values at the same temperature

   (2) The value of K_H for a gas decreases with increase of temperature

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

   (4) Mole fraction of a gas in the solution is proportional to the partial pressure of the gas over the solution

6. The mass of CO_2 in 500 ml of soda water when packed under 2.5 atm CO_2 pressure at 298 K is ($K_H = 1.67 \times 10^8$ Pa)

   [NCERT Pg. 43]

   (1) 1.85 g   (2) 2.67 g

   (3) 1.21 g   (4) 0.93 g

7. For a solution of two volatile liquids, the correct relation is [NCERT Pg. 44]

   (1) $p_{total} = p_1^o + p_2^o$

   (2) $p_{total} = p_1^o x_2 + p_2^o x_1$

   (3) $p_{total} = p_1^o + \left(p_2^o - p_1^o\right)x_2$

   (4) $p_{total} = p_1^o + \left(p_2^o - p_1^o\right)x_1$

8. Which among the following solution shows positive deviation from raoult's law?

   [NCERT Pg. 48]

   (1) Nitric acid + water

   (2) Chloroform + acetone

   (3) Phenol + aniline

   (4) Ethanol + water

9. At a particular temperature if the vapour pressure of pure liquids P and Q are 450 and 700 mm Hg respectively then the mole fraction of P in vapour phase will be (Given: total vapour pressure of solution is 600 mm Hg)

   [NCERT Pg. 45]

   (1) 0.4   (2) 0.3

   (3) 0.6   (4) 0.7

10. The value of K_f is given by [NCERT Pg. 53]

    (1) $\dfrac{R \times M_1 \times T_f^2}{1000 \times \Delta_{fus}H}$ (2) $\dfrac{R \times M_1 \times T_f^2}{\Delta_{fus}H}$

    (3) $\dfrac{R \times M_1 \times T_f}{1000 \times \Delta_{fus}H}$ (4) $\dfrac{R \times M_1 \times \Delta_{fus}H}{T_f}$

11. Mass of benzoic acid required to prepare 500 mL of 0.3 M solution in ethanol is

    [NCERT Pg. 53]

    (1) 25.2 g   (2) 15.2 g

    (3) 18.3 g   (4) 21.5 g

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

    [NCERT Pg. 56]

    (1) Hypotonic solutions

    (2) Isotonic solutions

    (3) Hypertonic solutions

    (4) Ideal solutions

13. The vapour pressure of a solution at 298 K containing 50 g of urea in 850 g of water will be (Given: $p^o_{H_2O}$ = 23.8 mm at 298 K)

    [NCERT Pg. 49]

    (1) 22.4 mm   (2) 22.9 mm

    (3) 23.1 mm   (4) 23.4 mm

14. van't Hoff factor (i) for complete dissociation of K_2SO_4 will be   [NCERT Pg. 59]

    (1) 7   (2) 1

    (3) 2   (4) 3

15. Which colligative property is used to determine the molar masses of proteins?

    [NCERT Pg. 56]

    (1) Osmotic pressure

    (2) Elevation in Boiling point

    (3) Relative lowering of vapour pressure

    (4) Depression in freezing point

16. The approximate composition (by mass) of azeotrope formed by nitric acid and water is

    [NCERT Pg. 49]

    (1) 48% HNO_3 + 52% H_2O

    (2) 72% HNO_3 + 28% H_2O

    (3) 68% HNO_3 + 32% H_2O

    (4) 50% HNO_3 + 50% H_2O

17. van't Hoff factor is defined as the ratio of

    [NCERT Pg. 58]

    (1) Calculated colligative property to observed colligative property

    (2) Normal molar mass to experimentally determined molar mass

    (3) Cryoscopic constant to Ebullioscopic constant

    (4) Molal depression constant to molal elevation constant

18. The molar mass of a non-volatile solute whose 2% aqueous solution exerts a osmotic pressure of 1.004 bar at 273 K, will be   [NCERT Pg.55]

    (1) 625.5 g/mol   (2) 700.3 g/mol

    (3) 226.4 g/mol   (4) 445.9 g/mol

19. Which of the following aqueous solution have highest freezing point?

    [NCERT Pg. 58]

    (1) 0.1 m NaCl   (2) 0.3 m Na_2SO_4

    (3) 0.2 m Sucrose   (4) 0.1 m urea

20. If depression in freezing point of 0.2 m CH_2FCOOH solution is 0.5°C then van't Hoff factor of CH_2FCOOH will be (k_f = 1.86 K kg mol^{-1})   [NCERT Pg. 51]

    (1) 1.34   (2) 1.75

    (3) 1.62   (4) 1.12

? Thinking in Context

1. At high altitudes the partial pressure of oxygen is _____ than that at the ground level.   [NCERT Pg. 50]

2. Solutions which obey Raoult's law over the entire range of concentration are called _____.   [NCERT Pg. 47]

3. Relative lowering of vapour pressure of the solvent over a solution is equal to the _____ of a non-volatile solute present in the solution.   [NCERT Pg. 50]

4. The properties of solutions which depend on the number of solute particles and are independent of their chemical identity are called _____.   [NCERT Pg. 49]

5. The process of osmosis can be reversed if a pressure _____ than the osmotic pressure is applied to the solution.

    [NCERT Pg. 57]

6. The value of i for ethanoic acid in benzene is nearly _____.   [NCERT Pg. 58]

7. The osmotic pressure associated with the fluid inside the blood cell is equivalent to that of _____ (mass/volume) sodium chloride solution. [NCERT Pg. 56]

8. The concentration of pollutants in water is often expressed in terms of _____.
[NCERT Pg. 37]

9. _____ does not have any significant effect on solubility of solids in liquids. [NCERT Pg. 40]

10. The tanks used by scuba divers are filled with air diluted with _____ to avoid bends. [NCERT Pg. 43]

11. The type of intermolecular attractive interactions among I_2 and CCl_4 are _____. [NCERT Pg. 63]

12. The mole fraction of benzene in solution containing 30% by mass in carbon tetrachloride is _____. [NCERT Pg. 39]

13. Molarity is a function of temperature because _____ depends on temperature. [NCERT Pg. 39]

14. Raoult's law becomes a special case of Henry's law in which K_H becomes equal to _____. [NCERT Pg. 46]

15. The enthalpy change of mixing of the pure components to form a ideal solution is _____. [NCERT Pg. 47]

16. The boiling point (in Kelvin) of solution containing 6 g urea in 1 kg of water (K_b = 0.52 K kg mol^{-1}) will be _____. [NCERT Pg. 51]

17. The osmotic pressure (in atm) of a solution containing 5.55 g of NaCl in 1 L of aqueous solution at 300 K will be _____.
[NCERT Pg. 55]

18. The mass percentage of benzene in mixture of 22 g benzene and 122 g of carbon tetrachloride is _____. [NCERT Pg. 39]

19. A solution will freeze when its vapour pressure equals the vapour pressure of the pure _____. [NCERT Pg. 52]

20. The flow of solvent from dilute solution to the concentrated solution across a semipermeable membrane is due to _____. [NCERT Pg. 55]

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