BYJU'S Home Learning Program

Topic covered:

- **Solutions (Session - 1) - JEE**

Daily Practice Problems

1. Select the correct statement:
   a. A solution must have only one solvent and only one solute
   b. A solution can have only one solvent but more than one solute
   c. A solution can have only one solute but more than one solvent
   d. All the above

2. Identify the solute and the solvent in the following solutions:
   a. Sugar solution
   b. Air
   c. Aerated drinks
   d. Zn-Hg amalgam

3. Calculate the molality, molarity and normality of an 8.5 %(w/v) solution of sodium nitrate. The density of the solution is 1.25 g/mL.

4. Which of the following concentration terms is independent of temperature?
   a. Molarity
   b. Normality
   c. Mole fraction
   d. ppm (w/w)

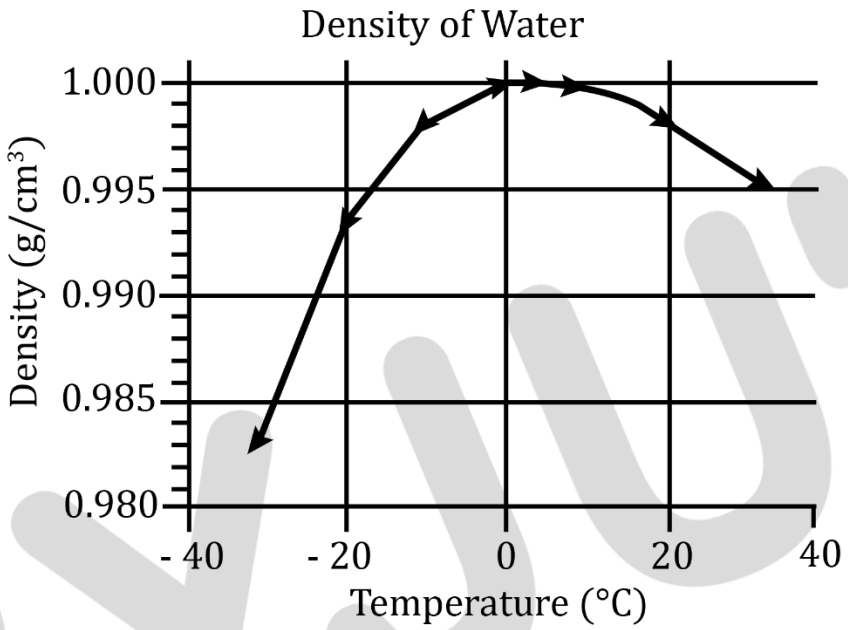
5. If the mole fraction of the solute in a 2 molal solution is 0.2 and the ratio of molar masses of solute and solvent is 1:5. Calculate the molar mass of solute in grams.

6. Calculate the mole fraction of benzene in a solution of benzene in HCl. The concentration of the solution is 30 % by mass. (molar mass of Cl = 35.5 g)

7. A water sample contains 81 ppm of $Ca(HCO_3)_2$, 73 ppm of $Mg(HCO_3)_2$, 68 ppm of $CaSO_4$ and 60 ppm of $MgSO_4$. What is the hardness of the water sample?

8. The largest value of Henry's law constant for the liquid solvent H_2O will be obtained in which of the following cases?
   a. He at 300 K
   b. O_2 at 300 K
   c. He at 400 K
   d. O_2 at 400 K

9. Density of pure water is maximum at 4^0 C and is 1 g/mL. It decreases on both sides as a function of temperature as shown by the following graph.
   i. Predict the temperature at which molality of pure water will be equal to its molarity.
   ii. Predict whether molarity of pure water will be more than or less than its molality at freezing point of pure water.



10. The condition for the validity of Henry's law is:
    a. The pressure should not be too high
    b. The temperature should not be too low
    c. The gas should neither dissociate nor enter into chemical combination with the solvent
    d. All of the above

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Answer Key

Question Number	1	2	3	4	5
Answer Key	(b)	a. Sugar, Water b. Oxygen other gases, Nitrogen c. CO_2, H_2O d. Mercury, Zinc	m = 0.86, M = 1, N = 1	c, d	25 g/mol

Question Number	6	7	8	9	10
Answer Key	0.165	200 ppm	(c)	4°C, M<m	(d)

Solutions

1. (b)
   A solution is the one in which the solute(s) is/are dissolved in a solvent i.e., a solution can have many solutes dissolved in the same solvent. If there is only one solute, the solution is called a binary solution.

2.

Solution	Solute	Solvent
Sugar solution	Sugar	Water
Air	Oxygen and other gas	Nitrogen
Aerated drinks	CO_2	Water
Zn-Hg Amalgam	Mercury	Zinc

3. 100 mL of the solution contains 8.5 g of solute
   $\Rightarrow$ 1 L solution will contain 85 g of solute
   The weight of 1 L of solution $= \text{volume} \times \text{density}$
   $= 1000 \text{ mL} \times 1.25 \text{ g/mL}$
   $= 1250 \text{ g}$
   The molar mass of $NaNO_3$ $= 85 \text{ g}$
   Therefore, moles of $NaNO_3$ $= \frac{\text{Given mass}}{\text{Molar mass}}$
   $= \frac{85}{85}$
   $= 1 \text{ mole}$

   $$\text{Molality} = \frac{\text{moles of solute} \times 1000}{\text{weight of solvent (g)}} = \frac{1 \times 1000}{(1250 - 85)} = 0.86 \text{ m}$$

   $$\text{Molarity} = \frac{\text{no. of moles of solute}}{\text{Volume of solvent (L)}} = \frac{1}{1} = 1 \text{ M}$$

   Also, Normality = Molarity × n-factor

   Since, n- factor for $NaNO_3$ is 1. So, the normality of the solution is 1 N.

4. (c, d)
Molarity is the number of moles of solute present in 1 L of a solution and normality is the number of equivalents of solute present in 1 L of a solution. Since, both the quantities are dependent on volume of a solution which is a function of temperature. Thus, both molarity and normality are dependent on temperature.
Whereas, mole fraction and ppm (w/w) are quantities that are dependent on mass and the number of moles of the components of a solution. Hence, are independent of temperature.

5. (25 g/mol)
$$\text{Molality} = \frac{n_{solute} \times 1000}{W_{solvent(g)}} = \frac{n_{solute} \times 1000}{n_{solvent} \times M_{solvent(g)}} = \frac{\chi_{solute} \times 1000}{\chi_{solvent} \times M_{solvent}}$$
$$2 = \frac{0.2 \times 1000}{0.8 \times M_{solvent}}$$
$M_{solvent} = 125$ g/mol
$M_{solute} = 25$ g/mol

6. (0.165)
Let the mass of the solution be 100 g.
Mass of benzene $= 30$ g
Moles of benzene $= 30/78$
$= 0.38$ moles
Moles of HCl $= 70/36.5$
$= 1.92$ moles
$\chi_{benzene} = \frac{0.38}{0.38+1.92} = 0.165$

7. (200 ppm)
162 ppm of $Ca(HCO_3)_2$ is equivalent to 100 ppm of $CaCO_3$
162 ppm ≡ 100 ppm
∴ 81ppm ≡ 50 ppm
146 ppm of $Mg(HCO_3)_2$ is equivalent to 100 ppm of $CaCO_3$
146 ppm ≡ 100 ppm
∴ 73ppm ≡ 50ppm
136 ppm of $CaSO_4$ is equivalent to 100 ppm of $CaCO_3$
136ppm ≡ 100ppm
∴ 68ppm ≡ 50ppm
120 ppm of $MgSO_4$ is equivalent to 100 ppm of $CaCO_3$
120ppm ≡ 100ppm
∴ 60ppm ≡ 50ppm
Total degree of hardness of water $= 50 \times 4 = 200$ ppm

8. (c)
Higher the value of K_H, lower will be the solubility. Since He gas has lower intermolecular interactions with water than with O_2 and at a higher temperature, the solubility will be lower,
So, the maximum value of K_H will be obtained in the case of He at 400 K.

9. (i) $m = \frac{n_{solute}}{W_{solvent(kg)}}$ and $M = \frac{n_{solute}}{V_{Solution(L)}}$
When the density of pure water is 1 g/mL, the volume of 1000 g of water is 1000 mL. So, the molality becomes equal to molarity at 4^0C.

(ii) At the freezing point, density will be less than 1 g/mL. So, the volume of 1 kg of pure water will be more than 1 L. Hence, the molarity will be less than the molality.

10. (d)
Henry's Law is valid when the following conditions are fulfilled:
1. Pressure should not be too high
2. Temperature should not be too low
3. Solute should not undergo association or dissociation in the solvent