SCHOOL NAME:_____

WORKSHEET – 7/Module-7(OVERALL)

Sub: CHEMISTRY   Class : XII

Lesson : SOLUTIONS

Name:_____   Roll No.:____   Date: _____

Maximum Marks : 20   Marks Obtained: _____

READ THE FOLLOWING PASSAGE AND ANSWER THE QUESTIONS (5X1=5M)

Colligative properties of a solution depend upon the number of moles of the solute dissolved and do not depend upon the nature of the solute. However, they are applicable only to dilute solutions in which the solutes do not undergo any association or dissociation. For solutes undergoing such changes, van't Hoff introduced a factor, called van;t Hoff factor(i). This has helped not only to explain the abnormal molecular masses of such solutes in the solution but has also helped to calculate the degree of association or dissociation

1. **Name the colligative property in which universal gas constant is involved?**

2. **What is the value of van't Hoff factor when the given electrolyte undergoes tetramerisation?**
3. **Why boiling point of water is increased on addition of sodium chloride into it?**
4. **What do you mean by isotonic solutions?**
5. **What is the value of I for $Al_2(SO_4)_3$(very dilute)?**

ONE - WORD ANSWERS   (5X1=5M)

6. **Liquid 'Y' has higher vapour pressure than liquid ' X' . Which of them will have higher boiling point.**

7. **Liquids A and B on mixing produce a warm solution. Which type of deviation from Raoult's law is shown?**
8. **Under what condition Van't Hoff factor is less than 1?**
9. **Two liquids X and Y boil at 380 K and 400K respectively, which of them is more volatile?**
10. **Out of molarity(M) and molality(m), which is temperature dependent?**

(MULTIPLE CHOICE QUESTION)MCQ (5X1=5M)

11. **The unit of ebullioscopic constant is_____.**
    (i) K kg /mol or K (molality)$^{-1}$
    (ii) mol kg/ K or K^{-1}(molality)
    (iii) kg mol^{-1} K^{-1} or K^{-1}(molality)$^{-1}$
    (iv) K mol kg^{-1} or K (molality)

12. **An unripe mango placed in a concentrated salt solution to prepare pickle, shrivels because** _____.
    (i) it gains water due to osmosis.
    (ii) it loses water due to reverse osmosis.

(iii) it gains water due to reverse osmosis.

 (iv) it loses water due to osmosis**.**

13. The values of Van't Hoff factors for KCl, NaCl and K₂SO₄, respectively, are_____.

 (i) 2, 2 and 2

 (ii) 2, 2 and 3

 (iii) 1, 1 and 2

 (iv) 1, 1 and 1

14. The value of Henry's constant K_H is_____.

 (i) greater for gases with higher solubility.

 (ii) greater for gases with lower solubility.

 (iii) constant for all gases.

 (iv) not related to the solubility of gases.

15. We have three aqueous solutions of NaCl labeled as 'A', 'B' and 'C' with concentrations 0.1M, 0.01M and 0.001M, respectively. The value of van't Hoff factor for these solutions will be in the order____.

 (i) iA < iB < iC

 (ii) iA > iB > iC

 (iii) iA = iB = iC

 (iv) iA < iB > ic

ASSERTION -REASON TYPE (5X1=5M)

A statement of assertion is followed by a statement of reason. Mark the correct choice from the options given below:

(a) Both assertion and reason are true and reason is the correct explanation of assertion.

(b) Both assertion and reason are true but reason is not the correct explanation of assertion.

(c) Assertion is true but reason is false.

(d) Both assertion and reason are false.

16. **Assertion :** In an ideal solution, $\Delta_{mix} H$ is zero.

 Reason : In an ideal solution, A - B interactions are lower than A-A and B-B interactions.

17. **Assertion** : Osmosis does not take place in two isotonic solutions separated by semi-permeable membrane.

 Reason : Isotonic solutions have same osmotic pressure.

18. **Assertion** : Lowering of vapour pressure is not dependent on the number of species present in the solution.

 Reason : Lowering of vapour pressure and relative lowering of vapour pressure are colligative properties.

19. **Assertion :** 1 M solution of KCl has greater osmotic pressure than 1 M solution of glucose at same temperature.

 Reason : In solution KCl dissociates to produce more number of particles.

20. Assertion : Two liquids nitric acid and water form a maximum boiling azeotrope when mixed in the ratio of 68% and 32% respectively.

Reason : Interaction between nitric acid and water are stronger than nitric acid - nitric acid interactions and water - water interactions.

SOLUTIONS

SOLUTION=SOLUTE+SOLVENT

SOLUTION is the homogeneous mixture of two or more than two components. Most of the solutions are binary i.e. consists of two components out of which that is present in the largest quantity is called solvent & one which is present in smaller quantity called solute.

EXPRESSING CONCENTRATIONS OF SOLUTIONS

Mass percentage : Mass of solute per 100g of solution Mass % = (mass of solute / total mass of solution) X100

Volume percentage : volume of solute per 100ml of solution Volume % = (volume of solute/ total volume of solution) X 100

Parts per million: parts of a component per million (10^6) parts of the solution.

ppm=no. of parts of the component / total no. of parts of all components of the sol. X10^6

Molefraction(x):   It is the ratio of no. of moles of one component to the total no. of all the components present in the solution. For binary solution:-the no. of moles of A and B are n_A and n_B respectively

so, $x_A = n_A/n_A + n_B$

; $x_B = n_B/n_A + n_B$

In binary solution $x_A + x_B = 1$

Molarity: No. of moles of solute dissolved in one litre of solution.

Molarity(M) = moles of solute/ vol. of solution in litre

molality(m): No. of moles of solute per kg of the solvent.

molality(m) = moles of solute/mass of solvent in kg

Molality is independent of temp. whereas molarity is a function of temp. because vol. depends on temp. and mass does not.

HENRY'S LAW

It states that at a constant temp. the solubility of the gas in liquid is directly proportional to the pressure of the gas above the surface of the liquid .

It also states that the partial pressure(p) of a gas in vapour phase is proportional to the mole fraction of the gas (x) in the solution.

$P=K_H X$

K_H is Henry's law constant .

APPLICATION OF HENRY'S LAW

- To increase the solubility of CO_2 in soda water and soft drinks the bottle is sealed under high pressure.
- To avoid bends, toxic effects of high concentration of nitrogen in the blood the tanks
   Used by scuba divers are filled with air diluted with He.

RAOULT'S LAW :- it states that :

- For a solution of volatile liquid, the partial vapour pressure of each component of the solution is

directly proportional to its mole fraction present in solution.

$P_A = P^O_A X_A$ $P_B = P^O_B X_B$

The total pressure is equal to sum of partial pressure. $P_{total} = P_A + P_B$

For a solution containing non-volatile solute the vapour pressure of the solution is directly proportional to the mole fraction of the solvent.

IDEAL SOLUTION:

The solution which obeys Raoult's law over the entire range of concentration when enthalpy of mixing and vol. of mixing of pure component to form solution is zero.

CONDITIONS:

I. $P_A = P^O_A X_A$ $P_B = P^O_B X_B$

II. $\Delta H_{mix} = 0$

III. $\Delta V_{mix} = 0$

This is only possible if A-B interaction is nearly equal to those between A-A and B-B interactions. Ex:- solution of n-hexane and n-heptane.

NON IDEAL SOLUTION: The solution which do not obey Raoult's law over the entire range of concentrations.

CONDITIONS :

I. $P_A \neq P^0_A X_A$ and $P_B \neq P^0_B X_B$

II. $\Delta H_{mix} \neq 0$

III. $\Delta V_{mix} \neq 0$

The vapour pressure of such solutions is either higher or lower than that predicted for Raoult's law.

I.   If vapour pressure is higher, the solutions shows positive deviation (A-B interactions are weaker than those between A-A and B-B).

Ex: mixture of ethanol and acetone .

$P_A > P_A{}^0 X_A$; $P_B > P_B{}^0 X_B$

ΔH_{mix} = Positive ; ΔV_{mix} = Positive

II.   If vapour pressure is lower, the solution shows negative deviation (A-B interactions are stronger than those between A-A and B-B).

III. Ex: mixture of chloroform and acetone .

IV. $P_A < P_A{}^0 X_A$; $P_B < P^0{}_B X_B$

V. ΔH_{mix} = negative ΔV_{mix} = negative

AZEOTROPE

Mixture of liquid having the same composition in liquid and vapour phase and boil at constant temp. Azeotropes are of two types :-

a) **Minimum boiling azeotrope** :- the solution which shows a large positive deviation from Raoult's law. Ex- ethanol – water mixture.

b) **Maximum boiling azeotrope :-** the solution which shows large negative deviation from Raoult's law. Ex- nitric acid – water mixture.

COLLIGATIVE PROPERTIES Properties of ideal solution which depends upon no. of particles of solute but independent of the nature of the particles are called colligative properties.

1. RELATIVE LOWERING OF VAPOUR PRESSURE

$P^0_A - P_A/P^0_A = X_B$

$X_B = n_B/n_A + n_B$

For dilute solution, $n_B \ll n_A$, hence n_B is neglected in the denominator. $P^0_A - P_A/P^0_A = n_B/n_A$

$P^0_A - P_A/P^0_A = W_B M_A/M_B W_A$

2. ELEVATION OF BOILING POINT

$\Delta T_b = k_b m$ Where , $\Delta T_b = T_b - T^0_b$

K_b = molal elevation constant/Ebullioscopic constant
m = molality
$M = k_b \ 1000 \ W_B/\Delta T_b W_A$

3. DEPRESSION IN FREEZING POINT

$\Delta T_f = K m_f$ where, $\Delta T_f = T^0 - T$
K_f = molal depression constant / Cryoscopic constant
m = molality
$M = k_f \ 1000 \ W_B/\Delta T_f W_A$

4. OSMOTIC PRESSURE

The excess pressure that must be applied to a solution side to prevent osmosis i.e.to stop the passage of solvent molecules into it through semi-permeable membrane is called osmotic pressure.
$\Pi = CRT$
$\Pi = n/VRT$ (n=no. of moles; V=volume of solution(L)

$R = 0.0821$ Latm $K^{-1} mol^{-1}$; T= temperature in kelvin
ISOTONIC SOLUTION
Two solutions having same osmotic pressure and same concentration are called isotonic solutions.
Hypertonic solution have higher osmotic pressure and hypotonic solution have lower osmotic pressure than the other solution.
0.91% of sodium chloride is isotonic with fluid present inside blood cell.
VAN'T HOFF FACTOR (i)
Ratio of normal molecular mass to the observed molecular mass of the solute. i =

normal molecular mass/ observed molecular mass

= observed colligative properties / calculated value of colligative properties

i<1 (for association)   i>1 (for dissociation)

MODIFIED FORMS OF COLLIGATIVE PROPERTIES

1) $P^0_A - P_A / P^0_A = i \ n_B/n_A$
3) $\Delta T_b = iK_b \ m$
4) $\Delta T_f = iK_f \ m$
5) $\Pi = iCRT$

2 MARKS QUESTIONS

Q1. State Henry's law. What is the significance of K_H ?

Ans. Henry's Law: It states that "the partial pressure of the gas in vapour phase (p) is directly proportional to the mole fraction of the gas (x) in the solution", and is expressed as: $p = K_H X$ where, K_H is the Henry's Law constant

Significance of K_H: Higher the value of Henry's law constant K_H, the lower is the solubility of the gas in the liquid.

Q2. How is that measurement of osmotic pressure is more widely used for determining molar masses of macromolecules than the elevation in boiling point or depression in freezing point of their solutions?

Ans. The osmotic pressure method has the advantage over elevation in boiling point or depression in freezing point for determining molar masses of macromolecules because

1. Osmotic pressure is measured at the room temperature and the molarity of solution is used instead of molality.
2. Compared to other colligative properties, its magnitude is large even for very dilute solutions.

Q3. Suggest the most important type of intermolecular interaction in the following pairs:

i) n-hexane and n-octane

ii) methanol and acetone

Ans. i) Dispersion or London forces as both are non-polar.

ii) Dipole-dipole interactions as both are polar molecules.

Q4. Calculate the mass percentage of aspirin ($C_9H_8O_4$) in acetonitrile (CH_3CN) when 6.5 g of $C_9H_8O_4$ is dissolved in 450 g of CH_3CN .

Ans.   Mass of solution = 6.5g + 450g = 456.5g

Mass% of aspirin = $\dfrac{\text{Mass of aspirin X100}}{\text{Mass of solution}}$

= 6.5/456.5 X 100 = 1.424%

Q5. If 30 mL of 0.5 M H2SO4 is diluted to 500 mL. What is concentration of diluted solution.

Ans. M1V1=M2V2 i.e M2=0.5x2x30/500=0.06M

3   MARK QUESTIONS

Q1. Non-ideal solution exhibit either positive or negative deviations from Raoult's law. What are these deviation and why are they caused? Explain with one example for each type.

Ans. When the vapour pressure of a solution is either higher or lower than that predicted by Raoult's law, then the solution exhibits deviation from Raoult's law. These deviation are caused when solute -solvent molecular interactions A–B are either weak or stronger than solvent – solvent A – B or solute– solute B – B molecular interactions. Positive deviations : When A – B molecular interactions are weaker than A – A and B – B molecular interaction . For example, a mixture of ethanol and acetone.

Negative deviations: When A – B molecular interaction are stronger than A – A and B – B molecular interaction. For example, a mixture of chloroform and acetone.

Q2 .a) Why is an increase in temperature observed on mixing chloroform and acetone?

b) Why does sodium chloride solution freeze at a lower temperature than water?

Ans: a) The bonds between chloroform molecules and molecules of acetone are dipole-dipole interactions but on mixing, the chloroform and acetone molecules, they start forming hydrogen bonds which are stronger bonds resulting in the release of energy. This gives rise to an increase in temperature.

b) When a non- volatile solute is dissolved in a solvent, the vapour pressure decreases. As a result, the solvent freezes at a lower temperature.

Q3. A solution of glycerol ($C_3H_8O_3$) in water was prepared by dissolving some glycerol in 500g of water. This solution has a boiling point of 100.42C while pure water boils at 100-C. What mass of glycerol was dissolved to make the solution ? (K_b of water=0.512Kkg/mol)

Ans. $\Delta T_b = 100.42°C - 100°C = 0.42°C$ or 0.42K; $W_A = 500g$; $K_b = 0.512$Kkg/mol;

$M_B = 92$ g /mol Substituting these values in the expressions,

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

$$W_B = \frac{0.42 \times 92 \times 500}{0.512 \times 1000} = 37.73 \text{ g}$$

Q4. Determine the amount of $CaCl_2$ (i = 2.47) dissolved in 2.5 litre of water such that its osmotic pressure is 0.75 atm at 27^0C.

Ans. $\prod = iCRT$

Molar mass of $CaCl_2$, M = 40+2X 3 5.5 = 111 g mol^{-1}

Therefore, mass of $CaCl_2$, $\quad W_B = \dfrac{0.75 \text{ atm} \times 111g/mol \times 2.5L}{2.47 \times 0.0821 \times 300 \text{ K}}$

$$= 3.42g$$

5. **The molar freezing point depression constant for benzene is 4.90K $kgmol^{-1}$. Selenium exists as polymerize ^{X} When 3.26 gmof Se is dissolved in 226 gmof benzene, the observed freezing point is 0.112^0C lower than for pure benzene. Decide the molecular formula of Selenium. (At.wt. of selenium is 78.8 $gmol^{-1}$)**

Ans $\quad \Delta T_f = \dfrac{1000 \times K_f \times W_B}{W_A \times M_B}$

0.112 K=1000x4.9x 3.26

$$226 \times M_B$$

$$M_B = 1000 \times 4.90 \times 3.26 / 226 \times 0.1112 = 63g/mol$$

No. of Se atoms in a molecule = 631g / mol/78.8 g/mol = 8

Therefore, molecular formula of Selenium = Se_8

5 MARKS QUESTION

Q1.a) State Raoult's Law for a solution containing volatile components. How does Raoult's law become a special case of Henry's Law?

b) 1.00 g of a non-electrolyte solute dissolved in 50 g of benzene lowered the freezing point of a benzene by

0.40 K. Find the molar mass of the solute.(K$_f$ for benzene = 5.12 K kg mol^{-1})

Ans.   a) For a solution of volatile liquids, Raoult's law states that the partial vapour pressure of each   component of the solution is directly proportional to its mole fraction present in solution, i.e., $p_A \propto x_A$

OR

$$p_A = p_A^O \, x_A$$

According to Henry's Law, the partial pressure of a gas in vapour phase (p) is Directly

proportional to mole fraction(x) of the gas in the solution.

i.e., $p = K_H X$ on comparing it with Raoult's Law it can be seen that partial pressure of the volatile component or gas is directly proportional to its mole fraction in solution

i.e; $p \propto x$

only the proportionality constant K_H differs from p_A^O . Thus, it becomes a special case of

Henry's law in which $K_H = p_A^O$.

b)   Substituting the values of various terms involved in equation $M_B = \dfrac{K_f \times W_B \times 1000}{\Delta T_f \times W_A}$

$$M_B = \dfrac{.12 \times 1.00 \times 1000}{0.40 \times 50} = 256g \ mol^{-1}$$

Q2.a)Calculatethe molarity of a sulphuric acid solution in which the mole fraction of water is 0.85.

b)The graphical representation of vapour pressure of two component system as a function of compositionis given alongside.

i)   Are the A–B interactions weaker, stronger or of the same magnitude as A–A and B–B

ii)   Name the type of deviation shown by this system from Raoult's law.

iii) Predict the sign of $\Delta_{mix}H$ for this system.

iv)   Predict the sign of $\Delta_{mix}V$ for this system.

v)   Give an example of such a system.

vi)   What type of azeotrope will this system form, if possible?

$X_A = 1$ Mole fraction ➔ $X_A = 0$
$X_B = 0$ $X_B = 1$
P-X graph for non-ideal solution
showing –ve deviation
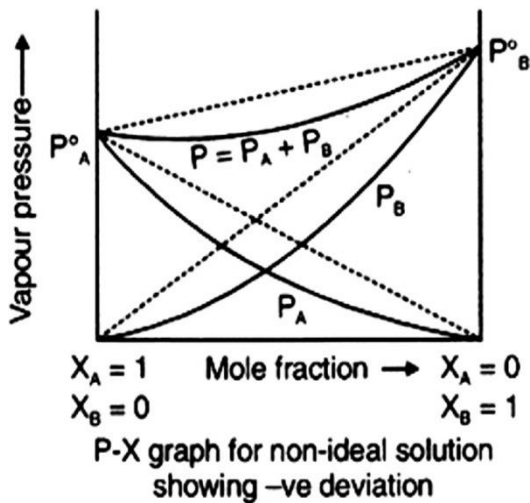
Ans.   a)

$n_A/n_A+n_B=0.85$………..(I)

$n_B/n_A+nB=1-0.85$……..(II)

Eq (II)/Eq(I)
$n_B/n_A=0.15/0.85$

$n_B=0.15/0.85$ X n_A
$(n_A=1000/18)$

hence molality = 9.8 m

b) i) Stronger

ii) Negative deviation
iii) Negative
iv) Negative
v) 20% acetone and 80%
chloroform by mass
vi) maximum
boiling azeotrope

	Solute	Solvent	Common Examples
Gaseous Solutions	Gas	Gas	Mixture of oxygen and nitrogen gases
	Liquid	Gas	Chloroform mixed with nitrogen gas
	Solid	Gas	Camphor in nitrogen gas
Liquid Solutions	Gas	Liquid	Oxygen dissolved in water
	Liquid	Liquid	Ethanol dissolved in water
	Solid	Liquid	Glucose dissolved in water
Solid Solutions	Gas	Solid	Solution of hydrogen in palladium
	Liquid	Solid	Amalgam of mercury with sodium
	Solid	Solid	Copper dissolved in gold