Chapter: 09

Solutions

Objective

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1. The Oxidation Number of Sulphur in SO_4^{2-} is:
   (A) 1 (B) 2 (C) 4 **(D) 6**
2. 10g of NaOH has been dissolved per dm^3 of solution. The molarity of solution is:
   (A) 2 M (B) I M (C) 0.5 M **(D) 0.25 M**
3. The sum of mole fraction of all the components of solution is always equal to:
   (A) Less than 100 (B) 100 **(C) Unity** (D) Less than one
4. Which of the following concentration unit is used for very dilute solutions:
   (A) Normality **(B) ppm** (C) Molality (D) Molarity
5. Which has maximum freezing point:
   (A) 1 m Urea (B) 1 m KCI (C) 1 m NaCl (D) 1 m $CaCl_2$
6. Which caption has least heat of hydration:
   (A) K^+ (B) Mg^{+2} (C) Li^+ **(D) K^+**
7. 10% aqueous solution of glucose freezes at:
   (A) Greater than 0°C **(B) Less than 0°C** (C) Greater than 10°C (D) 0°C
8. A mixture of benzene and toluene form:
   (A) Ideal solution (B) Suspension (C) Azeotropic mixture (D) Non-ideal solution
9. The substance which has water of crystallization in it, is called:
   (A) Complex (B) Hydrolysis (C) Hydride **(D) Hydrate**
10. Hydrolysis of CH_3COOK will produce:
    (A) Neutral solution (B) Acidic solution **(C) Basic solution** (D) None of these
11. The molarity of 2% $\frac{W}{V}$ NaOH solution is:
    (A) 0.05 **(B) 0.5** (C) 1.5 (D) 2
12. If 9.8 g H_2SO_4 is present in one dm^3 of solution, the solution is:
    (A) 0.1 M (B) 0.5 M (C) 0.1 N (D) 0.1 m
13. An aqueous solution boils at 100.52 °C. It should freeze at:
    (A) −2 °C (B) 0 °C (C) +1.86 °C **(D) −1.86 °C**
14. 15g urea is dissolved in 180 cm^3 of water. The relative lowering of vapour pressure will be:
    (A) 10.25 (B) 2.5 **(C) 0.024** (D) 25.024
15. A solution of glucose is 10% w/v. The volume in which 1g mole of it dissolved will be:
    (A) 900 cm^3 (B) 200 cm^3 (C) 1 dm^3 **(D) 1.8 dm^3**
16. Molal boiling point constant is the ratio of the elevation in boiling point to:
    (A) More fraction of (B) Molarity **(C) Molality** (D) More fraction of solute

17. Molarity of pure water is:

Ⓐ 60 **Ⓑ 55.5** Ⓒ 18 Ⓓ 10

18. The salt dissolved in water forms a solution of pH greater than 7:

Ⓐ Na_2CO_3 Ⓑ $CuCO_4$ Ⓒ NH_4CI Ⓓ NaCI

19. Liquids which are practically immiscible:

Ⓐ $H_2O + CH_3 - O - CH_3$ Ⓑ $H_2O + HCI$ Ⓒ $H_2O + C_2H_5 - OH$ **Ⓓ $H_2O + C_6H_6$**

20. Osmotic pressure is an example of:

Ⓐ Constitutive properties **Ⓑ Colligative properties**
Ⓒ internal energy Ⓓ Additive properties

21. Mathematical expression of Raoult's law is:

Ⓐ $\frac{\Delta p}{p^\circ} = x_2$ Ⓑ $\Delta p \propto x_2$ **Ⓒ All of these** Ⓓ $p \propto x_1$

22. The correct equation of Raoult's law:

Ⓐ $\frac{p^\circ}{\Delta p} = X_2$ **Ⓑ $\frac{\Delta p}{p^\circ} = X_2$** Ⓒ $\frac{p^\circ}{\Delta p} = X_2 - X_1$ Ⓓ $\frac{\Delta p}{p^\circ} = X_1$

23. Which one of the given salts will not hydrolyse in water?

Ⓐ NaCI Ⓑ CH_3COONa Ⓒ Na_2CO_3 Ⓓ $AlCl_3$

24. Colligative properties are the properties of:

Ⓐ Concentrated solutions which behave as nearly non-ideal solutions
Ⓑ Dilute solutions which behave as nearly ideal solutions
Ⓒ Neither A nor B
Ⓓ Both A & B

25. Which one of the following pair of liquids is not completely miscible?

Ⓐ Alcohol and ether Ⓑ Benzene and cyclohexane
Ⓒ Alcohol and water **Ⓓ Phenol and water**

26. Amount of NaOH required to prepare 250 cm³ of 1M solution is:

Ⓐ 10g Ⓑ 6g Ⓒ 4g Ⓓ 2g

27. The consulate temperature of water-aniline system is:

Ⓐ 49.1°C Ⓑ 64.5°C Ⓒ 69.5°C **Ⓓ 167°C**

28. Upper - Consulate temperature for water - phenol System is:

Ⓐ 120 °C Ⓑ 130 °C **Ⓒ 65.9 °C** Ⓓ 150 °C

29. Which one is not equation of Raoult's law:

Ⓐ $\Delta P/P^\circ = X_2$ **Ⓑ $PV = n_2RT$** Ⓒ $P = P^\circ X_1$ Ⓓ $\Delta P = P^\circ X_2$

30. The sum of mole fraction of gases in a mixture of gases is:

Ⓐ May be less or more than 1 Ⓑ Always less than 1
Ⓒ Always 1 Ⓓ Always more than 1

31. Which one is not an electrolyte:

Ⓐ Cu metal Ⓑ H_2SO_4 Ⓒ Aqueous $CuSO_4$ Ⓓ Aqueous NaCl

32. An azeotropic mixture of two liquids boils at a lower temperature than either of the when:
Ⓐ It is metastable
Ⓑ It shows (+) deviation from Raoult's law
Ⓒ It is saturated
Ⓓ It shows (–) deviation from Raoult's law

33. Which of the following gives acidic solution when dissolved in H_2O:
Ⓐ Na_2SO_4 Ⓑ CH_3COONH_4 Ⓒ NaCl Ⓓ NH_4Cl

34. The mass of glucose required to prepare 1 dm^3 of 20% glucose solution is:
Ⓐ 100 g Ⓑ 180 g Ⓒ 200 g Ⓓ 50 g

35. Relative lowering of vapour pressure is equal to:
Ⓐ Mole fraction of solute
Ⓑ Molality
Ⓒ Mole fraction of solvent
Ⓓ Molarity

36. 18 g of glucose is dissolved in 90 g of water. The relative lowering of vapour pressure is equal to:
Ⓐ 5.1 Ⓑ $\frac{1}{51}$ Ⓒ 6.0 Ⓓ $\frac{1}{5}$

37. Melting point of ice can be lowered by the use of:
Ⓐ NaCl Ⓑ AgCl Ⓒ $BeCl_2$ Ⓓ LiCl

38. A thermometer used in Lands Berger's method can read up to:
Ⓐ 0.01 F Ⓑ 0.01 °C Ⓒ 0.1 K Ⓓ 0.01 K

39. Elevation of boiling point is:
Ⓐ Colligative property
Ⓑ Substitution property
Ⓒ Constitutive property
Ⓓ Additive property

40. Which of the following solutions has highest boiling point elevation:
Ⓐ 18% solution of Glucose
Ⓑ 34.2% solution of Sucrose
Ⓒ 5.85% solution of NaCl
Ⓓ 6% solution of Urea

41. Which of the following concentration unit is temperature dependent?
Ⓐ percentage w/w Ⓑ mole fraction Ⓒ molarity Ⓓ molality

42. The Number of Moles of Solute per kg of Solvent is called:
Ⓐ Normality Ⓑ Molality Ⓒ Molarity Ⓓ Mole Fraction

43. One molar solution of glucose ($C_6H_{12}O_6$) contains the amount of solute in 500 cm^3 solution:
Ⓐ 90 g Ⓑ 180 g Ⓒ 270 g Ⓓ 45 g

44. ……….. used as antifreeze in radiator of automobile:
Ⓐ Hydrazine Ⓑ Serotenin Ⓒ Aspartame Ⓓ Ethylene glycol

45. The number of water molecules in $CuSO_4.5H_2O$ attacked with Cu^{+2} ion:
Ⓐ two Ⓑ three Ⓒ four Ⓓ one

46. Ideal solutions obey:
Ⓐ Smith's law Ⓑ Raoult's law Ⓒ Avogardo's law Ⓓ Henry's law

47. An aqueous solution of ethanol in water may have vapour pressure:
Ⓐ equal to ethanol
Ⓑ more than that of water

Ⓒ less than that of water Ⓓ equal to water

48. In order to maintain the boiling point of water at 110 °C, the external pressure should be:
   - Ⓐ any value of pressure
   - Ⓑ 765 torr
   - **Ⓒ between 760 torr and 1200 torr**
   - Ⓓ between 200 torr and 760 torr

Fill in the blanks

Q1: Number of molecules of sugar in 1 dm^3 of 1 M sugar solution is ....

Q2: 100 g of a 10% aqueous solution of NaOH contains 10 g of NaOH in .... g of water.

Q3: When an azeotropic mixture is distilled, its .... remains constant.

Q4: The molal freezing point constant is also known as .... constant.

Q5: The boiling point of an azeotropic solution of two liquids is lower than either of them because the solution shows .... from Raoult's law.

Q6: Among equimolal aqueous solutions of NaCl, $BaCl_2$, and $FeCl_3$, the maximum depression in freezing point is shown by .... solution.

Q7: A solution of ethanol in water shows .... deviations and gives azeotropic solution with .... boiling point than other components.

Q8: Colligative properties are used to calculate .... of a compound.

Q9: The hydration energy of Br^- ion is .... than that of F^- ion.

Q10: The acqueous solution of NH_4Cl is .... while that of Na_2SO_4 is ....

Answers

1.	$6.02 \times 10^{+23}$	2.	90g	3.	composition	4.	cryoscopic
5.	(+) deviation	6.	$FeCl_3$	7.	Positive, lower	8.	molar mass
9.	less	10.	acidic, neutral				

Chapter : 09 Solutions

Subjective

Q1: *Define solution with an example.*

Ans: *A solution is homogeneous mixture of two or more kind of different molecular or ionic substances. The substance which is present in large quantity is called solvent and the other component in small quantity is called solute.*

For example:

NaCl *is dissolved in water*

Q2: *How will you prepare* 10% $\frac{w}{v}$ *urea solution in water?*

Ans: *When* 10g *of urea is dissolved in* 100 cm³ *of solution. It is* 10% $\frac{w}{v}$ *solution of urea. The quantity of solvent is not exactly known.*

Q3: *How will you prepare* 10% $\frac{w}{v}$ *glucose solution?*

Ans: *For this purpose we dissolve* 10 grams *of glucose in water to make the volume* 100 cm^3.

Q4: *How will you prepare one molar solution of sucrose?*

Ans: *One molar solution of sucrose is prepared by dissolving one mole of it* (342 g) *in sufficient amount of water to make the total volume up to* 1 dm^3 *in a measuring flask.*

Q5: *Define consulate solution temperature with example.* ***OR***
What is consulate temperature?

Ans: *Consulate Temperature:*

The temperature at which two conjugate solutions merge into each other to form homogenous mixture is called critical solution temperature or consulate temperature.

Example:

Water-Aniline has consulate temperature 167 °C *with* 15% H_2O.

Q6: *Calculate percentage by weight of* NaCl *when* 2g *of* NaCl *is dissolved in* 20g *of water?*

Ans:

Mass of NaCl = 2 g

Mass of water = 20 g

Mass of solution = 20 + 2 = 22 g

$$\%\text{ by weight of NaCl} = \frac{2}{22} \times 100 = 9.09\%$$

Q7: *Define percentage weight / weight. Give an example.*

Ans: *It is the weight of the solute dissolved per* 100 *parts by weight of solution.* 5% *w/w sugar solution will contain* 5 g *of sugar dissolved in* 100 g *of solution in water. This solution contains* 95 g *of water.*

$$\%\text{ by weight} = \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 100$$

Q8: *The concentration in terms of molality is independent of temperature but molarity depends upon temperature. Why?*

Ans: *In molality mass of solvent is taken, Mass is independent of temperature. In molarity volume of solution is taken. Volume changes by change in temperature.*

Q9: *What is meant by molar and molal solutions?*

Ans: 1 molar *means* $1 mol\ dm^{-3}$ *or one mole of solute dissolved in one* dm^3 *of solution.*

1 molal *means* $1 mol\ Kg^{-1}$ *or one mole of solute dissolved in one* kg *of solvent.*

Actually 1 molal *solution of any solute is more dilute as compared to is* 1 molar *solution.*

Q10: *One molal solution of glucose in water is dilute as compared to one molar solution of glucose. Justify*

Ans: *Both one molar and one molal solution of glucose contain one mole of substance or we can say equal number of particles i.e.* 6.02×1023. *For one molal solution* 1 *mole of glucose is dissolved in* 1 kg *of* H_2O.

For one molar solution, 1 *mole of glucose is taken in a flask and then made a volume of* 1 dm^3. *Hence* 1 *molar solution contains less amount of* H_2O *than* 1 *molal solution.*

Q11: *Calculate the molarity of the solution containing* 20.7 g of K_2CO_3 *dissolved in* 500 cm^3 *of the given solution?*

Ans:

Mass of K_2CO_3(m) = 20.7 g

Molar mass of K_2CO_3(M) = 2(39) + 12 + 3(16)

Molar mass of K_2CO_3(M) = 78 + 12 + 48

Molar mass of K_2CO_3(M) = 138 g mol^{-1}

Volume of solution (V) = 500 cm^3

Volume of solution (V) = 0.5 dm^3

Molality (m) = ?

$$\text{Molarity} = \frac{m}{M} \times \frac{1}{V} = \frac{20.7}{138} \times \frac{1}{5}$$

Molarity = 0.3 M OR mol dm^{-3}

Just for information.

Name of Acid	% (w/w)	Molarity (M dm^{-3})	Density (gcm^{-3})
H_2SO_4	98%	18	1.84
H_3PO_4	85.5%	4.8	1.70
HNO_3	70.4%	15.9	1.42
HCl	37.2%	12.1	1.19
CH_3COOH	99.8%	17.4	1.05

Q12: *Calculate the mass of urea in* 100 g *of* H_2O *in* 0.3 *molal solution.*

Ans:

Molality of solution = 0.3 molal

Molar mass of urea = 60 g

$$\text{Mass of solvent } H_2O = 100\ g = \frac{100}{1000} = 0.1\ Kg$$

Mass of urea = ?

$$\text{Molality} = \frac{\text{Mass of urea}}{\text{Molar mass of urea}} \times \frac{1}{\text{Mass of solvent in Kg}}$$

$$0.3\ m = \frac{\text{Mass of urea}}{60\ g\ mol^{-1}} \times \frac{1}{0.1\ Kg}$$

Mass of urea = 0.3 mol Kg^{-1} × 60 g mol^{-1} × 0.1 Kg

Mass of urea = 1.8 g

Q13: *Calculate the molality of the solution prepared by dissolving* 5 g *toluene* (C_7H_8) *in* 250 g *of benzene?*

Ans:

Mass of toluene (m_r) = 5 g

Molar mass of C_7H_8 (M) = 92 $gmol^{-1}$

Mass of benzene (m_2) = 250 g = 0.250 kg

Molality (m) = ?

$$\text{Molarity} = \frac{m_1}{M} \times \frac{1}{m_2} = \frac{5}{92} \times \frac{1}{0.250}$$

$$\text{Molarity} = 0.217\ \text{M}$$

$$\text{Molarity} = 0.217\ \text{M mol Kg}^{-1}$$

Q14: *Define molarity and molality. Give mathematical form.*

Ans: *Molarity:*

Number of moles of solute dissolved in 1 dm³ *of solution is called molarity. It is denoted by* "M".

$$\text{M} = \frac{\text{Mass of solute}}{\text{Mass of solution}} \times \frac{1}{\text{Volume of solution in dm}^3}$$

Molality:

Number of moles of solute dissolved in 1 Kg *of solvent is called molality. It is denoted by* "m".

$$\text{Molality} = \frac{\text{Mass of solute}}{\text{Mass of solution}} \times \frac{1}{\text{Mass of solvent in Kg}}$$

Q15: *Calculate the molality of the 8% w/w NaCl solution.*

Ans: 8% w/w *of* NaCl *mean* 8 g *of* NaCl *are dissolved in* 100 g *of solution. Therefore*

$$\text{Mass of NaCl } (m_1) = 8\ \text{g}$$

$$\text{Mass of water } (m_2) = 92\ \text{gmol}^{-1}$$

$$\text{Mass of benzene } (m_2) = 100 - 8 = 92\ \text{g}$$

$$\text{Formula of mass} = \ \text{M} = 58.5\ \text{gmol}^{-1}$$

$$\text{m} = \frac{m_1}{M} \times \frac{1}{m_2} = \frac{8}{58.5} \times \frac{1}{0.092}$$

$$\text{m} = 1.487\text{m}$$

Q16: *One molal solution of urea is more dilute as compared to its one molar solution. Why?*

Ans: One molal solution contains one mole of urea per kg of solvent, while one molar solution contains one mole of urea per one dm³ *of solution. In one molal solution amount of water is greater than one molar solution because amount (of solute is not included in it.*

Q17: *Define Molarity of a solution. How is Molarity related to mass of solute?*

Ans: Molarity is the number of moles of solute, dissolved per dm³ *of the solution.*
The following formula is used to prepare the solution of any mola rity.

$$\text{Molarity(M)} = \frac{\text{Mass of solute}}{\text{Mass of solution}} \times \frac{1}{\text{Volume of solution in dm}^3}$$

As mentioned in above formula, the molarity has direct relationship with mass and molar mass of solute.

Q18: *What is molarity? Calculate the molarity of a solution containing 9 grams of glucose ($C_6H_{12}O_6$) in 250 cm³ of solution.*

Ans: Molarity is the number of moles of solute in dissolved per dm³ *of the solution.*
The following formula is used to prepare the solution of any molarity.

$$\text{Molarity(M)} = \frac{\text{Mass of solute}}{\text{Mass of solution}} \times \frac{1}{\text{Volume of solution in dm}^3}$$

Molarity of Glucose:

$$\text{Mass of glucose} = 9\ \text{g}$$

$$\text{Molar mass of glucose } (C_6H_{12}O_6) = 12 \times 6 + 1 \times 12 + 16 \times 6$$

Molar mass of glucose $(C_6H_{12}O_6) = 72 + 12 + 96$

Molar mass of glucose $(C_6H_{12}O_6) = 180 \ gmol^{-1}$

Volume of solution $= 250 \ cm^3 = 0.25 \ dm^3$

$$\text{Molarity(M)} = \frac{\text{Mass of solute}}{\text{Mass of solution}} \times \frac{1}{\text{Volume of solution in dm}^3}$$

$$\text{Molarity (M)} = \frac{9}{180} \times \frac{1}{0.25}$$

Molarity (M) = 0.2 moles per dm^3

Q19: ***One molal solution of urea in water is dilute as compared to one molar solution of urea but the number of practices of solute is same. Justify it.***

Ans: *Both one molar and one molal urea solution contains equal number of molecules* (6.022×10^{23}). *Numbers of water molecules are different in both cases. One molal solution contains* 1000 g or 55.5 moles *of water. One Molar solution has less number of water molecules than one molal.*

Q20: ***How has 100 g of 98% H_2SO_4 volume of 54.34 Cm^3 of H_2SO_4? (Density = 1.84 g cm^{-3})***

Ans:

Mass of 98% H_2SO_4 = 100 g

Density of 98% H_2SO_4 = 1.84 g cm^{-3}

Volume of 98% H_2SO_4 = ?

Now using the formula:

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

So,

$$\text{Volume} = \frac{\text{Mass}}{\text{Density}}$$

$$\text{Volume} = \frac{100}{1.84}$$

Volume = 54.34 cm^3

Hence, 100 g of 98% H_2SO_4 *has a volume of* 54.34 cm^{-3} *of* H_2SO_4 *because its density is* 1.84 g cm^{-3}.

Q21: ***What do you mean by mole fraction of solution?***

Ans: *The mole fraction of any component in a mixture is the ratio of the number of moles of it to the total number of moles of all the components present.*

Let there be three components A, B and C making a solution. The number of moles is n_A, n_B and n_C respectively. If the mole fraction of A, B and C are denoted by X_A, X_B and X_C respectively. Then mathematically it can be written as:

$$X_A = \frac{n_A}{n_A+n_B+n_C}$$

$$X_B = \frac{n_B}{n_A+n_B+n_C}$$

$$X_C = \frac{n_C}{n_A+n_B+n_C}$$

Q22: ***The sum of all the mole fractions is equal to one (unity). Discuss.*** ***OR***
Why the sum of mole fractions is always equal to unity?

Ans: *Consider a solution which consists of two components A and B. Their mole fraction X_A and X_B are given as:*

$$X_A = \frac{n_A}{n_A + n_B}$$

$$X_B = \frac{n_B}{n_A + n_B}$$

So, $$X_A + X_B = \frac{n_A}{n_A + n_B} + \frac{n_B}{n_A + n_B}$$

$$X_A + X_B = \frac{n_A + n_B}{n_A + n_B} = 1$$

Hence it is proved that sum of mole fraction for only solution is always unity.

Q23: ***Define mole fraction and parts per million (ppm).***

Ans: *Mole fraction:*

The ratio of number of moles of a component to the total number of moles in a solution is called mole fraction. It is denoted by "x".

$$X = \frac{\text{No.of moles of one component}}{\text{Total no.of moles of all connponents of solution}}$$

Part per million (ppm):

The number of parts (by mass or volume) of a solute per million parts (by mass or by volume) of a solution is called ppm.

Q24: ***Define parts per million and when this concentration unit is used.***

Ans: *Part per million:*

It is the number of parts of solute (by weight or volume) present per million parts (by weight or volume) of solution.

$$\text{ppm} = \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 10^6$$

This unit is used to express very low concentrations of solutions. e.g, to express impurities of substances in water.

Q25: ***Sea water has 5.65×10^{-3}g of dissolved oxygen in one kg of water. Calculate the concentration of oxygen in sea water in parts per million.***

Ans: Mass of oxygen = 5.65×10^{-3} g

Mass of water = 1 kg = 1000 g

Million (ppm) = ?

Formula:

$$\text{ppm} = \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 10^6$$

$$\text{ppm} = \frac{5.65\times10^{-3}}{1000} \times 10^6 = 5.65 \text{ ppm}$$

Q26: ***Define azeotropic mixture. Give two examples.***

Ans: *Azeotropic mixtures:*

The liquid mixture which boils at constant temperature and distills over without changes in composition like a pure compound at any temperature is called azeotropic mixtures. e.g. HCI forms azeotropic mixture with water.

Q27: **Differentiate between zeotropic and azeotropic mixture.**

Ans: *The difference between zeotropic and azeotropic mixture is:*

Zeotropic mixture	Azeotropic mixture
The liquid mixtures which distills with change in composition is called zeotropic mixtures, e.g. Methyl Alcohol-water solution.	*The liquid mixtures which boil at constant temperature and distill over without changes in composition like a pure compound at any temperature is called azeotropic mixtures. e.g. HCI forms azeotropic mixture with water.*

Q28: **Define ebullioscopic constant with example.**

Ans: *Ebullioscopic constant:*

It is elevation in boiling point which is produced, when 1 mole of solute is dissolved in 1 kg of solvent. It is denoted by K_b.

The higher the concentration of solute, the greater will be the lowering in vapour pressure of solution and hence higher will be its boiling point. So, elevation of boiling point ΔT_b *is directly proportional to the molality of solution.*

$$T_b \propto m$$

$$T_b = K_b\, m$$

Where K_b *is called the ebullioscopic constant or molal boiling pint constant.*

For solution in water the value of K_b *is* $0.52°C/m$.

Q29: **What is critical solution temperature? Give the critical solution temperature of phenol water system.**

Ans: *Critical Temperature:*

The temperature at which two conjugate solutions merge into each other to form homogenous mixture is called critical solution temperature or consulate temperature. Phenol-Water system has critical temperature of 65.9 °C at which two conjugate solution merge into one another.

Q30: **Dissolution of KCl and Na_2SO_4 in water give neutral solutions. Why?**

Ans: *These are the salts of strong acids and bases. Such salts do not hydrolyze. Cation and anions of such salt do not react with water and number of* H^+ *and* OH^- *ions remain constant. That's why these salts give neutral solution in water.*

Q31: **Define fractional crystallization. How is it useful?**

Ans: *Fractional crystallization:*

The separation of solid substances from a solution one by one on cooling is called fractional crystallization. This technique is used for separation of impurities from sample.

Q32: **Polar solids are not dissolved in non-polar solvent, give reason.**

Ans: *There is a general principle that "Like dissolve like". That's why polar compounds are not dissolve in non-polar solvent because they have no polar ends like water to make interactions.*

Q33: Give two examples of liquid-liquid solution.

Ans: The examples of liquid-liquid solution are:

- Alcohol in water
- Benzene in toluene

Q34: The total volume of the solution by mixing 100 cm^3 of water with 100 cm^3 of alcohol may not be equal to 100 cm^3 justify it.

Ans: Alcohol and water are mix in all proportions. However, the properties of such solutions are not strictly additive. Generally, the volume decreases on mixing but in some cases it increases. Heat may be evolved or absorbed during the formation of such solutions.

Q35: What is upper consulate temperature and give one example?

Ans: The temperature of 65.9 °C at which two conjugate solutions merge into one another is called critical solution temperature or upper consulate temperature.

For example 34% phenol and 66% water solution.

Q36: What is conjugate solution with one example?

Ans: Conjugate solution:

On shaking equal volume of two partially miscible liquids, (e.g water and ether) two layers are formed. Each liquid layer is a saturated solution of other liquid. Such solutions are called conjugate solutions.

Example:

- Phenol-water system.
- Nictoine-water system.

Q37: Give two definitions of Raoult's law.

Ans: Raoult's law:

The vapour pressure of a solvent above a solution is equal to the product of the vapour pressure of pure solvent and mole fraction of solvent in solution.

$$p = p^\circ X_1$$

Relative lowering of vapour pressure of a solution is equal to the mole fraction of solute.

$$\frac{\Delta p}{p^\circ} = X_2$$

Q38: Relative lowering of vapour pressure is independent of temperature. Explain.

Ans: Relative lowering of vapour pressure of a solution is equal to the mole fraction of solute.

$$\frac{\Delta p}{p^\circ} = X_2$$

Vapour pressure (p°) and lowering of vapour pressure (Δp) changes with temperature. When temperature of solution increases both factors (Δp) and (p°) increases. Solvent ratio remains same.

Q39: Why the non-ideal solutions do not obey the Raoult's law?

Ans: Many solutions do not behave ideally as they show deviations from Raoult's law due to difference in their molecular structure i.e. size, shape and intermolecular forces. During their formation change in volume and enthalpy take place.
Hence they show deviation from ideality.

Q40: *Differentiate between ideal and non-ideal solutions.* ***OR***
Define non-ideal solution with example.

Ans: The difference between ideals and non-ideal solutions is:

Ideal solution	***Non-ideal solution***
➢ *The solutions which obey Raoult's law are called ideal solutions.* ➢ *In these solutions, enthalpy change is zero.* ➢ $\Delta H = 0$ *e.g. Benzene-Ether solution*	➢ *The solutions which do not obey Raoult's law are called non-ideal solution.* ➢ *In these solutions, enthalpy change is not zero.* ➢ $\Delta H \neq 0$ *e.g. Ethanol-water*

These graphs are just for information.

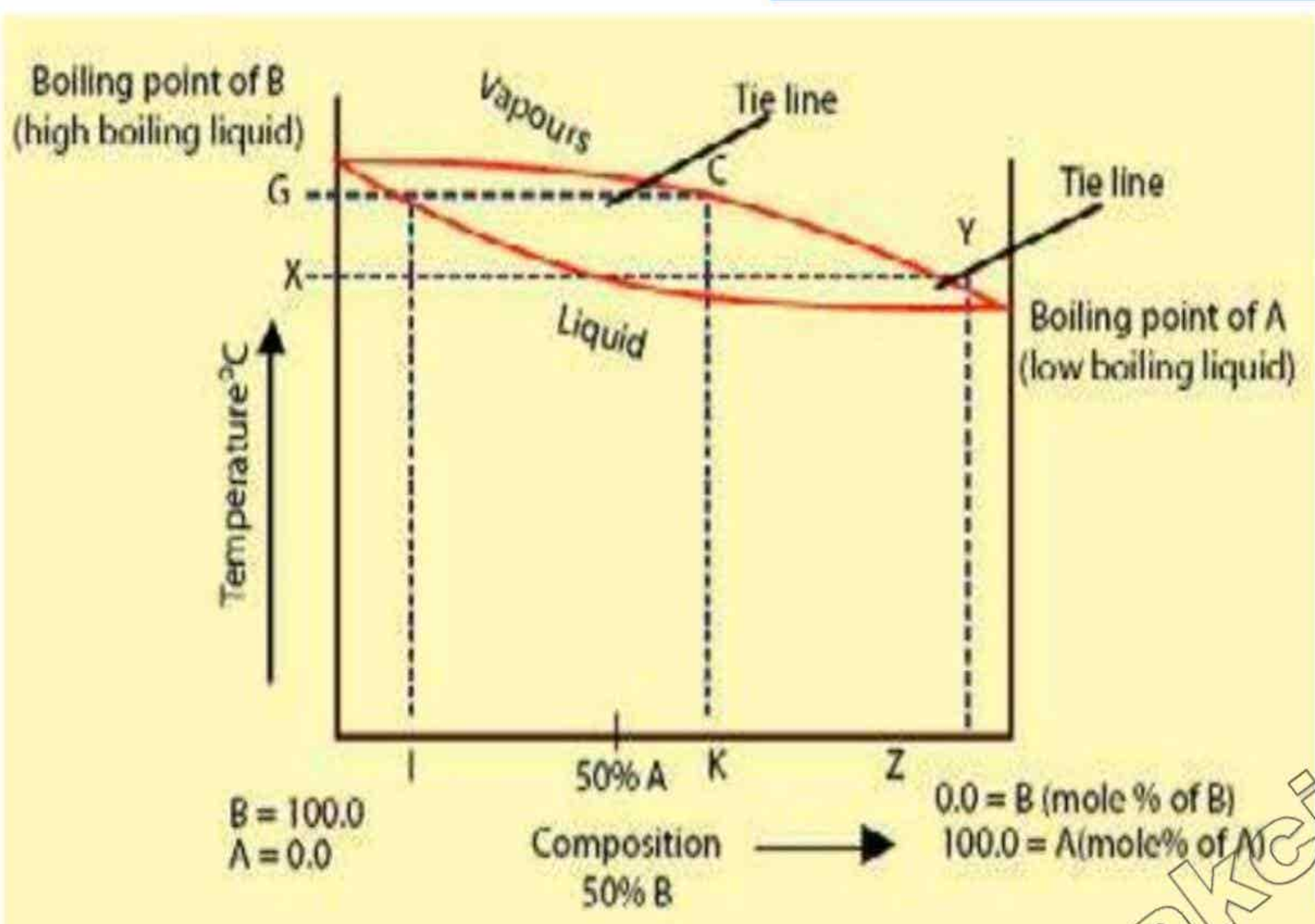

Fig Composition - temperature curve of an ideal solution.

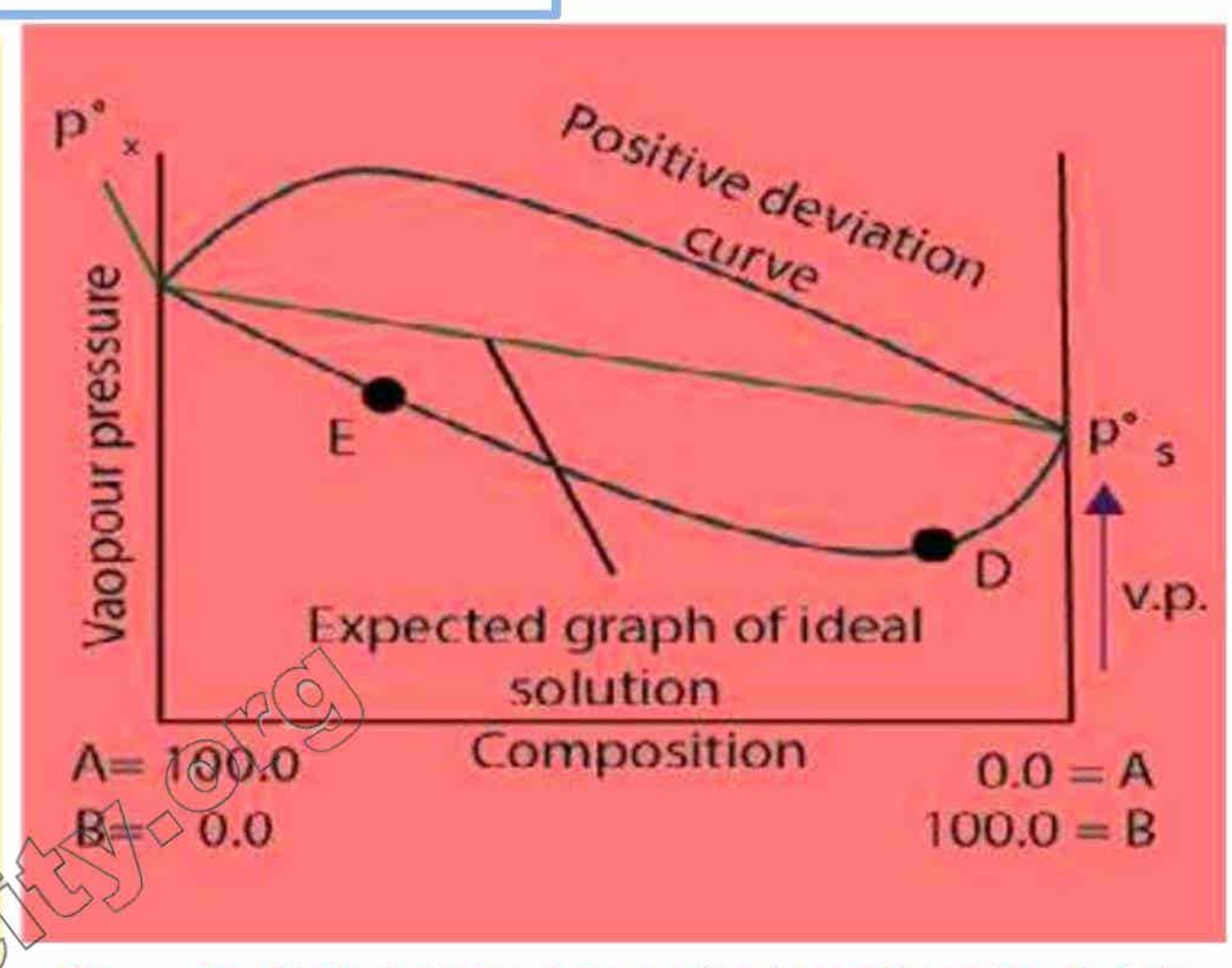

Fig Non-ideal solutions and azeotropic mixtures for positive deviation

Q41: *Define solubility and solubility curves.*

Ans: *Solubility:*

Solubility is the concentration of the solute in the solution when it is in equilibrium with the solid substance at a particular temperature.

Solubility curves:

A graphical representation between temperature and solubility of a solution is called solubility curves.
It has two types, continuous solubility curves and discontinuous solubility curves.

Q42: *Differentiate between continuous and discontinuous solubility curves.*

Ans: The difference between continuous and discontinuous solubility curves is:

Continuous solubility curves	***Discontinuous solubility curves***
➢ *These are smooth curves and do not shows any sharp break points. Continuous increase or decrease in solubility with temperature.* ➢ *Examples: Solubility curves of* $KClO_3$, $K_2Cr_2O_7$ *etc.*	➢ *These are not smooth and show sudden breaks due to sudden changes in solubility's with increase in temperature.* ➢ *Examples: Solubility curves of* Na_2SO_4, $CaCl_2$ *etc.*

These graphs are just for information.

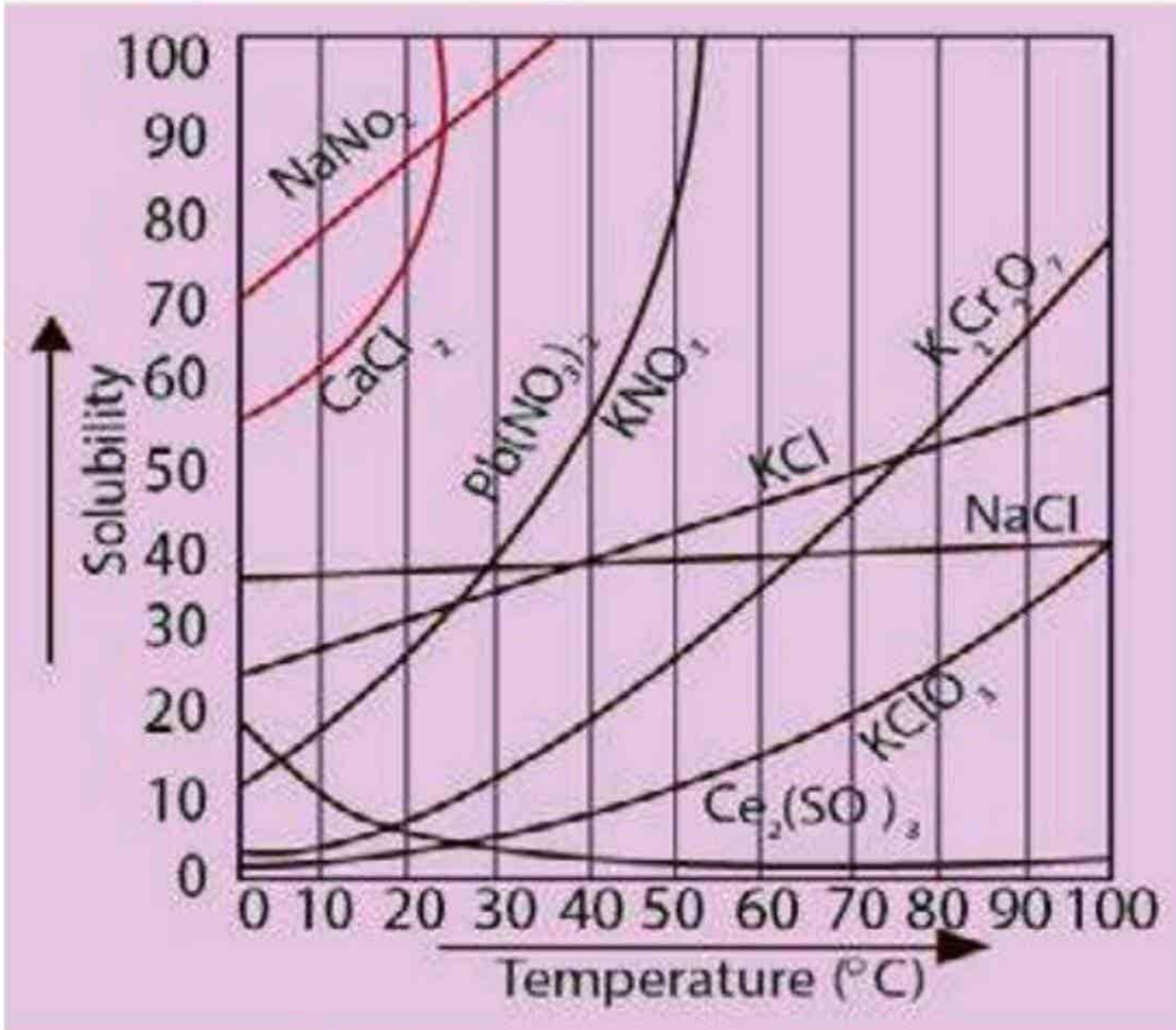

Fig Continuous solubility curves

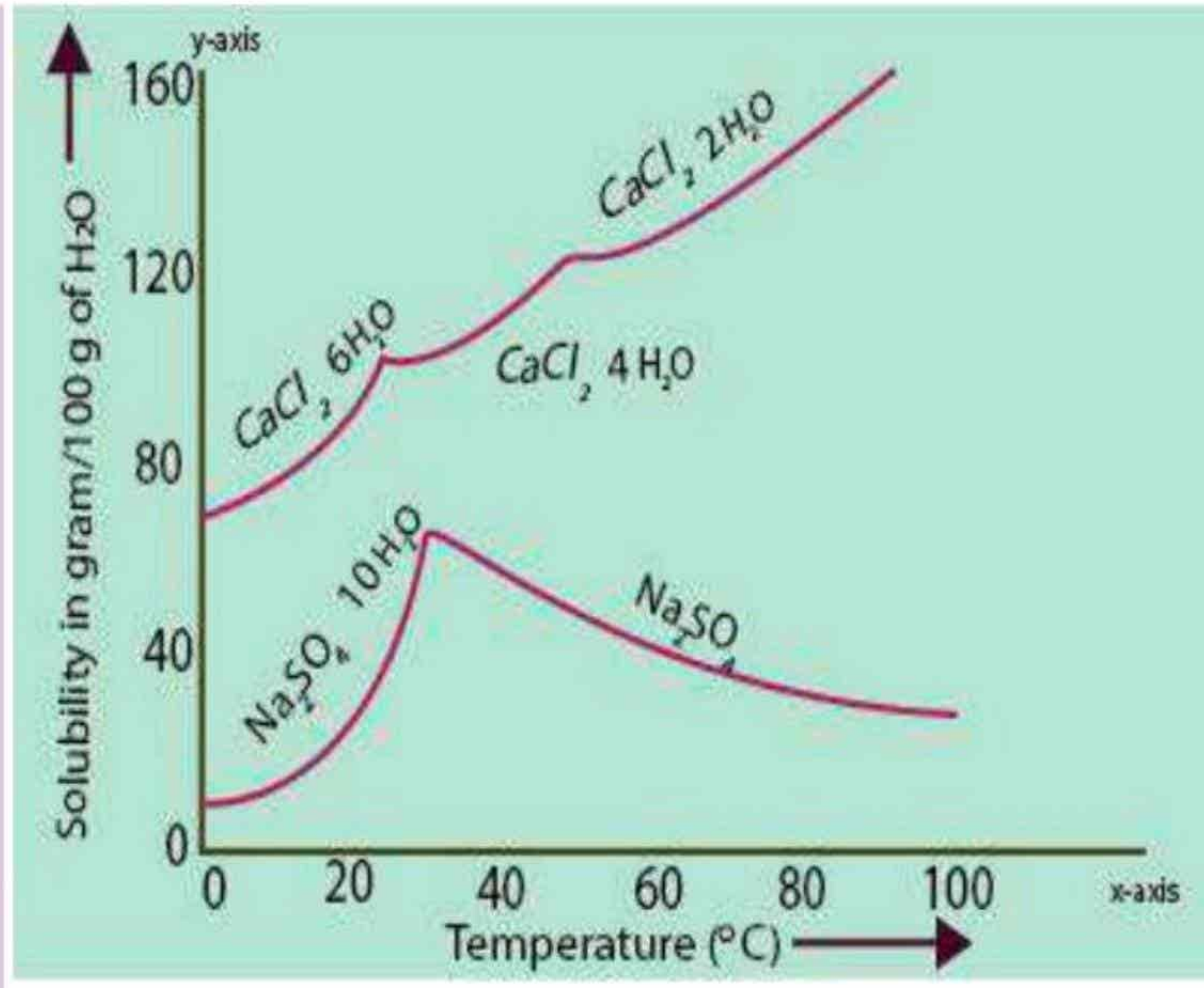

Fig Discontinuous solubility curves

Q43: ***Why $Na_2SO_4.10H_2O$ shows discontinuous solubility curve?***

Ans: *Actually, discontinuous solubility curves are combination of two or more solubility curves. At the break a new solid phase appears and another solubility curve of that new phase begins. It is the number of molecules of water crystallization which changes and hence solubility changes.*

Q44: ***What is fractional crystallization? How is it useful?***

Ans: *Fractional crystallization:*

Fractional crystallization is carried out to separate impurities from the chemical product. By using this method, the impurities are dissolved in a hot solvent in which desired solute is less soluble than impurities.

When hot solution is cooled, the desired solute separates out first leaving the impurities behind in mixture.

Q45: ***Fractional crystallization technique is used to purify the chemical products. Justify.***

Ans: *The separation of solid substance from a solution one by one on cooling is called fractional crystallization. Solubility's depend upon temperature.*

Example:

Solubility of KNO_3 rapidly changes with temperature but solubility of KCl and KBr change gradually. Thus one substance may precipitate earlier by cooling, leaving behind others.

Q46: ***Why the solubility of glucose increases on increasing temperature?***

Ans: *When glucose is dissolve in water it show endothermic heat of solution. Solute molecules separate from each other to dissolve in solvent. This process required energy. So when temperature is increased solubility also increases.*

Q47: ***Describe that NaCl and KNO_3 are used to lower the melting point of ice.***

Ans: *NaCl and KNO_3 are use as antifreeze. They depress the freezing point of ice and it melts. This method is used to melt the ice from the roads in winter.*

Q48: ***Cane sugar cannot be dissolved in benzene. Give reason.***

Ans: *Cane sugar is a polar covalent substance and it is soluble in polar solvent like water. Sugar dissolves in water due to the formation of H-bonding between solute and solvent, but not in benzene. As we simply say that solubility based upon principle "Like dissolve like"*

Q49: ***Define solubility giving one example.***

Ans: *The solubility is defined as the concentration of the solute in the solution when it is in equilibrium with the solid substance at a particular temperature. Solubility is expressed in terms of number of grams of solute in* 100g *of solvent. At a particular temperature, saturated solution of* NaCl *in water at* 0°C *contains* 37.5g of NaCl in 100g *of water.*

Q50: ***Define colligative properties. Name important colligative properties.***

Ans: *Colligative properties:*

The property of a solution which is based upon the number of solute particles and independent of the nature of solute is called colligative properties.

Name of some colligative properties are:

- *Osmotic pressure.*
- *Lowering of vapour pressure.*
- *Elevation of boiling point.*
- *Depression of freezing point.*

Q51: ***Give the conditions of colligative properties. / Fulfilled.***

Ans: *There are following conditions for colligative properties:*

- *Solute should be non-volatile.*
- *Solute should be non-electrolyte.*
- *Solution should be dilute.*

Q52: ***Why some properties are called colligative properties?***

Ans: *Colligative properties are called so because these depend upon the number of solute particles in definite amount of solvent and independent on the nature of solute.*

For example:

Lowering of vapour pressure of water, caused by the addition of 6 g *of urea,* 18 g *of glucose and* 34.2 g *of sucrose is same although the solute particles are of different nature but their numbers are same.*

Q53: ***What are the conditions should be fulfilled to observe colligative properties?***

Ans: *Following conditions should be fulfilled to observe colligative properties:*

- *Solute should be non-volatile*
- *Solute should be non-electrolyte*
- *Solution should be dilute*

Q54: ***Elevation of boiling point is a colligative property. Justify it.***

Ans: *Property of solution which depends upon the number of solute and solvent molecules or ions is called colligative property.*

For example:

B.point of 0.1molal *solution of urea* (6 g urea/1 kg H_2O) = 0.052 °C

B.point of 1molal *solution of urea* (60g urea/1 kg H_2O) = 0.52 °C

Q55: ***What are the names of four major parts of apparatus used in Landsberger's method for elevation of boiling point?***

Ans: *The names of four major parts of apparatus used in Landsberger's method for elevation of boiling point are:*

- *An inner tube with a hole in its side. This tube is graduated.*

- *An outer tube, which receives hot solvent vapours coming from the side hole of the inner tube.*
- *A thermometer which can read up to* 0.01 K.
- *A boiling flask which send the solvent vapours into the graduated tube through a rose head.*

This diagram is just for Understanding.

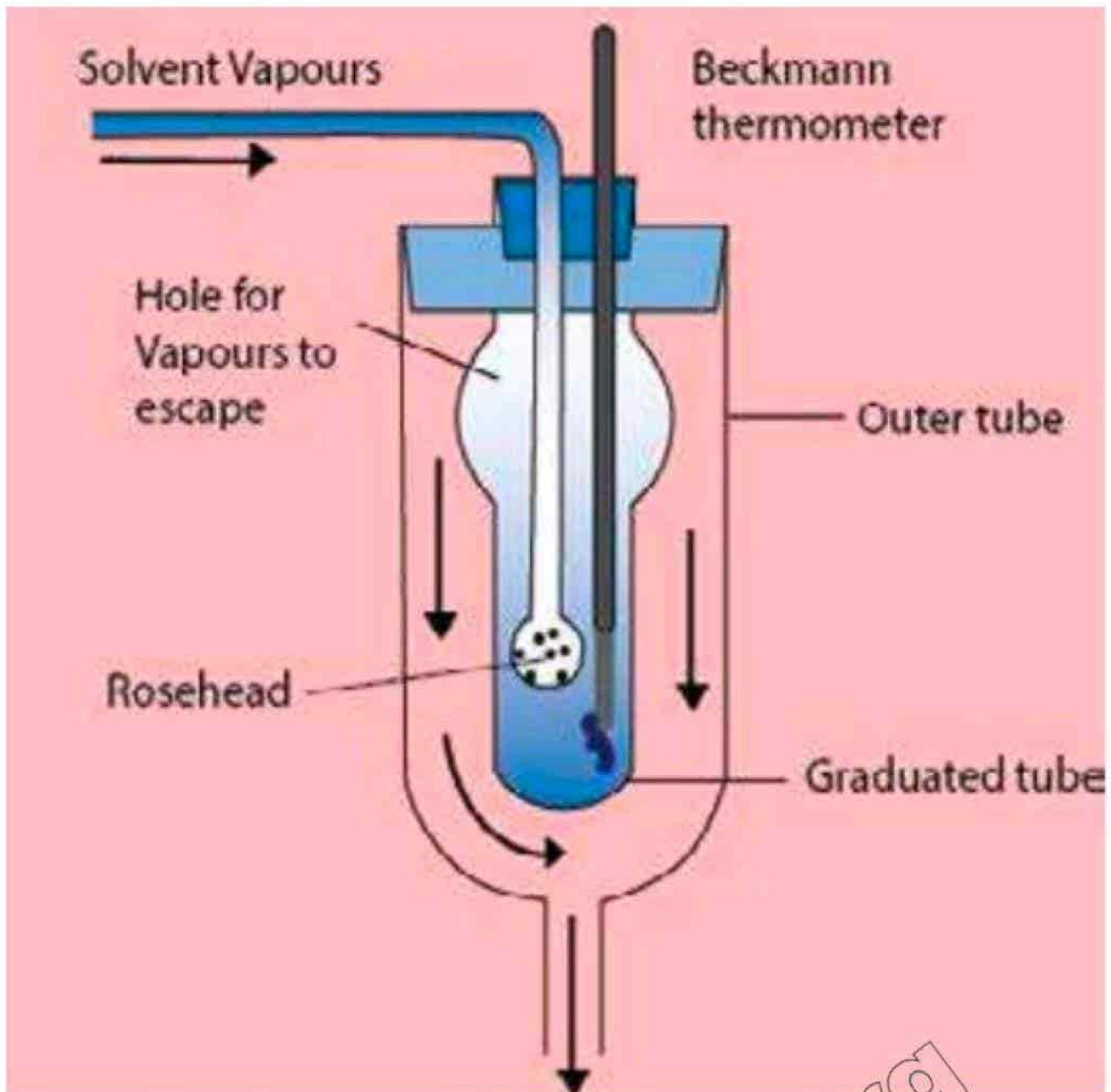

Fig Landsberger method for measurement of elevation of boiling point

Q56: ***Colligative properties are obeyed when the solute is non-volatile and also when the solutions are dilute. Explain.***

Ans: *Colligative properties depend upon number of solute, particles in solution of non-electrolyte. Solute does not ionize in solution and its number of particles remains same.*

For example:

1 *mole of urea produces* 6.02×10^{23} *particles in solution. When solution is dilute, less number of solute particles far away from each other and they behave independently and colligative properties are obeyed.*

Q57: ***Write down factors affecting relative lowering of vapour pressure.***

Ans: *Following are the factors affecting relative lowering of vapour pressure:*

- *It depends upon the concentration of solute.*
- *It is independent of the temperature.*
- *It is constant when equimolecular proportions of different solutes are dissolved in the same mass of solvent.*

Q58: ***Why is the vapour pressure of a solution less than pure solvent?***

Ans: *In pure solvent all the surface of solvent is covered by solvent molecules. But when a solute is added to it to from a solution. Some surface is occupied by solute particles. Hence escaping tendency of solvent is decreased and thus vapour pressure of solution also lowered.*

Q59: ***State ebullioscopic constant and cryoscopic constant.***

Ans: *Ebullioscopic constant:*

It is elevation in boiling point which is produced, when 1 mole *of solute is dissolved in* 1 kg *of solvent. It is denoted by* K_b. *Its value is* 0.52 °C *for water.*

Cryoscopic constant:

It is depression in freezing point which is produced when 1 mole *of solute is dissolved in* 1 kg *of solvent. It is denoted by* K_f. *Its value is* 1.86 °C *for water*

Q60: ***In summer the antifreeze solutions protect the radiator from boiling over. How?***

Ans: *The boiling point of liquid is increased by the addition of solute such as ethylene glycol in water. Therefore in summer the antifreeze liquids protect the water in car radiators from boiling over.*

Similarly the addition of a solute in water depresses its freezing point. During winter it protects a car by preventing the liquid from freezing in radiators.

Q61: ***Beckmann's thermometer is used to note the depression of freezing point. Explain with reason.***

Ans: *There is a very small difference between freezing point of pure solvent and its dilute solution. Ordinary thermometer can read up to* 0.5K. *Hence these cannot differentiate between freezing point of pure solvent and solution. Beckmann's thermometer can read up to* 0.01 K.

Hence it can exactly measure the freezing point of pure solvent and solution.

This diagram is just for Understanding.

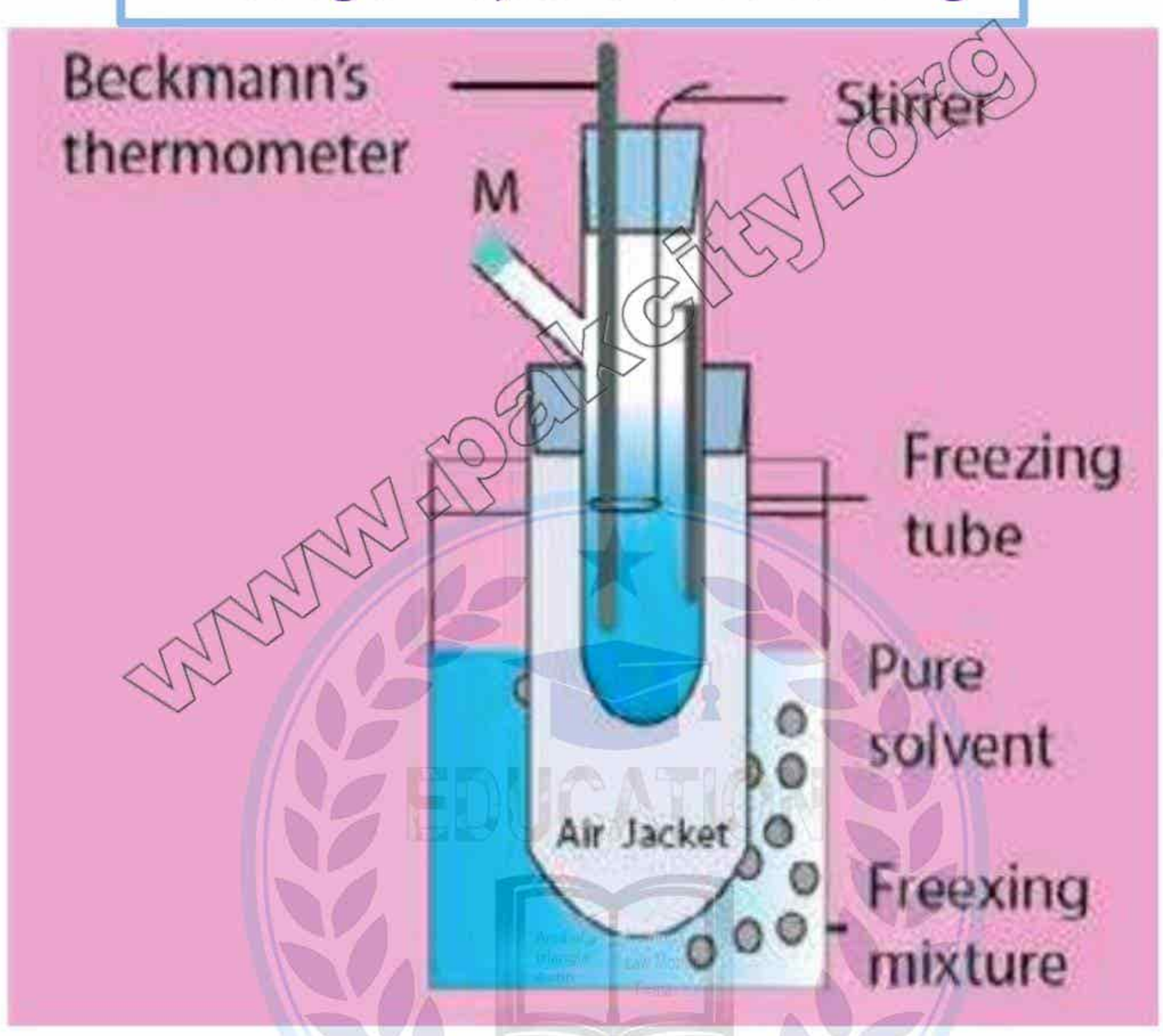

Fig Beckmann's freezing point apparatus

Q62: ***Define molal freezing point constant giving example.***

Ans: *It is depression of freezing point, when one mole of non-volatile and non-electrolyte solute is dissolved in one kg of solvent. It is denoted by* K_b.

Q63: ***The freezing points are depressed due to the presence of solutes. Give reasons.***

Ans: *Freezing point of a substance also related to its vapour pressure. It is a temperature at which there is equilibrium between a solid and a liquid. At freezing point, vapour pressure of liquid and solid phase is same. When some solute is added to solvent, its vapour pressure decreases and freezing point also decreases.*

Q64: ***Justify all solutions containing 1 mole of non-volatile, non-electrolyte solutes in same solvent will have the same freezing point depression.***

Ans: *Freezing point depression is colligative property. Colligative properties depend upon the number of solute particles in a definite amount of solvent and are independent of nature of solute.*

So, 1 mole *of non-volatile, non-electrolyte solutes in same solvent will have same number of particles* (i.e. 6.02×10^{23}). *So, they show same freezing point depression.*

Q65: ***Boiling points of liquid are increased when solute is added to them. Give reason.***

Ans: Because the vapour pressure of solvent decrease due to the presence of solute. Therefore, we have to supply high temperature in order to equalize the vapour pressure of solvent to external pressure to boil it. This results in the increase of boiling point of solvent in the presence of solute.

Q66: ***Why ethylene glycol is added in radiator of an automobile?***

Ans: The most important application of this phenomenon is the use of antifreeze in the radiator of an automobile. The solute is ethylene glycol, which is not only completely miscible with water but has a very low vapour pressure and non-volatile in character. When mixed with water it lowers the freezing point as well as raised the boiling point.

Q67: ***In $CuSO_4.5H_2O$, four water molecules are attached with Cu^{2+} ion while one water molecule with SO_4^{-2} ions. Give reason.***

Ans: The $CuSO_4.5H_2O$ *is a coordination compound of copper sulphate with water molecules. In* $[Cu(H_2O)_4]SO_4.H_2O$ *four water molecules are attached with* Cu^{2+} *and one with* SO_4^{-2}. *The reason is that* Cu^{2+} *has greater charge density. The size of* Cu^{2+} *is much smaller than* SO_4^{-2} *which has same amount of charge.*

Q68: ***Justify that boiling point of solvents increase due to the presence of solute.***

Ans: When non-volatile solute is dissolved in solvent, the escaping tendency of solvent particles from the surface of the solution is decreased and its vapour pressure is lowered and hence boiling point is increased.

Q69: ***Define critical temperature. On what factors it depends.***

Ans: The temperature at which two conjugate solutions merge into each other to form homogeneous mixture is called critical solution temperature OR upper consulate temperature.

The factors on which it depends are:

- *Pressure.*
- *Strength of intermolecular interactions of components.*
- *Impurities present in solution.*

Q70: ***Justify the boiling point of one molal urea solution is 100.52 °C but the boiling point of two molal urea solution is less than 101.04 °C.***

Ans: Elevation in boiling point is a colligative property. It obeys only when solution is dilute. In concentrated solutions the solute is not dissolved completely.

So, the numerical value of colligative property (i.e; elevation of boiling point) is the less than the expected values.

Q71: ***What are liquids practically immiscible? Give one example.***

Ans: Those liquids which do not dissolve into each other in any proportion are immiscible.
For example:
Water and Benzene, ($H_2O + C_6H_6$).

Q72: ***Write two applications of boiling point elevation and freezing point depression in daily life.*** ***OR***
Two applications of Colligative properties.

Ans: Applications of Colligative properties:

The most important application of this phenomenon is the use of antifreeze in the radiator of an automobile. The solute is ethylene glycol, which is not only completely miscible with water but has a very low vapour pressure and non-volatile in character. When mixed with water it lowers the freezing point as well as raised the boiling point.

Another common application is the use of NaCI or KNO_3 to lower the melting point of ice. One can prepare a freezing mixture for use in an ice cream machine.

Q73: Define "heat of solution" and "hydration energy"?

Ans: Heat of solution:

The quantity of heat energy that is absorbed or released when a substance forms solution is termed as heat of solution.

Hydration energy:

When ionic compound is dissolved in water, the first step is the separation of ions from solid and second step is separated ions are surrounded by solvent molecules. A hydrated ion is attracted by the solvent dipoles and energy is released, so second step is exothermic. The energy given out by the second step is knows the hydration energy.

Just for information

Table Heats of solution of some ionic solids

Sub-stance	Heats of solution (kJ mol^{-1})
NaCl	4.98
NH_4NO_3	26.0
KCl	17.8
KI	21.4
NH_4Cl	16.2
LiCl	-35.0
Li_2CO_3	-12.8

Q74: Differentiate between hydration and hydrolysis with two examples.

Ans: The difference between hydration and hydrolysis is:

Hydration	Hydrolysis
The process in which water molecules surround and interact with solute ions or molecules is called hydration.	*The reaction of cation or anions of salt to form acidic or basic solution is called hydrolysis.*
For example:	*For example:*
$CuSO_4 .5H_2O$ and $MgCl_2 .6H_2O$	$CuSO_4 + 2H_2O \longrightarrow Cu(OH)_2 + 2H^+ + SO_4^{2-}$

Q75: Why hydration energy of Na^+ ion is less than Li^+ ion?

Ans: Hydration energy depends upon charge/size ratio. Greater the charge to size ratio, greater would be the value of hydration energy. As Li^+ ion has greater charge to size ratio than Na^+ ion. Thus, its hydration energy is greater.

Q76: Why energy of Mg^{2+} ion is higher than Na^+ ion?

Ans: Hydration energy depends upon charge to size ratio (charge density) of ion. As Mg^{2+} has greater charge to size ratio as compared to Na^+ ion, so it has greater value of hydration energy.

Q77: Hydration energy of Li^+ is greater than Cs^+.

Ans: Li^+ has greater charge /size ratio as compared to Cs^+. So therefore it has greater hydration energy.

Q78: What are hydrates? How they are formed?

Ans: Hydrates and its formation:

The crystalline substance containing chemically combined H_2O in definite proportion is called hydrate.

Hydrates are prepared by evaporating their aqueous solution.

Just for information

Ion	ΔH^0 (ionmole^{-1})
H^+	-1075
Li^+	-499
Na^+	-390
Ag^+	-464
K^+	-305
Mg^{2+}	-1891
Cu^{2+}	-1562
NH_4^+	-281
F^-	-457
Cl^-	-384
Br^-	-351
OH^-	-460

Table Hydration energies of common ions

For example:

$CaSO_4 .5H_2O$

Q79: *Define hydrolysis with suitable example.*

Ans: *Hydrolysis:*

"The process in which water reacts chemically with the added solute is called hydrolysis." The concentration of H^+ *and* OH^- *ion in pure* H_2O *remain same. So it is neutral. When* Na_2CO_3 *is dissolved in water the* pH *of solution will be greater than 7 Or "the interactions between salts and water are called Hydrolytic reactions and the phenomenon is known as Hydrolysis."*

Q80: *Aqueous solution $CuSO_4$ is acidic in nature. Justify it.*

Ans: $CuSO_4$ *is a salt of strong acid. The cations of such salts react with water and form hydronium ions and solutions become acidic.*

$$CuSO_4 + 2H_2O \longrightarrow Cu(OH)_2 + H_2SO_4$$

Q81: *Aqueous solution of CH_3COONa is basic in nature. Discuss.*

Ans: *On dissolving* $CH_3COO^-Na^+$ *in water, acetic acid and sodium hydroxide is produce.*

$$CH_3COONa + H_2O \longrightarrow CH_3COOH + NaOH$$

In this solution base is strong and acid is weak, so the resulting solution will be basic in nature.

Q82: *Why aqueous solution of NH_4Cl is acidic but that of CH_3COONa is basic?*

Ans: *NH_4Cl is a salt of weak base. The* NH_4^+ *ion when react with water it produce hydronium ion and solution become acidic.*

$$NH_4^+ + 2H_2O \rightleftharpoons NH_4OH + H_3O^+$$

While CH_3COONa *when dissolved in* H_2O

$$CH_3COO^-Na^+ + H_2O \rightleftharpoons CH_3COOH + NaOH$$

NaOH *is a strong base therefore overall solution is basic.*

Q83: *What is meant by water of crystallization? Give an example.*

Ans: *Water of crystallization:*

The water molecules which are attached with compound when crystallized from aqueous solution is called water of crystallization.

For example:

$CuSO_4 .5H_2O$ and $MgCl_2 .6H_2O$

Q84: *Define water of crystallization with one example.*

Ans: *During crystallization process, some salts crystalized with water molecules, which is fixed in number. Those water molecules which are present in the crystal of such compounds are called water of crystallization.*

For example:

Mohr's salt:	$FeSO_4.(NH_4)_2SO_4.6H_2O$
Potash alum:	$K_2SO_4.Al_2(SO_4)_3.24H_2O$
Potash ferric alum:	$K_2SO_4.Fe_2(SO_4)_3.24H_2O$
Calcium Sulphate:	$CaSO_4 .2H_2O$

Copper Sulphate: $CuSO_4 .5H_2O$

Q85: ***What are partially miscible liquids? Give its two examples.***

Ans: *A large number of liquids are known which dissolve into one another upto a limited extant.*

For example:

Ether dissolves water to the extent of about 1.2% and water dissolves ether upto the extent of about 6.5%.

Chapter : 09 Solutions

Long Questions

Q1: *Define the following terms:* *(V.Imp)*

- *Azeotropic mixture*
- *Parts per million (ppm)*
- *Molarity.*
- *Molality.*
- *Mole fraction.*

Q2: *Describe four points of differences between ideal and non-ideal solution.* OR

Explain positive and negative deviation of non-ideal solution. OR

What is the difference between ideal and non-ideal solution. Give two points for each. Also define Raoults Law in two ways mathematically? OR

What are ideal solutions? Explain the fractional distillation of ideal mixture of two liquids?

Q3: *Explain Raoult's law when both components in the solution (solute and solvent) are volatile.* OR

Define Raoults' Law and derive its different mathematical forms when solute is Non Volatile and Solvent is Volatile. OR

State and explain Raoult's law in three forms. OR

Explain negative deviation of solution from Raoult's law. *(V.Imp)*

Q4: *Define colligative properties. Explain elevation of the boiling point.* *(V.Imp)* OR

How lowering of the vapour pressure as colligative property is used to find out molecular mass of solute? OR

What are colligative properties? Why they are called so? Explain.

Q5: *Define solubility and make clear difference between continuous and discontinuous solubility curves.*

Q6: *Give graphical explanation for elevation of boiling point of a solution.* OR

Describe the method to determine the elevation of boiling point of a solution.

Q7: *How can you measure elevation of boiling point by Landsberger's method?* OR

How molecular mass of an organic compound is determined by Landsberger's method?

Q8: *Write a note on hydration reaction.* OR

What is hydration and hydrolysis explain with examples?

Q9: *Define colligative properties and discuss freezing point depression by Backman's apparatus. (V.Imp)* OR

Explain Beckmann method to determine depression of Freezing Point. OR

What do you mean by depression of freezing point and describe Beckmann's method for measurement of depression of freezing point.

Q10: *The solubility of* CaF_2 *in water at* 25 °C *is found to be* 2.05×10^{-4} *mol* dm^{-3}*. What is value of* K_{sp} *at this temperature?*

Q11: *Define Solubility Curves. Discuss Solubility Curves of NaCl and* $Ce_2(SO_4)_3$*.*