CHEMISTRY (XI)
Chapter 9
Solutions
Short Questions

1. Define phase. Give an example.

Ans: Every sample of matter with uniform properties and a fixed composition is called a phase. For example, water at room temperature and normal pressure exists as a single liquid phase, that is, all the properties of water are uniform throughout this liquid phase.

2. Define solution. Give an example.

Ans: A solution, on average, is a homogeneous mixture of two or more kinds of different molecular or ionic substances. For example, sugar added in water makes a solution.

3. Define solvent and solute.

Ans: The substance which is present in large quantity is called a solvent and the other component in small quantity is called a solute. For example, in the mixture of sugar and water sugar is solute and water is solvent.

4. Define concentration of solution.

Ans: For a given solution, the amount of solute dissolved in a unit volume of solution (or a unit amount of solvent) is termed as the concentration of the solution.

5. Define dilute solution and concentrated solution.

Ans: Solutions containing relatively lower concentrations of solute are called dilute solutions, whereas, those containing relatively higher concentrations of solutes are called concentrated solutions.

6. Mention the concentration units of solution.

Ans: Following are the concentration units of solution:

a. Percentage weight/weight

b. Percentage weight/volume

c. Percentage volume/weight

d. Percentage volume/volume

e. Molarity (M)

f. Molality (m)

g. Mole Fraction (x)

h. Parts per million (ppm)

7. Mention the units showing percentage composition.

Ans: Following are the units showing percentage composition:

a. Percentage weight/weight

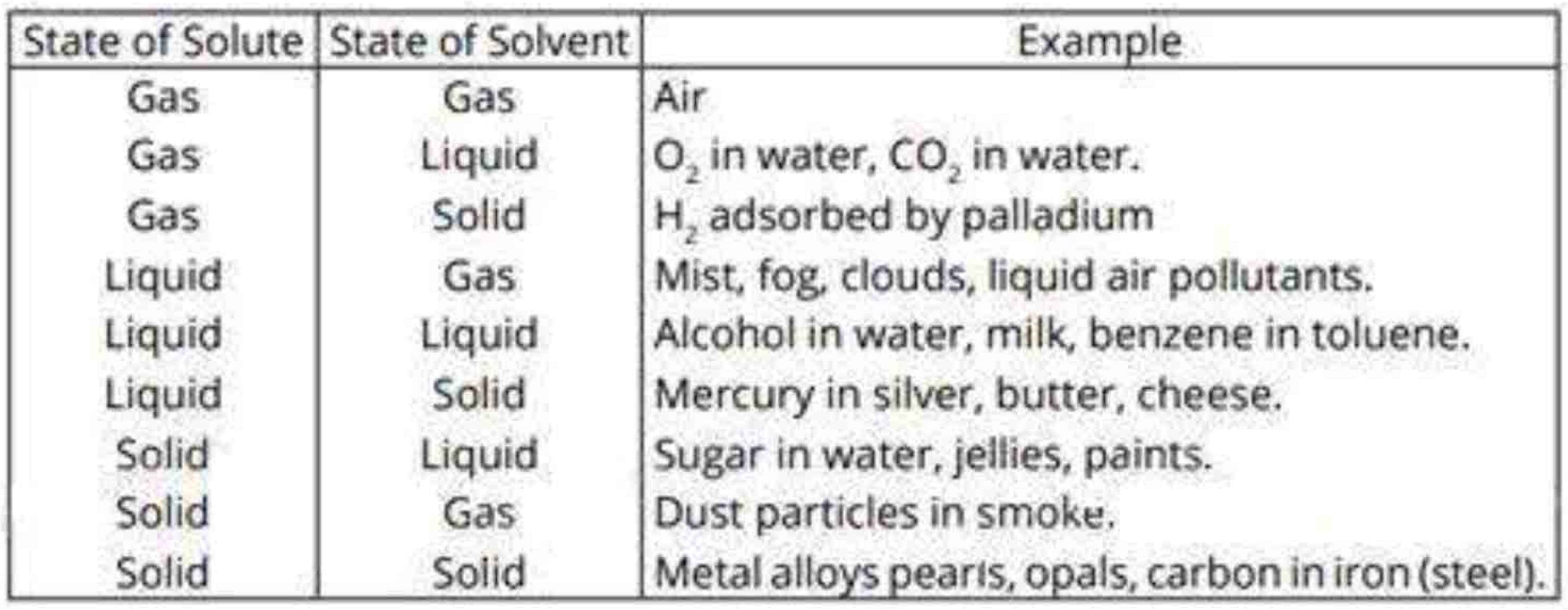
b. Percentage weight/volume

c. Percentage volume/weight

d. Percentage volume/volume

8. Mention the various types of solution (Any type can come for short question)

Ans:



State of Solute	State of Solvent	Example
Gas	Gas	Air
Gas	Liquid	O_2 in water, CO_2 in water.
Gas	Solid	H_2 adsorbed by palladium
Liquid	Gas	Mist, fog, clouds, liquid air pollutants.
Liquid	Liquid	Alcohol in water, milk, benzene in toluene.
Liquid	Solid	Mercury in silver, butter, cheese.
Solid	Liquid	Sugar in water, jellies, paints.
Solid	Gas	Dust particles in smoke.
Solid	Solid	Metal alloys pearls, opals, carbon in iron (steel).

(Use the table to write in your own words)

9. What is percentage weight/weight? Give an example.

Ans: It is the weight of a 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.

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

10. What is percentage weight/volume? Give an example.

Ans: It is the weight of a solute dissolved per 100 parts by volume of solution. 10 g of glucose dissolved in 100 cm^3 of solution is 10% w/v solution of glucose. The quantity of the solvent is not exactly known. In such solutions, the total volume of the solution is under consideration.

11. What is percentage volume/weight? Give an example.

Ans: It is the number of cm^3 of a solute dissolved per 100 g of the solution. If we dissolve 10 cm^3 of alcohol in water and the total weight of the solution is 100 g then it is 10% v/w solution of alcohol in water. In such type of solutions, we don't know the total volume of the solution.

12. What is percentage volume/volume? Give an example.

Ans: It is the volume of a solute dissolved per 100 cm^3 of the solution. This unit of concentration is best applicable to the solutions of liquids in liquids. A 12 % alcohol beverage is 12 cm^3 of alcohol per 100 cm^3 of solution. In such solutions, the total volume of the solution may not be necessarily equal to the sum of volumes of solute and the solvent.

13. Define molarity. Give an example.

Ans: Molarity is the number of moles of solute dissolved per dm^3 of the solution. To prepare one molar solution of glucose in water, we take 180 g of glucose and add sufficient water to make the total volume 1 dm^3 (litre) in a measuring flask.

Mathematical relation

$$\text{Molarity(M)} = \frac{\text{Number of moles of solute}}{\text{Volume of soultion } (dm^3)}$$

14. Define molality. Give an example.

Ans: Molality is the number of moles of solute in 1000 g (1 kg) of the solvent. In order to prepare molal solutions, we don't have to take any flask. 180 g of glucose when dissolved in 1000 g of water gives one molal solution of glucose.

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

15. Define mole fraction (x). Give an example.

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.

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

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

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

The sum of the mole fractions of all the components of a solution must be equal to one. In the case of mixture of gases, one can determine the mole fraction from the partial pressure data of the mixture. Hence,

$$X_A = \frac{p_A}{p_A + p_B + p_C}, \quad X_B = \frac{p_B}{p_A + p_B + p_C}, \quad X_C = \frac{p_C}{p_A + p_B + p_C}$$

Where p_a, p_b, p_c are the partial pressures of various gases in the mixture. Generally, we can say that

$$\text{Mole fraction of any gas} = \frac{\text{Partial pressure of that gas}}{\text{Total pressure of the mixture of gases}}$$

16. Define parts per million (ppm).

Ans: It is defined as the number of parts (by weight or volume) of a solute per million parts (by weight or volume) of the solution. This unit is used for very low concentrations of solutions, e.g. to express the impurities of substances in water.

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

17. *Tell about the solutions of solids in liquids.*

Ans: When a solid comes in contact with a suitable liquid, it dissolves forming a solution i.e. a homogeneous mixture. This process of dissolution can be explained in terms of attraction between the particles of a solute and that of a solvent. The molecules or ions in solids are arranged in such a regular pattern that the inter-molecular or inter-ionic forces are at a maximum.

18. *Justify that the solubility principle is "like dissolves like".*

Ans: The inter-ionic forces of attraction are very strong in ionic solids so equally strong polar solvents are needed to dissolve them. Such solids cannot be dissolved by moderately polar solvents e.g. acetone. A moderately polar solvent, fails to dissolve sodium chloride, which is an ionic solid. Thus the solubility principle is "like dissolves like".

19. *What are completely miscible liquids?*

Ans: Liquids which mix completely with each other are called completely miscible liquids. For example, liquids like alcohol and water or alcohol and ether mix in all proportions.

20. *What are partially miscible liquids?*

Ans: A large number of liquids are known which dissolve into one another up to a limited extent. For example, ether C_2H_5-O-C_2H_5 dissolves water to the extent of about 1.2 % and water dissolves ether up to the extent of about 6.5%.

21. *What are conjugate solutions?*

Ans: Each liquid layer when is a saturated solution of the other liquid then such solutions are called conjugate solutions. The mutual solubility of these conjugate solutions is affected by temperature changes. Typical examples of such systems are:

a. Phenol-water system

b. Triethylamine-water system

c. Nicotine-water system

22. What is critical solution temperature or upper consulate temperature?

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.

23. How a water-phenol system works?

Ans: If equal volumes of water and phenol are mixed together they show partial miscibility. It has been observed that around room temperature phenol will dissolve in a lot of water giving us the upper layer and water will dissolve in a lot of phenol giving us the lower layer. At 25 °C the upper layer is 5% solution of phenol in water and the lower layer is 30% water in phenol. These two solutions are conjugate solutions to each other. The lower layer has a greater density due to greater percentage of phenol. Water acts as a solute in the lower layer while phenol is a solute in the upper layer. When the temperature of water-phenol system is increased, the compositions of both layers change. Water starts travelling from upper to the lower layer and phenol travels from lower to the upper layer. When the temperature of this system approaches 65.9 °C, a homogeneous mixture of two components is obtained. This homogeneous mixture contains 34% phenol and 66% water.

24. What are immiscible liquids?

Ans: Those liquids which do not dissolve into each other in any proportion are immiscible. Examples:

(i) Water and benzene ($H_2O + C_6H_6$)

(ii) Water and carbon disulphide ($H_2O + CS_2$)

25. What is the difference between ideal and non-ideal solutions?

Ans: Following points are the differences between ideal and non-ideal solution:

i. If the forces of interactions between the molecules of different components are same as when they were in the pure state, they are ideal solutions, otherwise non-ideal.

ii. If the volume of solution is not equal to the sum of the individual volumes of the components, the solution is non-ideal.

iii. Ideal solutions have zero enthalpy change as their heat of solution.

iv. If the solutions obey Raoult's law then they are ideal. This is one of the best criterion for checking the ideality of a solution

26. State Raoult's law.

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

$$p = p^{\circ}x_1$$

27. Define solubility. Give an 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. For example, solubility is expressed in terms of number of grams of solute in 1000g of solvent. At a particular temperature, saturated solution of NaCl in water at 0°C contains 37.5g of NaCl in 100 g of water. Similarly the solubility of $CuSO_4$ in water at 0°C is 14.3g/100g, while at 100°C it is 75.4g/100g.

28. Define solubility curves.

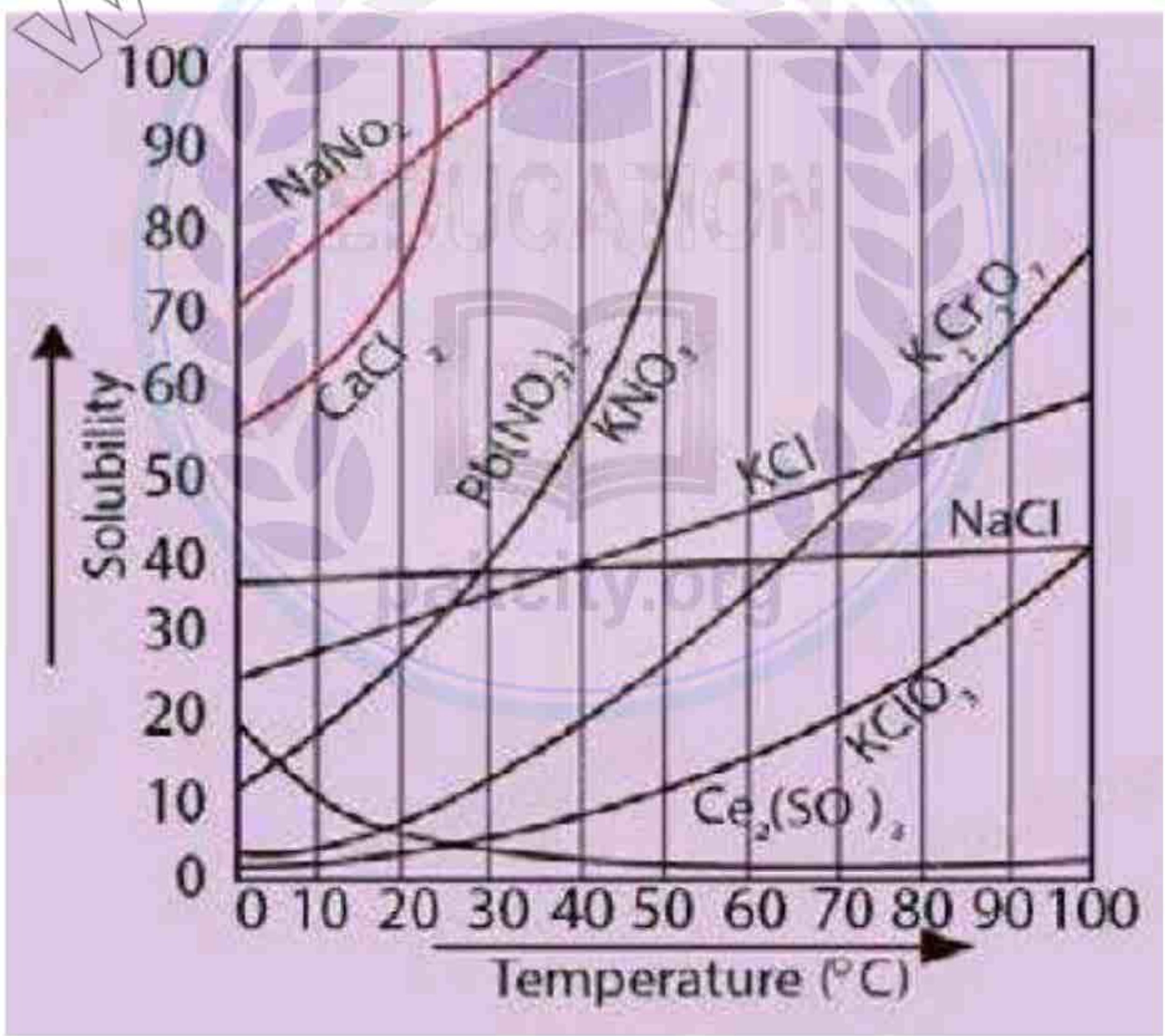
Ans: A graphical representation between temperature and solubility of solution is called solubility curves. There are two types of solubility curves.

(a) Continuous solubility curves

(b) Discontinuous solubility curves

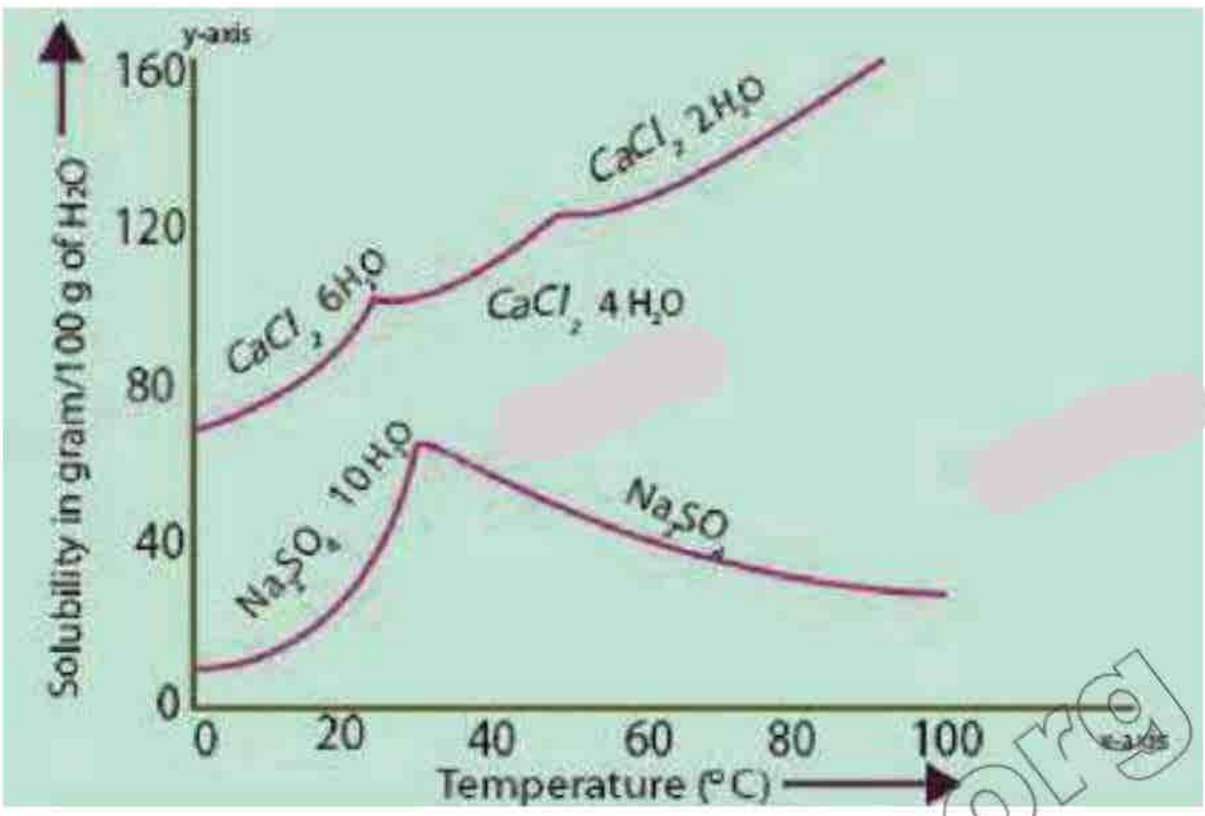
29. What are continuous solubility curves?

Ans: Continuous solubility curves don't show sharp breaks anywhere. $KCIO_3$, $K_2Cr_2O_7$, $Pb(NO_3)_2$ and $CaCI_2$ are showing continuous solubility curves. The solubility curves of KCl, NaCl and $NaNO_3$ give the straight lines. NaCl shows a very small change of solubility from 0°C to 100°C increase of temperature. $Ce_2(SO_4)_3$ shows the exceptional behaviour whose solubility decreases with the increase in temperature and becomes constant from 40°C onwards. It shows continuous solubility curve.



30. What are discontinuous solubility curves?

Ans: Sometimes, the solubility curves show sudden changes of solubilities and these curves are called discontinuous solubility curves. The best examples in this reference are $Na_2SO_4.10\ H_2O$, $CaCl_2.6H_2O$. Actually, these 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.



31. What is fractional crystallization? How is it carried out?

Ans: Fractional crystallization is a technique for the separation of impurities from the chemical products. By using the method, the impure solute is dissolved in a hot solvent in which the desired solute is less soluble than impurities. As the hot solution is cooled, the desired solute being comparatively less soluble, separates out first from the mixture, leaving impurities behind. In this way, pure desired product crystallizes out from the solution.

32. Define colligative properties.

Ans: The colligative properties are the properties of solution that depend on the number ofsolute and solvent molecules or ions. Following are colligative properties of dilute solution:

(i) Lowering of vapour pressure

(ii) Elevation of boiling point

(iii) Depression of freezing point

(iv) Osmotic pressure

33. Why molal solution is dilute as compared to molar solution?

Ans: Molal solution is dilute as compared to molar solution because in molal solution 1 kg of solvent is used whereas in molar solution 1 litre of solvent is used. As 1 kg solvent is more than 1 litre solvent so molal solution is dilute as compared to molar solution.

34. What is ebullioscopic constant?

Ans: The elevation in boiling point of 1 molal solution of non-volatile non-electrolyte solute in water as solvent is 0.52 ° C. It is also called molal boiling point elevation constant.

$$\triangle T_b = K_b m$$

When m=1

$\triangle T_b = K_b$

Unit

The unit of K_b is ° C $Kgmol^{-1}$

Example

Dissolve 6g of urea in 500g of H_2O or 18g of glucose in 500g of H_2O both give 0.2 molal solution and both have same elevation of boiling points i.e. 0.1° C.

35. What is cryoscopic constant?

Ans: The depression in freezing point of 1 molal solution of non-volatile non-electrolyte solute in water as solvent is 1.86 ° C. It is called molal freezing point depression constant or cryoscopic constant.

36. What are the conditions to observe colligative properties?

Ans: To observe the colligative properties following condition should be fulfilled by the solutions:

(i) Solution should be dilute

(ii) Solute should be non-volatile

(iii) Solute should be non-electrolyte

37. What are the parts in assembly of Landsberger's apparatus?

Ans: The apparatus consists of four major parts.

(a) An inner tube with a hole in its side. This tube is graduated.

(b) A boiling flask which sends the solvent vapours into the graduated tube through a rosehead.

(c) An outer tube, which receives hot solvent vapours coming from the side hole of the inner tube.

(d) A thermometer which can read up to 0.01K.

38. Why ethylene glycol is used as an anti-freeze in car radiators?

Ans: Ethylene glycol is used as an antifreeze in the radiator of an automobile. It 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 raises the boiling point. During winter it protects a car by preventing the liquid in the radiator from freezing. In hot summer, the antifreeze solution also protects the radiator from boiling over.

39. Why the relative lowering of vapour pressure is independent of temperature?

Ans: The expression of relative lowering of vapour pressure is as follows:

$$\Delta p/p^{o} = x_2$$

In this expression temperature is not involved so it is independent of temperature.

40. Non-ideal solutions do not obey the Raoult's law. Why?

Ans: The molecules of components in non-ideal solutions have forces of attractions for each other. The values of vapour pressures of individual components are not proportional to their mole fractions as in Raoult's law.

41. Boiling points of solvents increase due to the presence of solutes. Why?

Ans: Solute particles hinder the escape of solvent particles so more energy is required by the solvent particles to leave the surface of solvent. That is why in the presence of solute boiling point increases.

42. Why Beckmann thermometer is used to note the depression of freezing point?

Ans: Beckmann thermometer can read up to 0.01 K. The elevation of boiling point and depression in freezing point are very small quantities so this small temperature change can be read by Beckmann thermometer.

43. Why the freezing points are depressed due to presence of solutes?

Ans: The lowering of vapour pressure compels the solutions to freeze at those temperatures which are below the freezing point of pure solvent. The reason is that the vapour pressure temperature curve meets the solid phase of pure solvent at lower temperature than the pure solvent.

44. Calculate the molarity of a solution containing 9g of glucose in 250 cm^3 ofsolution.

Ans:

18 g of glucose in 1000 mL of solution is 0.1 molar.

Calculation

1M solution of glucose contains 180 g of glucose in 1 L water

250 cm^3 of solution= 250/1000=0.25 dm^3

$$\text{Molarity (M)} = \text{Mass/Molar Mass} \times 1/\text{volume of soln. in } dm^3$$

$$= 9/180 \times 1/0.25$$

$$= 0.2 \text{ M}$$

$$= 2\times10^{-1}\text{M}$$

45. How molality is independent of temperature but molarity depends ontemperature?

Ans: In molal solutions the mass of the solvent and that of the solute are also fixed. The masses of the substances are not temperature dependent. In molar solutions we have the volumes of solutions. Volume of a liquid is temperature dependent. So, the molality is not influenced by temperature but molarity does change.

$$\textbf{Molality} = \frac{\textit{Moles of solute}}{\textit{Mass of solvent in Kg}}$$

$$\textbf{Molarity} = \frac{\textbf{Moles of solute}}{\textbf{Volume of solution in dm}^3}$$

46. One molal solution of glucose is dilute as compared to one molar solution of glucose. Justify it.

Ans: In one molal solution of glucose, 180 g of glucose is dissolved in 1000 g of water. In one molar solution of glucose, 180 g of glucose is added in water to make total volume of solution as

1000 cm^3. As 1000g (1 kg) of solvent is greater than 1000 mL of solvent so molar solution is concentrated and molal solution is dilute.

47. One molal solution of urea is dilute as compared to one molar solution ofurea. Justify it.

Ans: In one molal solution of urea, 60 g of urea is dissolved in 1000 g of water. In one molar solution of urea, 60 g of urea is added in water to make total volume of solution as 1000 cm^3. So the volume of water in molar solution is less than that in molal solution. Hence, molar solution is concentrated and molal solution is dilute.

48. Relative lowering of vapor pressure is independent of temperature. Justify it.

Ans: The relative lowering of vapour pressure and mole fraction of solute are related as:

$$\frac{\Delta P}{po} = x_2$$

Vapour pressure and lowering of vapour pressure depends upon temperature. So, when the temperature of a solution is increased both the factors $\triangle P$ and P^o increase in such a way that the ratio remains the same.

49. Justify that boiling point of solvents increase due to presence of non- volatile solutes.

Ans: The surface of the solution has molecules of solute as well. They do not allow the solvent to leave the surface as rapidly as in pure solvent. To boil the solutions, we have to increase the temperature of solutions in comparison to pure solvents. So the boiling points of solutions are higher than pure solvents.

50. Depression of freezing point is a colligative property. Justify it.

Ans: Depression of freezing point is a colligative property as colligative properties depend upon number of particles. Suppose there is 6g of urea, 18g of glucose and 34.2g of sucrose and they are dissolved separately in 1kg of water. This will produce 0.1 molal solution of each substance. In these three solutions, the vapour pressure of water will be lowered. The reason is that the molecules of a solute present upon the surface of a solution decrease the evaporating capability. The lowering of vapour pressure in all these solutions will be same at a given temperature as the number of particles of the solute in the solutions is equal. We have added 1/10th of Avogadro's number of particles. The lowering of vapour pressure depends upon the number of particles and not upon their molar mass and structures. The freezing points will be depressed for these solutions and the value of depression in these three cases is 0.186^{o} C.

51. Why NaCl and KNO_3 are used to lower the melting points of ice?

Ans: NaCl and KNO_3 are electrolytes and are sufficiently soluble in water. They double the number of particles after dissociation in water. In this way they can manage to decrease the freezing point of water to a greater extent as compared to a non-electrolyte.

52. Why is the vapor pressure of a solution lesser than vapor pressure of pure solvent?

Ans: The particles of the solute are distributed throughout the bulk of the solution and some of the particles of the solute are also present on the surface of the solution. The number of molecules of the solvent per unit area on the surface of the solution becomes less. Hence, the evaporating tendency of the solvent decreases and vapour pressure of solution becomes less.

53. Calculate the percentage by weight of NaCl if 2g of it is dissolved in 20g ofwater.

Ans:

$$\% \text{ by weight} = \text{Mass of Solute}/\text{Mass of Solution} \times 100$$

$$\% \text{ by weight} = 2/20 \times 100$$

$$= 10\%$$

54. What is meant by water of crystallization? Give an example.

Ans: The number of water molecules which combine with compounds as they are crystallized from aqueous solutions are called water of crystallization or water of hydration.

Examples

$(COOH)_2.2H_2O$

$BaCl_2.2H_2O$

$Na_2CO_3.10H_2O$

55. What are zeotropic and azeotropic mixtures?

Ans: **Zeotropic mixtures**

Such liquid mixtures which distil with a change in composition are called zeotropic mixtures.

Example

methyl alcohol-water solution.

Azeotropic mixtures

Azeotropic mixtures are those which boil at constant temperature and distil over without change in composition at any temperature like a pure chemical compound.

Example

ethanol-water mixture.

56. Differentiate between hydration and hydrolysis.

Ans:

Hydration

Hydration is the process in which water molecules surround and interact with solute ions or molecules.

Example

When a salt is added to water it is dissolved because of hydration process.

Hydrolysis

When a salt is dissolved in water, it dissociates into cations and anions. These ions may react with water and the resulting solution may be acidic, basic or neutral, depending upon the extent of hydrolysis.

Example

When NaCl is dissolved in water, the resulting solution is neutral because in solution the concentration of H^+ and OH^- ions is equal to 10^{-7} M.

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

Ans: The four major parts of Landsberger's apparatus are:

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

2. A boiling flask which sends the solvent vapours into the graduated tube through a rosehead.
3. An outer tube, which receives hot solvent vapours coming from the side hole of the inner tube.
4. A thermometer which can read up to 0.01K.

58. Why the solubility of glucose into water increases by increasing temperature?

Ans: The solubility of glucose into water increases by increasing temperature because the space between the water molecules increases due to increase in kinetic energy and more glucose molecules are accommodated in between the spaces.

59. Give two statements of Raoult's law.

Ans:

Statement 1

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

Relation

$$p \ \alpha \ x_1$$

$$p = p^o x_1 \text{ ------- } (1)$$

Where P^o is vapour pressure of pure solvent. P is the vapour pressure of solvent in solution or of pure solution and x_1 is the mole fraction of solvent.

Statement 2

The lowering of vapour pressure of a solvent is directly proportional to the mole fraction of solute.

Relation

$$\Delta p = p^o x_2$$

$$\Delta p / p^o = x_2$$

$\dfrac{\Delta p}{p^o}$ is called relative lowering of vapour pressure and it is more important than lowering of vapour pressure.

60. Aqueous solution of $CuSO_4$ is acidic in nature. Justify it.

Ans:

$$CuSO_4 + 2HOH \longrightarrow Cu(OH)_2 + 2H^+ + SO_4^{-2}$$

As sulphuric acid is a strong acid and copper hydroxide is a weak base so the solution is overall acidic in nature.

61. Aqueous solution of CH_3COONa is basic in nature.

Ans:

$$CH_3COONa + HOH \longrightarrow CH_3COOH + NaOH$$

As acetic acid is a weak acid and sodium hydroxide is a strong base so the solution is overall basic in nature.

62. Define and explain the following with one example in each case.

i. A homogeneous phase:

Definition:

Every sample of matter with uniform properties and fixed composition is called a phase.

Example:

Water at room temperature and normal pressure exists as a single liquid phase. Its all properties are uniform throughout this liquid phase.

ii. A concentrated solution:

Definition:

A solution which has relatively larger concentration of solute is called concentrated solution.

Example:

10 g $CuSO_4.5H_2O$ in 5 mL water

iii. A solution of solid in a solid:

Definition:

When solid solute is dissolved in solid solvent such solution is said to be solution of solid in solid.

Example:

Metal alloys like Brass, Bronze etc.

iv. Upper consulate temperature:

Definition:

The temperature at which two conjugate solutions merge into one another is called critical solution temperature or upper consulate temperature.

Example:

Upper consulate temperature of phenol water system is 65.9°C.

v. A non-ideal solution:

Definition:

Solutions which do not follow Raoult's law are called non-ideal solutions. They show deviations from Raoult's Law due to difference in their molecular structures i.e. size, shape and intermolecular forces.

Example:

Solution of 95.5 % Ethanol and 4.5 % water(B.P.=78.1ºC)

vi. Zeotropic solutions:

Definition:

The solutions which follow Raoult's law are called ideal solutions or Zeotropic mixtures

Example:

The solution of 50% ethanol and water

vii. Heat of hydration

Definition:

The heat energy released or absorbed when one mole ions are dissolved into water is called heat of hydration.

Example:

Heat of hydration of H^+ ions is -1075 kJ mol^{-1}

viii. Water of crystallization

Definition:

Those water molecules which combine with substances as they are crystallized from aqueous solutions are called water molecules of crystallization or water of hydration. Some familiar examples are as follows:

Example:

$(COOH)_2 . 2H_2O$ (Oxalic acid)

ix. Azeotropic solution

Definition:

Solution which does not follow Raoult's law is called non-ideal solution or azeotropic solution. It shows deviations from Raoult's law.

Example:

Solution of 95.5 % Ethanol and 4.5 % water (B.P.=78.1°C)

x. Conjugate solution:

Definition:

The solution of two partially miscible liquids is called conjugate solution.

Example:

Solution of phenol and water

63. The sum of mole fractions of all the components is always equal to unity for any solution. Justify.

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

$$x_A = \frac{n_A}{n_A+n_B} \qquad x_B = \frac{n_B}{n_A+n_B}$$

$$x_A + x_B = \frac{n_A}{n_A+n_B} + \frac{n_B}{n_A+n_B}$$

$$x_A + x_B = \frac{n_A+n_B}{n_A+n_B}$$

$$x_A + x_B = 1$$

Hence it is proved that sum of mole fractions for any solution is always unity.

64. 100g of 98% H_2SO_4 has a volume of 54.34 cm^3 of H_2SO_4. (Density =1.84g cm^{-3})?

Ans: Mass of 98% H_2SO_4 =100g

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

Volume of 98% H_2SO_4=?

Now using the formula:

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

Or Volume = mass / density

$$\text{Volume} = \frac{\text{mass}}{\text{density}}$$

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

$$= 54.34\ cm^3$$

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 gcm^{-3}.

65. Colligative properties are obeyed when the solute is non-electrolyte, and also when the solutions are dilute. Justify.

Ans: Yes, colligative properties are only obeyed by the solution when the solute is non-electrolyte. If it would be electrolyte then it will ionize in the solution and number of solute particles will be changed means increased and solution will not remain dilute.

When amount of solute is very high in solution the force of attraction between solute and solvent particles becomes very strong creating non-ideal solution so it should be dilute.

66. The solutions showing positive and negative deviations cannot be fractionally distilled at their specific compositions. Explain it.

Ans: Many solutions do not behave ideally. Such solutions are also called Azeotropic mixtures. They show positive or negative deviations from Raoult's Law due to differences in their molecular structures i.e. size, shape and intermolecular forces. Such solutions boil at constant temperature and distil over without change in composition at any temperature like a pure chemical compound. It means solute cannot be separated from solvent as both do not maintain their original boiling points in the solution. Solute and solvent start boiling at the same temperature.

***Examples**:*

i. Solution of 95.5% ethanol and 4.5 % water

ii. Solution of 20.24% HCl and 79.76% water

67. Explain the effect of temperature on phenol-water system.(You may consult how a phenol-water system works for answer)

Ans: At 25°C the upper layer is 5% solution of phenol in water and the lower layer is 30% water in phenol. Water acts as a solute in the lower layer while phenol is a solute in the upper layer. When the temperature of water-phenol system is increased, the compositions of both layers change. Water starts travelling from upper solution to lower solution and phenol from lower to upper layer. When temperature of this system approaches 65.9°C, a single homogeneous mixture (solution) will be obtained. This homogeneous mixture contains 34% (25.75 ml) phenol and 66% (50ml) water. The temperature of 65.9°C at which two conjugate solutions merge into one another is called critical solution temperature or upper consulate temperature.

68. What is the physical significance of Kb and Kf of solvents? OR Define ebullioscopic constant and cryoscopic constant with an example.

Ans: Physical significance of K_b

The elevation in boiling point of one molal solution is called molal boiling point constant or ebullioscopic constant (K_b).

The unit of K_b is °C $Kg.mol^{-1}$

Value of K_b indicates strength of attractive forces which solvent particles can develop with solute particles.

Physical significance of K_f

The depression in freezing point of one molal solution is called molal freezing point constant or cryoscopic constant (K_f). Its significance and units are also the same as that of K_b.

69. Boiling points of the solvents increase due to the presence of solutes. How?

Ans: A substance boils at that temperature when its vapour pressure equalizes external pressure. The vapour pressure of solvent decreases due to the addition of non-volatile solute. Therefore, we have to supply more (high) temperature in order to equalize the vapour pressure of solvent to external pressure in order to boil it. In this way boiling point of solution will be greater than boiling point of solvent.

70. In summer the antifreeze solutions protect the liquid of the radiator from boiling over. Justify.

Ans: By adding some antifreeze into water for example ethylene glycol, the boiling point of water shows elevation. This mixture is used in the radiators of automobiles. In hot summer, antifreeze protects the water of radiator from boiling at 100 °C. In winter ethylene glycol protects the freezing of the radiator water at 0 °C.

71. Freezing points are depressed due to the presence of solutes. Justify.

Ans: Presence of non-volatile and non-electrolyte solutes decreases freezing point of solvent because forces of attraction between solvent molecules become weak and vapour pressure of solution is reduced.

Example:

The freezing point of pure water is 0ºC and that of solution containing 1 mole solute is -1.86 ºC.

72. The boiling point of one molal urea solution is 100.52ºC but the boiling point of two molal urea solution is less than 101.04ºC.

Ans: Two molal urea solution contains twice the number of solute particle ($2\times6.02\times10^{23}$) as compared to one molal urea solution. If a solution has large number of solute particles then some of its particles will not be associated with solvent molecules and hence will not contribute in decrease of vapour pressure of solvent. Therefore, the lowering of vapour pressure will not be in accordance to Raoult's law. So the boiling point of two molal urea solution is lesser than 101.14 ºC which is expected from two molal solution.

73. The total volume of the solution by mixing 100 cm³ of water with 100 cm³ of alcohol may not be equal to 200 cm³. Justify it.

Ans: If the solution formed by mixing 100 cm^3 of water with 100 cm^3 of alcohol is ideal the total volume will be 200 cm^3 otherwise not. As alcohol makes hydrogen bonding with water it is likely to be less than 200 cm^3.

74. 100 g of 98 % H_2SO_4 has a volume of 54.34 cm^3 of H_2SO_4.

Ans:

Mass of 98% H_2SO_4 =100g
Density of 98% H_2SO_4=1.84 g cm^{-3}
Volume of 98% H_2SO_4=?

Now using the formula:

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

Or Volume = mass / density

$$\text{Volume} = \frac{\text{mass}}{\text{density}}$$

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

$$= 54.34\ \text{cm}^{-3}$$

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 gcm^{-3}.

75. Non-ideal solutions do not obey the Raoult's law. Justify.

Ans: Non-ideal solutions have strong attractive forces among the particles means solute and solvent molecules. As a result the vapor pressures of both are changed from the expected values. Such solutions do not obey the Raoult's law.

76. The concentration in terms of molality is independent of temperature but molarity depends upon temperature.

Ans: In case of molality the concentration of solvent is expressed in terms of mass. The mass of a substance is not affected by the change in temperature. Hence, molality is independent of temperature.

$$\textbf{Molality} = \frac{\textit{Moles of solute}}{\textit{Mass of solvent in Kg}}$$

In case of molarity the concentration of solution is expressed in terms of volume which changes with the change of temperature. Hence, molarity is affected by temperature.

$$\textbf{Molarity} = \frac{\textit{Moles of solute}}{\textit{Volume of solution in dm}^3}$$

Moreover, molal solution is dilute as compared to molar so change in temperature does not affect it.