UNIT-9
SOLUTIONS

I. Choose the correct answer.

1. A solution is a _____ mixture.
   a. homogeneous b. heterogeneous
   c. homogeneous and heterogeneous d. non homogeneous

2. The number of components in a binary solution is _____
   a. 2 b. 3 c. 4 d. 5

3. Which of the following is the universal solvent?
   a. Acetone b. Benzene
   c. Water d. Alcohol

4. A solution in which no more solute can be dissolved in a definite amount of solvent at a given temperature is called _____
   a. Saturated solution b. Unsaturated solution
   c. Super saturated solution d. Dilute solution

5. Identify the non aqueous solution.
   a. sodium chloride in water b. glucose in water
   c. copper sulphate in water **d. sulphur in carbon-di-sulphide**

6. When pressure is increased at constant temperature the solubility of gases in liquid _____.
   a. No change **b. increases** c. decreases d. no reaction

7. Solubility of NaCl in 100 ml water is 36 g. If 25 g of salt is dissolved in 100 ml of water how much more salt is required for saturation _____.
   a. 12g **b. 11g** c. 16g d. 20g

8. A 25% alcohol solution means
   a. 25 ml alcohol in 100 ml of water b. 25 ml alcohol in 25 ml of water
   c. 25 ml alcohol in 75 ml of water d. 75 ml alcohol in 25 ml of water

9. Deliquescence is due to _____
   a. Strong affinity to water b. Less affinity to water
   c. Strong hatred to water d. Inertness to water

10. Which of the following is hygroscopic in nature?
    a. ferric chloride b. copper sulphate penta hydrate
    c. silica gel d. none of the above

II. Fill in the blanks

1. The component present in lesser amount, in a solution is called **solute**

2. Example for liquid in solid type solution is **mercury with sodium** (amalgam)

3. Solubility is the amount of solute dissolved in **100g** of solvent.

4. Polar compounds are soluble in **polar** solvents

5. Volume percentage decreases with increases in temperature because **of expansion of liquids.**

III. Match the following

1.	Blue vitriol	$CaSO_4.2H_2O$	**(2)**
2	Gypsum	CaO	**(4)**
3	Deliquescence	$CuSO_4$.	**(1)**
4	Hygroscopic	NaOH	**(3)**

IV. True or False: (If false give the correct statement)

1. Solutions which contain **three** components are called binary solution. **False**

Solutions which contain **two** components are called binary solution.

2. In a solution the component which is present in lesser amount is called **solvent. False**

In a solution the component which is present in lesser amount is called **solute.**

3. Sodium chloride dissolved in water forms a **non-aqueous** solution. **False**

Sodium chloride dissolved in water forms an **aqueous** solution

4. The molecular formula of green vitriol is **$MgSO_4.7H_2O$ False**

The molecular formula of green vitriol is **$FeSO_4.7H_2O$**

5. When Silica gel is kept open, it absorbs moisture from the air, because it is hygroscopic in nature **True**

V. Short answer

1. Define the term: Solution

A solution is a homogeneous mixture of two or more substances.

Solute + Solvent ⟶ Solution

2. What is meant by binary solution?

solutions which are made of one solute and one solvent (two components) are called binary solutions. e.g. On adding copper sulphate crystals to water, it dissolves in water forming a solution of copper sulphate

3. Give an example each i) gas in liquid ii) solid in liquid iii) solid in solid iv) gas in gas

	Solute	**Solvent**	**Example**
i	Gas	Liquid	**carbon-di-oxide dissolved in water (Soda water)**
ii	Solid	Liquid	**Sodium chloride dissolved in water**
iii	Solid	Solid	**Copper dissolved in gold (Alloys)**
iv	gas	gas	**Mixture of Helium-Oxygen gases,**

4. What is aqueous and non-aqueous solution? Give an example.

Aqueous solution:

The solution in which water acts as a solvent is called aqueous solution. In general, ionic compounds are soluble in water and form aqueous solutions more readily than covalent compounds. E.g. Common salt in water, Sugar in water, Copper sulphate in water etc.

Non – Aqueous solution:

The solution in which any liquid, other than water, acts as a solvent is called non-aqueous solution. Examples for non-aqueous solutions: Sulphur dissolved in carbon disulphide, Iodine dissolved in carbon tetrachloride.

5. Define Volume percentage

Volume percentage is defined as the percentage by volume of solute (in ml) present in the given volume of the solution.

$$Volume\ Percentage = \frac{Volume\ of\ the\ Solute}{Volume\ of\ the\ Solution}\ X\ 100$$

$$Volume\ Percentage = \frac{Volume\ of\ the\ Solute}{Volume\ of\ the\ Solute + Volume\ of\ the\ Solvent}\ X\ 100$$

6. The aquatic animals live more in cold region Why?

Aquatic animals live more in cold regions because, <u>more amount of dissolved oxygen</u> is present in the water of cold regions. This shows that the solubility of oxygen in water is more at low temperatures.

7. Define Hydrated salt.

When ionic substances are dissolved in water to make their saturated aqueous solution, their ions attract water molecules which then attached chemically in certain ratio. This process is called hydration. These ionic substances crystallize out from their saturated aqueous solution with a definite number of molecules of water. The number of water molecules found in the crystalline substance is called water of crystallization. Such salts are called hydrated salts.

Example **Blue Vitriol ($CuSO_4.5H_2O$) and Epsom Salt ($MgSO_4.7H_2O$)**

8. A hot saturated solution of copper sulphate forms crystals as it cools. Why?

As the temperature decreases, solubility decreases; because the solvent can no longer hold all the solute molecules. Solute molecules begin to leave the solution and form solid crystals.

9. Classify the following substances into deliquescent, hygroscopic.
   i. Conc. Sulphuric acid
   ii. Copper sulphate penta hydrate
   iii. Silica gel
   iv. Calcium chloride

v. Gypsum salt

Answers:

i. Conc. Sulphuric acid - **hygroscopic**.,
ii. Copper sulphate penta hydrate - **deliquescent**,
iii. Silica gel - **hygroscopic.**,
iv. Calcium chloride - **hygroscopic.**,
v. Gypsum salt - **deliquescent**

VI. Long answer:

1. Write notes on i) saturated solution ii) unsaturated solution

Saturated solution: A solution in which no more solute can be dissolved in a definite amount of the solvent at a given temperature is called saturated solution. e.g. 36 g of sodium chloride in 100 g of water at 25°C forms saturated solution.
Further addition of sodium chloride, leave it undissolved.

Unsaturated solution: Unsaturated solution is one that contains less solute than that of the saturated solution at a given temperature. e.g. 10 g or 20 g or 30 g of Sodium chloride in 100 g of water at 25°C forms an unsaturated solution.

2. Write notes on various factors affecting solubility.

(i) Nature of the solute and solvent

The nature of the solute and solvent plays an important role in solubility. Although water dissolves an enormous variety of substances, both ionic and covalent, it does not dissolve everything. The phrase that scientists often use when predicting solubility is "like dissolves like." This expression means that dissolving occurs when similarities exist between the solvent and the solute.

- **For example: Common salt is a polar compound and dissolves readily in polar solvent like water.**
- **Non-polar compounds are soluble in non-polar solvents. For example, Fat dissolved in ether.**
- **But non-polar compounds, do not dissolve in polar solvents; polar compounds do not dissolve in non-polar solvents.**

(ii) Effect of Temperature

- **Solubility of Solids in Liquid:**

Generally, solubility of a solid solute in a liquid solvent increases with increase in temperature. For example, a greater amount of sugar will dissolve in warm water than in cold water.

- **In endothermic process, solubility increases with increase in temperature.**
- **In exothermic process, solubility decreases with increase in temperature.**

- **Solubility of Gases in liquid**
  - **It is bubbling when water is boiled. Solubility of gases in liquid decrease with increase in temperature. Generally, water contains dissolved oxygen.**

When water is boiled, the solubility of oxygen in water decreases, so oxygen escapes in the form of bubbles.

- **Aquatic animals live more in cold regions because, more amount of dissolved oxygen is present in the water of cold regions. This shows that the solubility of oxygen in water is more at low temperatures.**

(iii) <u>Effect of Pressure</u>

- **Effect of pressure is observed only in the case of solubility of a gas in a liquid. When the pressure is increased, the solubility of a gas in liquid increases.**
- **The common examples for solubility of gases in liquids are carbonated beverages, i.e. soft drinks, household cleaners containing aqueous solution of ammonia, formalin-aqueous solution of formaldehyde, etc.**

3 a) What happens when $MgSO_4.7H_2O$ is heated? Write the appropriate equation

Magnesium sulphate heptahydrate $MgSO_4.7H_2O$ (Epsom salt):

Its water of crystallization is 7. When magnesium sulphate heptahydrate crystals are gently heated, it loses seven water molecules, and becomes anhydrous magnesium sulphate.

$$\underset{\text{(Magnesium sulphate heptahydrate)}}{MgSO_4 \cdot 7H_2O} \overset{\text{Heating}}{\underset{\text{Cooling}}{\rightleftharpoons}} \underset{\text{(Anhydrous Magnesium sulphate)}}{MgSO_4 + 7H_2O}$$

3 b) Define solubility

Solubility is defined as the number of grams of a solute that can be dissolved in 100 g of a solvent to form its saturated solution at a given temperature and pressure. For example, 36 g of sodium chloride need to be dissolved in 100 g of water to form its saturated solution at 25°C. **Thus, the solubility of NaCl in water is 36 g at 25°C.**

$$\textbf{Solubility} = \frac{\boldsymbol{Mass\ of\ the\ solute}}{\boldsymbol{Mass\ of\ the\ solvent}}\ \boldsymbol{X}\ \mathbf{100}$$

4. In what way hygroscopic substances differ from deliquescent substances.

Hygroscopic substances	Deliquescence substances
When exposed to the atmosphere at ordinary temperature, they absorb moisture and do not dissolve.	When exposed to the atmospheric air at ordinary temperature, they absorb moisture and dissolve.
Hygroscopic substances do not change its physical state on exposure to air.	Deliquescent substances change its physical state on exposure to air.
Hygroscopic substances may be amorphous solids or liquids.	Deliquescent substances are crystalline solids.

5. A solution is prepared by dissolving 45 g of sugar in 180 g of water. Calculate the mass percentage of solute.

$$\boldsymbol{Mass\ Percentage\ of\ solute} = \frac{\boldsymbol{Mass\ of\ the\ Solute}}{\boldsymbol{Mass\ of\ the\ Solute + Mass\ of\ the\ Solvent}}\ \boldsymbol{X}\ \mathbf{100}$$

$$= \frac{45\ X\ 100}{45 + 180} = \frac{4500}{225} = 20\%$$

6. 3.5 litres of ethanol is present in 15 litres of aqueous solution of ethanol. Calculate volume percent of ethanol solution.

$$\boldsymbol{Volume\ Percentage} = \frac{\boldsymbol{Volume\ of\ the\ Solute}}{\boldsymbol{Volume\ of\ the\ Solution}}\ \boldsymbol{X\ 100}$$

$$= \frac{3.5\ X\ 100}{15} = \frac{350}{15} = 23.3\%$$

VII. HOT

1. Vinu dissolves 50 g of sugar in 250 ml of hot water, Sarath dissolves 50 g of same sugar in 250 ml of cold water. Who will get faster dissolution of sugar? and Why?

   Vinu will get faster dissolution of sugar. Because solubility increases with increase in temperature.

2 'A' is a blue coloured crystaline salt. On heating it loses blue colour and to give 'B'. When water is added, 'B' gives back to 'A'. Identify A and B, write the equation.

A is Blue Vitriol $CuSO_4.5H_2O$

B is anhydrous copper Sulphate. $CuSO_4$.

$$\underset{\text{(Copper sulphate pentahydrate)}}{CuSO_4 \cdot 5H_2O} \underset{\text{Cooling}}{\overset{\text{Heating}}{\rightleftharpoons}} \underset{\text{(Anhydrous copper sulphate)}}{CuSO_4 + 5H_2O}$$

Blue colour — colourless

3 Will the cool drinks give more fizz at top of the hills or at the foot? Explain

Air Pressure is lower at the top of the hills than at its foot. Hence, cool drinks fizz more at the top of the hills as the difference between air pressure and pressure of the gas in cool drinks is more.

Book Inside problems

I. <u>Problems based on solubility</u>

1) 1.5 g of solute is dissolved in 15 g of water to form a saturated solution at 298K. Find out the solubility of the solute at the temperature.

   Mass of the solute = 1.5 g

   Mass of the solvent = 15 g

$$\textbf{Solubility} = \frac{\boldsymbol{Mass\ of\ the\ solute}}{\boldsymbol{Mass\ of\ the\ solvent}}\ \boldsymbol{X\ 100}$$

$$= \frac{\boldsymbol{1.5\ X\ 100}}{\boldsymbol{15}} = \boldsymbol{10g}$$

2. Find the mass of potassium chloride would be needed to form a saturated solution in 60 g of water at 303 K? Given that solubility of the KCl is 37/100 g at this temperature.

Mass of the solute = ?

Mass of the solvent = 60 g

Solubility = 37g

$$\textbf{Solubility} = \frac{\boldsymbol{Mass\ of\ the\ solute}}{\boldsymbol{Mass\ of\ the\ solvent}}\ \boldsymbol{X}\ \mathbf{100}$$

$$\boldsymbol{Mass\ of\ the\ solute} = \frac{\textbf{Solubility} \quad \textbf{X} \quad \boldsymbol{Mass\ of\ the\ solvent}}{\mathbf{100}}$$

$$= \frac{\mathbf{37}\ \boldsymbol{X}\ \mathbf{60}}{\mathbf{100}} = \mathbf{22.2}\boldsymbol{g}$$

3) What is the mass of sodium chloride that would be needed to form a saturated solution in 50 g of water at 30°C. Solubility of sodium chloride is 36 g at 30°C?

Mass of the solute = ?

Mass of the solvent = 50 g

Solubility = 36g

$$\textbf{Solubility} = \frac{\boldsymbol{Mass\ of\ the\ solute}}{\boldsymbol{Mass\ of\ the\ solvent}}\ \boldsymbol{X}\ \mathbf{100}$$

$$\boldsymbol{Mass\ of\ the\ solute} = \frac{\textbf{Solubility} \quad \textbf{X} \quad \boldsymbol{Mass\ of\ the\ solvent}}{\mathbf{100}}$$

$$= \frac{\mathbf{36}\ \boldsymbol{X}\ \mathbf{50}}{\mathbf{100}} = \mathbf{18}\boldsymbol{g}$$

4) The Solubility of sodium nitrate at 50°C and 30°C is 114 g and 96 g respectively. Find the amount of salt that will be thrown out when a saturated solution of sodium nitrate containing 50 g of water is cooled from 50°C to 30°C?

- Mass of the solute = ?

  Mass of the solvent = 50 g

  Solubility = 114g

$$\textbf{Solubility} = \frac{\boldsymbol{Mass\ of\ the\ solute}}{\boldsymbol{Mass\ of\ the\ solvent}}\ \boldsymbol{X}\ \mathbf{100}$$

$$\boldsymbol{Mass\ of\ the\ solute\ at}\ \mathbf{50}^{\boldsymbol{o}}\ \boldsymbol{C} = \frac{\textbf{Solubility} \quad \textbf{X} \quad \boldsymbol{Mass\ of\ the\ solvent}}{\mathbf{100}}$$

$$= \frac{\mathbf{114}\ \boldsymbol{X}\ \mathbf{50}}{\mathbf{100}} = \mathbf{57}\boldsymbol{g}\ \ldots\ldots\ldots\ldots\ldots\ldots(\mathbf{1})$$

- Mass of the solute = ?

  Mass of the solvent = 50 g

  Solubility = 96g

$$\textbf{Solubility} = \frac{\boldsymbol{Mass\ of\ the\ solute}}{\boldsymbol{Mass\ of\ the\ solvent}}\ \boldsymbol{X\ 100}$$

$$\boldsymbol{Mass\ of\ the\ solute\ at\ 30^oC} = \frac{\textbf{Solubility} \quad \textbf{X} \quad \boldsymbol{Mass\ of\ the\ solvent}}{\textbf{100}}$$

$$= \frac{\boldsymbol{96\ X\ 50}}{\textbf{100}} = \boldsymbol{48g} \ \ldots\ldots\ldots\ldots\ldots (\textbf{2})$$

From equation (1) and (2), **the mass of solute** thrown when 50g of water (solvent) is cooled from 50^o C to 30^o C = **57g – 48 g = 9g**

II. Problem based on mass percentage

1) A solution was prepared by dissolving 25 g of sugar in 100 g of water. Calculate the mass percentage of solute.

Mass of the solute = 25 g

Mass of the solvent = 100 g

$$\boldsymbol{Mass\ Percentage\ of\ solute} = \frac{\boldsymbol{Mass\ of\ the\ Solute}}{\boldsymbol{Mass\ of\ the\ Solute + Mass\ of\ the\ Solvent}}\ \boldsymbol{X\ 100}$$

$$= \frac{25\ X\ 100}{25 + 100} = \frac{2500}{125} = 20\%$$

2. 16 grams of NaOH is dissolved in 100 grams of water at 25°C to form a saturated solution. Find the mass percentage of solute and solvent.

Mass of the solute (NaOH) = 16 g

Mass of the solvent H_2O = 100 g

- Mass percentage of Solute

$$\boldsymbol{Mass\ Percentage\ of\ solute} = \frac{\boldsymbol{Mass\ of\ the\ Solute}}{\boldsymbol{Mass\ of\ the\ Solute + Mass\ of\ the\ Solvent}}\ \boldsymbol{X\ 100}$$

$$= \frac{16\ X\ 100}{16 + 100} = \frac{1600}{116} = 13.79\%$$

- Mass percentage of Solvent

$$Mass\ percentage\ of\ Solvent$$
$$= 100 - Mass\ percentage\ of\ solute$$
$$= 100 - 13.79 = 86.21\%$$

3. Find the amount of urea which is to be dissolved in water to get 500 g of 10% w/w aqueous solution?

$$\boldsymbol{Mass\ Percentage\ W/W} = \frac{\boldsymbol{Mass\ of\ the\ Solute}}{\boldsymbol{Mass\ of\ the\ Solution}}\ \boldsymbol{X\ 100}$$

$$\boldsymbol{Mass\ of\ the\ solute\ (urea)} = \frac{\boldsymbol{Mass\ percentage\ X\ Mass\ of\ the\ solution}}{\textbf{100}}$$

$$= \frac{10\ X\ 500}{100} = 50g$$

III. Problem based on Volume – volume percentage.

1. A solution is made from 35 ml of Methanol and 65 ml of water. Calculate the volume percentage.

   Volume of the ethanol = 35 ml

   Volume of the water = 65 ml

$$\boldsymbol{Volume\ Percentage} = \frac{\boldsymbol{Volume\ of\ the\ Solute}}{\boldsymbol{Volume\ of\ the\ Solute + Volume\ of\ the\ Solvent}}\ \boldsymbol{X\ 100}$$

$$= \frac{35\ X\ 100}{35 + 65} = \frac{3500}{100} = 35\%$$

2. Calculate the volume of ethanol in 200 ml solution of 20% v/v aqueous solution of ethanol.

   Volume of aqueous solution = 200 ml

   Volume percentage = 20%

$$\boldsymbol{Volume\ Percentage} = \frac{\boldsymbol{Volume\ of\ the\ Solute}}{\boldsymbol{Volume\ of\ the\ Solution}}\ \boldsymbol{X\ 100}$$

$$\boldsymbol{Volume\ of\ the\ Solute} = \frac{\boldsymbol{Volume\ Percentage\ X\ Volume\ of\ the\ Solution}}{\boldsymbol{100}}$$

$$= \frac{\boldsymbol{20\ X\ 200}}{\boldsymbol{100}} = \boldsymbol{40ml}$$