UNIT

9

Solutions

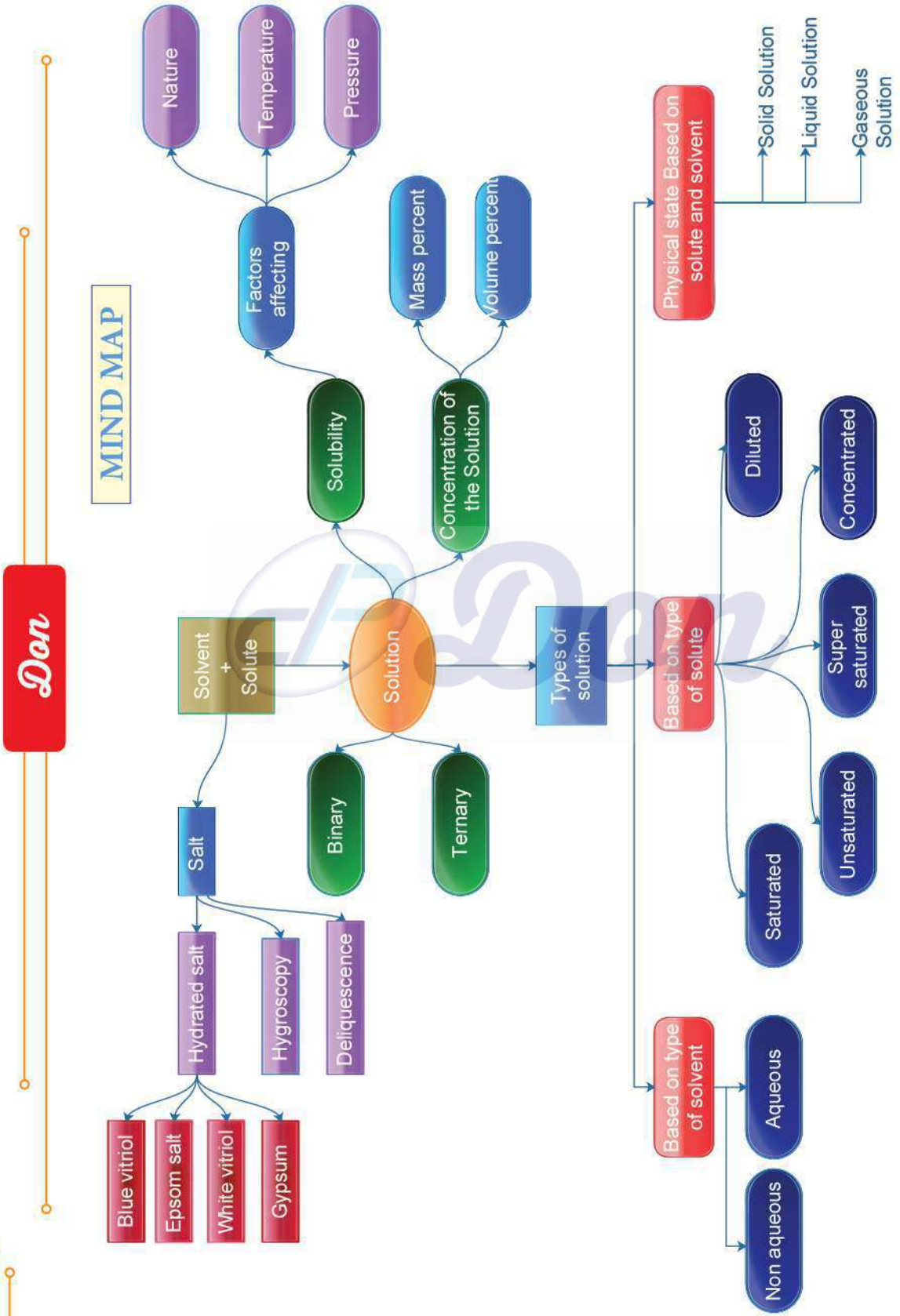
POINTS TO REMEMBER

- Polar compounds are soluble in polar solvents.
- Non-polar compounds are soluble in non-polar solvents.
- In endothermic process, solubility of solid solute increases with increase in temperature.
- In exothermic process, solubility of solid solute decreases with increase in temperature.
- Solution : Homogeneous mixture of two or more substances
- Solute : Present lesser amount in a solution
- Solvent : Present larger amount in a solution.
- Water : " Universal solvent"
- Aqueous solution : Water acts as a solvent
- Non – aqueous solution : Other than water as a solvent
- Saturated solution : Solution in which no more solute can be dissolved in a definite amount of solvent.
- Unsaturated solution : Solution contains less solute than that of the saturated solution
- Super saturated solution : Solution that contains more solute than the saturated solution
- Factors affecting solubility : Nature of solute and solvent, temperature, pressure.
- Concentration : The quantity of solute in a solution
- Hydrated salts : Blue vitriol, Epsom salt, Green vitriol.
- $CuSO_4.5H_2O$: Copper Sulphate pentahydrate (Blue vitriol)
- $MgSO_4.7H_2O$: Magnesium sulphate hepta hydrate
- Hygroscopy : Substance exposed to the atmosphere air at ordinary temperature absorb moisture without changing their physical state.
- Hygroscopic substances : Quick lime, Silica gel, Phosphorous pentoxide.
- Deliquescent substances : Calcium chloride, caustic soda, Ferric chloride

Formulae

Solubility	$\frac{\text{mass of the solute}}{\text{mass of the solvent}} \times 100$
Mass Percentage	$\frac{\text{mass of the solute}}{\text{mass of the solution}} \times 100$
Volume Percentage	$\frac{\text{volume of the solute}}{\text{volume of the solute + volume of solvent}} \times 100$

MIND MAP



Textbook Evaluation

I. Choose the most suitable answer from the given four alternatives and write the option code and corresponding 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

Ans:

1.	a)	Homogeneous	6.	b)	Increases
2.	a)	2	7.	b)	11 g
3.	c)	Water	8.	c)	25 ml alcohol in 75 ml of water
4.	a)	Saturated solution	9.	a)	Strong affinity to water
5.	d)	Sulphur in carbon di sulphide	10.	c)	Silica gel

II. Fill in the blanks:

1. The component present in lesser amount, in a solution is called _____
2. Example for liquid in solid type of solution is _____ ★★★
3. Solubility is the amount of solute dissolved in _____ g of solvent.
4. Polar compounds are soluble in _____ solvents
5. Volume percentage decreases with increases in temperature because _____ ★★

Ans:

1.	Solute	4.	Polar
2.	Amalgam (or) mercury with sodium	5.	of expansion of liquid
3.	100		

III. Match the following:

1.	1. Blue vitriol	– a) $CaSO_4.2H_2O$	(c)
	2. Gypsum	– b) CaO	(a)
	3. Deliquescence	– c) $CuSO_4.5H_2O$	(d)
	4. Hygroscopic	– d) NaOH	(b)

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.

   (or)

   In a solution the component which is present in more amount is called solvent.

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 questions:

1. **Define the term: Solution.** ★★★

   - A solution is a **homogeneous mixture** of two or more substance.
     E.g: Sea water.
   - In a solution, the component present in **lesser** amount by weight is called a **solute**.
   - The component present in a **larger** amount by weightis called a **solvent**.

2. What is meant by binary solution?

- A solution must at least be consisting of **two components** a solute and a solvent.
- Such solution which are made of **one solute** and **one solvent** (two components) are called binary solution.
- **E.g:** Addition of copper sulphate crystals to water.

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

i) gas in liquid – CO_2 dissolved in water
ii) solid in liquid – NaCl dissolved in water
iii) solid in solid – Copper dissolved in Gold
iv) gas in 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.
- **Example:** Salt in **water**

Non-aqueous solution:

- The solution in which **any liquid** other than water acts as a solvent is called non-aqueous solution.
- **Example:** Sulphur dissolved in carbon di sulphide.

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** $= \frac{\text{volume of the solute}}{\text{volume of the solute} + \text{volume of the solvent}} \times 100$

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

- Aquatic animals live more in cold regions.
- 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 pressure.

7. Define Hydrated salt. ✶✶✶

- 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 substance is called **water of crystallization.**
- Such salts are called **hydrated salts.**
- E.g: Blue vitriol - $CuSO_2.5H_2O$

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

- The number of water molecule in blue vitriol is **five**.
- The hot saturated solution of copper sulphate has **no water molecule**.
- When cooled the hot saturated solutions **gain five molecules** of water and it will **turn to crystal.**

9. Classify the following substances into deliquescent, hygroscopic. Conc. Sulphuric acid, Copper sulphate pentahydrate, Silica gel, Calcium chloride, and Gypsum salt.

Deliquescent	Hygroscopic
Copper sulphate pentahydrate, Calcium chloride, Gypsum salt.	Conc. Sulphuric acid, Silica gel.

VI. Long answer questions:

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

i. 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, leaves it **undissolved**.

ii. 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. ★★★

There are three main factors which govern the solubility of a solute. They are:

- Nature of the solute and solvent
- Temperature
- Pressure

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.

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:

- 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.

Effect of Pressure:

- 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.
b) Define solubility.

a) $MgSO_4.7H_2O$ heating process:

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

$$\underset{\text{(magnesium sulphate hepta hydrate)}}{MgSO_4.7H_2O} \underset{\text{Cooling}}{\overset{\text{Heating}}{\rightleftharpoons}} \underset{\text{(Anhydrous Magnesium sulphate)}}{MgSO_4 + 7H_2O}$$

- If you add few drops of water or allow it to cool, the colourless anhydrous salt again turns back into hydrated salt.

b) 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.

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.

Formula used:

$$\text{Mass percentage} = \frac{\text{mass of solute}}{\text{mass of solute} + \text{mass of solvent}} \times 100$$

Given, mass of solute = 45 g

mass of solvent = 180 g

Mass of percentage = ?

$$\text{Mass percentage} = \frac{\text{mass of solute}}{\text{mass of solute} + \text{mass of solvent}} \times 100$$

$$= \frac{45}{45+180} \times 100 = \frac{4500}{225}$$

Mass percentage = 20%

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

Formula used:

$$\text{Volume percentage} = \frac{\text{volume of the solute}}{\text{volume of the solution}} \times 100$$

Given, Volume of ethanol = 3.5 lit

Volume of aqueous ethanol solution = 1.5 lit

Volume percent ethanol solution = ?

$$\text{Volume percentage} = \frac{\text{volume of the solute}}{\text{volume of the solution}} \times 100$$

$$= \frac{3.5}{15} \times 100 = \frac{350}{15}$$

Volume percentage = 23.33 %

VII. Higher Order Thinking Skill (HOTS)

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.
- Temperature is one of the factors.
- It will affect the solubility of a solute in a liquid.
- Solvent increases with increase in temperature.

2. 'A' is a blue coloured crystalline 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 copper sulphate pentahydrate ($CuSO_4.5H_2O$)
- 'B' is Anhydrous copper sulphate ($CuSO_4$)

$$CuSO_4.5H_2O \underset{\text{Cooling}}{\overset{\text{Heating}}{\rightleftharpoons}} CuSO_4 + 5H_2O$$

(Copper sulphate Penta hydrate) (Anhydrous copper sulphate)

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

- Cool drinks give more fizz at the foot of mountain because the atmospheric pressure is less at the top of the mountain.
- So the pressure affects the fizz of the cool drink.

Additional Questions

I. Choose the most suitable answer from the given four alternatives and write the option code and corresponding answer:

1. _____ is the human activity involved in the formation of solution with water.
   a) Dancing b) Fighting c) Cleaning d) Laughing
2. The _____ is a solvent.
   a) Aerated drinks b) Fruit juice c) Tea d) Water
3. In a solution the component which is present in lesser amount is called _____. ★
   a) Solute b) Solvent c) Mixture d) Solution
4. The process of uniform distribution of solute with solvent is called _____.
   a) binary solution b) ternary solution
   c) dissolution d) colloidal solution
5. Cloud is the example of _____ binary solution.
   a) Gas - Gas b) Liquid – Gas c) Gas – Liquid d) Liquid – liquid
6. ____ is a solid – liquid binary solution.
   a) Aqueous solution of ethanol b) Soda water
   c) Salt water d) Water vapour
7. 40 g of sodium chloride in 100 g of water at 25°C forms _____ solution. ★
   a) Saturated b) Unsaturated c) Supersaturated d) Ternary
8. More amount of dissolved _____ is present in the water of cold regions.
   a) oxygen b) carbon dioxide c) sulphur d) chlorine
9. Green vitriol has _____ water molecules in it.
   a) Two b) Five c) Seven d) Three
10. Among the following _____ is a deliquescent substance.
    a) Quick lime b) Caustic soda c) Silica gel d) Con. Sulphuric acid

Ans:

1.	c)	Cleaning	6.	c)	Salt water
2.	d)	Water	7.	c)	Super saturated
3.	a)	Solute	8.	a)	Oxygen
4.	c)	Dissolution	9.	c)	Seven
5.	b)	Liquid – Gas	10.	b)	Caustic soda

II. Fill in the blanks:

1. One of the naturally existing solutions is _____ water.
2. The component which is present in larger amount is called _____ ★
3. The ternary solution has _____ components.
4. _____ is the mixture of gases in gas – gas type of binary solution.

5. _____ is a non-aqueous solution.
6. Non polar compounds are soluble in _____ solvents.
7. In _____ process solubility increases with increase in temperature.
8. The quantity of the solute in a solution is termed as _____.
9. The IUPAC name of white vitriol is _____.
10. The common name of magnesium sulphate heptahydrate is ___
11. ____ is the best example of hygroscopy.
12. ____ substances are crystalline solids.

Ans:

1.	Sea	7.	Endothermic
2.	Solvent	8.	Concentration
3.	Three	9.	Zinc sulphate heptahydrate
4.	Helium – oxygen	10.	Epsom salt
5.	Iodine dissolved in carbon di sulphide	11.	P_2O_5
6.	Non – polar	12.	Deliquescent

III. Match the following:

1.
1) Liquid solid	–	a) Soda water	(c)
2) Liquid liquid	–	b) Cloud	(e)
3) Gas liquid	–	c) Amalgam	(a)
4) Liquid Gas	–	d) Mixture of Helium-oxygen gas	(b)
5) Gas Gas	–	e) Ethyl alcohol dissolved in water	(d)

2.
1) Binary solution	–	a) Three components	(c)
2) Ternary solution	–	b) Sulphur dissolved in carbon di sulphide	(a)
3) Aqueous solution	–	c) 2 Components	(d)
4) Non aqueous solution	–	d) Common salt in water	(b)

3.
1) Calcium carbonate	–	a) 48 grams	(d)
2) Sodium chloride	–	b) 80 grams	(c)
3) Ammonia	–	c) 36 grams	(a)
4) Glucose	–	d) 0.0013 grams	(e)
5) Sodium hydroxide	–	e) 91 grams	(b)

4.
1) Copper sulphate pentahydrate	–	a) $FeSO_4.7H_2O$	(c)
2) Magnesium sulphate heptahydrate	–	b) $ZnSO_4.7H_2O$	(e)
3) Calcium sulphate dihydrate	–	c) $CuSO_4.5H_2O$	(d)
4) Iron (II) sulphate heptahydrate	–	d) $CaSO_4.2H_2O$	(a)
5) Zinc sulphate heptahydrate	–	e) $MgSO_4.7H_2O$	(b)

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

1. **Benzene is called as universal solvent** — **False**
   Water is called as universal solvent.
2. **The solution in which water acts as a solvent called non-aqueous solution** — **False**
   The solution in which water acts as a solvent is called aqueous solution.
3. **Unsaturated solution is one that contains more solute than the saturated solution at a given temperature.** ✶ — **False**
   Super saturated solution is one that contains more solute than the saturated solution at a given temperature.
4. **Water dissolves an enormous variety of substances both ionic and covalent.** — **True**
5. **Fat is soluble in water.** — **False**
   Fat is soluble in ether.
6. **Polar compounds are soluble in non-polar solvents.** ✶ — **False**
   Polar compounds are not soluble in non polar solvents.
7. **Solubility of a solid solute in a liquid solvent increases with decrease in temperature** — **False**
   Solubility of a solid solute in a liquid solvent increases with increase in temperature.
8. **In endothermic process solubility decreases with increase in temperature.** — **False**
   In exothermic process solubility decreases with increase in temperature.
9. **The number of water molecule in blue vitriol is seven.** — **False**
   The number of water molecule in blue vitriol is five.

VI. Short answer questions:

1. **Air is the naturally existing solution. Why?**
   - It is a mixture of gases like nitrogen, oxygen, carbon dioxide, and other gases.
   - So, it is called as naturally existing solution.
2. **Define Ternary solution.**
   - In some, solution is made up of **three components.**
   - This solution is known as ternary solution.
   - Ex: Salt, sugar are dissolved with water in a beaker.
3. **Differentiate aqueous and non-aqueous solution.** ✶ ✶

S.No.	Aqueous solution	Non-Aqueous solution
1.	**Water** acts as a solvent.	Any liquid **other than water** acts as a solvent.
2.	**Example:** Common salt in water	**Example:** Sulphur dissolved in carbondisulphide.

4. **Give the factors affecting the solubility.**
   Three main factors which affect the solubility are:
   - Nature of the solute and solvent
   - Temperature
   - Pressure

5. Why does it bubble when water is boiled? ✶

- Water contain dissolved oxygen.
- When water is boiled the solubility of oxygen in water decreases.
- So oxygen escape in the form of bubbles.

6. Define mass of percentage. ✶ ✶

- It is defined as the **percentage by mass** of the solute present in a solution.
- **Mass percentage** $= \frac{\text{mass of solute}}{\text{mass of solute + mass of solvent}} \times 100$

7. Write Henry's law. ✶ ✶

Henry's law states that the solubility of a gas in a liquid is directly proportional to the pressure of the gas over the solution at a definite temperature.

8. Define – Hygroscopy.

- Certain substance when exposed to the atmospheric air at ordinary temperature absorb moisture without changing their physical state.
- This property is called as hygroscopy.

9. Define – deliquescence. ✶

- Certain substances which are so hygroscopic, when exposed air at ordinary temperature it **absorbs enough water** and gets completely dissolved.
- This property is called **deliquescence**.

VII. Long answer questions:

1. Describe types of solution based on

a) Physical state of the solute and the solvent

b) Type of solvent. ✶

a)

- We know that substances normally exist in three physical states (phases) i.e., solid, liquid and gas.
- In binary solutions, both the solvent and solute may exist in any of these physical states.
- But the solvent constitutes the major part of the solution.
- Its physical state is the primary factor which determine the characteristics of the solution.
- Therefore, there are different types of **binary solutions** as listed in Table.

Solute	Solvent	Example
Solid solution		
Solid	Solid	Copper dissolved in gold (Alloys)
Liquid	Liquid	Mercury with sodium (amalgam)
Liquid solution		
Solid	Liquid	Sodium chloride dissolved in water
Liquid	Liquid	Ethyl alcohol dissolved in water

Solute	Solvent	Example
Gas	Liquid	Carbon-di-oxide dissolved in water (Soda water)
Gaseous solution		
Liquid	Gas	Water vapour in air (cloud)
Gas	Gas	Mixture of Helium-Oxygen gases

b)

- Most of the substances are soluble in water.
- That is why, water is called as 'Universal solvent".
- However some substances do not dissolve in water.
- Therefore, other solvents such as ethers, benzene, alcohol, etc., are used to prepare a solution.
- On the basis of type of solvent, solutions are classified into two types.
- They are **aqueous solutions** and **non-aqueous solutions.**

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.
- Solvent other than water is referred to as non-aqueous solvent.
- Generally, alcohol, benzene, ether, carbon di sulphide, acetone, etc., are used as non-aqueous solvents.
- **Examples for non-aqueous solutions:** Sulphur dissolved in carbon di sulphide, Iodine dissolved in carbon tetrachloride.

Unit Test -9

Solutions

Time : 1 hr | Marks : 30

I. Choose the most suitable answer and write the code with the corresponding answer. 5 × 1 = 5

1. The number of components in a binary solution is _____
   a) 2 b) 3 c) 4 d) 5
2. Which of the following is the universal solvent?
   a) Acetone b) Benzene c) Water d) Alcohol
3. When pressure is increased at constant temperature the solubility of gases in liquid _____.
   a) No change b) Increases c) Decreases d) No reaction
4. 40 g of sodium chloride in 100 g of water at 25°C forms _____ solution.
   a) Saturated b) Unsaturated c) Supersaturated d) Ternary
5. Among the following _____ is a deliquescent substance.
   a) Quick lime b) Caustic soda c) Silica gel d) Con. Sulphuric acid

II. Answer the following questions in one or two lines. 5 × 2 = 10

1. What is meant by binary solution?
2. Define Volume percentage.
3. Define Hydrated salt.
4. Define – Hygroscopy.
5. List some examples of deliquescent substance.

III. Answer the following questions in brief. 2 × 4 = 8

1. What happens when $MgSO_4.7H_2O$ is heated? Write the appropriate equation.
2. Describe types of solution based on physical state of the solute and the solvent.

IV. Answer the following questions in detail. 1 × 7 = 7

1. i) Define Hydrated salt.
   ii) 3.5 litres of ethanol is present in 15 liters of aqueous solution of ethanol. Calculate volume percent of ethanol solution.