CHAPTER # 06: SOLUTIONS

SOLUTION: A solution is a homogeneous mixture of different substances that has uniform composition throughout.

BINARY SOLUTION: A solution which is obtained by mixing only two substances is called binary solution.

SOLUTE: The substance which is present in lesser amount is called solute.

SOLVENT: The substance which is present in larger amount is called solvent.

AQUEOUS SOLUTION: A solution in which water is solvent is called an aqueous solution.

SATURATED SOLUTION: A solution which cannot dissolve more amount of the solute at a particular temperature is called saturated solution.

UNSATURATED SOLUTION: A solution which can dissolve more amount of solute at a particular temperature is called unsaturated solution.

SUPERSATURATED SOLUTION: A solution which has more amount of solute than the required amount to prepare the saturated solution is called super saturated solution.

CONCENTRATION UNITS

CONCENTRATION OF SOLUTION: The quality of a solute present in a given amount of solvent or solution is called concentration of solution.

DILUTE SOLUTION: A solution whose concentration is relatively low is called dilute solution.

CONCENTRATED SOLUTION: A solution whose concentration is relatively high is called concentrated solution.

PERCENTAGE OF SOLUTION: The mass of solute dissolved in 100 gram of solution is called percentage of a solution.

OR

The volume of solute dissolved in 100 cm^3 of solution is called percentage of a solution.

There are four ways to express percentage of solutions.

i) If we dissolve 10 g NaCl in 90 g water to make 100 g of solution. In this case the concentration of the solution will be 10% m/m.

ii) If we dissolve 10 g NaCl in sufficient water to make 100 cm^3 of solution. In this case the concentration of the solution will be 10% m/v.

iii) If we dissolve 10 cm^3 of alcohol in sufficient water to make 100 g of solution. In this case the concentration of the solution will be 10% v/m.

iv) If we dissolve 10 cm^3 of alcohol in sufficient water to make 100 cm^3 of solution. In this case the concentration of the solution will be 10% v/v.

MOLARITY: The number of moles of a solute dissolved per dm^3 of a solution is called molarity.

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

Where

$$\text{Moles} = \frac{Mass\ of\ solute}{Molar\ Mass}$$

PAGE – NO – 112: EXAMPLE

Urea (NH_2CONH_2) is a white solid used as fertilizer and starting material for synthetic plastic. A solution contains 40 gram urea dissolve in 500 cm^3 of solution. Calculate the molarity.

SOLUTION: Mass of urea = 40 gram

Volume of solution = 500 cm^3 $= \frac{500}{1000} = 0.5\ dm^3$

Molar mass of urea (NH_2CONH_2) = 14 + (1 x 2) + 12 + 16 + 14 + (1x 2)

= 14 + 2 + 12 + 16 + 14 + 2 = 60 g/mole

We know Moles = $\frac{Mass\ of\ solute}{Molar\ mass}$

Moles = $\frac{40}{60}$ ⇒ Moles = 0.667 moles

Now; Molarity = $\frac{Mass\ of\ solute}{Volume\ in\ dm^3}$

= $\frac{0.667}{0.5}$ = 1.334 M

PAGE – NO – 112: EXAMPLE – NO – 6.1:

Potassium permanganate ($KMnO_4$) is a dark blue-black compound. When it is dissolved in water, it forms a bright purple solution. It is used as disinfectant in water tanks. It is also known as pinky. A solution contains 0.05 moles of $KMnO_4$ in 600 cm^3 of solution. Calculate molarity of this solution.

Moles of $KMnO_4$ = 0.05

Volume of solution = 600 cm^3 = $\frac{600}{1000}$ = 0.6 dm^3

Molarity = ?

We know Molarity = $\frac{Moles\ of\ solute}{Volume\ in\ dm^3}$

= $\frac{0.05}{0.6}$ = 0.083 M

PAGE – NO – 113: SELF ASSESSMENT EXERCISE - NO - 6.4:

Potassium chlorate ($KClO_3$) is a white solid. It is used in making matches and dyes. Calculate the molarity of solution that contains. (a) 1.5 moles of this compound dissolved in 250 cm^3 of solution (b) 75 g of this compound dissolved to produce 1.25 dm^3 of solution. (c) what is the molarity of a 50 cm^3 sample of potassium chlorate solution that yields 0.25 residue after evaporation of the water.

Solution : **Part a**:

Moles of $KClO_3$ = 1.5

Volume of solution = 250 m^3 = $\frac{250}{1000}$ = 0.25 dm^3

Molarity = ?

We know Molarity = $\frac{Moles\ of\ solute}{Volume\ in\ dm^3}$

Molarity = $\frac{1.5}{0.25}$ = 6 M

Part b:

Given mass of $KClO_3$ = 75 g
Volume of solution = 1.25 dm^3
Molarity = ?
Molar mass of $KClO_3$ = 39 + 35.5 + (16 x 3)
= 122.5 g/moles

Now;

$$\text{Moles} = \frac{\text{Mass of solute}}{\text{Molar mass}}$$
$$= \frac{75}{122.5} = 0.6122 \text{ moles}$$

Now;

$$\text{Molarity} = \frac{\text{Moles of solute}}{\text{Volume in } dm^3}$$
$$= \frac{0.6122}{1.25} = 0.4897 \text{ M}$$

Part c:

Volume of solution = 50 cm^3 = $\frac{50}{1000}$ = 0.05 dm^3
Given mass of $KClO_3$ = 39 + 35.5 + (16 x 3)
= 39 + 35.5 + 48
Molar mass = 122.5 g/moles

Now;

$$\text{Moles} = \frac{\text{Mass of solute}}{\text{Molar mass}}$$
$$= \frac{0.25}{122.5}$$
$$= 0.00204 \text{ moles}$$

Now;

$$\text{Molarity} = \frac{\text{Moles of solute}}{\text{Volume in } dm^3}$$
$$\text{Molarity} = \frac{0.00204}{0.05}$$
$$= 0.0408 \text{ M}$$

PAGE – NO – 115 – SELF ASSESSMENT EXERCISE 6.5:

1 Sodium hydroxide solutions are used to neutralize acids and in the preparation of soaps and rayon. If you dissolve 25g of NaOH to make 1 dm^3 of solution, what is the molarity of this solution.

Mass of NaOH = 25 g
Volume of Solution = 1 dm^3
Molarity = M = ?

Solution: Molar mass of NaOH = 23 + 16 + 1 = 40 g/mol

We know Moles of solute = $\frac{\text{mass of solute}}{\text{Molar mass}} = \frac{25}{40}$ = 0.625 moles

We know that if volume of solution is 1 dm^3 then molarity and moles are equal so

Molarity = Moles of solute
Molarity = 0.625 M

(2) A solution of NaOH has concentration 1.2M. Calculate the mass of NaOH in g/dm^3 in this solution.

Molarity = 1.2 M

Mass of NaOH in g/dm^3 = ?

Volume of solution = 1 dm^3

Solution:

Molar mass of NaOH = 23 + 16 + 1 = 40 g/mol

We know that if volume of solution is 1 dm^3 then molarity and moles are equal

so, Molarity = Moles

1.2 = Moles

Moles = 1.2

Now; Moles of solute = $\frac{Mass\ of\ NaOH}{Molar\ Mass}$

$1.2 = \frac{Mass\ of\ NaOH}{40}$

1.2 x 40 = Mass of NaOH

Mass of NaOH = 40 g/dm^3

(3) A solution is prepared by dissolving 10g of haemoglobin in enough water to make up 1 dm^3 in volume. Calculate molarity of this solution. Molar mass of haemoglobin is 6.51 x 10^4 g/mole.

Mass of Hemoglobin = 10g

Volume of solution = 1dm^3

Molar mass of Hemoglobin = 6.5 x 10^{4}g/mole

Molarity = ?

SOLUTION: Moles of hemoglobin = $\frac{Mass\ of\ Hemoglobin}{Molar\ mass\ hemoglobin}$

Moles of hemoglobin = $\frac{10}{6.5 \times 10^4}$

Moles of hemoglobin = $\frac{10}{6.51} \times 10^{-4}$ = 1.536 x 10^{-4} moles

We know that if volume of solution is 1 dm^3 then molarity and moles are eq.

so, Molarity = Moles

Molarity = 1.536 x 10^{-4}M

PAGE – NO – 116: SELF – ASSESSMENT EX – NO – 6.6:

(1) How can you prepare 500 cm^3 of 0.2 M $KMnO_4$ Solution?

SOLUTION:

Required volume = 500 cm^3 = $\frac{500}{1000}$ = 0.5 dm^3

Morality = 0.2M

We know If volume of solution is 1dm^3 then

Number of moles = Molarity

So, Number of moles = 0.2moles

Therefore; 1 dm^3 solution = 0.2 moles of $KMnO_4$

0.5 dm^3 solution = 0.5 x 0.2 moles of $KMnO_4$

0.5 dm^3 solution = 0.1 moles of $KMnO_4$

Now; Molar mass of $KMnO_4$ = 39 + 55 + (16 x 4) = 39 + 55 + 36 = 158 g/mol e know Moles of solute = $\frac{mass\ of\ solute}{Molar\ mass}$

So; Moles of $KMnO_4$ = $\frac{Mass\ of\ KMnO_4}{Molar\ mass\ of\ KMnO_4}$

0.1 = $\frac{Mass\ of\ KMnO_4}{158}$

0.1 x 158 = Mass of $KMSO_4$

Mass of $KMnO_4$ = 15.8 g

(2) How can you prepare 25 cm^3 of 0.25 M solution of $CuSO_4$ $5H_2O$ (Blue vitriol)

Required volume = 25 cm^3 = $\frac{25}{1000}$ = 0.025 dm^3

Morality = 0.25 M

We know If volume of solution is 1dm^3 then

Number of moles = Molarity

So, Number of moles = 0.25

Therefore; 1 dm^3 solution = 0.25 moles of $CuSO_4.5H_2O$

0.025 dm^3 solution = 0.025 x 0.25 moles of $CuSO_4.5H_2O$

0.025 dm^3 solution = 0.0065 moles

Now; Molar mass of $CuSO_4.5H_2O$ = 63.5 + 32 + (16 x 4) + 5[1 x 2.6]

= 63.5 + 32 + 64 + 5(18) = 249.5 g/moles

We know, Moles of solute = $\frac{Mass\ of\ solute}{Molar\ mass}$

0.0065 moles = $\frac{Mass\ of\ CuSO_4.5H_2O}{249.5}$

(0.0065)(249.5) = mass of $CuSO_4.5H_2O$

Mass of $CuSO_4.5H_2O$ = 1.5593 g

PAGE – NO – 117: SELF ASSESSMENT – EX – NO 6.7:

1. A stock solution of hydrochloric acid is 12.1 M. How many cm^3 of this solution should you use to prepare 500 cm^3 of 0.1 M HCl.

Molarity of given HCl = M = 12.1 M

Volume of given HCl = V_1 = ?

Molarity of required HCl = M_2 = 0.1 M

Volume of required HCl = V_2 = 500 cm^3

Solution: We know that $M_1V_1 = M_2V_2$

$(12.1)V_1 = (0.1)(500)$

$(12.1)V_1 = 50$

$V_1 = \frac{50}{12.1} = 4.13$ cm^3

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3. Commercial acetic acid is 17.8 molar. How can you convert this into 0.1 M acetic acid.

Number of moles = 17.8
Molarity = 0.1 M
Volume of solution = ?

Solution:

We know

$$\text{Molarity} = \frac{Number\ of\ moes}{Volume\ in\ dm^3}$$

$$0.1 = \frac{17.8}{Volume\ in\ dm^3}$$

$$\text{Volume in dm}^3 = \frac{17.8}{0.1}$$

$$\text{Volume in dm}^3 = 178\ \text{dm}^3$$

SOLUBILITY

The amount of solute that dissolve in 100 g of a solvent at a particular temperature is called solubility.

EFFECT OF TEMPERATURE ON SOLUBILITY:

Change in temperature has different effects on the solubility of a compound. By the change in temperature the solubility can increase, decrease or remain same.

i. INCREASE IN SOLUBILITY: Generally the solubility of ionic compounds increases with the increase in temperature. For example if we add **34.7 g** of **KCl** to **100 g** of water at **20ºC**. At this temperature **KCl** will dissolve in water completely. But if we increase the amount of **KCl** from **34.7 g** then more amount of **KCl** will not dissolve in water at **20ºC.** However if we increase temperature up to **100ºC** then more amount of **KCl** will dissolve in water easily. This shows that the solubility of **KCl** increases due to increase in temperature.

ii. DECREASE IN SOLUBILITY: The solubility of solids such as Na_2SO_4 decreases with increase in temperature. The solubility of air in water also decreases with increase in temperature.

In a home aquarium on a hot day the temperature of air is also very high. Due to this high temperature a very small amount of oxygen dissolve in water. Therefore the fish feel difficulty in breathing and shows sign of stress.

iii. SOLUBILITY REMAINS SAME: There are some substances whose solubility does not change by the change in temperature. For example the solubility of '**NaCl**' in water does not change by the change in temperature.

Q: Explain the fact that like dissolve like. **OR Why methanol dissolve in water**?

Ans: It is a well known fact that "Like dissolve like". It means that similar substances can be dissolve into similar substance. Different substances cannot be dissolved into each other. For example methanol and water both are polar substances hydrogen and water is present in both similar intermolecular forces. Therefore methanol dissolves in water easily.

Q: Why Gasoline and oils do not dissolve in water?

Ans: It is a well known fact that "Like dissolve like". It means that similar substances can be dissolve into similar substance. Different substances cannot be dissolve in each other. We know that gasoline and oil are non polar substances and water is a polar substance. The forces of attraction of water molecules with the molecules of oil and gasoline are very weak so gasoline do not dissolve in water.

COMPARISON OF PROPERTIES OF SOLUTIONS, SUSPENSION AND COLLOIDS

S. No	Solutions	Suspensions	Colloids
1.	Homogeneous	Heterogeneous	Heterogeneous
2.	Particles size vary from 0.1 to 1nm	Particles size is greater than 10^3 nm	Particles size vary from 1 to 10^3 nm
3.	Particles are invisible by naked eye, ordinary microscope as well as electron microscope	Particles are visible by naked eye	Particles are invisible by naked eye and in ordinary microscope but visible under electron microscope
4.	Particles can pass through ordinary as well as ultra filter paper	Particles cannot pass through ordinary as well as ultra filter paper	Particles can pass through ordinary filter paper but cannot pass through ultra filter paper.
5.	Cannot scatter light	Scatter light	Scatter light

PAGE – NO – 119: SELF ASSESSMENT: EX – NO 6.3:

Q: Sodium chloride and glucose both are soluble in water. But the solubility of NaCl is greater than glucose. Explain why?

Ans: The solubility of sodium chloride in water is greater than solubility of glucose. This is because in sodium chloride the attraction of sodium **(Na^+)** and Chloride **(Cl^-)** ions with water molecules is greater than the attraction of glucose molecules with water.

Q: Why the fish shows the signs of stress on a hot day in a home aquarium?

Ans: In a home aquarium the fish shows sign of stress on a hot day. This is because on a hot day the temperature of air is also very high. Due to this high temperature a very small amount of oxygen dissolve in water. As a result the fish feel difficulty in breathing.

PAGE – NO – 123: EXERCISE QUESTION

Q.2(i): Different between saturated and unsaturated solution?

Saturated Solution: A solution which cannot dissolve more amount of solute at a particular temperature is called saturated solution.

Unsaturated Solution: A solution which can dissolve more amount of solute at a particular temperature is called unsaturated solution.

Q.2(ii): Give example of a solid solution containing two solids?

Alloy is an example of a solution containing two solids.

Brass: Brass is an alloy of copper and zinc.

Steel: Steel is an alloy of iron containing small amount of carbon and silicon.

Q: Can you call colloid a solution?

Yes. we can call colloid a solution because we know that a heterogeneous mixture of tiny particles of a substance dispersed through a medium is called colloids.

Q: Gasoline does not dissolve in water, Why?

It is well know that "like dissolve like". It means that similar substance can be dissolve into similar substances. Different substances cannot dissolve into different substances. We know that gasoline and oil are non – polar substance and water is a polar substance. Therefore the forces of attraction between the molecules of water with gasoline or oil are very weak. So gasoline and oil do not dissolve in water.

Q-No-2-(v): Are gemstone solution?

Ans: Yes, gemstone are solution. They are called solutions of solid in a solid. There are many naturally occurring gemstone which are solid solution. For example, Ruby and opal both these gemstone are solid solution.

Page – No – 123: Q-No-3 (a): A tiny crystal of a solid substance is added to an aqueous solution of the some substance. What would happen if the original solution was

a) Saturated b) Unsaturated c) Super saturated?

Ans: **Super saturated**: If a tiny crystal of a solid substance is added to an aqueous super saturated solution then crystallization will start.

Unsaturated Solution: If a tiny crystal of a solid substance is added to an aqueous unsaturated then tiny crystal of solid will dissolve in the solution.

Saturated Solution: If a tiny crystal of a solid substance is added to an aqueous saturated solution then crystal of solid will settle down to the bottom of the solution.

Page – No – 124: Q-No-4: Explain why CH_3OH is soluble in water but C_6H_6 is not.

Ans: We know that it is a well known fact that "like dissolve like". It means that similar substances can be dissolve into similar substances. **CH_3OH** and water both are polar substances. Hydrogen bonding is present between their molecules. They also have similar structure and similar intermolecular forces. Therefore **CH_3OH** is soluble in water. But **C_6H_6** is non polar molecule and its properties are different form properties of water. Therefore **C_6H_6** cannot be dissolve into water.

Page-No-124: Q-No-5

How can you prepare 250 cm^3 of 0.5M $MgSO_4$ from a stock solution of 2.5 M $MgSO_4$?

Molarity of given $MgSO_4$ = M_1 = 2.5 M

Volume of given $MgSO_4$ = V_1 = ?

Molarity of required $MgSO_4$ = M_2 = 0.5 M

Volume of required $MgSO_4$ = V_2 = 250 cm^2

Solution: We know

$$M_1V_1 = M_2V_2$$

$$(2.5)(V_1) = (0.5)(250)$$

$$V_1 = \frac{(0.5)(250)}{2.5}$$

$$V_1 = 50\ cm^3$$

Page-No-124: Q-No-8

What is the morality of a solution prepared by dissolving 1.25 g of HCl gas into enough water to make 30 cm^3 of solution.

Mass of HCl = 1.25 g

Volume of solution = 30 cm^3 $= \frac{30}{1000}$ = 0.03 cm^3

Molarity = ?

Molar mass of HCl = 1 + 35.5 = 36.5 g/mol

We know

$$\text{Moles of solute} = \frac{Mass\ of\ solute}{Molar\ mass}$$

$$= \frac{1.25}{36.5} = 0.03\ \text{moles}$$

$$\text{Molarity} = \frac{Mass\ of\ solute}{Volume\ in\ dm^3}$$

$$= \frac{0.03}{0.03} = 1\ M$$

Page-No-124: Q9: Formalin is an aqueous solution of formaldehyde (HCHO), used to preservative for biological specimens. A biologist wants to prepare 1dm^3 of 11.5M formalin. What mass of formaldehyde he requires?

Volume of formalin = 1 dm^3

Molarity = 11.5 M

Mass of formaldehyde = ?

We know that if volume is 1 dm^3 then molarity and moles are equal

Moles = Molarity

Moles = 11.5

Molar mass of HCHO = 1 + 12 + 1 + 16 = 30 g/mole

$$\text{Moles of solute} = \frac{Mass\ of\ solute}{Molar\ mass}$$

$$\text{Moles of solute} = \frac{Mass\ of\ formaldehyde}{Molas\ mass}$$

$$11.5 = \frac{Mass\ of\ HCHO}{30}$$

11.5 x 30 = Mass of HCHO

Mass of HCHO = 345 g

Page-No-124:Q. 10: A solution of $Ca(OH)_2$ is prepared by dissolving 5.2 mg of $Ca(OH)_2$ to a total volume of 100 cm^2. Calculate the molarity of this solution.

$$\text{Mass of } Ca(OH)_2 = \frac{5.2}{1000} = 0.0052 \text{ g}$$

$$\text{Volume} = \frac{1000}{1000} = 1 \text{ dm}^3$$

Molarity = ?

Molar mass of $Ca(OH)_2$ = 40 + (16 x 2) + (1 x 2)

= 40 + 32 + 2 = 74 g/mol

$$\text{Moles of solute} = \frac{Mass\ of\ solute}{Molar\ mass} = \frac{0.0052}{74}$$

= 0.0000702 Moles or 7.02 x 10^{-5} moles

We know if volume is 1 dm^3 then moles and molarity are equal

Molarity = Moles

So, Molarity = 7.02 x 10^{-5} M

Q-No-11: Calculate the number of moles of solute present in 1.2 cm^3 of 0.5 M H_3PO_4 solution.

Moles = ?

Molarity = 0.25 M

Volume = 1.25 cm^3 = $\frac{1.25}{1000}$ = 1.25×10^{-3}

Solution: Molarity = $\frac{\text{Moles of solute}}{\text{Volume in } dm^3}$

0.25 = $\frac{\text{Moles of solute}}{1.25 \times 10^{-3}}$

Moles of solute = $0.25 \times 1.25 \times 10^{-3}$ = 3.125×10^{-4}

Q-No-12: Calculate the new molarity when 100 cm^3 of water is added to 100 cm^3 of 0.5 M HCl?

Given Molarity = M_1 = 0.5 M

Given Volume = V_1 = 100 cm^3

New Molarity = M_2 = ?

New Volume = V_2 = 100 + 100 = 200 cm^3

Solution: We know that

$M_1V_1 = M_2V_2$

$(0.5)(100) = (M_2)(200)$

$\frac{(0.5)(100)}{200} = M_2 = 0.25M$

Page – No – 153: Q-No-13:

Solutions play a very important role in our daily life some of the important uses of solutions are given as.

i) The air we breathe is a gaseous solution of nitrogen, Oxygen, carbondioxide and some other gases.

ii) The water we use for drinking, cooking and washing is not pure it contains some gases and minerals that are very important for our health.

iii) Some important commercial products such as shampoo, jams. jellies, milk, butter and cheese are also solutions.