Chapter 6

SOLUTIONS

Time Allocation

Teaching periods	= 15
Assessment period	= 3
Weightage	= 16

Major Concepts

6.1 Solution, aqueous solution, solute, and solvent

6.2 Saturated, unsaturated, supersaturated solutions and dilution of solution

6.3 Types of solution

6.4 Concentration Units

6.5 Solubility

6.6 Comparison of Solutions, Suspension, and Colloids

STUDENTS LEARNING OUT COMES (SLO'S)

By the end of Chapter Students will be able to:

- Define the terms: solution, aqueous solution, solute and solvent and give an example of each. (Remembering)
- Explain the difference between saturated, unsaturated and supersaturated solutions. (Analyzing)
- Explain the formation of solutions (mixing gases into gases, gases into liquids, gases into solids) and give an example of each. (Understanding)
- Explain the formation of solutions (mixing liquids into gases, liquids into liquids, liquids into solids) and give an example of each. (Understanding)
- Explain the formation of solutions (mixing solids into gases, solids into liquids, solids into solids) and give an example of each. (Understanding)
- Explain what is meant by the concentration of a solution. (Understanding)
- Define Molarity. (Remembering)
- Define percentage solution. (Remembering)
- Solve problems involving the Molarity of a solution. (Applying)
- Describe how to prepare a solution of given Molarity. (Applying)
- Describe how to prepare dilute solutions from concentrated solutions of known Molarity.
- (Applying)
- Conversion between the Molarity of a solution and its concentration in g/dm^3. (Applying)
- Use the rule that "like dissolves like" to predict the solubility of one substance in another. (Understanding)
- Define colloids and suspensions. (Remembering)Differentiate between solutions, suspension and colloids (Analyzing)

Introduction

A solution is the homogenous mixture of solute and solvent. Solutions are everywhere around us. Many substances around us are solution as like a glass of milk, drugs and medicines, blood, alloy, kerosene oil, tap water, cooking utensils and surgical tools. These all are the example of a solution. The nutrient absorbed by plants from the soil is also the example of the solution. The foods we eat come into contact enzymes with the help of a solution. The majority of chemical reactions occur in solutions. All these are possible with the presence and support of the solution.

In this chapter, we will study about solutions, types of solution and comparison of solutions, suspension and colloids in detail.

6.1 Solution, Aqueous Solution, Solute and Solvent

6.1.1 Solution

A solution is a homogeneous mixture of two or more substances to form a single phase. A solution exists in all three states of matter. An example of solid solution is brass (Zinc dissolved in copper), the liquid solution is sugar into water and gaseous solution is air we breathe. Air is made up of gases like oxygen, nitrogen, carbon dioxide etc.

6.1.2 Aqueous Solution

An aqueous solution is formed by dissolving a substance in water. The word aqueous is derived from the Latin word called aqua meaning water. Sugar, salt, and acid in water are the examples of aqueous solution. In aqueous solution, water (H_2O) is present in greater amount and termed as solvent.

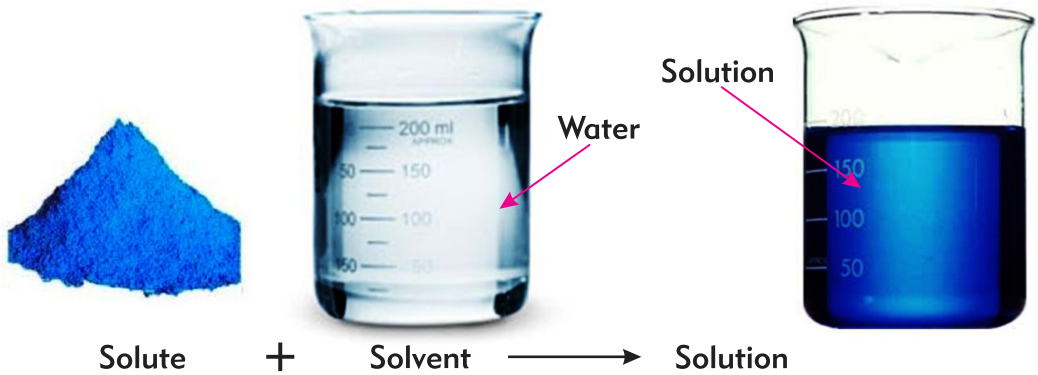


Figure 6.1 Preparation of Solution

6.1.3 Solute

The component of solution which is always present in smaller amount is called the **solute**. A solute is dissolved in a solvent to make a solution. An everyday example of a solute is sugar in water. Sugar is the solute and water is solvent. In a solution more than two solute may be present. For example, in a soft drink, sugar, salt and carbon dioxide are solute and water is a solvent. Consider another example, air is a solution of several gases like nitrogen, carbon dioxide, oxygen and inert gases. In this solution carbon dioxide, oxygen and inert gases are solute and nitrogen is solvent.

6.1.4 Solvent

The component of the solution which is present in larger amount is called **solvent**. Solvent are generally liquid, but can also be gas or solid. The component of solution which can dissolve solute is called solvent. Water is the most common solvent because it can dissolve most of the solutes. It is also called as the **universal solvent.**

Test Yourself

- Why solutions are important for us?
- Why solution is called mixture?
- How is solution formed?
- What is an aqueous solution?
- Write any two examples of solute and solvent.
- Air is solution of general gases like nitrogen, carbon dioxide, oxygen and inert gases, why nitrogen is called solvent?

6.2 Saturated, Unsaturated, Supersaturated Solutions and Dilution of the Solution

6.2.1 Saturated solution

Take some water in a beaker and add sugar in a small amount. The sugar dissolves very easily in the water at a certain temperature. If the adding of sugar continues, it is found that a limit is reached when the water cannot dissolve any more sugar and settling down occurs and no more solute can dissolve in it. Such a solution is said to be saturated solution. Thus we can define a saturated solution as follows:

A solution which cannot dissolve more solute in it at a particular temperature is called a **saturated solution.**

6.2.2 Unsaturated solution

A solution which contains lesser amount of solute than is required to saturate it at a particular temperature, is called **unsaturated solution.** Salt dissolved in water is the example of unsaturated solution if the solution has ability to dissolve more solute to become a saturated solution.

6.2.3 Supersaturated solution

When we heat the saturated solution, it develops further capacity to dissolve more amount of sugar (solute). This solution contains greater amount of solute than that present in a saturated solution and the solution become more concentrated. Now solution is called super saturated.

Thus, we can define a supersaturated solution as:

A solution that can dissolve more solute than it contained in the saturated solution after heating is called a **Supersaturated solution.**

For better understanding of saturated, unsaturated and supersaturated solution, a brief comparison of their differences is given in table.6.1

Table 6.1
The difference between Saturated, Unsaturated and Supersaturated solution

Saturated	Unsaturated	Supersaturated
In saturated solution maximum amount of solute that can be dissolved at particular temperature.	In unsaturated solution less amount of solute is dissolved at particular temperature.	In super saturated solution more amount of solute has been dissolved than its maximum capacity.
The solution has high concentration than unsaturated solution.	The solution has low concentration than saturated solution.	The solution has more concentration than saturated solution.
There is no formation of precipitation at the bottom of container.	There is also no precipitation at the bottom of container.	There is formation of precipitation at the bottom of container on cooling.
A solution having 36 gram of sodium chloride per 100cm^3 of water at 20°C is the example of saturated solutions.	A solution having amount of salt less than 36 gram per 100cm^3 of water at 20°C is the example of unsaturated solution.	A solution having more amount than 36 gram of salt per 100cm^3 of water at higher temperature is the example of supersaturated solution.

6.2.4 Dilution of solution

We already know about two basic terms dilute and concentrated solutions and both are depending on the relative amount of solute present in it. **Dilute solution** contains a relatively small amount of a solute in a large amount of solvent like adding more water to a solution.

Whereas, **concentrated solution** contains a relatively large amount of solute in a small amount of solvent.

Dilution of a solution is necessary process in the laboratory, as stock solution (more concentrated) are often purchased and stored in laboratory when the desired concentration of solution is required can be prepared by diluting the stock solution by given formula.

Preparing dilute solution

In a laboratory, we can make a dilute solution from a concentrated solution by using formulas:

Concentrated Solution = Dilute Solution

$$M_1V_1 = M_2V_2$$

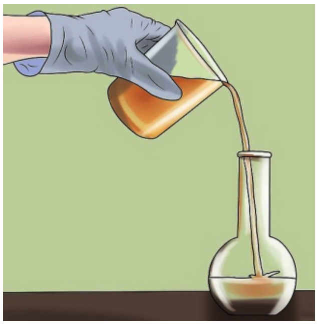
Where, M_1 = Molarity of concentrated solution

V_1 = Volume of Concentrated solution

M_2 = Molarity of dilute solution

V_2 = Volume of dilute solution

Note: $1cm^3 = 1ml$ and $1dm^3 = 1L$



6.2 Dilute solution

Example 6.1

How do you prepare solution of 100ml of 0.40M $MgSO_4$ from a stock solution of 2.0M $MgSO_4$?

Solution:

Data M_1 = 2.0M $MgSO_4$

M_2 = 0.40M $MgSO_4$

V_2 = 100ml

V_1 = ?

Concentrated Solution = Dilute Solution

$$M_1 V_1 = M_2V_2$$

$$2 \times V_1 = 0.40 \times 100$$

$$V_1 = \frac{0.4 \times 100}{2}$$

$$= 20\ cm^3$$

Transfer $20cm^3$ of 2 M $MgSO_4$ to a $100cm^3$ measuring flask and dilute it by adding water up to the marks. It is 0.40M solution of $MgSO_4$

Example 6.2

How would you prepare 500 cm^3 of 0.20 M NaOH (aq) from a stock solution of 1.5 M NaOH?

Solution

M_1 = 1.5M NaOH
M_2 = 0.2M NaOH
$V_2 = 500cm^3$
V_1 = ?

Concentrated Solution = Dilute Solultion

$$M_1V_1 = M_2V_2$$

$$1.5 \times V_1 = 0.20 \times 500$$

$$V_1 = \frac{0.20 \times 500}{1.5}$$

$$= 66.67cm^3$$

Take 66.67 cm^3 of concentrated NaOH and placed in a $500cm^3$ measuring flask and dilute it by adding water up to the mark. It will become 0.2M solution of NaOH.

Test Yourself

- Consider two beakers A and B. Each one having 20ml of water. Add 10 g of sodium thiosulphate in beaker A and 20 g in beaker B and stir carefully. Answer the following questions:
- Which beaker's solution is saturated?
- How can be supersaturated solution prepared from above experiment?
- Compare the term saturated and unsaturated solution.
- Which beaker's solution is unsaturated solution?
- How is unsaturated solution prepared?
- 10M HNO_3 solution is available in laboratory. How would you prepare 500 cm^3 of 0.1M solution?

6.3 TYPES OF SOLUTION

As we know that there are three states of matter, i.e. solid, liquid and gas. A solute as well as solvent can exist in any one of the three states of matter. By the combination of these three states different types of solutions are formed, which are given in table 6.2

Table 6.2 Types of Solution with Examples

Sr. No	State of Solute	State of Solvent	State of Solution	Example of Solution
1.	Gas	Gas	Gas	Air, mixture of hydrogen and helium in water balloon, oxygen in air
2.	Gas	Liquid	Liquid	Carbonated drinks (carbon dioxide dissolved in water)
3.	Gas	Solid	Solid	Hydrogen gas in palladium, nitrogen in titanium.
4.	Liquid	Gas	Gas	Fog (water vapour in air) liquid air pollutants
5.	Liquid	Liquid	Liquid	Alcohol dissolves in water , oil in ether.
6.	Liquid	Solid	Solid	Amalgam, butter, cheese
7.	Solid	Gas	Gas	Smoke (carbon particles in air)
8.	Solid	Liquid	Liquid	Salt in water, Sugar in water
9.	Solid	Solid	Solid	Brass an alloy (Zinc dissolved in copper), Bronze (tin dissolved in copper)

6.4 CONCENTRATION UNITS

We already discussed in section 6.2.4 that concentration is the amount of solute present in a given amount of solvent or solution. It is also the ratio of amount of solute to the amount of solution or ratio of amount of solute to the amount of solvent.

We can express the concentration in terms of grams of solute per $dm^3 (g/dm^3)$ of solution.

$$\text{Concentration in } g/dm^3 = \frac{\text{Mass of solute in gram}}{\text{volume of solution in } dm^3}$$

Do you know?

$1\ L = 1 dm^3$

$1 ml = 1 cm^3$

$1 L = 1000 ml$

$1 dm^3 = 1000 cm^3$

There are many ways of expressing the concentration of the solution. In this class we will discuss only two main concentration units.

6.4.1 Percentage

It is a unit of concentration. It refers to the percentage of solute present in a solution. It can be expressed in four different ways:

(i) Mass by mass percent (%m/m)

It is the mass of solute in gram dissolved in 100 grams of solution.

For example, 5% m/m sugar solution means that 5 grams of sugar dissolved in 95 grams of water to make 100 grams of solution.

$$\text{Percent solution } \left(\frac{m}{m}\%\right) = \frac{\text{Mass of Solute (g)}}{(\text{Mass of Solute + masss of solvent (g)})} \times 100$$

or

$$= \frac{\text{Mass of solute (g)}}{\text{Mass of solution (g)}} \times 100$$

(ii) Mass by volume percent (%m/v)

It is the mass of the solute in grams dissolved per $100 cm^3$ of the solution.

For example, 5%m/v sugar solution means that 5 grams of sugar in $100 cm^3$ of the solution.

(iii) Volume by mass percent (%v/m)

It is the volume of solute in cm^3 dissolved in 100 gram of the solution.

For example, 5%(v/m) Alcohol solution means $5cm^3$ of alcohol is dissolved in (unknown) volume of water so that mass of solution become 100g.

$$\text{Percent of solution } \frac{V}{m} = \frac{\text{Volume of Solute } (cm^3)}{\text{Mass of Solution (g)}} \times 100$$

(iv) Volume by volume percent (%v/v)

The volume of solute in cm^3 is dissolved per $100cm^3$ of the solution.

For example, 5%(v/v) Alcohol solution means that $5cm^3$ of alcohol is dissolved in 95 cm^3 of the water to make 100 cm^3 of the solution.

$$\text{Percent of solution } \frac{V}{V} = \frac{\text{Volume of Solute } (cm^3)}{\text{Mass of Solution } (cm^3)} \times 100$$

Example 6.3 (Percent by Mass)

Calculate the percentage concentration (m/m) of the solution obtained by dissolving 15g salt in 110g water.

Solution

Mass of salt = 15 g

Mass of water = 110 g

Mass % of salt = ?

Total mass of solution = 15 g salt + 110 g water = 125 g

Percent by mass would be calculated as:

$$\text{Percent (mass/mass)} = \frac{\text{Mass of Solute (g)}}{\text{Mass of Solution (g)}} \times 100$$

$$= 15/125 \times 100 = 12\%$$

Thus the concentration of a solution is 12% by mass.

Example 6.4 (Percent by Volume)

Calculate the volume/volume percent of solution obtained by mixing 25cm^3 of ethanol in water to produce 150cm^3 of the solution.

Solution

Volume of solute = 25cm^3

Volume of solution = 150cm^3

Volume/volume percent =?

$$\text{Percent of solution } \frac{V}{V} = \frac{\text{Volume of Solute (cm}^3)}{\text{Volume of Solution (cm}^3)} \times 100$$

$$= \frac{25}{150} \times 100$$

$$=16.7\%$$

Thus the concentration of a solution is 16.7% by volume

6.4.2 Molarity

Molarity is defined as the number of moles of solute dissolved in one dm^3 (1 Litre)of the solution. Molarity is the concentration unit in which the amount of solute is expressed in gram and the volume of solution is expressed in dm^3. It is denoted by "M" and its unit is mol/dm^3.

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

$$\text{Number of moles of solute} = \frac{\text{Mass of solute}}{\text{Molar mass of the solute (gmol}^{-1})}$$

$$\text{Volume of solution in dm}^3 = \frac{\text{Volume of solution (cm}^3)}{1000}$$

$$\therefore \quad \text{Molarity} = \frac{\text{Mass of solute (g)}}{\text{Molar mass of the solute (gmol}^{-1})} \times \frac{1000}{\text{Volume of solution (cm}^3)}$$

Preparation of Molar Solution

One mole (molar mass) of a solute is dissolved in a sufficient amount of water so that the total volume is 1dm^3. The solution is said to be one molar solution.

For example, prepare 1.0 M solution of NaCl in 1 dm^3.

Following steps may be considered:

1. Weigh out 58.5 grams of NaCl — Molar mass of NaCl = 23 + 35.5 = 58.5g/mol

2. Put the NaCl into a volumetric flask

3. Add water to dissolve the salt and prepare 1dm^3 solution.

You have prepared 1M NaCl solution by dissolving 58.5 grams of NaCl in sufficient water to make the volume 1dm^3.

Similarly, to make a 0.1M solution, you could dissolve 5.85g of NaCl in 1dm^3 of water.

Problems based on Molarity of a solution

Example 6.5

20 gram of salt (NaCl) is dissolved in 500cm^3 of a solution. Calculate the molarity of that solution.

Data:

Mass of solute = 20g

Molar mass of NaCl = 23 + 35.5

= 58.5g/mol

Volume of solution = 500cm^3.

Molarity (M) = ?

Formula

$$\text{Molarity} = \frac{\text{Mass of solute (g)}}{\text{Molar mass of the solute (gmol}^{-1}\text{)}} \times \frac{1000}{\text{Volume of solution (cm}^3\text{)}}$$

Solution:

$$\text{Molarity} = \frac{20\text{g}}{58.5\text{g/mol}} \times \frac{1000}{500}$$

$$\text{Molarity} = 0.683 \text{ mole / dm}^3.$$

Example 6.6

What is the mass of oxalic acid present in 100 cm^3 of 2 molar solution?

Data:

Molarity = 2 mol/dm^3

Volume in cm^3 = 100

Molar mass of oxalic acid ($C_2H_2O_4$) $= (12 \times 2) + (1 \times 2) + (16 \times 4)$

$= 24+2+64 = 90$g/mol

Mass of solute = ?

Formula

$$\text{Molarity} = \frac{\text{Mass of solute (g)}}{\text{Molar mass of the solute (gmol}^{-1}\text{)}} \times \frac{1000}{\text{Volume of solution (cm}^3\text{)}}$$

Solution:

$$2 = \frac{\text{Mass of solute}}{90} \times \frac{1000}{100}$$

$$\text{Mass of solute} = \frac{2 \times 90 \times 100}{1000} = 18\text{gm}$$

Example 6.7

A sample of sulphuric acid has the molarity 20M. How many cm^3 of solution should we use to prepare 500 cm^3 of 0.5M H_2SO_4?

Solution:

M_1 = Molarity of given H_2SO_4 = 20M

M_2 = Molarity of required H_2SO_4 = 0.5M

V_2 = Volume required in H_2SO_4 on = 500 cm^3

V_1 = volume of concentrated solution needs for dilution =?

By using dilution formula

$M_1V_1 = M_2V_2$

$$V_1 = \frac{M_2V_2}{M_1} = \frac{0.5 \times 500}{20}$$

V_1 = 12.5 cm^3

12.5cm^3 of 20M is used to make 500cm^3 aqueous solution to form 0.5M H_2SO_4.

Test Yourself

- Define concentration
- Brass contains 20% zinc and 80% copper. Identify state of solute and solvent in this solution? Also write the type of solution.
- Write the difference between diluted and concentrated solution.
- Which one of the solution is more diluted; 2M or 3M?
- A solution of NaOH has concentration 1.2M, calculate the mass of NaOH in g/dm^3 in this solution ($50\ cm^3$).
- Determine the percentage concentration of the solution obtained by dissolving 10g sugar in 140g water
- A student asked to prepare 10%(m/m) solution of sugar. How much solvent will be required to prepare this solution?

6.4 SOLUBILITY

Solubility is defined as the maximum quantity of solute that can be dissolved in 100 grams of solvent to prepare saturated solution at a particular temperature.

Different substances have different capability to dissolve in the same solvent at a particular temperature. For example, the solubility of sodium chloride in 100g of water at 100°C is 39.12g, whereas, the solubility of silver chloride in 100g of water at 100°C is 0.002g. This shows that sodium chloride is much more soluble in water than silver chloride.

General Principles of Solubility

1. The general principle of solubility is **"Like dissolves like"**. Its mean that two substances with similar intermolecular forces are likely to be soluble in one another. It has been observed that:
   - Ionic and polar solute dissolved in polar solvents. For example, Na_2CO_3, sugar and alcohol are polar and dissolved in water because water is also polar.
   - Nonpolar solute dissolved in non-polar solvents. Such as oil and paints are non-polar, they are dissolved in ether as both are non-polar. Similarly, waxes and fats dissolve in benzene and not in water.
   - Nonpolar compounds are not soluble in polar solvents (water). For example, oil, petrol, benzene are non-polar, they are not dissolved in water because water is polar.
2. Solute-solvent interaction
3. Temperature

Do you know?

When solute-solute or solvent-solvent interactions are much more than solute-solvent interaction, a solution will not form.

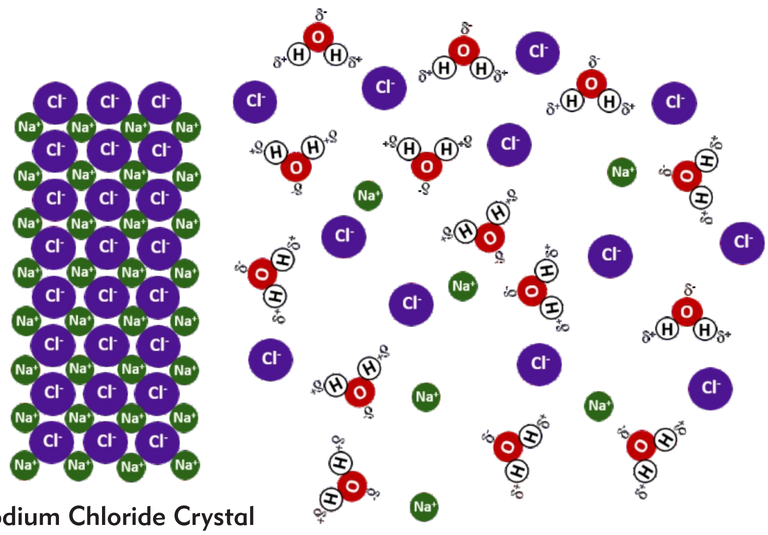
6.5.1 Solubility and Solute-Solvent Interaction

In order to dissolve the solute into solvent, the following conditions must be fulfilled.

- Solute-Solute bonding should be broken.
- Solvent-Solvent bonding should be broken to provide space for solute particles.
- Solute-Solvent attraction should be maximized.

The process of solution formation depends upon the relative strength of attractive forces between solute-solute, solvent-solvent and solute-solvent. A solute will dissolve in a solvent if the solute-solvent forces of attraction are greater enough to overcome the solute-solute and solvent-solvent forces of attraction. A solute will not dissolve if the solute-solvent forces of attraction are weaker than individual solute and solvent intermolecular attractions.

As we know that sodium chloride is an ionic compound. When sodium chloride (NaCl) is added into water, it dissolves quickly. The negative end of water molecules is attracted to sodium ions and the positive end of water molecules is attracted to chlorine ions. In this case, solute-solvent attractions are more in comparison with solute-solute interaction, therefore solution of sodium chloride is formed. These attractive forces of water are stronger enough to overcome the attraction between Na^+ and Cl^- ions in NaCl. Figure 6.3 shows the attraction of Na^+ and Cl^- ions with water molecules.



Sodium Chloride Crystal

Sodium Chloride Dissolved in Water

Figure 6.3 Interaction of sodium chloride and water

Now it is concluded that if there is more attraction between solute and solvent in comparison with solute-solute interaction, then the solution will be formed. If Solute-solute interaction is greater than solute-solvent attraction, then solute will not dissolve in solvent.

6.5.2 Effect of Temperature on Solubility

Solubility is directly proportional to the temperature for solid & liquid solutes. Solubility is increased by increasing the temperature because hot water molecules have greater kinetic energy and collide with solid solute more vigorously. For example, a greater amount of sugar will dissolve in warm water than in cold water. The solubility of potassium chloride is 277.7g/L in water at 20°C. It will become 540.2g/L at 100 °C.

For all gases, the solubility decreases as the temperature of the solution increases.

Test Yourself

- Explain the general principle for solubility, “like dissolves like“?
- Why solute dissolves in solvent?
- Why benzene does not dissolve in water?
- Suppose solute-solute forces are weaker than those of solute-solvent forces. Will solute dissolve in solvent and to be form a solution?
- What is the main reason that non-polar solute does not dissolve in water?

6.6 COMPARISON OF SOLUTION, SUSPENSION AND COLLOIDS

When a solute (sugar or table salt) is placed in water, after some time sugar or salt completely dissolve in water and we cannot even see the particles of sugar or salt. Now if you repeat the same practice with sand or clay, would you get same results? The solution of sugar in water is a clear solution, whereas sand or clay in water is not a clear solution. After some time, sand or clay settles at the bottom and we can see the particles of sand clearly. Now compare these two solutions with milk. Milk is not a clear solution but particles do not settle at the bottom with time. So we can say that particles remain dispersed in solution, but the size is big enough that does not allow the clear appearance of the solution.

On the basis of particles size and their characteristics, mixtures can be classified as true solution, colloid and suspension.

6.6.1 Solution

A solution is a homogeneous mixture of two or more than two components. When we dissolve sugar in water, after some time sugar completely dissolve in water and we cannot even see the particles of sugar. Sugar is dissolved into the water and a drop of ink mixed in water are the examples of the true solution. The solute particles in true solutions are very tiny so that we cannot see them with naked eyes.

6.6.2 Colloid

In a colloid, the particles are larger than those present in a true solution, but smaller than the particles that make up a suspension. Therefore, they will not settle to the bottom of the container and remain dispersed in the medium. The dispersed particles of colloids cannot be separated by filtration, but they scatter the beam of light. This phenomenon is called the Tyndall effect. These solutions are also called false solutions. Milk, butter, jelly, blood are the example of colloidal solution. Few other examples of colloid are fog, smoke and dust particles which are suspended in the air and the beam of light can be easily scattered.

Do You Know?

The scattering of visible light by Colloidal particles is called Tyndall effect. This phenomenon was discovered by Physicist John Tyndall in the 19th century.

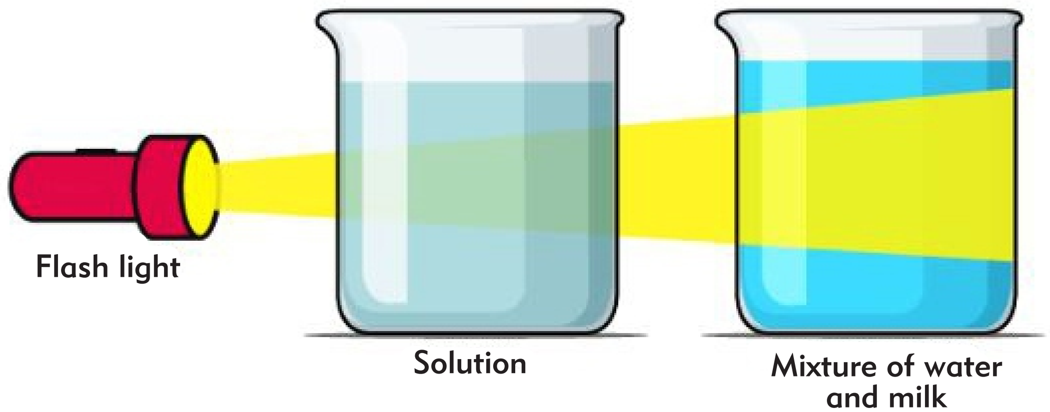


Figure: 6.4Tyndall effect by colloids

6.6.3 Suspension

A suspension is a heterogeneous mixture of solute and solvent in which solute particles do not dissolve. A suspension contains large particles suspended in a liquid. The particles will eventually, slowly settle to the bottom in the absence of agitation. For examples mud in water, chalk in water, paints etc. The solute particles are big enough to be seen with naked eyes and they can scatter light like colloids.

Table 6.3 shows the comparison of the characteristics of solution, suspension and colloid.

Table 6.3 Comparison of the characteristics of solution, Suspension and Colloid.

Solution	Suspension	Colloid
Particle size less than 1 nm	Particle size greater than1000 nm	Particle size 1 to 100 nm
Homogeneous (particles dissolve uniformly)	Heterogeneous (particles settle down after sometimes)	Homogeneous and heterogenous (Particles do not settle down for a long time)
Particles cannot be distinctly seen with the naked eye.	Particles are big enough but can be seen with naked eyes	Colloidal particles can not be with the naked eye but can be seen through ultra microscope
Clear, transparent and homogeneous	Cloudy, non uniform and heterogeneous	Cloudy, homogeneous, and uniform
Transparent but often colored	Translucent and often opaque	Often opaque, but can be transparent
Solutes cannot easily be separated	Solutes can be separated easily	Solutes can not be separated easily
Do not scatter light	Scatter light, but are not transparent	Scatter light (Tyndall effect)
Particles can pass through filter paper	Particles do not pass through filter paper	Particles pass through filter paper

Test Yourself

- How is a colloid different from a solution?
- Which one is colloidal solution, Starch solution or Glucose solution?
- Paint is colloidal solution. Give reason?
- Why paints should be stirred thoroughly before using?
- Write two examples of suspension.
- Differentiate between suspension and colloid.
- Justify that milk is a colloidal solution.
- Why sugar solution don't scatters the light?
- Define false solution.
- Why does the colloidal show tyndall effect?

Society, Technology and Science

Relate Solution to Different Products in the Community

Solutions have great importance and influence in our daily life. As we look in our surrounding, such as air, soft drinks, beverages, medicines, butter, tooth pastes, natural gas and even water are solutions. When we stirr sugar in a cup of tea, we are making a solution. Most of chemical reactions take place in the bodies of living organism occur in presence of water as a solvents. The food assimilation process in our bodies also occurs in solution. Brass and steel are also solution. These solutions are widely used for making cooking utensils, surgical instruments, cutlery, and many other objects. Silver and tin amalgams are widely used to make dental filling. The majority of chemical processes are reactions that occur in solution. Gaseous solutions are also used in chemical industries for the preparation of urea, ammonia gas, nitric acid, rubber, vegetable oil etc.

Summary

- A **solution** is a **homogeneous mixture** of two or more substances.
- The substance which is dissolved is called **solute**.
- The substance in which the solute is dissolved is called a **solvent.**
- The solution is single phase homogeneous mixture of solute and solvent.
- Component of solution which is present in small quantity and it can be dissolved in solvent is called **"solute"**.
- Component of solution which is present in large quantity and it can dissolve solute is called **"solvent"**.
- The aqueous solution is a type of solution, in which water used as a solvent.
- In unsaturated solution the amount of solute is less than its original capacity to dissolve.
- In a saturated solution maximum amount of solute dissolves in solvent according to their capacity.
- In supersaturated solution the capacity to dissolve the solute is increased by increasing the temperature.
- A solution has nine types based on the nature of solute and solvent. A solute may be solid, liquid and gas. If the solution is in liquid form so it is considered a true solution.
- A dilute solution has a small amount of solute in a large amount of solvent.
- A concentrated solution has a large amount of solute in small amount of solvent.

- We can dilute the solution by the formula. $M_1V_1=M_2V_2$.
- The proportion of solute in a solution is called concentration.
- Molarity is defined as the number of moles dissolved in a dm^3 of the solution. Those solutions whose concentration is expressed in molarity are called molar solution.
- Percent solution is based on mass and volume of the components of solute and solvent.
- The quantity of solute and solvent may be increase or decrease according to the percentage of the solution. Percent solution has four types
- Solubility is defined as the amount of solute dissolved in 100g of solvent. The main factors which effect the solubility are temperature, pressure and nature of solute and solvent.
- Nature of solute and solvent obey the principle of" like dissolves like".
- A heterogeneous mixture containing undissolved particles large enough to be seen with naked eyes is called suspension.
- In colloidal solutions, solute particles are larger than those present in the true solution but not large enough to be seen by naked eyes. They are also called false solution.

EXERCISE

SECTION- A: MULTIPLE CHOICE QUESTIONS

Tick Mark (✓) the correct answer

1. An alloy is the homogeneous mixture of:
   (a) two solids (b) two liquids
   (c) two gases (d) solid and liquid
2. A saturated solution of KCl on heating becomes:
   (a) unsaturated (b) supersaturated
   (c) diluted (d) all of these
3. If we dissolve sand into the water, then the mixture is said to be:
   (a) solution (b) suspension
   (c) colloids (d) concentrated solution
4. Solubility is usually expressed in grams of the solute dissolved in ________grams of a solvent
   (a) 10 (b) 100
   (b) 500 (d) 1000
5. Example of heterogeneous mixture is:
   (a) sugar and water (b) sand and water
   (c) salt and water (d) ink and water
6. 2 moles of sodium chloride (NaCl) is equal to:
   (a) 123 grams (b) 135 grams
   (c) 158 grams (d) 117 grams
7. Molarity of a solution which is prepared by dissolving 40g sodium chloride in 500cm^3 of solution is:
   (a) 1.4M (b) 1.5M
   (c) 1.6M (d) 1.7M
8. 10% (w/w) sugar solution mean that 10 grams of solute dissolved in:
   (a) 90g of water (b) 95g of water
   (c) 100g of water (d) 105g of water

9. An example of true solution is:
   (a) solution of starch (b) solution of soap
   (c) ink in water (d) tooth paste
10. Which solution contain more water:
   (a) 1.0M (b) 0.75M
   (c) 0.5M (d) 0.25M
11. When a saturated solution is diluted, it change into:
   (a) saturated solution (b) unsaturated solution
   (c) concentrated solution (d) supersaturated solution
12. Butter is example of solution:
   (a) gas-liquid (b) solid-liquid
   (c) liquid-solid (d) gas-solid
13. A solution that contain solid solute into liquid solvent is called:
   (a) solids in gas (b) liquids in solids
   (c) solids in solids (d) solids in liquid
14. What is the particle size in suspension?
   (a) 10^3nm (b) 10^2 nm
   (c) less than 10^3nm (d) greater than 10^3nm
15. Write the example of each type of solution.

Solute	Solvent	Example
Solid	Liquid	
Gas	Gas	
Solid	Solid	
Liquid	Solid	
Liquid	Gas	
Liquid	Liquid	

Section B: Short Questions

1. Explain the solute-solvent interaction to prepare sodium chloride solution.
2. Differentiate between the saturated and unsaturated solution?
3. Define solution and explain the major components of solution?
4. What do you mean by mass/volume percent ?
5. Define with example one molar solution.
6. Why does colloidal show Tyndall effect?
7. Define the terms
   i. Dilution ii. Concentration iii. Solubility iv. Molarity
8. Polar and ionic solutes dissolve in polar solvent only. Why?
9. Why does Polar solute not dissolve in nonpolar solvent?
10. How are solutions beneficial for community?
11. Why salt dissolves in water?
12. Air is a solution containing oxygen, carbon dioxide, nitrogen and other gases. Which one of the gas is called solvent and why?
13. Why gasoline does not dissolve in water?

Section C: Detailed Questions

1. Describe how to prepare dilute solution from concentrated solution.
2. Define the term solubility. How does nature of solute and solvent determine the extent of dissolution?
3. Why the solubility of a salt increases with the increase in temperature?
4. Explain the attraction of Na^+ and Cl^- ions for water molecule.
5. Explain the solubility with reference to "like dissolve like" principle.
6. What is the difference between solution, colloids and suspension?

Section D: Numerical

1. What is the molarity of the solution prepared by dissolving 1.25 g of HCl gas into enough water to make 30 cm^3 of solution?
2. A solution of potassium chloride was prepared by dissolving 2.5 g of potassium chloride (KCl) in water and making the volume up to 100 cm^3. Find the concentration of solution in mol/ dm^3.
3. A flask contains 0.25 M NaOH solution. What mass of NaOH is present per dm^3 of solution?
4. What volume of 0.5M acid is needed to neutralize 200ml of 4M base?
5. A mineral water bottle contains 28 mg of calcium in 100 cm^3 of solution. What is the concentration in g/dm^3?
6. A solution of 20cm^3 of alcohol is dissolved in 80cm^3 of water. Calculate the concentration (v/v) of this solution.
7. How much sodium hydroxide (NaOH) is required to prepare 400 cm^3 of 0.3M solution?