Ratna Sagar

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9

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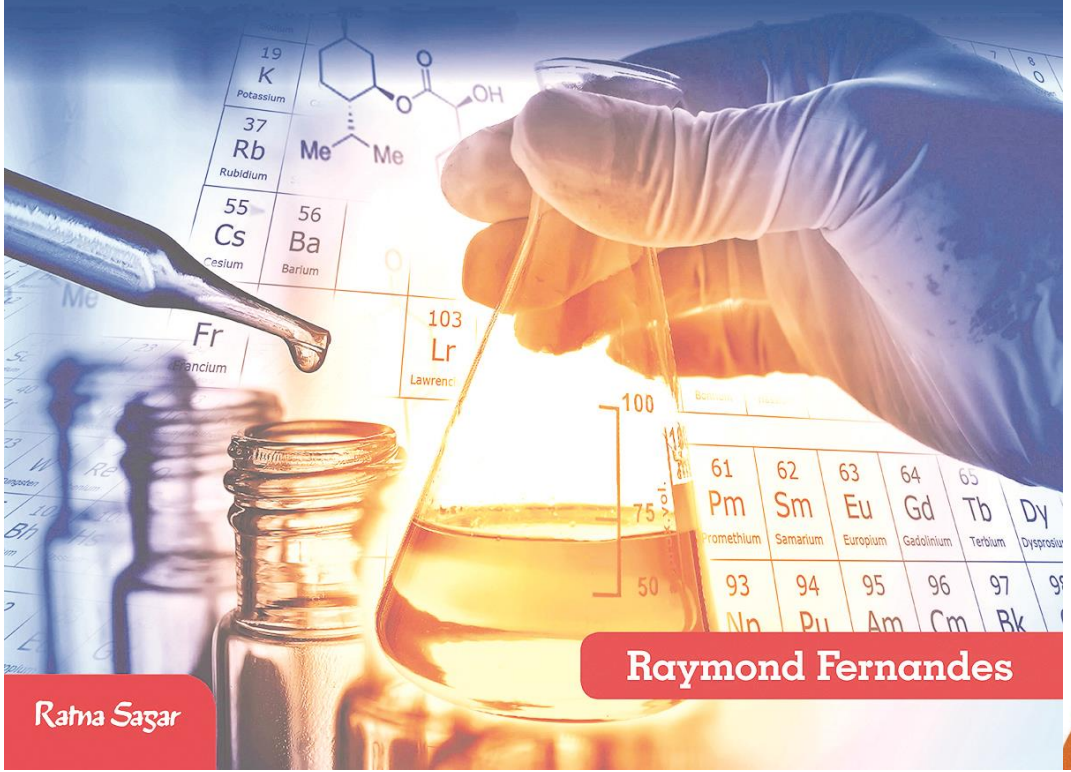
Living Science CHEMISTRY



Raymond Fernandes

Ratna Sagar

ICSE
Living Science
Chemistry

Class 9

Chapter 3 Water

LEARNING OBJECTIVES

Solutions as Mixtures of Solids in Water

- ❖Characteristics of a true solution
- ❖Types of solutions

Solubility

- ❖Solubility curve
- ❖Characteristics of Solubility Curve
- ❖Uses of solubility curve

Hydrated and Anhydrous Substances

- ❖Efflorescence
- ❖Deliquescence
- ❖Hygroscopic substances
- ❖Drying and dehydrating substances

Soft Water and Hard Water

- ❖Causes of hardness of water
- ❖Types of hardness

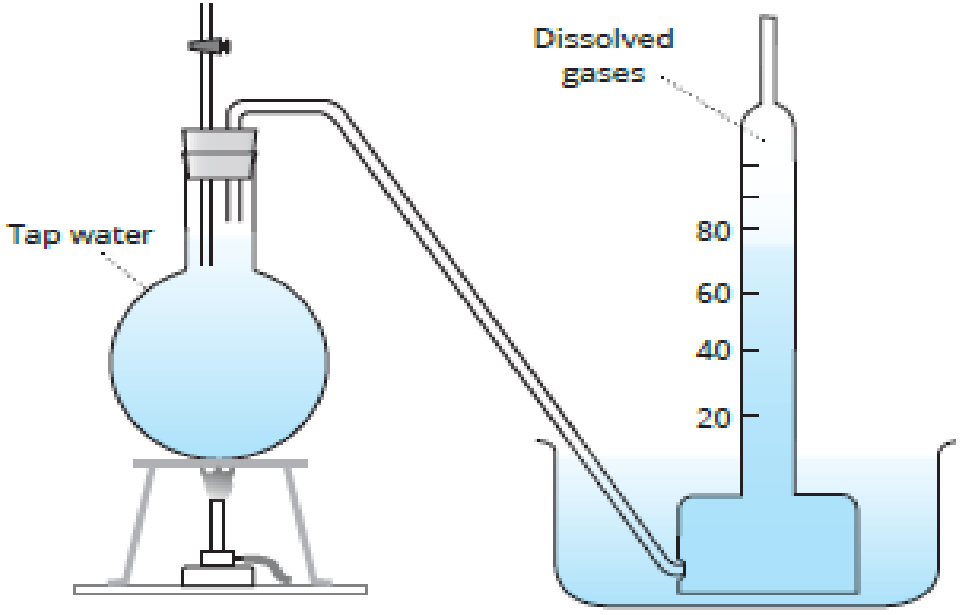
Why is Water called a Universal Solvent?

Water is a universal solvent. It dissolves most of the known substances. The exceptional solubility of water is due to its polar nature and its high dielectric constant.

Natural water contains dissolved gases.

A large percentage of these dissolved gases are oxygen, nitrogen and carbon dioxide. The composition of the dissolved gases is 34% oxygen, 65% nitrogen and about 1% carbon dioxide. The percentage of oxygen in boiled off air is more than that in normal air because the solubility of oxygen in water is greater than that of nitrogen. The percentage composition of gases varies depending on the sample of water.

To remove the dissolved gases from water, the easiest way is to boil tap water. On heating the flask the dissolved gases bubble out of water and can be collected by the downward displacement of water.



Water contains dissolved gases

The air dissolved in water has immense biological importance because:

a. Aquatic plants make use of the dissolved carbon dioxide for photosynthesis.

b. Marine life form uses dissolved oxygen for respiration.

c. Shells of marine animals such as molluscs and sea urchins are composed of calcium carbonate in the form of calcite and aragonite crystallized out in an organic matrix. Calcium carbonate is formed from dissolved carbon dioxide.

Solutions as Mixtures of Solids in Water

A solution is formed when a solid dissolves in a liquid. A solution is a homogeneous mixture of two or more substances.
The component of the solution that dissolves the other component in it is called the **solvent**. The component of the solution that is dissolved in the solvent is called the **solute**.
A solution in which a substance is dissolved in water is called an **aqueous solution**. A solution obtained by dissolving a substance in a liquid other than water is called **non-aqueous solution**.

Characteristics of a true solution

1. In a true solution, the particles of solute does not separate under gravity.

2. The solute particles cannot be removed by filtration.
3. The solute particles can be recovered from its solution in its original chemical form by changing the temperature or evaporation.
4. The properties of the solution show close resemblance to those of the solute and the solvent.

Type of solutions

Saturated solution

Every solvent has a capacity to which it can dissolve a solute, at a given temperature. A solution, which will dissolve no more of the solute at a given temperature, irrespective of how long the solute is in contact with the solvent, is called a **saturated solution**.

Unsaturated solution

An unsaturated solution is a solution that can dissolve more of the solute at a given temperature.

Supersaturated solution

A solution that contains more solute than is present in the saturated solution for the same quantity of the solvent is termed as a **supersaturated solution**.

Concentration of solution

The **concentration** of a solution may be defined as the amount of solute present in a given amount (mass or volume) of solution or the amount of solute dissolved in a given mass or volume of a solvent.

1. Solid in liquid solutions: For solutions, in which solid solute is dissolved in liquid solvent, concentration can be expressed in mass percentage or mass by volume percentage.

a. Mass percentage: It is defined as the mass of the solute in grams dissolved in 100 grams of the solution.

$$\text{Mass percentage of solution} = \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 100$$

$$= \frac{\text{Mass of solute}}{(\text{Mass of solute} + \text{Mass of solvent})} \times 100$$

b. Mass by volume percentage: It is defined as the mass of the solute in grams dissolved in 100 millilitres or 100 mL of the solution.

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

2. Liquid in liquid solutions: If a solution is prepared by dissolving a liquid solute in a liquid solvent, then the concentration of the solution is expressed in volume percentage.

Volume percentage of the solution is defined as the volume of the solute in millilitres which is dissolved in 100 mL of the solution.

$$\text{Volume percentage} = \frac{\text{Volume of solute in ML} \times 100}{\text{Volume of solution in mL}}$$

Solubility

The **solubility** of a solid in a given solvent is defined as the number of grams of the solute required to saturate 100 g of the solvent at a particular temperature. The factors that affect solubility of a solid in a solvent are as follows:

1. The nature of the solute and the solvent: Polar solvents can generally dissolve solutes that are ionic whereas, non-polar substances will dissolve in non-polar solvents.

2. Temperature: Generally an increase in the temperature of the solution increases the solubility of the solute.

3. Pressure: The solubility of solids in liquids or liquids in liquids does not change significantly with change in pressure.

The factors affecting the rate of dissolution are:

1. Particle size:
2. Stirring:
3. Amount of solute already dissolved:
4. Temperature:

Solubility curve

The relation between the solubility and the temperature can be plotted on **solubility–temperature** curve. This curve is also known as the **solubility curve**. The solubility curve shows variation of solubility with temperature.

Characteristics of the solubility curve

1. The curve plots the changes of the solubility of a solid at different temperatures in a solvent.
2. The variations in temperature are plotted on the X-axis.
3. The solubility is plotted on the Y-axis.

Uses of the solubility curve

1. It helps compare the solubilities of different solutes at any given temperature.
2. The knowledge of the solubility curves of different substances aids in fractional crystallisation.

These energy changes appear in the form of evolution or the absorption of heat, light, etc.

Internal Energy

The internal energy of a substance is the sum total of its kinetic energy and potential energy of its molecules.

$$\mathbf{E} = \text{K.E.} + \text{P.E.}$$

The internal energy is different for different substances. Hence, the internal energy of the reactants [$\mathbf{E_r}$] is different from the internal energy of the products [$\mathbf{E_p}$].

The change in internal energy for a reaction is therefore the difference between $\mathbf{E_p}$ and $\mathbf{E_r}$, i.e. $\Delta\mathbf{E} = \mathbf{E_p} - \mathbf{E_r}$

The heat content or enthalpy of a system

When chemical reactions are performed in an open system it means that these reactions are taking place at constant pressure. Under such conditions the enthalpy of a system denoted by **H** is the sum of the internal energy of the system and the product of the pressure and volume.

The change in enthalpy of a system is the amount of heat exchanged with the surroundings and is represented by $\Delta\mathbf{H}$, i.e.

3. A discontinuity in the solubility curve indicates that two different substances are involved.
4. The solubility of a solute can be determined at a particular temperature with the help of the curve.

Hydrated and Anhydrous Substances

A crystalline substance that contains a definite number of water molecules is called a **hydrated substance**. The water molecules that form part of the structure of a crystalline substance are called **water of crystallisation**. When the crystalline substance loses its water of crystallisation, it becomes amorphous. The substances which have lost their water of crystallisation are called **anhydrous substances**.

Efflorescence

The phenomenon in which a substance, on exposure to air, loses a part or whole of their water of crystallization is called **efflorescence**. Due to efflorescence, the substance loses its crystalline shape and crumbles into a powder. Substances which exhibit efflorescence are called **efflorescent substances**. Washing soda, $Na_2CO_3 \cdot 10H_2O$; Glauber's salt, $Na_2SO_4 \cdot 10H_2O$ and blue vitriol, $CuSO_4 \cdot 5H_2O$ are some examples of efflorescent substances.

Deliquescence

Certain water soluble substances when exposed to air absorb sufficient moisture from the air to completely dissolve in it and form a saturated solution. These substances are said to be **deliquescent** and the property is called **deliquescence**. Some examples of deliquescent substances are caustic soda (NaOH), caustic potash (KOH)

Hygroscopic substances

The substances which when exposed to the atmosphere at ordinary temperature absorb moisture from atmosphere without dissolving in it are called **hygroscopic substances**. Some examples of hygroscopic substances are calcium oxide (CaO), concentrated sulphuric acid (H_2SO_4).

Drying and dehydrating agents

Substances which can readily absorb moisture from other substances without reacting chemically with them are called **drying agents**. Drying agents are also called **dessicants** or **dessicating agents**. Some examples of drying agents are anhydrous zinc chloride, anhydrous calcium chloride, magnesium sulphate. **Dehydrating agents** are substances which can remove even the chemically combined water molecules from the compounds. For example, conc. sulphuric acid is a dehydrating agent.

Soft Water and Hard Water

Depending upon the behaviour of water towards soap solution with respect to lather formation, it may be classified into the following two categories.

a. Soft water: Water which produces lather with soap readily is called soft water.

b. Hard water: Water which does not produce lather with soap readily is called hard water.

Causes of hardness of water

The hardness of water is due to the presence of hydrogen carbonates, chlorides and sulphates of calcium and magnesium. These salts get dissolved in water as it flows on the surface of the earth.

Types of hardness

The hardness of water is of two types.

Temporary hardness: Temporary hardness of water is due to the presence of soluble hydrogencarbonates of calcium and magnesium in it.

Permanent hardness : Permanent hardness of water is due to presence of soluble chlorides and sulphates of calcium and magnesium in it.

Removal of hardness

a. By boiling: The temporary hardness of water can be removed by boiling the hard water. During boiling, the hydrogencarbonates of calcium and magnesium decompose to give carbon dioxide and insoluble carbonates. The insoluble carbonates are precipitated and can be removed by filtration.

$$Ca(HCO_3)_2 \longrightarrow CaCO_3\downarrow + CO_2\uparrow + H_2O$$

$$Mg(HCO_3)_2 \longrightarrow MgCO_3\downarrow + CO_2\uparrow + H_2O$$

b. By addition of washing soda (sodium carbonate):

Permanent hardness cannot be removed by boiling. One of the methods is by treating with washing soda. Washing soda reacts with soluble calcium and magnesium chlorides and sulphates in hard water to form insoluble carbonates which get precipitated.

$$CaCl_2 + Na_2CO_3 \longrightarrow CaCO_3\downarrow + 2NaCl$$

$$MgCl_2 + Na_2CO_3 \longrightarrow MgCO_3\downarrow + 2NaCl$$

$$CaSO_4 + Na_2CO_3 \longrightarrow CaCO_3\downarrow + Na2SO_4$$

$$MgSO_4 + Na_2CO_3 \longrightarrow MgCO_3\downarrow + Na2SO_4$$

SUMMARY...

1. **Solution:** A homogeneous mixture of two or more substances.
2. **Solute:** The component of the solution that is dissolved in the solvent.
3. **Solvent:** The liquid in which the solid dissolves.
4. **Saturated solution:** A solution that can dissolve no more of the solute at a given temperature.
5. **Unsaturated solution:** A solution that can dissolve more of the solute at a given temperature.
6. **Supersaturated solution:** A solution that contains more solute than is present in the saturated solution for the same quantity of the solvent.
7. **Concentration of a solution:** Amount of solute present in a given amount (mass or volume) of solution or the amount of solute dissolved in a given mass or volume of a solvent.
8. **Solubility:** The solubility of a solid in a given solvent is defined as the number of grams of the solute required to saturate 100 g of the solvent at a particular temperature.
9. **Factors that affect solubility:** Nature of the solute and the solvent; temperature, pressure.

10. The rate of dissolution is affected by particle size, stirring, amount of solute already present in the solution and temperature.

11. Solubility curve: The curve on which the variations of solubility with temperature are plotted.

12. Hydrated substance: A crystalline substance that contains a definite number of water molecules.

13. Water of crystallisation: The water molecules that form part of the structure of a crystalline substance.

14. Anhydrous substance: A substance which has lost its water of crystallisation.

15. Efflorescence: The phenomenon in which a substance, on exposure to air, loses a part or whole of their water of crystallisation.

16. Efflorescent substances: Substances which exhibit efflorescence.

17. Deliquescence: Substances which when exposed to air absorb sufficient moisture from air to completely dissolve in it to form a saturated solution.

18. Hygroscopic substances: Substances which when exposed to the atmosphere at ordinary temperature absorb moisture from atmosphere without dissolving in it.

19. Drying agents: Substances which can readily absorb moisture from other substances without reacting chemically with them.

20. Dehydrating agents: Substances which can remove even the chemically combined water molecules from the compounds.

21. Soft water: Water which produces lather with soap readily.

22. Hard water: Water which does not produce lather with soap readily.

23. The hardness of water is due to the presence of hydrogencarbonates, chlorides and sulphates of calcium and magnesium.

24. Temporary hardness: Hardness due to the presence of soluble hydrogencarbonates of calcium and magnesium.

25. Permanent hardness: Hardness due to the presence of soluble chloride and sulphate of calcium and magnesium.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