Class – 9

Sub. – Chemistry

Chapter–3

Water

Water is considered as one of the four elements of nature without which life cannot survive. Plants, animals, humans and other organisms are dependent on water for nourishment. Consuming enough water for land-based life is important to keep their bodies in optimum working condition. Humans use water for a variety of purposes like drinking, cooking, cleaning, bathing, ritual purposes etc.

In its purest form, water is tasteless, odourless ad colourless and you can find water in its varied form of solids, liquids and gas. The molecular formula of water is H_2O.
In this lesson, you will learn about the physical and nature of water and its different properties

Why is water considered a compound?

Water is a considered a compound, as it is a combination of two hydrogen atoms and one oxygen

atom. Water is also considered an amphoteric, meaning it acts both as an acid and a base as it produces H+ and OH- ions by self-ionisation. As a chemical compound, its properties are:

- **In a water molecule, hydrogen and oxygen are combined in a fixed ratio by mass (1:8).**
- **Components cannot be separated by physical means.**
- **It has a definite and constant composition.**
- **It has definite and constant melting point, boiling point, freezing point and density.**
- **Properties of water are different from properties of constituent elements.**
- **Water can react with metals to form the corresponding hydroxides. The ease with which the reaction occurs depends on the position of the metal in the reactivity series.**
  - **The reactivity series has metals arranged in order of reactivity from highest to lowest.**

Why is water called an universal solvent?

Water is called the universal solvent since it is capable of dissolving a variety of different substances more than any other liquid.

From a biological point of view, this is important for living organisms, as water is capable of transporting nutrients and minerals from the surrounding elements into their bodies and inside their bodies as well.

Water can dissolve more substances than any other compound because of its polar nature. The water molecules because of their composition – hydrogen with a positive charge on one side and oxygen with a negative charge on another, are able to attract other molecules easily.

Water of crystallisation: When crystals of certain salts are formed, they do so with a definite number of molecules of water that are chemically combined in a definite proportion. Water of crystallisation is defined as the number of water molecules, chemically combined in a definite molecular proportion, with the salt in its crystalline state. This water is responsible for the geometric shape and colour of the crystals. Hydrate: A substance containing water of crystallisation is called a hydrous substance or a hydrate. This water can be expelled, by heating, and then the salt is said to have become anhydrous. Examples of hydrated salts include:

- **$CuSO_4$. 5H2O(copper sulphate)**
- **FeSO4.7H2O(ferrous sulphate)**
- **Na2CO3.10H2O(sodium carbonate)**

Physical Properties of water

Property	Value/characteristic	Behaviour of water
Colour	Colourless	Water bodies appear blue due to scattering of light.
Odour	Odourless	
Taste	Tasteless	Taste of water may be due to dissolved salts.
Melting point/freezing point	0°C under normal pressure	↑ Pressure, ↓ Melting point

Boiling point	**100°C at normal pressure**	**↑ Pressure, ↑ Boiling point (Water boils at lower temperatures at high altitudes where pressure is low.)**
Density	**At 4°C, maximum density- 1g/cm3 or 1000kg/m3**	**Water expands on freezing, so ice floats on water. Water contracts when cooled, but expands from 4°C to 0°C. This allows for life in water under**

		a frozen water layer.
Specific heat	**1 cal/g/°C**	**High compared to other substances so used as a coolant. Water bodies can modify climate.**
Latent heat of fusion	**80cal/g**	**High value does not allow sudden solidification of water bodies.**
Latent heat of vaporization	**540cal/g**	**Steam causes more burns than boiling water.**

Conduction	**Non-conductor in pure form**	**When salts are dissolved, water forms ions and conducts electricity.**
Solvent	**High solvent properties, high dielectric constant**	**Its polar nature makes water an universal solvent.**

What does drinking water contain?

By its own nature, pure water is as tasteless and odourless, although it becomes contaminated easily because of its high solubility. Water can acquire a taste, odour and colour because of the following reasons:

- **Water in nature is generally mixed with different minerals from different sources such as earth, industrial effluents, animal and plant matter etc making it salty or putrid.**
- **Drinking or potable water is infused with many substances to make it safe for drinking and other uses giving it a particular taste.**

Water contains air and salts in dissolved states.

- **Importance of dissolved salts:**
  - **Supply all living organisms (most importantly plants) with nutrients, minerals.**
  - **Add taste to water.**
- **Importance of dissolved air: Marine life depends on:**
  - **Dissolved oxygen for breathing.**
  - **Dissolved carbon dioxide for photosynthesis and shell formation**

Chemical Properties of Water

Sodium and potassium	**React violently with cold water.** **Highly exothermic reaction.** **Released hydrogen immediately catches fire.** **$K + H_2O \rightarrow 2KOH + H_2\uparrow + heat$** **$Na + H_2O \rightarrow 2NaOH + H_2\uparrow + heat$**
Calcium	**Less violent reaction with water, the heat evolved is not enough for H_2 to catch fire.** **$Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2\uparrow$** **Ca starts floating as bubbles of H_2 stick to metal surface**
Magnesium	**Reacts with hot water, starts floating due to**

	H2bubbles sticking to it. **$Mg + 2H_2O \rightarrow Mg(OH)_2 + H_2\uparrow$**
Aluminium, Zinc, Iron (reversible reaction with steam)	**React with steam to form oxide and hydrogen** **$2Al + 3H_2O \rightarrow Al_2O_3 + 3H_2\uparrow$** **$Zn + H_2O \rightarrow ZnO + H_2$** **$3Fe + 4H_2O \leftrightarrow Fe_3O_4 + 4H_2\uparrow$**
Copper, Gold, Platinum	**No reaction with water**

Solutions

Definitions: The following are the definitions of terms that are commonly used with respect to solutions and solubility.
Solute: The substance that dissolves to form a solution.
Solvent: The substance in which a solute dissolves.
Solution: The fluid formed when the solute dissolves in a solution.

- **Solution = Solvent + Solute**

Saturated solution: When a solution cannot dissolve any more of the given solute at that temperature, it is called saturated solution.

Unsaturated Solution: A solution which contains less amount of solute than is required to saturate it at that temperature.

Supersaturated Solution: A solution that is more concentrated than a saturated solution is known as a super saturated solution. If a crystal of a solute is added to this solution, the excess solute crystallises.

Concentration of a Solution: Is the amount of solute dissolved in a given amount of solvent. It is expressed as:

- **Mass percent: {Mass of solute/mass of solution (solvent + solute)} x 100**
- **Volume percent: {Volume of solute/ volume of solution (solvent + solute)} x 100**

Solubility

Solubility is the property of a solid, liquid or gaseous chemical substance called as the solute to dissolve in a solid, liquid, or a gaseous substance called solvent. The solubility of a substance depends on factors such as physical and chemical properties of

the solute and solvent, temperature, pressure and the pH of the solution.

Solubility curves

Solubility: It is the quantity of a particular substance that can dissolve in a particular solvent to give a saturated solution. It varies for different solutes.

Some salts may also be insoluble in water. Generally, the solubility of a salt increases with increase in temperature. For example,

- **Potassium nitrate: As temperature increases, solubility increases.**
- **Sodium chloride: No significant change in solubility with an increase in temperature.**
- **Calcium sulphate: Solubility increases then decreases as temperature increases.**

Water of crystallization :- Water molecules present in the crystals of a substance is called water of crystallization.

Deliquescence :-Deliquescence is the process by which a substance absorbs moisture from the atmosphere until it dissolves in the absorbed water and forms a solution.

Examples of deliquescent substance – NaOH, KOH, $ZnCl_2$ etc.

Hygroscopic substance :- Certain substance absorb moisture from the atmosphere when they are exposed to it. Such substances are called hygroscopic substances.

Example – conc. H_2SO_4, P_2O_5, CaO.

Drying agent :- These are the substances that can readily absorb moisture from other substances without chemically reacting with them.

Dehydrating agent :- These are the substances that can remove even the chemically combined water molecules from compounds.