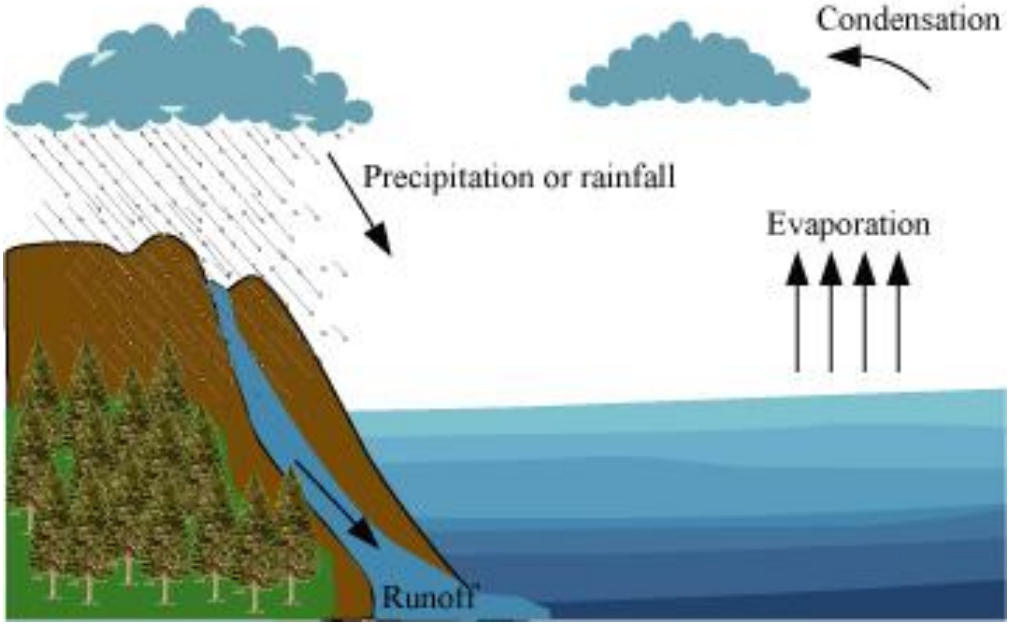
Water

- **Water Cycle**: The circulation of water between water bodies, lands and clouds is known as water cycle.



  - The change of water into its vapour is known as **evaporation**.
  - The change of vapour back into water is known as **condensation**.
  - Fall of water from clouds is known as **precipitation** or **rainfall**.
  - **Runoff** is the process by which rain water returns back to the water bodies.

- **Clouds** are formed during the process of condensation.
- Rain, snow, hail, etc. replenish rivers, lakes, and wells and recharge the ground water.

1. Water is present in three forms.

2. Solid form − snow and ice
3. Liquid form − oceans, lakes, rivers, and underground water
4. Gaseous form − water vapour in the atmosphere
5. The three forms of water circulate through the water cycle and keep the total amount of water constant on the earth.

- In free state, water occurs in solid, liquid, and gaseous state while in combined state, it is found in proteins, carbohydrates, etc.
- It is colourless, odourless, and tasteless.
- It boils at 100°C and freezes at 0°C.
- Pure water is a poor conductor of electricity. It has high latent heat of vaporisation and fusion and specific heat capacity.
- Water is a universal solvent as it dissolves maximum number of substances.
- It is stable to heat.
- Water has anomalous expansion property, i.e. it expands on cooling below 4 ^{0}C and it has maximum density at 4 ^{0}C

- **Experiment to Show the Presence of Dissolved Solids in Tap Water**

  Take some tap water in a beaker and heat it. Place a watch glass over the beaker and raise the edge of the watch glass from one side by placing a folded paper. Then pour about 10 mL of tap water into the watch glass. The steam produced from the boiling beaker water starts evaporating the water in the watch glass slowly. As the water evaporates slowly, the dissolved solids deposit and as a result, the concentric rings of the solid materials are formed. The dissolved salts in water are important because they provide taste to water and some of them are also required by our body.

- **Experiment to Show the Presence of Dissolved Gases in Tap Water**

  Take some tap water in a round bottom flask. Fix a cork fitted with a delivery tube in mouth of the flask. The lower end of the delivery tube

should be in line with under-surface of the cork. Its other end should be in the beehive shelf, placed in a trough of water. Heat the water in the round bottom flask. Water starts boiling and the gas bubbles start coming out of the beehive shelf. Invert a graduated tube completely filled with tap water over the beehive shelf. The boiled-off air starts collecting in the tube by replacing water.

Collect the tube filled with boiled off air and introduce a glowing splinter in it. The glowing splinter will burst into flame. It can be concluded that oxygen is dissolved in water. Similarly, gases such as nitrogen, carbon dioxide are dissolved in water. Dissolved oxygen and carbon dioxide in water is important because of the following reasons:

- **Oxygen** is required by animals living in water during their respiration. It helps to keep water purified by killing germs and bacteria.

- **Carbon dioxide** is required by water plants during photosynthesis.

- Dissolved carbon dioxide reacts with limestone to form soluble calcium carbonate, which is used by animals living in water to form hard shells for the protection of their soft bodies.
- Pure water can be obtained by the process known as distillation.
- Water obtained form distillation process is known as distilled water and is free from any salts and minerals.
- Distilled water should not be used in drinking purpose.

- **Concentration of solution**= Solute amount / Solvent amount
  - Mass by mass percentage = $\frac{\text{Solute mass}}{\text{Solution mass}} \times 100$
  - Mass by volume percentage = $\frac{\text{Solution mass}}{\text{solution volume}} \times 100$

Expressing Concentration of Solutions

- Mass percentage (*w*/*w*)

Mass % of a component = $\frac{\text{Mass of the component in the solution}}{\text{Total mass of the solution}} \times 100\%$

- Volume percentage (*v*/*v*)

Volume % of a component = $\frac{\text{Volume of the component}}{\text{Total volume of solution}} \times 100\%$

- Mass by volume percentage (*w*/*v*)

ss by volume % = $\frac{\text{Mass of the solute}}{\text{Total volume of solution}} \times 100\%$

- Parts per million (ppm)

Parts per million

$= \frac{\text{Number of parts of the component}}{\text{Total number of parts of all the components of the solution}} \times 10^6$

- Mole fraction (*x*)

Mole fraction of a component

$= \frac{\text{Number of moles of the component}}{\text{Total number of moles of all the components}}$

For solution containing *i* number of components,

$$x_i = \frac{n_i}{n_1 + n_2 + n_3 + ... + n_i} = \frac{n_i}{\sum n_i}$$

And, $x_1 + x_2 + x_3 + ... + x_i = 1$

- Molarity (M)

$$\text{Molarity} = \frac{\text{Moles of solute}}{\text{Volume of solution in litre}}$$

- Molality (m)

$$\text{Molality} = \frac{\text{Moles of solute}}{\text{Mass of solvent in kg}}$$

Solubility:

Solubility of a substance is the maximum amount of the substance that can be dissolved in a specified amount of a solvent at a specified temperature.

- **Solubility of a solid in a liquid:**

  -Effect of temperature (Le Chatelier's principle) –

  When the dissolution process is endothermic, the solubility will increase with increase in temperature.

  When the dissolution process is exothermic, the solubility will decrease with increase in temperature.

  -Effect of pressure: Pressure does not affect solubility.

- **Solubility of a gas in a liquid:**

  Henry's law → The solubility of a gas in a liquid is directly proportional to the pressure of the gas.

  Or

  The partial pressure of a gas in vapour phase (p) is proportional to the mole fraction of the gas (x) in the solution.

  $p = K_H x$

  Where, K_H → Henry's law constant

- Some applications of Henry's law –

  -The solubility of CO_2 in soft drinks and soda water is increased by sealing the bottles under high pressure.

  -At high pressure underwater, scuba divers have to cope with high concentrations of dissolved gases while breathing air.

  -At high altitudes, climbers become weak and are unable to think clearly, which are symptoms of a condition called anoxia

Effect of temperature –

With increase in temperature, the solubility of gases in liquids decreases.

- **Water of crystallisation :** It refers to a fixed number of water molecules present in one formula unit of salt.
- **Example -** In gypsum, the water of crystallisation is 2.

$$CaSO_4.\frac{1}{2}H_2O + 1\frac{1}{2}H_2O \rightarrow CaSO_4.2H_2O \ (solid)$$

(Gypsum)

- **Hydrated substances:** Substances containing water of crystallisation for example, hydrated copper sulphate ($CuSO_4.5H_2O$).
- **Anhydrous substances:** Substances either not containing water of crystallisation or from which water of crystallisation is removed, for example, sodium chloride (NaCl) and anhydrous copper sulphate ($CuSO_4$).
- **Drying agents:** Substances that absorb moisture without undergoing a chemical reaction, for example, anhydrous calcium chloride ($CaCl_2$).
- **Dehydrating agents:** Substances the remove chemically bonded water from a compound, for example, concentrated sulphuric acid (H_2SO_4).

Deliquescence

1. Substances which absorb water or moisture when exposed to the atmosphere at ordinary temperatures are called deliquescent substances and the phenomenon is known as deliquescence.

2. Solid sodium/potassium hydroxide, calcium chloride are examples of deliquescent substances.

3. Substances which are used to dry the surroundings by removing moisture from the air are called desiccants.

4. Concentrated sulphuric acid and calcium chloride are some examples of desiccants.

Efflorescence

1. Some substances, when exposed to the atmosphere, lose their water of hydration and become dry. These substances are called efflorescent substances and the phenomenon is known as efflorescence.

2. Sodium sulphate and sodium carbonate are examples of efflorescent substances.

Hygroscopy

1. Phenomenon of absorption of moisture from air upon exposure is known as hygroscopy. The substances showing this phenomenon are known as hygroscopic substances.

2. Phosphorous pentoxide (P_2O_5) and quicklime (CaO) are examples of hygroscopic substances.

(i) Water containing Ca^{2+} and Mg^{2+} ions and their salts is considered to be hard water.

(ii) Water free from Ca^{2+} and Mg^{2+} ions is called soft water.

(iii) Soft water forms lather with soap, while hard water forms insoluble scum with soap.

1.Types of hardness

(i) Hardness due to the presence of bicarbonate salts of calcium and magnesium is known as temporary hardness.

(ii) Hardness due to the presence of chloride and sulphate salts of calcium and magnesium is known as permanent hardness.

(iii) Temporary hardness can be removed by simple methods like boiling, while permanent hardness is removed by special methods.

2. Disadvantages of using hard water

(i) Causes dryness and leaves whitish residue on skin

(ii) Leaves yellow stain on clothes if used for washing clothes

(iii) Causes scales on inner walls of containers used for boiling and cooking food

3. Advantages of using hard water

(i) Enhances the taste of beverages and wines

(ii) Helps in strengthening of bones and teeth

(iii) Checks lead poisoning of water in lead water pipelines

4. Removal of hardness of water

(i) Temporary hardness can be removed by simple boiling or with Clark's method using $Ca(OH)_2$.

(ii) Permanent hardness can be removed by distillation, soda process and permutit method.

(a) Permutit is a sodium aluminium silicate, also known as zeolite.

(b) The principle of the permutit method is exchange of basic ions, Ca^{2+} and Mg^{2+}, with Na^{+} ion of the permutit.

Removal of hardness of water

(i) Boiling of hard water converts soluble bicarbonate into insoluble carbonate, which can be removed by simple filtration.

(ii) Certain metal ions like lead, iron and manganese cannot be removed by permutit method.

(iii) Water obtained from permutit method is soft water and not pure water.

(iv) Water that is free from any ions is known as distilled water.

- The addition of harmful substances to water, as a result of which its physical, chemical, and biological properties get altered, is called **water pollution.**

- **Types of water pollutants**
- **Domestic sewage**
    - It is composed of food wastes, detergents, and disease-causing pathogens.
    - The bacteria present in faecal matter of mammals indicate the pollution levels in a river and if such water is consumed, it may cause various diseases.
- **Industrial waste**
    - It is rich in toxic chemicals such as arsenic, fluorides, and lead.
    - It causes toxicity in plants and animals.
    - It affects the soil by causing changes in its acidity and growth of worms.
- **Agricultural waste**
    - It is rich in agricultural pesticides and weedicides.
    - It causes ground water pollution.
    - It causes an increase in the population of algae in water.
    - When these algae die, they are acted upon by decomposers, which use lots of oxygen dissolved in water leading to depletion of

dissolved oxygen.
    - This results in the death of fish and other aquatic organisms.

- **Release of Superheated Water**
    - The release of superheated water from some industries and nuclear power plants causes thermal pollution of the water bodies.
    - The abrupt change in the temperature of water body can kill the fish and other organisms adapted to particular temperature range.

Methods of preventing water pollution

- Industrial waste must be chemically treated to remove harmful substances before dumping into the water bodies.
- Disposal of human and animal excreta into water should be avoided.
- Sewage water must be treated before releasing into the rivers.

- **Conservation of water**
    - Reusing the waste water from the kitchen (water that has been used to wash vegetables, etc.) to water the plants in the garden
    - Turning the tap off while brushing or shaving
    - Checking for leaky taps and fixing them up
    - Rainwater harvesting
    - Using improved farming and irrigation techniques
    - Preventing pollution of water
    - Conserving and replenishing ground water
    - Proper removal of silt from water bodies
    - Preventing cutting of trees
- **Prevention of water pollution**
    - Proper treatment of industrial waste and domestic waste before their disposal into rivers.
    - Strict implementation of environmental laws in industrial units.

    - Reusing water used in kitchens (such as to wash vegetables) for watering plants.
    - Getting the leaky taps checked and preventing wastage of water.
- **Potable water**
    - Water that is fit for drinking is called potable water.
    - Methods of obtaining potable water.
- **Physical methods**
    - Sedimentation and filtration
    - Boiling of water
    - Use of domestic filters such as candle type filter
- **Chemical method**
    - Use of chlorine tablets
    - Infusion of ozone gas