

Chemicals

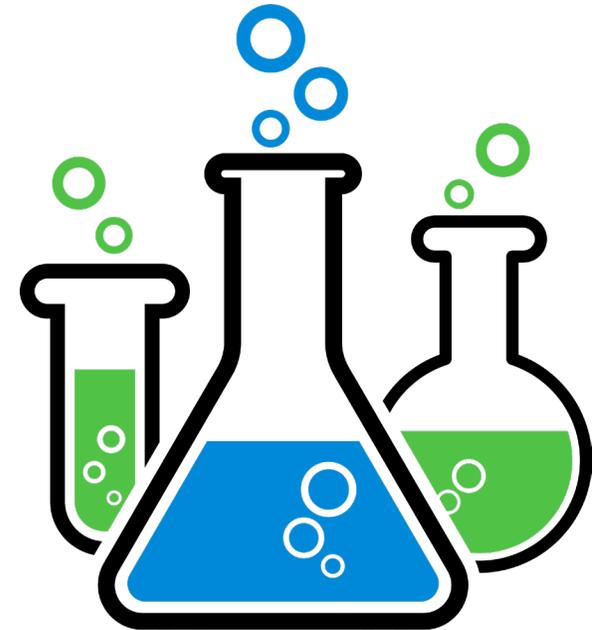


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What is a chemical?

- A chemical is any substance with a defined chemical composition that has specific physical and chemical properties.
- Chemicals can be:
 - Elements (e.g. copper, hydrogen)
 - Compounds (e.g. water, sodium chloride)
 - Mixtures (e.g. air, alloys, salt solution)
- A chemical's structure determines how it behaves:
 - Electrical conductivity
 - Reactivity with other substances
 - Solubility in liquids



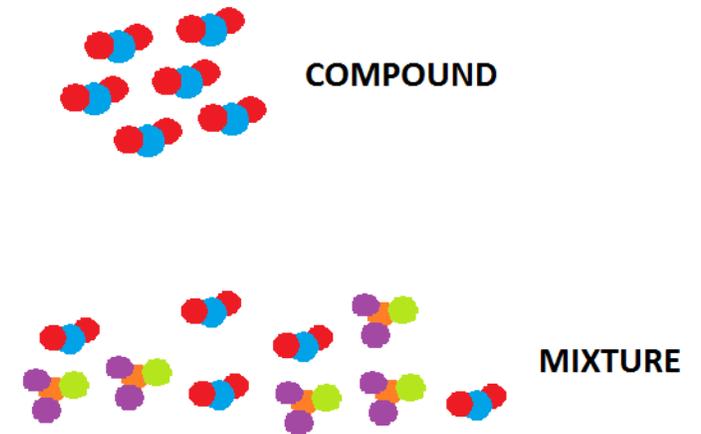
Why chemicals are important

- Engineering systems rely on chemical behaviour to function correctly
- Metals, polymers, ceramics, and composites are all chemicals
- Chemical structure affects:
 - Strength and durability
 - Corrosion resistance
 - Electrical conductivity
- Batteries and cells rely on chemical reactions to produce electricity
 - Electrolytes must be chemically suitable and soluble
 - Poor chemical selection increases internal resistance and heat



Types of Chemicals: Compound

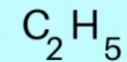
- A compound is a chemical made from two or more elements **chemically bonded** together in a fixed ratio.
- **Key features**
 - **Fixed composition**
 - New properties different from the original elements
 - Cannot be separated by physical means
- **Engineering examples**
 - Water (H_2O) – coolant, cleaning
 - Sodium chloride (NaCl) – electrolytes
 - Silicon dioxide (SiO_2) – glass, insulation



Types of Chemicals: Compound

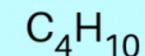
- Chemical Formula: Compounds are represented by their chemical formula.
- A chemical formula is a symbolic representation of the proportions of atoms that constitute a particular chemical compound.

Empirical Formula



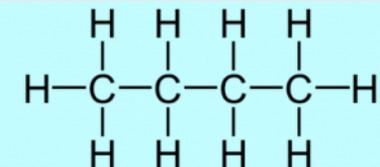
simplest whole number ratio

Molecular Formula



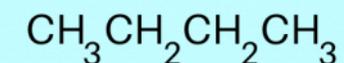
number and type of atoms

Structural Formula



graphic representation of structure

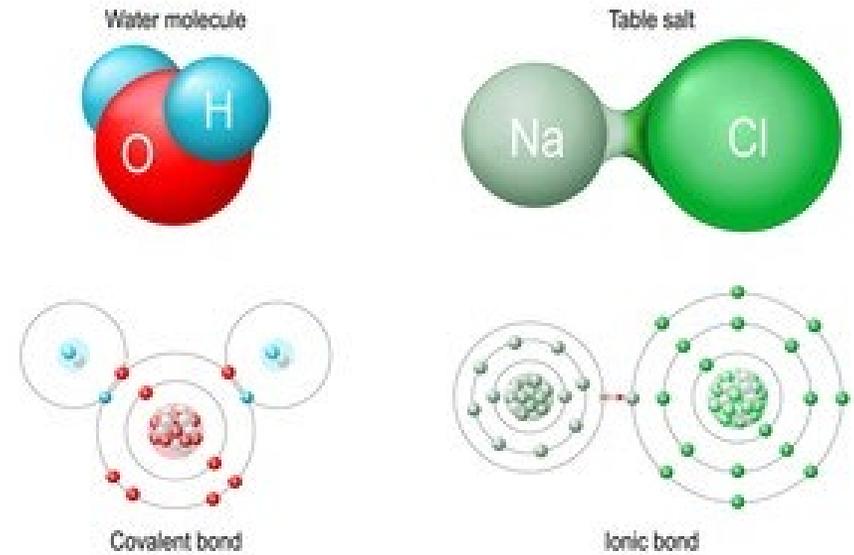
Condensed Formula



order and formula of functional groups

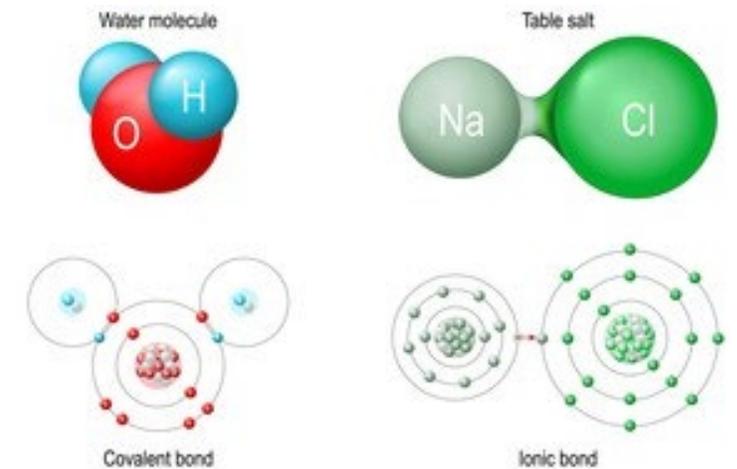
Types of Chemicals: Compound

- Compounds can be classified into two types, **molecular compounds** and **salts**:
 - In molecular compounds, the atom binds each other through **covalent bonds**. (when electrons are shared between atoms)
 - In salts, it is held together with **ionic bonds**. (when electrons are transferred from one atom to another)



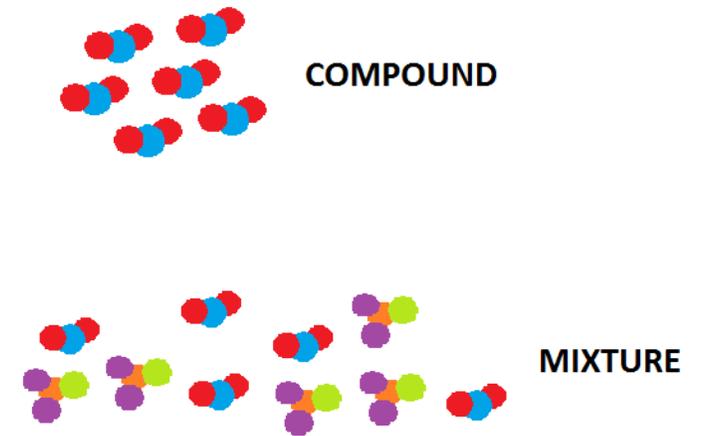
Why structure matters in engineering

- Bond type affects conductivity (ionic vs covalent)
- Molecular shape affects solubility
- Functional groups affect reactivity and corrosion
- Structure affects internal resistance in electrolytes



Types of Chemicals: Mixture

- A mixture is a combination of substances not chemically bonded.
- **Key features**
 - Variable composition
 - Components retain their properties
 - Can be separated by physical methods
- **Engineering examples**
 - Alloys (e.g. steel, brass)
 - Air
 - Oil with additives
 - Salt dissolved in water



Types of Chemicals: Mixture

- There are two main types of mixtures:
- **Homogeneous** solutions are solutions with **uniform composition** and properties throughout the solution. For example a cup of coffee, perfume, cough syrup, a solution of salt or sugar in water, etc.
- **Heterogeneous** solutions are solutions with **non-uniform composition** and properties throughout the solution. A solution of oil and water, water and chalk powder and solution of water and sand, etc.

Heterogeneous Mixture



particles distributed non-uniformly

Homogeneous Mixture



particles distributed uniformly

Types of Chemicals: Solution

- A solution is a specific type of **Homogeneous** mixture where:
 - A solute is dissolved in a solvent
 - Particles are at the molecular or ionic scale
 - The solute will not separate out
- Examples
 - Salt dissolved in water
 - Sugar in water
 - Electrolytes in batteries

Heterogeneous Mixture



particles distributed non-uniformly

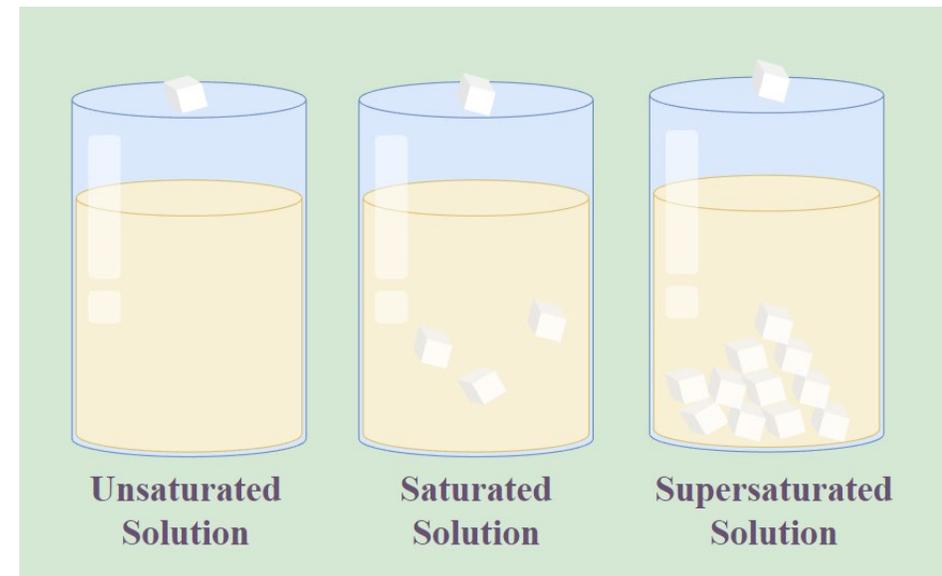
Homogeneous Mixture



particles distributed uniformly

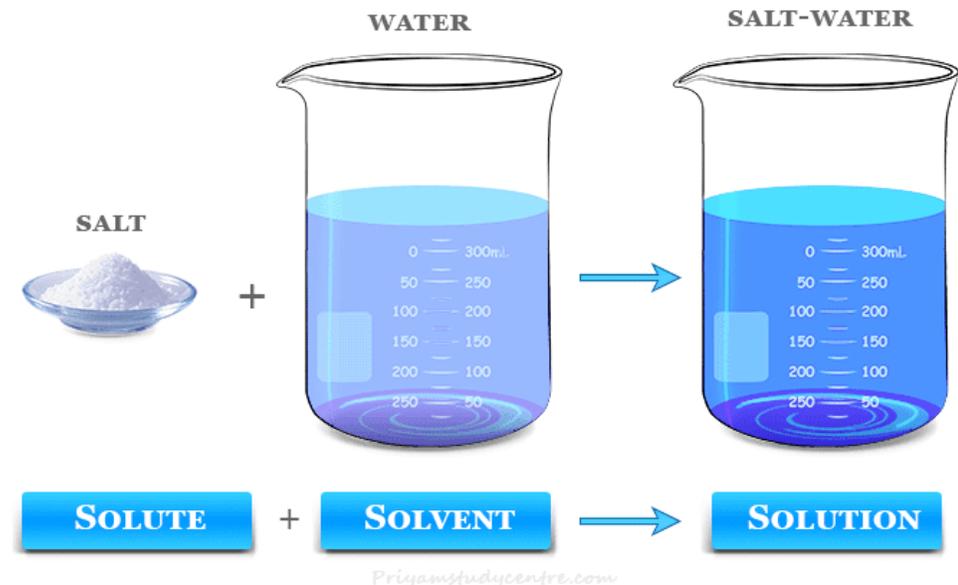
Types of Solutions – Saturation

- **A supersaturated solution** comprises a large amount of solute at a temperature wherein it will be reduced, as a result the extra solute will crystallize quickly.
- **An unsaturated solution** is a solution in which a solvent can dissolve more solute at a given temperature.
- **A saturated solution** can be defined as a solution in which a solvent cannot dissolve any more solute at a given temperature.



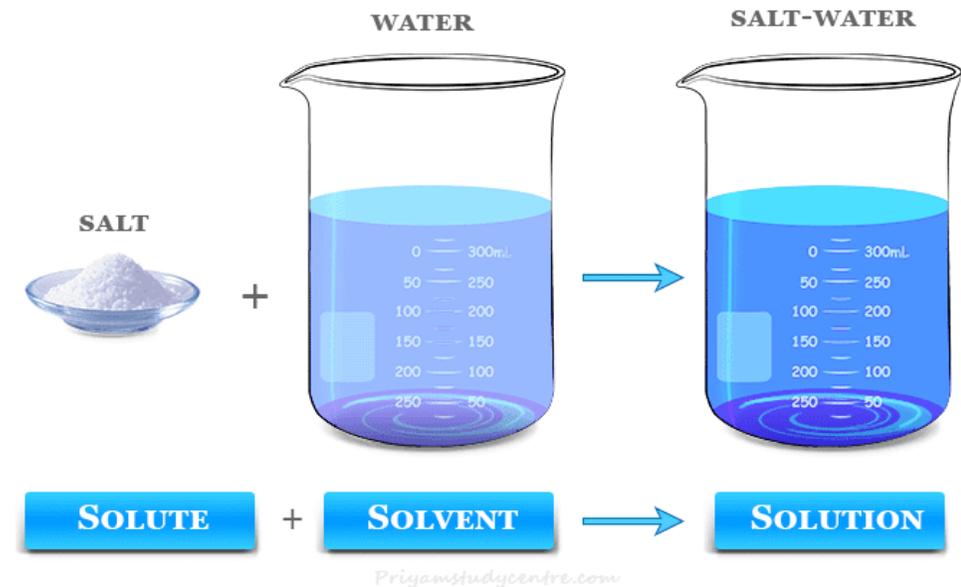
Types of Solutions – Aqueous

- **Aqueous solution** – When a solute is dissolved in water the solution is called an aqueous solution. Eg, salt in water, sugar in water and copper sulphate in water.
- **Non-aqueous solution** – When a solute is dissolved in a solvent other than water, it is called a non-aqueous solution. Eg, iodine in carbon tetrachloride, sulphur in carbon disulfide, phosphorus in ethyl alcohol.



Types of Solutions – Concentration

- A **dilute solution** contains a small amount of solute in a large amount of solvent.
- A **concentrated solution** contains a large amount of solute dissolved in a small amount of solvent.



Types of Chemicals: Suspension

- A suspension is a specific type of **Heterogeneous** mixture where:
 - Particles with a diameter greater than 1000 nm such that the particles are visible to naked eyes.
 - The particles of a suspension do not pass through a filter paper. So a suspension can be separated by filtration.
 - The suspension is unstable. The particles of a suspension settle down after some time.

- Examples

- Muddy water
- Sand particles suspended in water
- Flour in water

