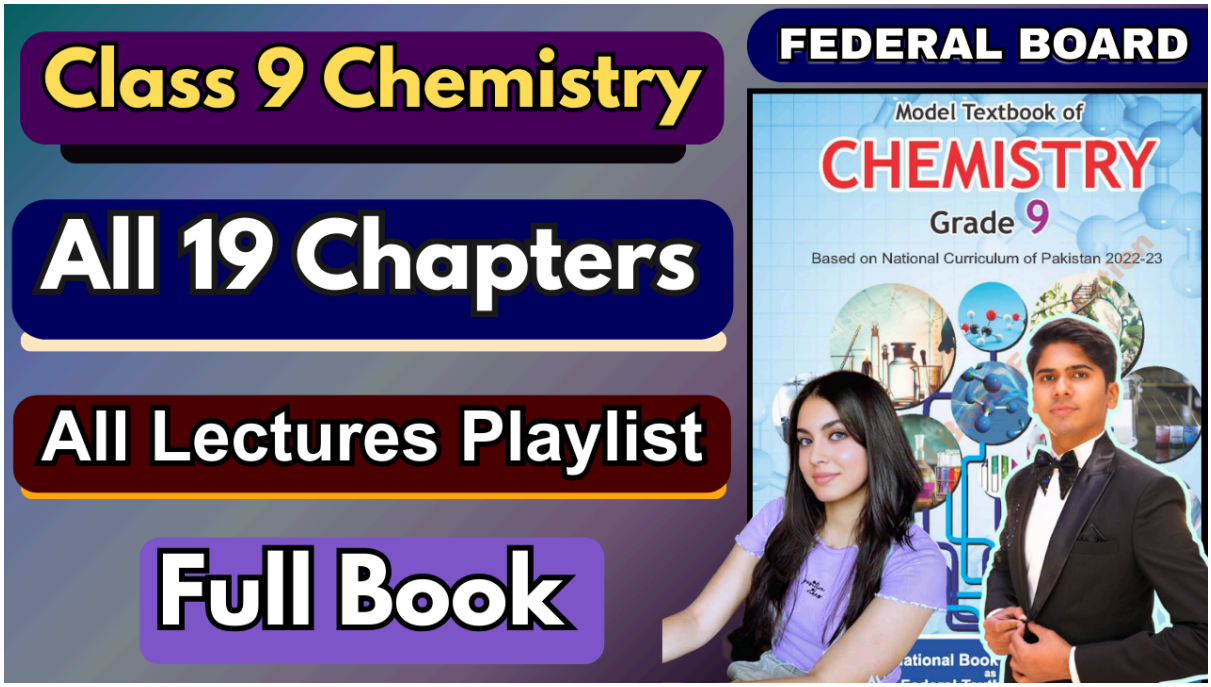
Chapter 2: Matter

All Lectures Uploaded on YouTube:

https://tinyurl.com/fkm9-chemistry



The study of chemistry revolves around the study of matter which is all around us; not only is the entire world made up of matter but so are we, so are the objects that we use. From this we can derive the definition of matter: Anything that has mass and occupies space is called matter.

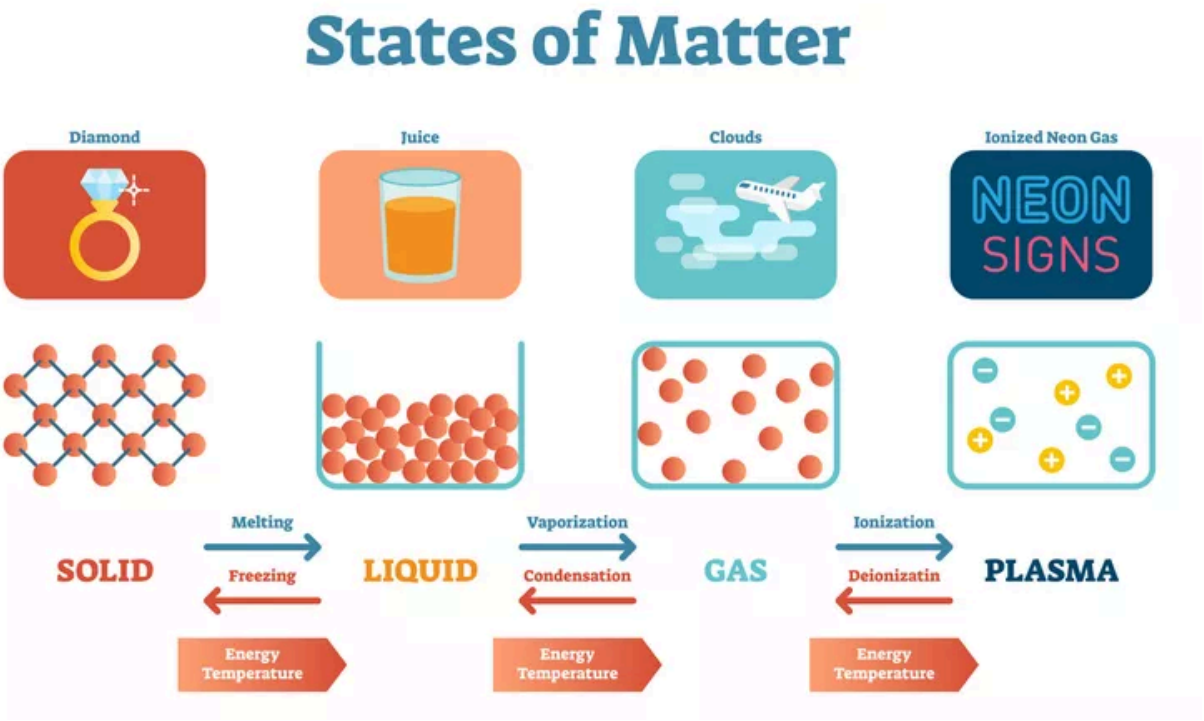
2.1. State of Matter

Matter is anything that **has mass and occupies space**. It is composed of atoms, which are the fundamental building blocks of all substances. The different materials around us appear different because atoms in matter are arranged differently.

Four States of Matter

1. **Solid**
2. **Liquid**
3. **Gas**

4. **Plasma**



Why States of Matter Differ

- States differ due to **arrangement and movement of particles** and the **strength of intermolecular forces**.
- **Energy** affects the state:

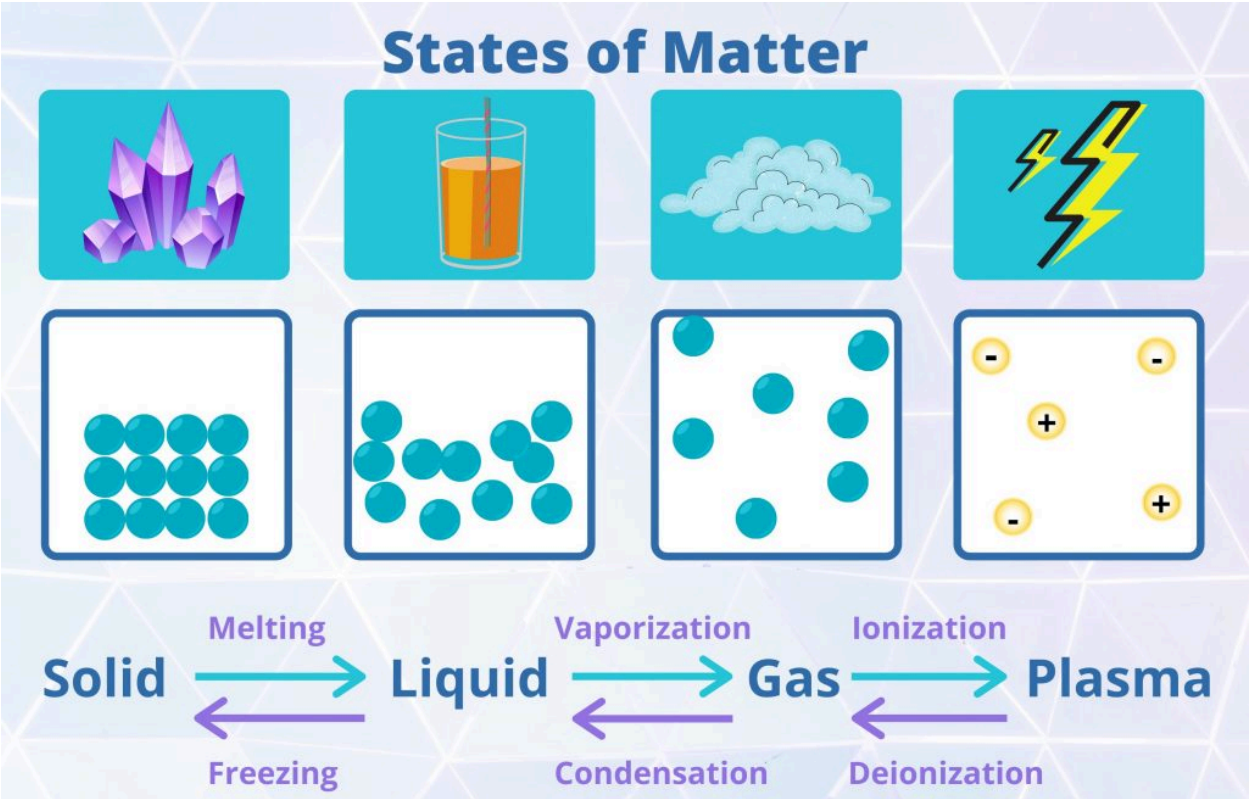
    - When heated ⟶ solids melt, liquids evaporate, gases ionize into plasma.
    - When cooled ⟶ gases condense, liquids freeze.

Additional/Modern States

- **Liquid Crystal:**

    - Formed when some crystalline solids melt into cloudy liquids that have properties of both solids and liquids.
    - Exists in a limited temperature range.

- **Bose–Einstein Condensates (BEC):**
    - Formed when atoms are cooled very close to **absolute zero**.
    - Found in superfluids and superconductors.



Macroscopic Properties of Matter (Visible to Naked Eye)

- Density
- Fluidity
- Compressibility

Properties of States of Matter (From Table 2.1)

Property	Gas	Liquid	Solid
Density	Low	High	High

Compressibility	Highly compressible	Moderately compressible	Not compressible
Fluidity	Can flow	Can flow	Cannot flow

State Interconversion

- By changing **temperature** or **pressure**, matter can change from one state to another.
- Chemical composition **remains the same** during physical changes.

2.2. Elements, Compounds, and Mixtures

Matter can be classified into:

1. Pure Substances

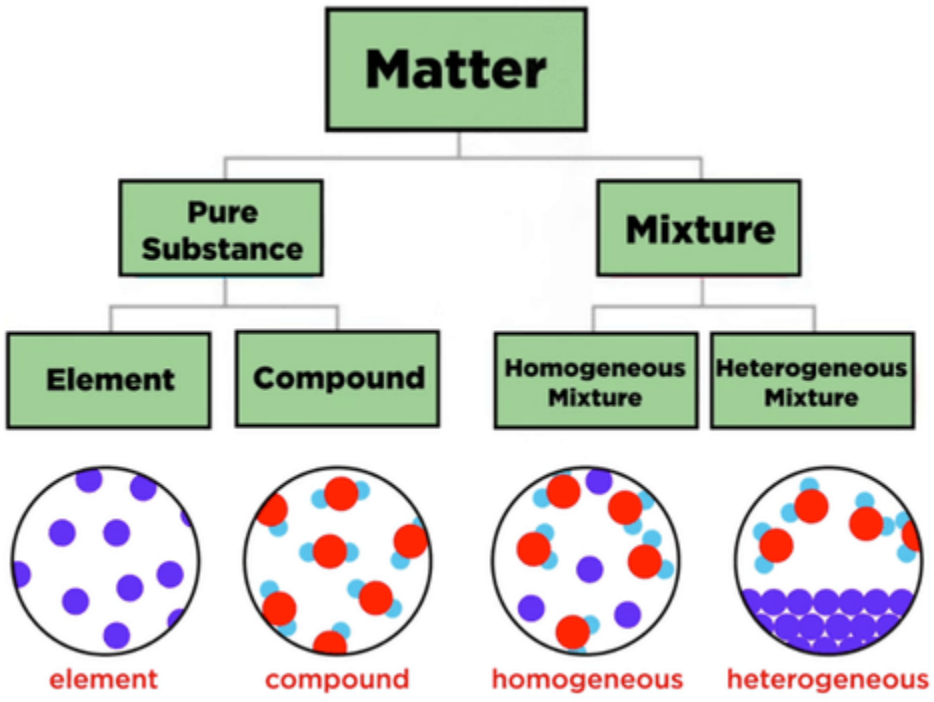
- **Elements**
    - Simplest forms of matter.
    - Made of atoms with the **same atomic number** (proton number).
    - Cannot be broken down by chemical means.
    - Example: Carbon, Hydrogen.
- **Compounds**
    - Formed when **two or more elements chemically combine**.
    - Properties are entirely different from the elements that form them.
    - Example: Water (H_2O), Carbon dioxide (CO_2).

2. Mixtures

- Physical combinations of substances.
- Components retain their **individual chemical properties**.

Types:

1. **Homogeneous Mixtures (Solutions)**
    - Uniform composition throughout.
    - Example: Salt water.
2. **Heterogeneous Mixtures**
    - Non-uniform composition.
    - Two important types:
        - **Colloids**
        - **Suspensions**



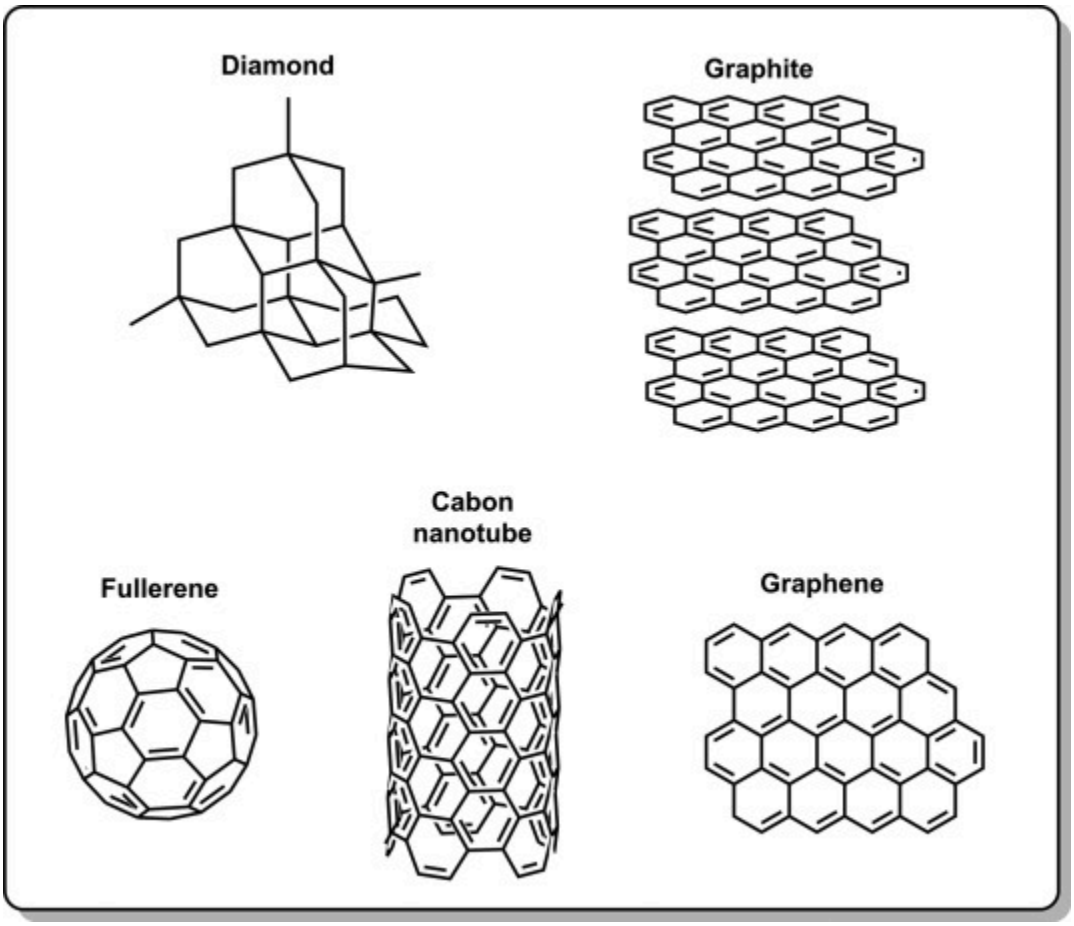
2.3. Allotropes

Allotropy:

The ability of an element to exist in **different physical forms** in the same physical state.

These forms are called **allotropes** and have different arrangements of atoms.

Important Allotropes of Carbon:



Graphite

- Made of **two-dimensional layers** of hexagonally arranged carbon atoms.
- Each carbon atom is covalently bonded to **three** other carbon atoms.
- Layers are held by **weak intermolecular forces**, allowing them to slide → graphite is soft and slippery.
- **Good conductor of electricity** because of free electrons.

Diamond

- The **hardest** and **purest crystalline** allotrope of carbon.

- Each carbon atom is covalently bonded to **four** others → rigid **tetrahedral** structure.
- Very **high melting point**.
- **Non-conductor of electricity** due to absence of free electrons.

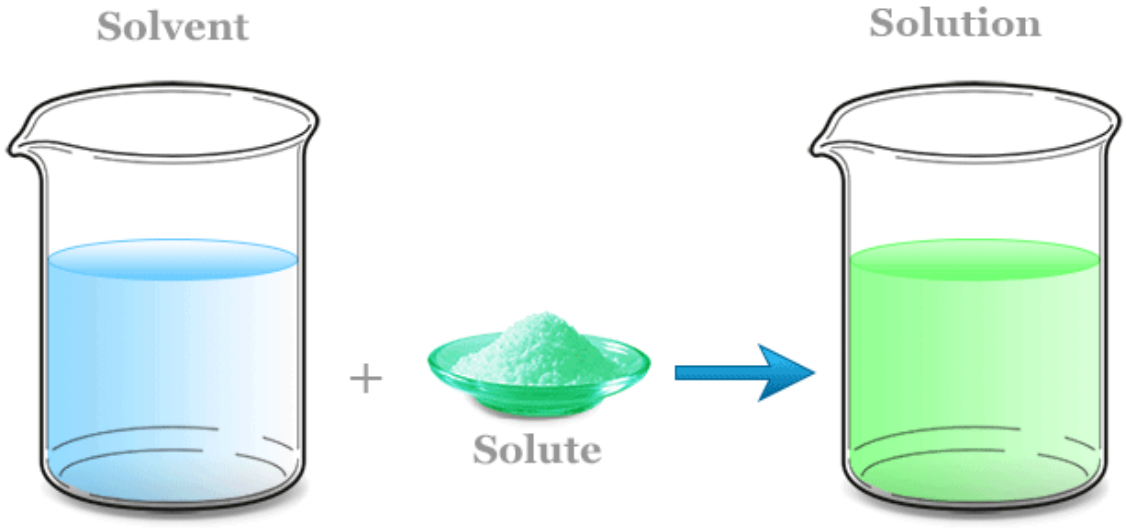
Buckyballs (C_{60} / Fullerenes)

- Hollow, football-like shape.
- Structure consists of **20 hexagons** and **12 pentagons**.
- Each carbon atom bonded to **three** others.

2.4. Solution

A **solution** is a **homogeneous mixture** of two or more substances where one substance dissolves completely in another.

- **Solute:** substance being dissolved
- **Solvent:** substance doing the dissolving
- Particle size: **< 1 nm**, microscopic
- Very stable; solute does not settle.



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Types Based on Physical State

- **Gaseous solutions**
    - Solvent is gas; solute may be gas, liquid, or solid.
    - Examples: Air, fog, smoke.
- **Liquid solutions**
    - Solvent is liquid.
    - Examples: Salt water, carbonated drinks, vinegar, sugar syrup.
- **Solid solutions**
    - Solvent is solid.
    - Examples: Alloys (brass, bronze, steel), amalgams.

2.4.1. Aqueous Solutions

- Solutions where **water is the solvent**.
- Solutes may be solid, liquid, or gas.
- Water is called the **universal solvent** because it dissolves most substances.
- Common in laboratory use.

2.4.2. Saturated Solutions

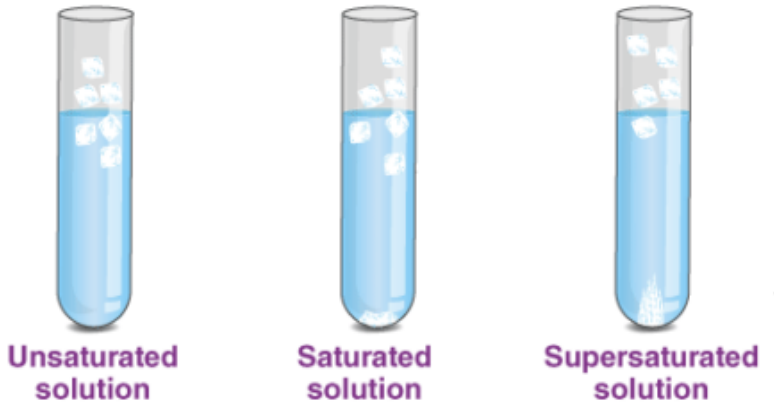
A solution that contains the **maximum amount of solute** at a given temperature.

- Additional solute **does not dissolve**; settles at the bottom.
- Dynamic equilibrium exists between dissolved and undissolved solute.

2.4.3. Unsaturated Solutions

A solution containing **less solute than its maximum capacity** at a given temperature.

- Can dissolve more solute.



2.4.5. Supersaturated Solutions

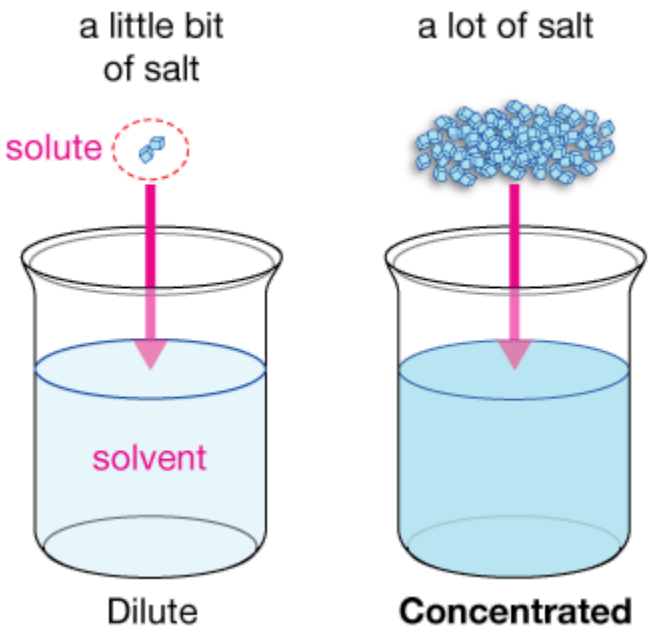
A solution that contains **more solute than a saturated solution** at that temperature.

- Formed by preparing a saturated solution at **high temperature** and then cooling it carefully.
- Unstable: crystals form when a seed crystal is added.

2.4.6. Concentrated and Dilute Solutions

- **Dilute solution:** contains a *small amount* of solute.

- **Concentrated solution:** contains a *large amount* of solute.
    - Example: Brine (concentrated NaCl solution)



- Adding more solvent → decreases concentration.

2.4.7. Solubility

Solubility = maximum amount of solute that dissolves in a **specific amount of solvent** at a **specific temperature**.

Depends on:

- Nature of solute
- Nature of solvent
- Temperature
- Pressure

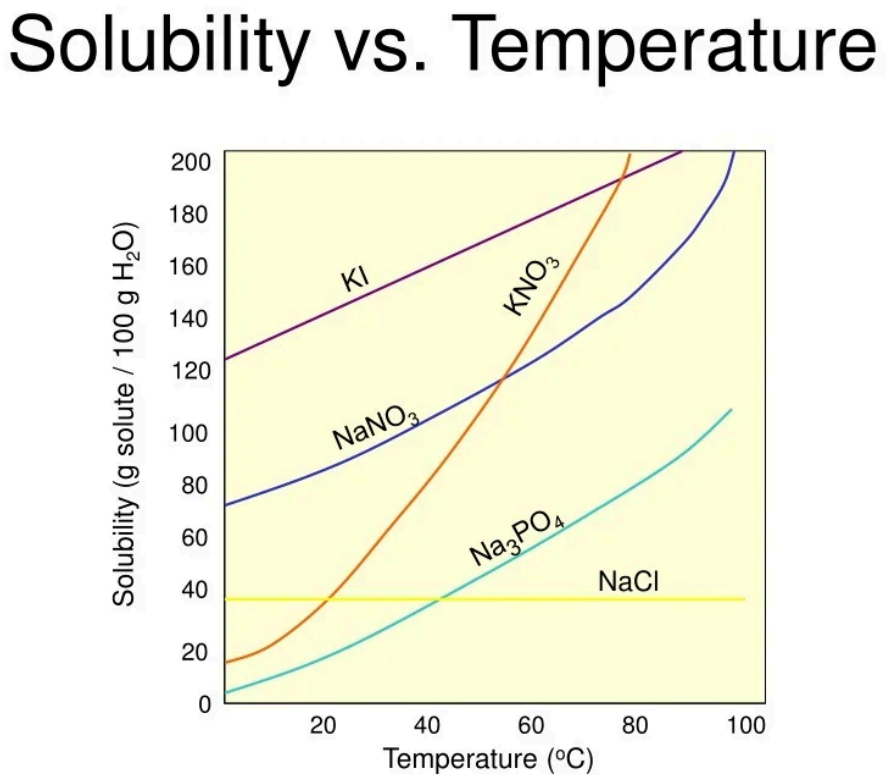
2.4.8. Effect of Temperature on Solubility

Temperature affects solubility differently for different solutes:

a) Solubility increases with temperature

Examples:

- KCl
- NH_4Cl



b) Solubility decreases with temperature

Examples:

- Na_2SO_4
- $Ca(OH)_2$

Solubility curves show how solubility varies with temperature.

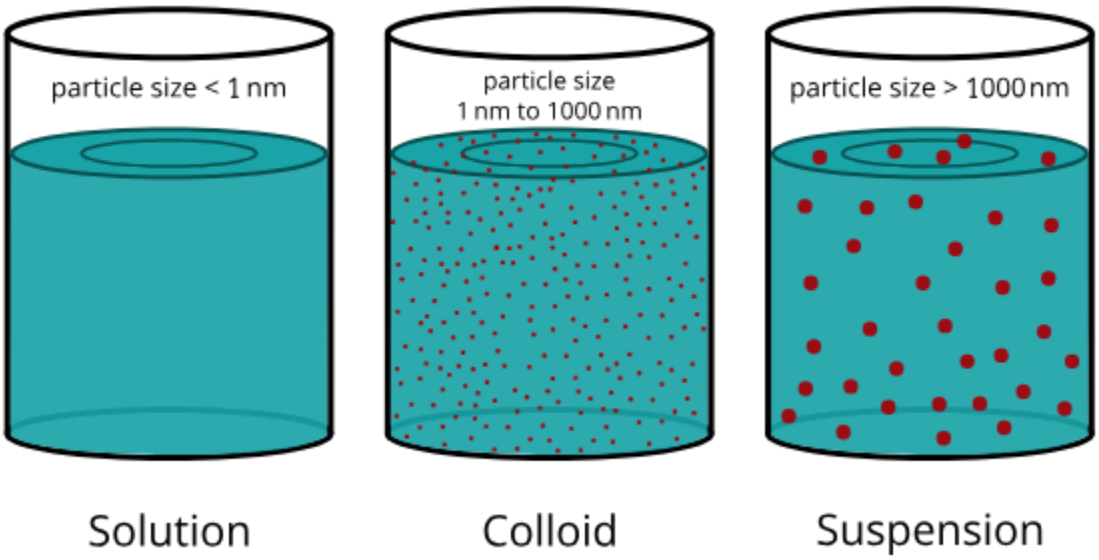
2.5. Colloids & Suspensions

Colloid

A **heterogeneous mixture** with particle sizes between **1–1000 nm**.

Characteristics:

- Particles do **not settle** on standing.
- Particles scatter light → **Tyndall effect** (path of light becomes visible).
- Called **false solutions** or **colloidal dispersions**.



Examples:

- Milk, starch, blood, jelly, ink, toothpaste.

Suspension

A **heterogeneous mixture** in which **solid particles remain dispersed** in a liquid but do not dissolve.

Characteristics:

- Particle size **> 1000 nm**.

- Particles **settle on standing**.
- Visible to naked eye.

Examples:

- Chalk in water
- Milk of magnesia
- Paints

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