# Kinetic Molecular Theory of Matter

## States of Matter

- **Solid**: definite shape, size & volume; molecules closely packed & ordered, **strong** attraction; only **vibrate** about mean position; rigid, incompressible, do not diffuse
- **Liquid**: definite mass & volume, **no definite shape**; molecules move but stay in contact (weaker attraction) → **fluidity**; two liquids may diffuse, depending on their nature
- **Gas**: definite mass only; molecules move **freely at high speed**, hardly any attraction; collisions with walls → **gas pressure**; highly compressible, no free surface
- **Diffusion**: molecules move from **higher** to **lower concentration** until evenly spread — two gases rapidly diffuse into a homogeneous mixture

## Condensation, Sublimation & Deposition

- **Condensation**: gas cooled → particles lose energy → liquid (steam → water on a lid)
- **Sublimation**: solid → gas **directly** on heating (endothermic) — iodine, $NH_4Cl$, camphor; **naphthalene** (moth balls) sublimes at room temperature
- **Deposition**: gas → solid directly — particles rapidly lose KE, vibrate in place

## Conservation of Mass

- In a chemical reaction, mass is **neither created nor destroyed**, only transformed
- **Carbon atoms keep their mass** when burning coal turns them into $CO_2$ (solid → gas)
- Needs a **closed system**: even when a gas forms, total mass at start = mass at end
- Reactions = **rearrangement of atoms** — total atoms on **reactant side = product side**
- **Unbalanced** $CO + O_2 \rightarrow CO_2$ (4 atoms → 3) doesn't show conservation; **balanced** $\mathbf{2CO + O_2 \rightarrow 2CO_2}$ (6 = 6) obeys the law

## Matter & Key Definitions

- Matter = anything that **occupies space** & has **mass**; built of **atoms** that join into **molecules**
- **Intermolecular forces** hold molecules together; **intermolecular space** = gap between them (negligible in solids, large in gases)
- **Kinetic theory**: molecules are in **continuous motion**, restrained by intermolecular attraction; as **temperature rises**, average KE / speed increases
- Even invisible **air** is matter — it **occupies space**
- **Atom**: smallest particle of an element, can't be sub-divided without losing identity. **Molecule**: smallest particle existing free in nature with the substance's properties. **Element**: only one kind of atom (O, Ag, Cu)

## Brownian Motion

- **Random motion** of particles suspended in a liquid/gas, from collisions with fast-moving molecules — named after botanist **Robert Brown**
- Trajectory of a suspended particle = **zig-zag path**
- **Increases** with smaller particle size (more collisions), **lower medium density** & **higher temperature**

## Kinetic Molecular Model

- **All matter = tiny particles** (different substances have different particles); attraction **decreases** as distance increases
- Particles in **constant motion**; more energy → faster they move
- **Kinetic energy** = energy of motion; **heating** raises average KE → particles move faster → matter **expands** or changes state; during the change of state itself, KE stays **constant**

## Boiling & Evaporation

- **Boiling**: heat → molecules gain KE, **vapour pressure** at surface rises; at the **boiling point** particles escape as gas and move independently
- **Evaporation**: higher-energy **surface** molecules overcome intermolecular attraction & escape as vapour
- Faster for **volatile liquids** (perfume, alcohol) and with higher **temperature**, more **air motion** (windy day), larger **exposed surface** (tea in a saucer)
- **Where**: surface only (evap) vs **throughout the mass** (boil)
- **Temperature**: any temperature (evap) vs **fixed boiling point** (boil)
- **Rate**: slow & silent, no extra heat source, always causes cooling (evap) vs **rapid & noisy**, needs extra source of heat, no cooling effect (boil)

## Melting & Freezing

- **Melting**: solid heated → particles vibrate faster, attraction weakens → molecules slide → liquid formed
- **Freezing / solidification**: reverse process — on cooling, average KE & molecular speed decrease; during the change of state itself KE stays constant
- Melting & freezing occur at a **fixed temperature** (melting/freezing point). **Melting absorbs latent heat of fusion** at that temperature — ice at 0°C melts fully before its temperature rises