PHYSICS TUTOR
ONLINE

Unit 14 - Particle Model

This unit explains how particles behave in solids, liquids, and gases and how we can model these behaviours using key physics principles. You'll explore how energy changes affect temperature and state, how gases create pressure, and how variables like volume and temperature interact. Key concepts include density, changes of state, specific heat and latent heat, pressure and volume relationships, and how doing work on gases changes their internal energy. This model helps explain real-world phenomena, from insulation to absolute zero.

Density

Definition:

The mass of a substance per unit volume.

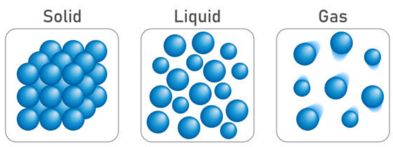
$$\text{Density} = \frac{\text{mass}}{\text{volume}} \quad \text{or} \quad \rho = \frac{m}{V}$$

Units: **kg/m³**

💡 Key Points:

- **Solids** and **liquids**: Similar densities (particles closely packed)
- **Gases**: Much lower density due to the large spacing between particles
- In state-change problems, **Mass remains constant**

States of matter



Changes of State

Mass is conserved – no mass is lost or gained

Physical, **not chemical** changes (reversible)

Original properties are retained after the state is reversed

Change	**Process**
Solid → Liquid	Melting
Liquid → Gas	Evaporating
Gas → Liquid	Condensing
Liquid → Solid	Freezing
Solid ↔ Gas	Sublimation

Heating a System

Adding energy to a system causes either:

1. Temperature increase, or
2. State change

Particles:

- Gain kinetic energy
- Vibrate more (in solids)
- Break bonds (in state changes)

Specific Heat Capacity

Definition: Energy needed to raise 1 kg of a substance by 1°C (or 1 K).

$$\text{Energy} = \text{mass} \times \text{SHC} \times \Delta T \quad \text{or} \quad E = mc\Delta T$$

Units: J/kg°C

Specific Latent Heat

Definition: Energy needed to change the state of 1 kg of a substance **without** changing temperature.

- Must be at the right temperature to begin the state change

$$\text{Energy} = \text{mass} \times \text{latent heat} \quad \text{or} \quad E = mL$$

Units: J/kg

Type	**Description**
Latent Heat of Fusion	Energy to melt/freeze
Latent Heat of Vaporisation	Energy to boil/condense

Insulation

Thermal energy always transfers out of systems unless insulated.

Reduce energy loss by:

- Poor thermal conductors (e.g. foam)
- Reflective surfaces (reflect infrared radiation)
- Using insulation in context-specific ways

💡 *Consider what type of heat transfer is involved: conduction, convection, or radiation.*

Pressure of a Gas

- Gas particles move randomly
- When they collide with container walls, they exert a force
- This leads to pressure acting perpendicular to the surface

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

Absolute Zero

- **Temperature = 0 K or −273°C**
- **Particles have no energy – no motion or vibration**
- **Lowest possible temperature**

Conversion Formula:

$$T_{\text{Kelvin}} = T_{\text{Celsius}} + 273$$

Kelvin	**Celsius**
0 K	-273°C
4 K	-269°C
273 K	0°C

Pressure & Volume

Situation	**Result**
Decrease Volume	Pressure increases
Increase Volume	Pressure decreases

$$\text{Pressure} \propto \frac{1}{\text{Volume}} \quad \text{(Inversely proportional)}$$

$$P_1V_1 = P_2V_2$$

Volume increases → more space → fewer wall collisions per second → lower pressure

Doing Work on a Gas

Doing work = transferring energy to a gas → increases temperature

$$\text{Work Done} = \text{Pressure} \times \text{Volume}$$

- Compressing or expanding gas changes volume
- Adds energy to the particles → raises kinetic energy

Example: Using a pump to inflate a tyre — the pump gets warm because you are doing work on the air inside.

Gas Behaviour Scenarios

Adding More Particles to a Fixed Volume:

- More particles = more collisions
- More pressure and more energy = higher temperature

Fixed Number of Particles, Decreasing Volume:

- Particles bounce off moving walls
- Rebound faster → gain momentum → increase in temperature and pressure

Summary Table:

Variable Changed	Particle Behaviour	Outcome
Add more particles	More collisions with walls	Increased pressure and temp
Decrease volume	Particles rebound faster off moving walls	Increased pressure and temp