

# **Edexcel Physics IGCSE**

## Topic 5: Solids, Liquids and Gases

### Summary Notes

(Content in bold is for physics only)

## Density and pressure

The **density** of a substance is defined as the **mass per unit volume** and is measured in **kilograms per metre cubed (kg/m<sup>3</sup>)**.

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

To find the density of a liquid:

- Find the mass of the measuring cylinder by placing it on a balance, then fill it with the liquid and measure the new mass. The difference in masses is the mass of the liquid.
- The volume can be read from the cylinder.
- Find the density using the equation.

To find the density of solid:

- Measure the mass of the solid by placing it on a balance.
- If the solid is:
  - regularly shaped, measure its dimensions using a ruler or other measuring tool and then use a mathematical formula to find the volume.
  - irregularly shaped, immerse it in water and measure the volume of the water displaced. This is the volume of the solid.
- Find the density using the equation.

Pressure is defined as the force per unit area and is measured in **Pascals (Pa)**.

$$\text{pressure} = \frac{\text{force}}{\text{area}} \quad p = \frac{F}{A}$$

For example, lying down on a bed of nails compared to a single nail:

- The **force** applied is the weight of your body
- The total **area** is either a single pin point or many points spread out over a larger area
  - Therefore, on a bed of nails, the pressure is lower as the area is greater.

The **pressure** at a point in a gas or liquid at rest acts **equally** in **all directions** and causes a force at right angles to any surface.

The pressure beneath a liquid surface increases with **depth**, the **density** of the liquid and the **gravitational field strength**.

- It is given by  $p = \rho gh$

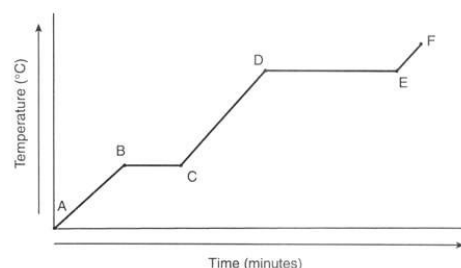
## Change of state

Heating a system **increases** its **internal energy** and causes either an **increase in temperature** or a **change of state**.

- When the **temperature** of a body **rises**, the energy goes towards making the molecules **vibrate more** and **increases** their **kinetic energy**.
- When a body **changes state**, energy goes towards making the molecules **freer** from each other rather than increasing their kinetic energy – the temperature stays **constant**.
  - **Melting** occurs when molecules in a solid vibrate enough to move away from their fixed positions, turning into a liquid.
  - **Boiling** occurs when molecules in a liquid gain enough energy to break their bonds and become separate molecules, turning into a gas.

Graph showing the temperature of ice with time when energy is put in at a constant rate:

- From A to B the ice is rising in temperature
- From B to C it is melting into water
- From C to D the water is rising in temperature
- From D to E the water is boiling into steam
- From E to F the steam is rising in temperature

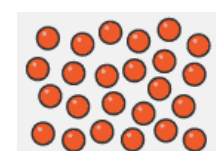
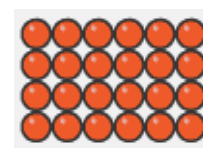


**Evaporation** is the escape of molecules with **higher energy** from the **surfaces** of liquids. After they escape, the remaining molecules have a **lower average kinetic energy** which means the temperature is lower (i.e. evaporation **cools** the liquid).

- To increase the rate of evaporation, increase temperature, increase surface area, or provide a draught.

Evaporation is different to boiling because it can happen at any temperature and only occurs at the surface of the liquid.

- **Solids**
  - Molecules **close** together in **regular** pattern
  - **Strong** intermolecular forces of attraction
  - Molecules **vibrate** but can't move about
- **Liquids**
  - Molecules **close** together in **random** arrangement
  - **Weaker** intermolecular forces of attraction than solids
  - Molecules **move around each other**
- **Gases**
  - Molecules **far** apart in **random** arrangement
  - Negligible/very weak intermolecular forces
  - Molecules move quickly in all directions



The **specific heat capacity** is the **amount of energy** required to raise the temperature of **1kg** of a substance by **1°C** and is measured in **Joules per kilogram degree Celsius (J/kg°C)**.

$$\text{change in thermal energy} = \text{mass} \times \text{specific heat capacity} \times \text{temperature change}$$

$$\Delta Q = mc\Delta T$$

## Ideal gas molecules

Gas molecules move **rapidly** and **randomly** due to **collisions** with other gas molecules.

Gases exert **pressure** on a container due to **collisions** between gas molecules and the wall. When the molecules rebound off the walls, they **change direction** so their velocity and therefore **momentum changes**. This means they exert a **force** because force is equal to the change in momentum over time.

- At a constant volume, if the **temperature increases**, the **pressure increases** because the molecules move faster so they collide **harder** and **more frequently** with the walls.
  - The temperature at which the **pressure is zero** is called **absolute zero** (-273°C). The **Kelvin** scale of temperature defines absolute zero to be 0K with an increment of one Kelvin equal to an increment of one degree Celsius. This means that:
    - $temperature\ in\ kelvin = temperature\ in\ degrees\ celsius + 273$
  - For a gas at fixed mass and volume, where the temperature is measured in Kelvin:
$$\frac{p_1}{T_1} = \frac{p_2}{T_2} \text{ or } \frac{p}{T} = constant$$
- At a constant temperature, if the **volume increases**, the **pressure decreases** because the molecules collide **less frequently** with the walls and over a **greater area**.
  - For a gas at fixed mass and temperature:
$$p_1V_1 = p_2V_2 \text{ or } pV = constant$$

The **temperature in Kelvin** of a gas is proportional to the **average kinetic energy** of the molecules. The higher the temperature, the greater the average kinetic energy and so the faster the **average speed** of the molecules.