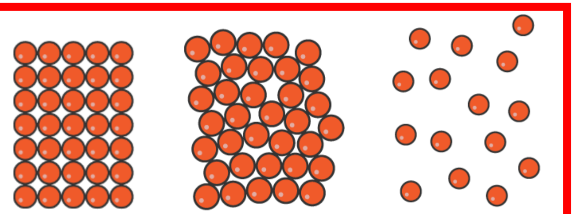
GCSE P3 – Particle Model of Matter

1. Particle model



	SOLID	LIQUID	GAS
Movement of Particles	Vibrate about a fixed point	Slide over each other	Random motion
Arrangement of Particles	Tightly packed, regular structure	Tightly packed, free flowing	Spread out

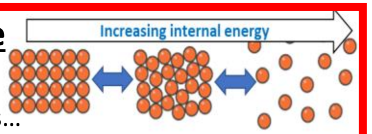
2. Density

Density is a measure of the amount of matter (mass) packed into a given space (volume)

$$\text{Density (kg/m}^3) = \frac{\text{mass (kg)}}{\text{volume (m}^3)}$$

Mass → measure on a top pan balance
Volume (regular) → l x w x h (measure dimensions with a ruler)
Volume (irregular) → lower object into a known volume of water and calculate: new volume – old volume = volume of object
The density of a material changes as its state changes:
Solid = most dense, Gas = least dense.

3. Energy and temperature



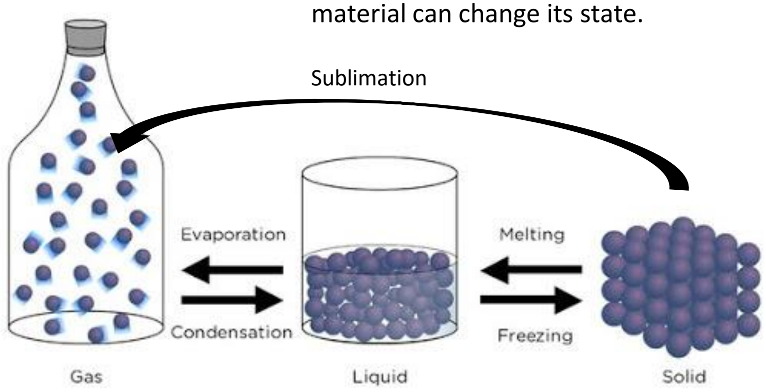
Heating or cooling a material causes…

1. a change in the chemical potential store (chemical **bonds** between **particles** form, break or stretch)
2. a change in the thermal energy store (particles gain or lose speed)

The **internal energy** is the total amount of kinetic energy and potential energy of all the particles in the system.
Temperature is a measure of the average kinetic energy of the particles.

4. Changing state

Adding or removing **energy** from a material can change its state.



Specific latent heat → The amount of energy required to **change the state** of **1kg** of substance **without changing the temperature**.

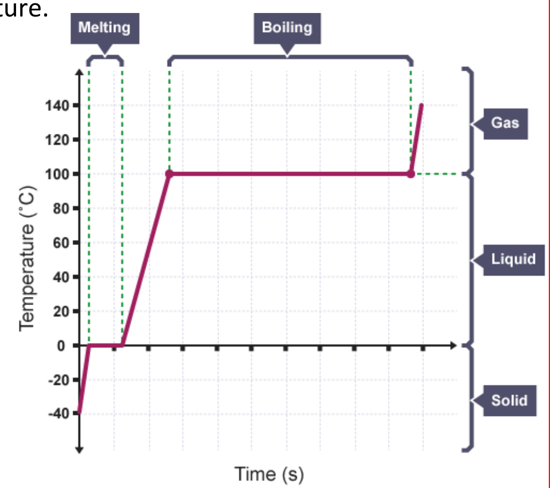
$$E = mL$$

Energy transferred (J) = mass (kg) x specific latent heat (J/kg)

Specific latent heat of fusion → The amount of energy required to convert 1kg of substance from **solid to liquid** at a constant temperature.

Specific latent heat of vaporisation → The amount of energy required to convert 1kg of substance from **liquid to gas** at a constant temperature.

Reading the latent heat graph:
* **Flat lines =** change of state with zero temp change
* **Sloping lines =** temperature of the substance is increasing



5. Specific heat capacity

The specific heat capacity of a material is the energy required to raise one kilogram (kg) of the material by one degree Celsius (°C).

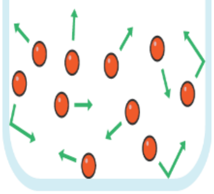
$$\Delta E = mc\Delta\theta$$

Energy (J) change = mass (kg) x specific heat capacity (J/Kg°C) x temperature (℃) change

A low SHC = material will heat up and cool down **quickly**
A high SHC = material will heat up and cool down **slowly**

The specific heat capacity of **water** is **4,200 J/kg°C**
It takes 4,200J of energy to raise the temperature of 1kg of water by 1°C)

6. Particle motion in gases



The particles in a gas are in **constant random motion** so they frequently **collide** with each other and the walls of the container they are in.

The force acting on the container due to these collisions is at **right angles** to the container and causes gas **pressure**.

↑ Number of particles colliding each second over the same area = ↑ Pressure

↑ Particles' speed = ↑ Pressure

Temperature and Pressure:

If the volume of a container with a gas inside is constant, the pressure of a gas will increase as its temperature increases.

This happens because the molecules increase their average kinetic energy, colliding with the container wall more frequently,

The relationship between Temperature and Pressure at a constant volume is **directly proportional.**

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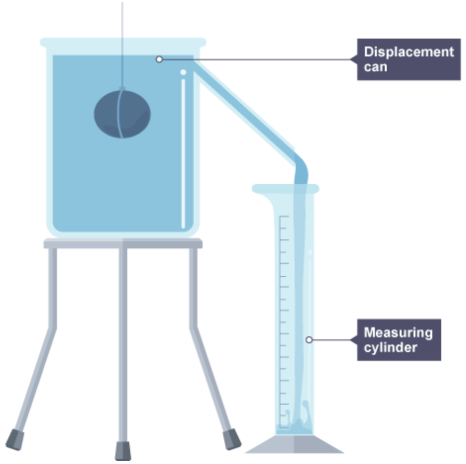
7. Required Practical – investigating density

Method 1: Regular solids
- Measure mass of object on a top pan balance.
- Use a ruler to measure the length (l), width (w) and height (h) of a steel cube.
- Calculate the volume of the cube using (l × w × h).
- Mass ÷ Volume = Density

Method 2: Stone or other irregular shaped object
- Measure mass of the object on a top pan balance.
- Fill the displacement can until the water is level with the bottom of the pipe.
- Place a measuring cylinder under the pipe ready to collect the displaced water.
- Carefully lower the stone into the can and wait until no more water runs into the cylinder.
- Measure the volume of the displaced water.
- Mass ÷ Volume = Density

Method 3: Water (or any liquid)
- Place the measuring cylinder on the top pan balance and measure its mass.
- Pour 50 cm^3 of water into the measuring cylinder and measure its new mass.
- Find the difference in mass
- Mass ÷ Volume = Density



8. Required Practical – specific heat capacity

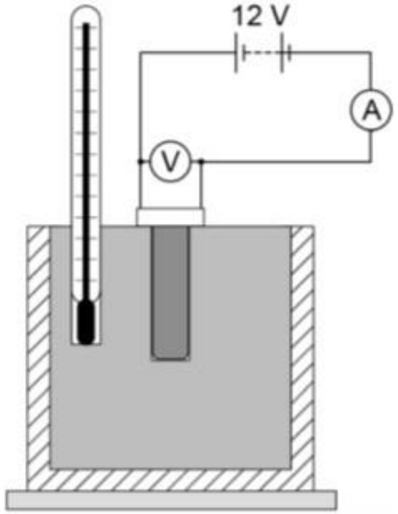
The increase in temperature of a system depends on 3 things:
- The mass of the substance
- The energy input to the system
- The type of material

Aim: To measure the specific heat capacity of a sample of material.

Method:
1. Place the immersion heater into the central hole at the top of the metal block.
2. Place the thermometer into the smaller hole and put a couple of drops of oil into the hole to make sure the thermometer is surrounded by hot material.
3. Fully insulate the block by wrapping it loosely with cotton wool.
4. Record the temperature of the block.
5. Connect the heater to the power supply and turn it off after ten minutes.
6. After ten minutes the temperature will still rise even though the heater has been turned off and then it will begin to cool. Record the highest temperature that it reaches and calculate the temperature rise during the experiment.
7. Energy transferred is calculated by **P=IV** and and then **E = Pt**

Error: some energy will transfer to the surroundings (dissipate) this causes an overestimate of the SHC of the material

Hazard: Hot material can cause burns. Do not touch and keep apparatus away from the edge of the table.



SINGLE PHYSICS ONLY

9. Pressure in gases

Gas pressure is caused by the force exerted when particles collide with the walls of the container.

↑ **temperature** of a gas (at a constant volume) ↑ **pressure** because the particles gain kinetic energy and collide more with the container walls.

↓ **volume** of container (at a constant temp) ↑ **pressure** because the same number of particles collides with the walls of the container more frequently as there is less space. However, the particles still collide with the same amount of force.

Boyle's Law = pressure is **inversely proportional** to volume:

pV = constant

Pressure (N/m^2) x Volume (m^3) = constant

$$p_1V_1 = p_2V_2$$

Doing work on a gas (eg. with a bike pump) transfers energy to the internal energy store and can cause the temperature of the gas to increase.