Year 11 Combined Science KO
Autumn Term 2026

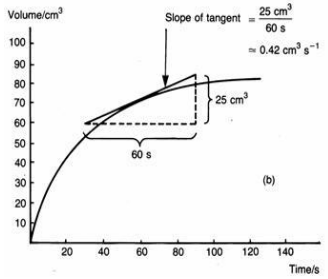
Pages	Topic
2	Rates of Reaction and Energy Changes in Reactions
3 – 4	Electromagnetic Introduction
5	Forces and their matter
6	Magnetism and the Motor Effect
7 – 8	Particle Model

KS4 Chemistry – Rates of Reaction and Energy Changes in Reactions

Rates of Reaction

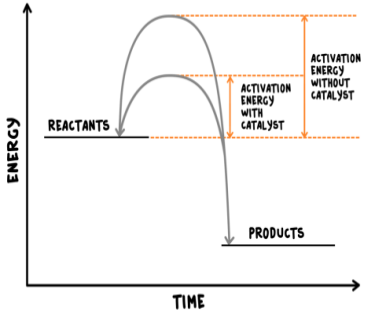
Rate of chemical reaction	This can be calculated by measuring the quantity of reactant used or product formed in a given time.	Rate = $\frac{\text{quantity of reactant used}}{\text{time taken}}$ Rate = $\frac{\text{quantity of product formed}}{\text{time taken}}$

Factors affecting the rate of reaction	
Temperature	The higher the temperature, the quicker the rate of reaction as particles have more kinetic energy to collide with.
Concentration	The higher the concentration, the quicker the rate of reaction as there are more particles colliding.
Surface area	The larger the surface area, the quicker the rate of reaction as there's more surfaces to collide with
Pressure (of gases)	When gases react, the higher the pressure upon them, the quicker the rate of reaction.

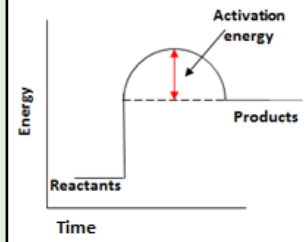
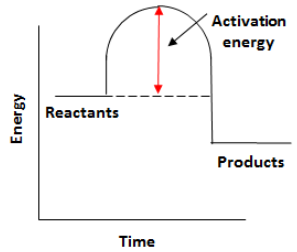


Quantity	Unit
Mass	Grams (g)
Volume	cm^3
Rate of reaction	Grams per cm^3 (g/cm^3) **Higher Tier**: moles per second (mol/s)

Catalyst	A catalyst changes the rate of a chemical reaction but is not used in the reaction.
Enzymes	These are biological catalysts.
How do they work?	Catalysts provide a different reaction pathway where reactants do not require as much energy to react when they collide.



Energy Changes

Endothermic		Products are at a higher energy level than the reactants. As the reactants form products, energy is transferred from the surroundings to the reaction mixture. The temperature of the surroundings decreases because energy is taken in during the reaction.
Exothermic		Products are at a lower energy level than the reactants. When the reactants form products, energy is transferred to the surroundings. The temperature of the surroundings increases because energy is released during the reaction.

Bond energy calculation (Higher tier only)

Calculate the overall energy change for the forward reaction
$N_2 + 3H_2 \rightleftharpoons 2NH_3$

Bond energies (in kJ/mol): H-H 436, H-N 391, N≡N 945

Bond breaking: 945 + (3 x 436) = 945 + 1308 = 2253 kJ/mol

Bond making: 6 x 391 = 2346 kJ/mol

Overall energy change = 2253 - 2346 =
-93kJ/mol

Therefore reaction is exothermic overall.

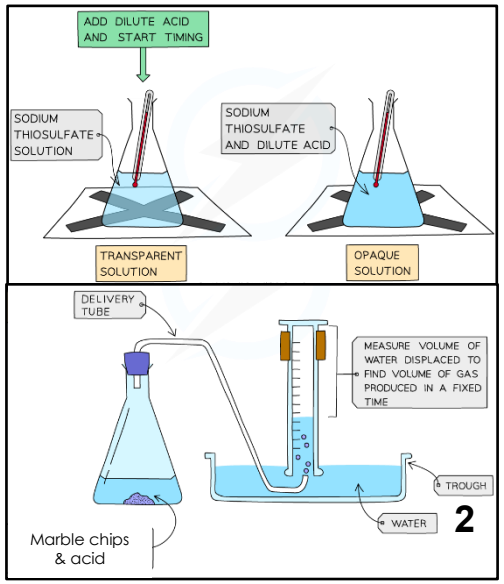
Keyword	Definition
Collision theory	Chemical reactions can only occur when reacting particles collide with each other with sufficient energy.
Activation energy	This is the minimum amount of energy colliding particles in a reaction need in order to react.
Heat energy changes	Occur in the following: - Salts dissolving in water - Neutralisation reactions - Displacement reactions - Precipitation reactions
Exothermic reactions	Heat energy is given out as bonds are being formed. Examples: neutralisation, displacement
Endothermic reactions	Heat energy is taken in as bonds are being broken. Examples: dissolving salt in water, photosynthesis

Investigating temperature on rate of reaction

- Independent variable: temperature of sodium thiosulfate and acid
- Dependant variable: time taken for 'X' to disappear
- Control variable: volume and concentration

Investigating surface area on rate of reaction

- Independent variable: surface area of marble chips
- Dependant variable: time taken to collect 50cm^3 of gas
- Control variable: volume & concentration of acid and mass of marble chips



KS4 Physics – Electromagnetic Induction

Inducing a potential difference

A potential difference can be induced (created) in a **conductor** when there is movement between the conductor and a magnetic field. This can occur in two different ways:

a coil of wire is moved in a magnetic field
a magnet is moved into a coil of wire

This is called **electromagnetic induction** and is often referred to as the **generator effect**.

The direction of the induced potential difference or induced current depends on the direction of movement. The current is reversed when:

The magnet is moved out of the coil
The other pole of the magnet is moved into the coil

An induced potential difference or induced current will increase if:

The speed of movement is increased
The magnetic field strength is increased
The number of turns on the coil is increased

Transformer Calculations

The primary coil of a transformer has a current of 0.5 A with a potential difference of 100 V. The current in the secondary coil is 25 A. What is the potential difference across the secondary coil? Use $V_p \times I_p = V_s \times I_s$

$$100\,V \times 0.5\,A = V_s \times 25\,A$$

$$50 = V_s \times 25$$

$$V_s = \frac{50}{25} = 2\,V$$

A radio runs off the 230 V mains supply but only needs 23 V. Its transformer has 100 turns of wire in the primary coil. How many turns are needed in the secondary coil?

$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

$$\frac{230\,V}{23\,V} = \frac{100}{N_p}$$

$$10 = \frac{100}{N_p}$$

$$10 \times N_p = 100$$

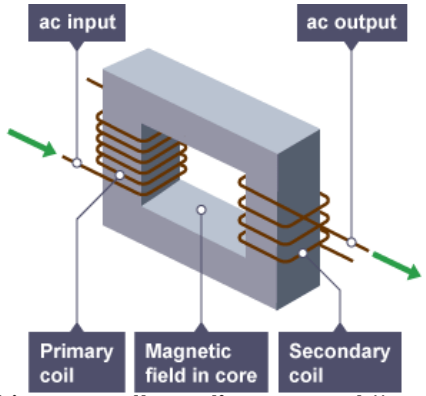
$$N_p = \frac{100}{10} = 10$$

So the secondary coil must have 10 turns.

Keyword	Definition
A.C	Alternating current, current that flow in both directions
Alternator	An electrical generator which produces alternating current
Conductor	Electrical conductors are materials that have low resistance and allow current to pass through them easily
Dynamo	An electrical generator which produces direct current
Electromagnetic Induction	The production of potential difference (voltage) when a conductor e.g. wire moves through a magnetic field. If the conductor is part an electric current, an induced current will flow
Generator	Device that converts kinetic energy into electrical energy
Generator Effect	When motion between a conductor and a magnetic field creates electricity, i.e. a magnet is moved into a coil of wire.
Magnetic Field	Area surrounding a magnet that can exert a force on magnetic materials
National Grid	The network that connects all of the power stations in the country to make sure that everywhere has access to electricity.
Potential Difference	The potential difference (or voltage) of a supply is a measure of the energy given to the charge carriers in a circuit. Units = volts (V). This is the voltage between two points that makes an electric current flow between them.
Power	The energy transferred each second, measured in watts (W). Power = work done ÷ time taken.
Transformer	An electrical device that increases, or decreases, the potential difference (voltage) of an alternating current.

KS4 Physics – Electromagnetic Induction

Transformers and how they work



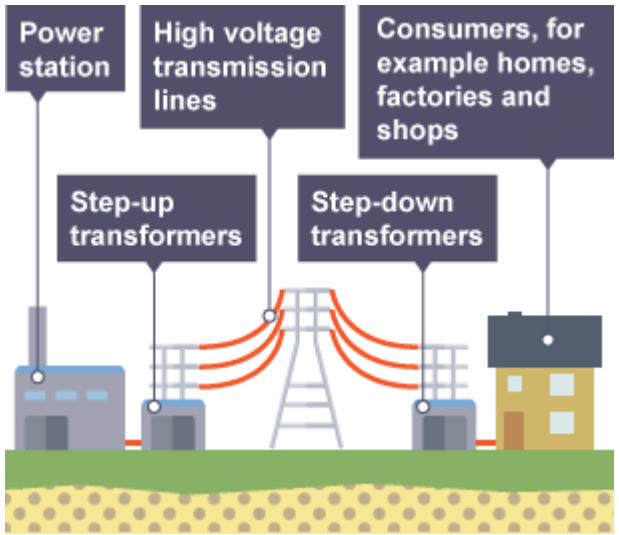
1.A primary voltage drives an **alternating current** through the primary coil.
2.The primary coil current produces a magnetic field, which changes as the current changes.
3.The iron core increases the strength of the magnetic field.
4.The magnetic field passes through (or cuts) the secondary coil.
5.The changing magnetic field induces a changing potential difference in the secondary coil.
6.The induced potential difference produces an alternating current in the external circuit.

Transmission Lines

To ensure that the minimum amount of power is lost from the cables:
- the cables are thick so that their resistance is low
- high voltages are used to reduce the current through the transmission lines

A low resistance and a low current mean that the transmission wires will not heat up as much. As a result, most of the power is delivered to the consumer, and not lost through the wires.

Transformers and how they work



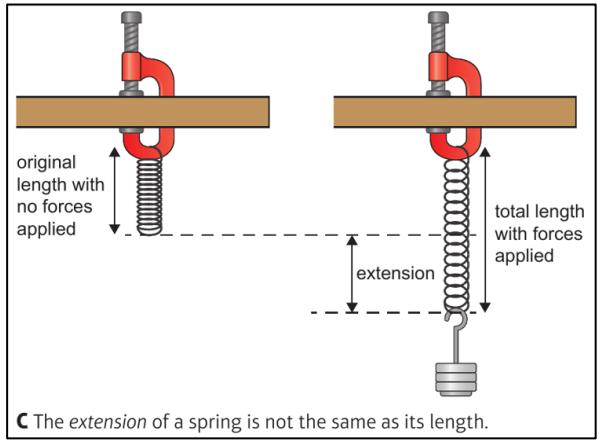
Transformers are used to change voltages and currents in transmission lines. A transformer is formed from two coils of wire around a magnetic core. The number of coils determines whether the transformers will step-up or step-down the voltage.

As the power transferred must stay the same:
- increasing voltage decreases current
- decreasing voltage increases current

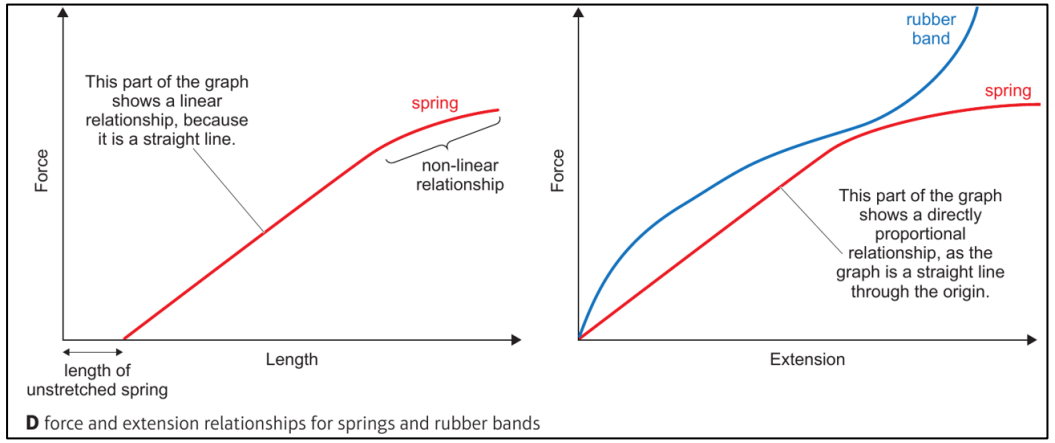
In the National Grid, a step-up transformer is used to increase the voltage and reduce the current. The voltage is increased from about 25,000 Volts (V) to 400,000 V causing the current to decrease. Less current means less energy is lost through heating the wire.

To keep people safe from these high voltage wires, pylons are used to support transmission lines above the ground.
Before reaching the end user, a step-down transformer, reduces the voltage from the transmission voltage to the safer voltage of 230 V for home use.

KS4 Physics – Forces and matter



C The *extension* of a spring is not the same as its length.



D force and extension relationships for springs and rubber bands

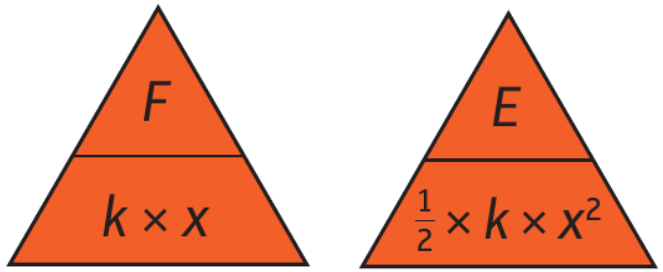
The force needed to extend a spring by 1 metre is called the spring constant. The stiffer the spring, the larger the spring constant.

The spring constant is calculated using the following equation:

spring constant = force / extension
(N/m) (N) (m)

The work done to stretch a spring is calculated using the following equation:

energy transferred in stretching = ½ × spring constant × (extension)²
(J) (N/m) (m)²



Key word	Definiton
Elastic	An object that can return to its original shape, after forces are removed
Inelastic	An object that cannot return to its original shape, so keeps its new shape, even after forces are removed
Extension	The change in length of an object after forces have been applied
Linear relationship	The graph shows a straight line
Non-linear relationship	The graph does not show a straight line (curve)
Directly proportional	If the value of one variable increase, the other variable also increase by the same percentage
Spring constant	The force needed to produce an extension of 1 metre in a spring
Work done	The energy transferred when a force moves through a distance

Separate physics ONLY

Calculating pressure in fluids

Liquids and gases are fluids. An object in a fluid experiences a pressure caused by both the fluid itself and the atmospheric pressure.

The pressure in fluids causes a force normal to a surface. A force that is normal to a surface acts at right angles (90°) to it. To calculate the pressure at the surface of a fluid use the equation:

$$pressure = \frac{force\ normal\ to\ a\ surface}{area\ of\ that\ surface}$$

$$P = \frac{F}{A}$$

This is when:

- pressure (P) is measured in pascals (Pa)
- force (F) is measured in newtons (N)
- area (A) is measured in metres squared (m^2)

Separate physics ONLY

Pressure in a liquid increases as the depth increases. The pressure in a liquid is due to the weight of the column of water above. Since the particles in a liquid are tightly packed, this pressure acts in all directions

Separate physics HIGHER ONLY

Calculating pressure in a liquid

The pressure caused by a column of liquid can be calculated using the equation:

pressure = height of column × density of the liquid × gravitational field strength

$$P = h\,\rho\,g$$

This is when:

- pressure (P) is measured in pascals (Pa)
- height of column (h) is measured in metres (m)
- density (ρ) is measured in kilograms per metre cubed (kg/m^3)
- gravitational field strength (g) is measured in newtons per kilogram (N/kg)

Separate physics ONLY

Atmospheric pressure decreases as the height of a surface above ground level increases. This is because, as the altitude increases:

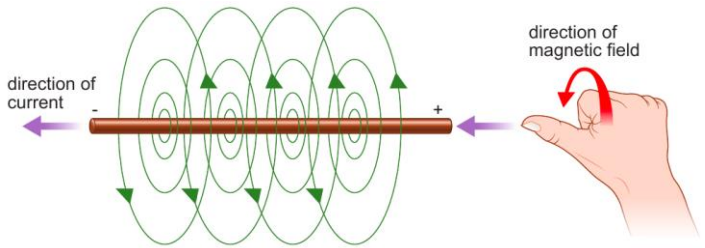
- the number of air molecules decreases
- the weight of the air decreases
- there is less air above a surface



This is why aircrafts that fly at high altitudes must be pressurised. If the air pressure is too low, humans cannot take in oxygen quickly enough to meet their bodies' needs.

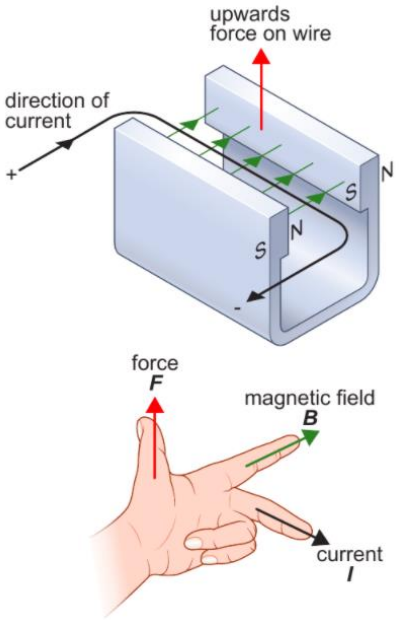
KS4 Physics – Magnetism and the Motor Effect

Maxwell's Right Hand Grip rule
A circular magnetic field forms around a current carrying wire. If you point your right thumb in the direction of the current (+ to -), the magnetic field goes in the direction your fingers are pointing.



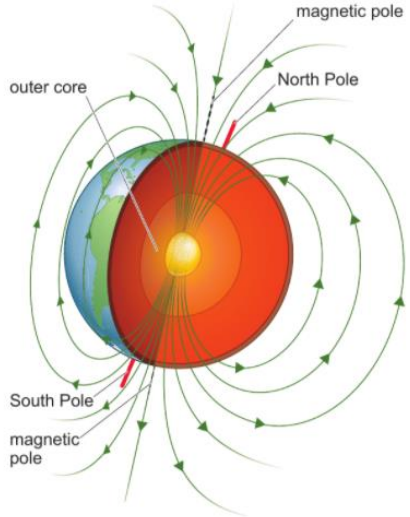
A current flowing through a wire causes a magnetic field. Electric motors and other devices depend on the magnetic effect of electric currents.

Fleming's Left Hand Rule (HT)
The motor effect describes the force that acts on a current carrying wire in a magnetic field.



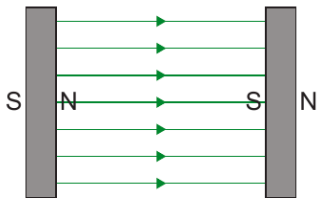
Earth's magnetic field
A plotting compass can also show the Earth's magnetic field.

The behaviour of compasses is evidence that the Earth has a magnetic field, which is similar in shape to the magnetic field of a bar magnet.

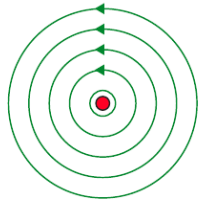


Keyword	Definition
Magnet	An object that has its own magnetic field around it.
Magnetic field	The area around a magnet where it can affect magnetic materials or induce a current.
Permanent magnet	A magnet that is always a magnet such as a bar magnet.
Solenoid	A coil of wire with electricity flowing in it. Also called an electromagnet.
Motor Effect	The force experienced by a wire carrying a current that is placed in a magnetic field.
Magnetic flux density	A way of describing the strength of a magnetic field. Measured in Teslas (T).
Split ring commutator (HT)	This reverses the direction of the current in the coil each half turn. This allows the motor coil to rotate continuously in one direction.

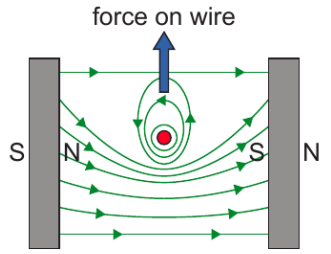
Magnetic field diagrams (HT)
Magnetic field flows from north to south. Also around a current carrying wire.



Two flat magnets produce a uniform magnetic field between them.

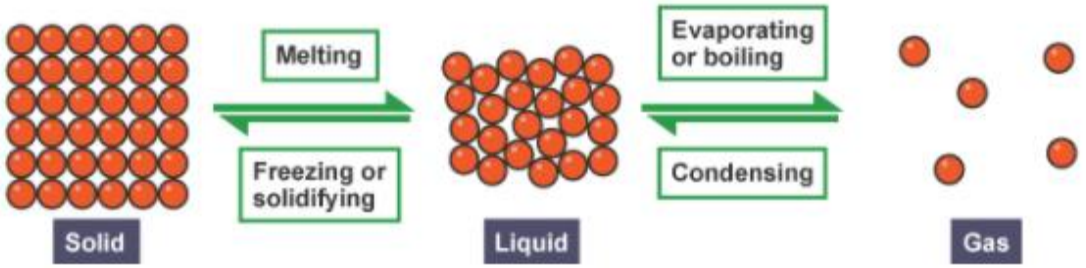


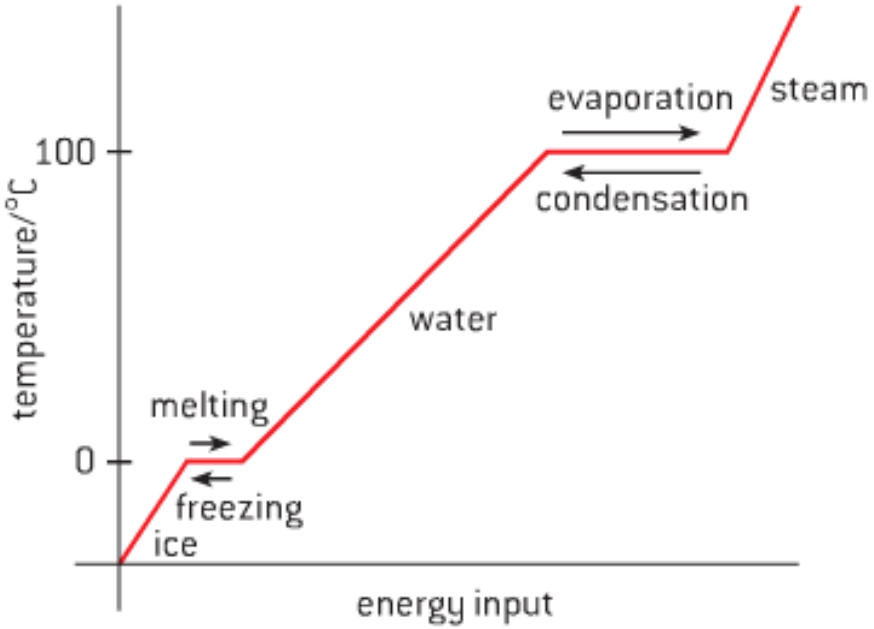
A magnetic field goes around a wire carrying a current.



When the wire carrying a current is put between the magnets, the two fields interact to produce a force.

KS4 Physics – Particle Model





Particles and pressure:

The pressure of a gas is due to the forces on the walls of the container, caused by the moving particles hitting the walls. The faster the particles are moving, the more frequent the collisions will be and the more force they will exert when they collide.

The faster the average speed of the particles in a gas, the higher the temperature of the gas.

The higher the temperature, the higher the pressure.

Worked example

What is the boiling point of water in kelvin?

boiling point = 100 °C + 273 = 373 K

To convert from kelvin to degrees Celsius, subtract 273.

To convert from degrees Celsius to kelvin, add 273.

When a substance undergoes a **change of state** the particles end up in a different arrangement. There are the same number of particles so the mass stays the same (mass is **conserved**). This is a **physical change**, because no new substances are formed and the substance recovers its original properties if the change is reversed. Mass is also conserved in **chemical changes**, but the change in the substances often cannot be reversed.

Key word	Definiton
Sublimation	When a solid turns straight into a gas without becoming a liquid first
State of matter	One of three different forms a substance can have: solid, liquid, gas
Change of state	Adding or removing energy to change the arrangment of particles in a material
Physical change	A reversible change in a substance
Chemical change	An irreversible change in a substance
Density	The mass of a certain volume of a substance
Specific heat capacity	The amount of energy it takes to make 1kg of a substance by 1°C
Specific latent heat	The amount of energy it takes to make 1kg of substanc change state
kinetic theory	The model that explains the properties of different states of matter in terms of movement of particles
Conserved	A quantity that is kept the same throughout
Joule (J)	A unit for measuring energy
Kelvin (K)	The unit in the Kelvin temperature scale. One kelvin is the same temperature interval as 1° C
Pascals (Pa)	The units for pressure

KS4 Physics – Particle Model

$\rho = m / v$

Density (g/cm^3) = $\frac{mass\ (g)}{volume\ (cm^3)}$

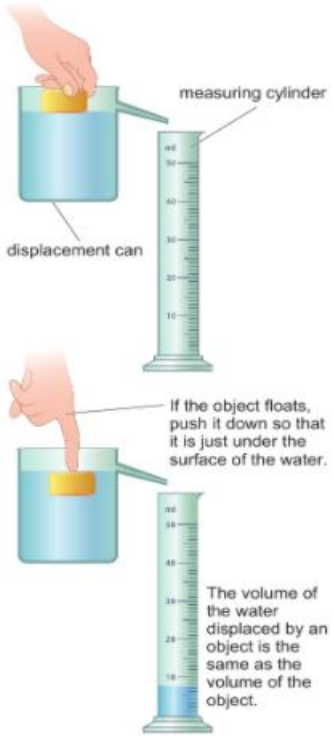
$Q = m \times L$

thermal energy for a change of state (J) = mass (kg) × specific latent heat (J/kg)

$\Delta Q = m \times c \times \Delta\theta$

change in thermal energy (J) = mass (kg) × specific heat capacity (J/kg °C) × change in temperature (°C)

Core Practical: Investigate the densities of solids and liquids



Method

Liquids

A Put an empty beaker on a balance, and set the balance to zero.

B Use a measuring cylinder to measure 50 cm^3 of a liquid and then pour it into the beaker. Write down the reading on the balance. This is the mass of 50 cm^3 of the liquid.

Solids

C Find the mass of the solid and write it down.

Diagram B shows how to find the volume of an irregular shape:

D Stand a displacement can on the bench with its spout over a bowl. Fill it with water until the water just starts to come out of the spout.

E Hold a measuring cylinder under the spout and carefully drop your object into the can. If your object floats, carefully push it down until all of it is under the water. Your finger should not be in the water.

F Stand the measuring cylinder on the bench and read the volume of water you have collected. This is the same as the volume of your object. Write it down.

Core Practical: Investigate the properties of water by determining the specific heat capacity of water



Method

Melting ice

Wear eye protection.

A Put a boiling tube full of crushed ice into a Pyrex [or heatproof] beaker. Put a thermometer in the ice and note the temperature.

B Put the beaker onto a tripod and gauze. Pour hot water from a kettle into the beaker, and keep it warm using a Bunsen burner.

C Measure the temperature of the ice every minute and record your results in a table. Stop taking readings three minutes after all the ice has melted.

D Note the times at which the ice starts to melt and when it appears to be completely melted.

Specific heat capacity

E Put a polystyrene cup in a beaker onto a battery-powered balance and zero the balance. Then fill the cup almost to the top with water and write down the mass of the water. Carefully remove the cup from the balance.

F Put a thermometer in the water and support it as shown in photo B. Put a 12 V electric immersion heater into the water, making sure the heating element is completely below the water level. Connect the immersion heater to a joulemeter.

G Record the temperature of the water, and then switch the immersion heater on. Stir the water in the cup gently using the thermometer.

H After five minutes record the temperature of the water again and also write down the reading on the joulemeter.