

P1 Energy

Physics Paper 1 | AQA Combined Science Trilogy | Key ideas to remember

Energy → joules (J)

1 Energy stores and transfers



Gravitational store decreases

Kinetic store increases

Stores: kinetic (moving), gravitational, elastic (stretched), chemical, thermal, magnetic, electrostatic and nuclear.

Transfer pathways: mechanically, electrically, by heating or by radiation.

Conservation: energy cannot be created or destroyed.

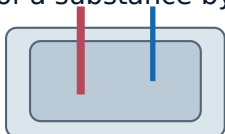
Wasted energy spreads to less useful stores, often thermal stores of the surroundings.

4 Heating and specific heat capacity

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

m in kg; c in J/kg °C; temperature change $\Delta \theta$ in °C. Energy in joules.

Specific heat capacity: energy to raise 1 kg of a substance by 1 °C.



Heater + thermometer

Insulate the block

Measure mass first

Practical: record starting temperature. Heat for a measured time at known power ($E = Pt$). Measure temperature rise; find $c = E / (m\Delta\theta)$. Higher conductivity → faster conduction. Thicker insulation → less heat loss.

Power → watts (W)

2 Three energy calculations

Kinetic: $E_k = \frac{1}{2}mv^2$

m = mass (kg); v = speed (m/s).

Greater mass/speed → more kinetic energy.

Gravitational: $E_p = mgh$

g = gravitational field strength (N/kg); h = height (m). Use the given g value.

Elastic: $E_e = \frac{1}{2}ke^2$

k = spring constant (N/m); e = extension (m). Valid below the limit of proportionality.

Worked example: 2 kg lifted 3 m, g = 10 N/kg:

$E_p = 2 \times 10 \times 3 = 60 \text{ J}.$

5 Efficiency and reducing waste

$$\text{Efficiency} = \frac{\text{useful energy output}}{\text{total energy input}}$$

Or use **useful power / total power**.

Multiply the fraction by 100 for a percentage. 40 J useful from 100 J input → **40%**.

Waste is transferred, not destroyed.

Friction increases thermal stores.

Lubrication: reduces friction.

Insulation: reduces unwanted heating.

HIGHER TIER

Explain how reducing unwanted transfers improves the intended energy transfer.

Energy is conserved

3 Work done and power

Work done = energy transferred.

$$W = F \times s$$

F = force (N); s = distance moved in the direction of the force (m). Work is in joules.

Example: 5 N through 2 m → **10 J**.

Power: energy transferred per second.

$$P = \frac{\text{energy transferred}}{\text{time}} = \frac{W}{t}$$

1 W = 1 J/s. Use time in seconds.

60 J in 3 s → **P = 20 W**.

More power means the same work is done in less time.

6 Energy resources

Renewable: replenished as used.

Solar, wind, hydroelectric, waves, tides, geothermal and biofuels.

Non-renewable: finite supplies.

Coal, oil, natural gas and nuclear fuels.

Fossil fuels: reliable on demand, but release CO₂ when burned.

Nuclear: reliable; no CO₂ from generating electricity, but radioactive waste.

Wind/solar: no fuel burned in use; output depends on conditions.

Compare: reliability, cost, environmental effects and the intended use. Biofuels are renewable but burning them releases CO₂.

P2 Electricity

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Current → A

Voltage → V

Resistance → Ω

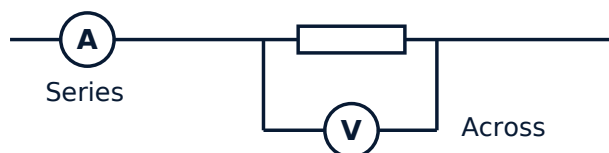
Power → W

1 Current, voltage and resistance

Current: rate of flow of charge.

Voltage (pd): energy transferred per coulomb.

Resistance: opposes current. At the same voltage, more $R \rightarrow$ less I .



$Q = It$ · charge (C), current (A), time (s).

$V = IR$ · volts, amperes, ohms.

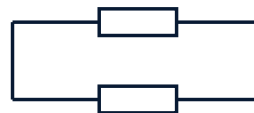
Charge is **not used up** in a component.

2 Series and parallel

Series: one path



Parallel: branches



Series: same current everywhere.

Supply voltage is shared.

$R_{\text{total}} = R_1 + R_2$. One break stops it all.

Parallel: same voltage across branches.

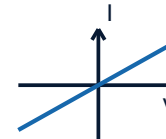
Total current = sum of branch currents.

Total R is less than any single branch R .

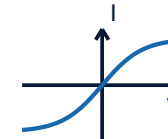
Other complete branches can still work if one branch breaks.

3 Components and I-V graphs

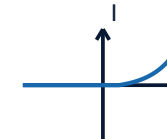
Resistor



Lamp



Diode



Ohmic resistor: constant R at constant temperature; straight line through origin.

Filament lamp: hotter $\rightarrow$ greater R .

Diode: current mainly one way.

LDR: brighter light $\rightarrow$ lower R .

Thermistor: warmer $\rightarrow$ lower R .

LDRs sense light; thermistors sense temperature.

4 Mains and electrical safety

UK mains: AC, about **230 V, 50 Hz**.

AC reverses direction; DC flows one way.

 **Brown: live**

 **Blue: neutral**

 **Green and yellow: earth**

Neutral completes the circuit; near 0 V.

Earth: 0 V; no current normally.

Fault to a metal case $\rightarrow$ earth fault current $\rightarrow$ fuse melts $\rightarrow$ live circuit breaks.

Live parts can remain dangerous with an open switch. Insulation prevents contact.

5 Power, energy and the Grid

Power: energy transferred per second.

1 W = 1 J/s.

$P = VI$ or $P = I^2R$

$E = Pt$ or $E = QV$

Use **W, s, J, C, V, A, Ω** as appropriate.

1 minute = 60 s; 1 kW = 1000 W.

Example: 10 W $\times$ 3 s = 30 J.

National Grid: cables and transformers.

Step-up: voltage increases. For the same power, current decreases $\rightarrow$ less heating loss in cables.

Step-down: reduces voltage for consumers.

6 Required practicals

Use a low-voltage supply.

Measure R : ammeter in series, voltmeter across component. $R = V / I$.

Wire length: measure between contacts. Keep material and thickness the same. Limit heating: low current; switch off between readings.

Combinations: compare one resistor with series and parallel combinations.

I-V: vary voltage/current, record pairs, then reverse supply for reverse readings. Plot I vertically against V horizontally.

Improve: repeat, check unusual readings and calculate suitable means.

P3 Particle model of matter

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$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

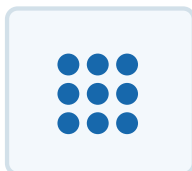
$$\Delta E = mc\Delta\theta$$

Temperature change

$$E = mL$$

Change of state

1 Particles and density



Solid



Liquid



Gas

Solid: close, regular; vibrate in place.

Liquid: close; move past neighbours.

Gas: far apart; random motion.

Gases compress: the **gaps** get smaller.

Density: mass per unit volume.

Same mass: larger volume → lower density.

2 Density practical

All samples: use a zeroed balance for mass.
Density = mass ÷ volume.

Regular solid: measure dimensions.

Cuboid volume = length × width × height.

Irregular solid: fully submerge an insoluble object that sinks. Volume = final water reading – initial reading.

Liquid: mass = filled container mass – empty container mass. Measure volume.

Check: eye-level meniscus, no trapped air, dry solids before weighing; repeat.

Units: kg/m³ or g/cm³; 1 ml = 1 cm³.

3 State changes and energy

Melting: solid → liquid.

Freezing: liquid → solid.

Boiling / evaporation: liquid → gas.

Condensation: gas → liquid.

Sublimation: solid → gas directly.

Evaporation happens at the **surface**, even below the boiling point.

These are physical changes: no new substance. **Mass is conserved.**

Internal energy = total kinetic + potential energy of all the particles.

4 Heating or changing state?

Specific heat capacity, c: energy to raise **1 kg** by **1°C**. Unit: J/kg°C.

$\Delta\theta$ = final temperature – initial temperature.

Example: $2 \times 500 \times 10 = 10,000 \text{ J}$.

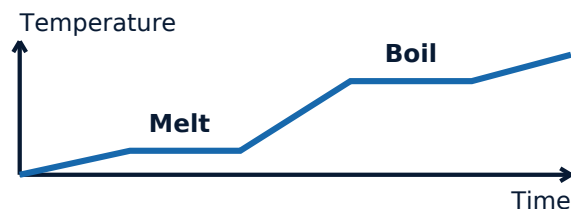
Specific latent heat, L: energy to change the state of **1 kg** with **no temperature change**. Unit: J/kg.

Fusion = melting; vaporisation = liquid to gas.

Example: $0.5 \times 200,000 = 100,000 \text{ J}$.

Use mass in **kg**; 500 g = 0.5 kg.

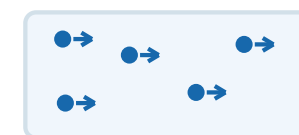
5 Read a heating graph



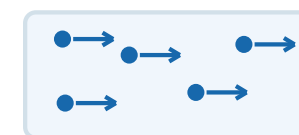
Slopes: temperature and average kinetic energy change.

Flat sections: temperature is constant; energy changes particle **potential energy**.
Cooling: energy leaves during condensation and freezing.

6 Gas temperature and pressure



Cooler



Warmer

At **fixed volume** with no gas escaping:

Heating: greater average kinetic energy; particles move faster. More frequent, harder **wall collisions** increase pressure.

Cooling: pressure falls.

Particle size stays the same.

P4 Atomic structure

Physics Paper 1 | AQA Combined Science Trilogy | Start with the nucleus and charges

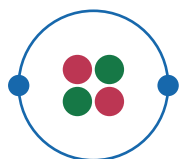
Proton +1

Neutron 0

Electron -1

Neutrons = mass – atomic number

1 Atoms, numbers and isotopes



Nucleus: protons + neutrons

Electrons outside

Almost all mass in nucleus

Atomic number: protons.

Mass number: protons + neutrons.

Neutral atom: protons = electrons.

Isotopes: same protons, different neutrons.

Carbon-14: 6 protons, **8 neutrons**.

Lose an electron → **positive ion**.

Atom radius $\approx 10^{-10}$ m; nucleus radius less than 1/10,000 of atom radius.

2 Evidence changes the model

Solid sphere → plum pudding: discovery of negative electrons changed the model. Plum pudding had spread-out positive charge.

Alpha scattering:

- Most pass through → mostly empty space.
- Very few turn sharply → tiny, dense, positive nucleus. Like charges repel.

Bohr: specific electron energy levels.

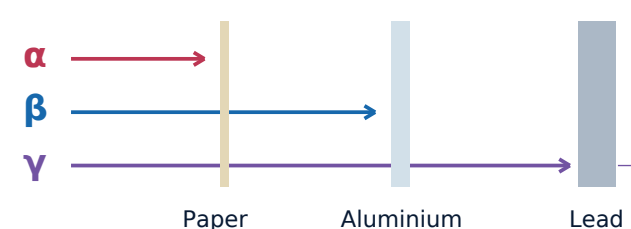
Chadwick: evidence for neutrons.

Electron absorbs energy → higher level.

Returns to lower level → emits

electromagnetic radiation.

3 Alpha, beta and gamma



Alpha: 2 protons + 2 neutrons. Most ionising; few cm in air; stopped by paper.

Beta: fast electron from nucleus. Medium ionisation; stopped by thin aluminium.

Gamma: EM wave. Least ionising; most penetrating. Thick lead/concrete **reduces** it.

4 Decay and nuclear equations

Unstable nuclei decay randomly.

Activity in **Bq** = decays per second.

A GM tube detects radiation. Count rate is not necessarily the source activity.

Alpha: mass -4, atomic number -2.



Beta-minus: neutron → proton + electron.

Mass unchanged; atomic number +1.

Gamma: neither number changes.

Check both rows: mass numbers balance; atomic numbers balance.

5 Half-life: halve, then halve again

Half-life: time for source activity to halve.

Also applies to undecayed nuclei.

Use counts with background subtracted.

160 → 80 → 40 → 20

0 min 2 min 4 min 6 min

Example: corrected counts/min above.

Half-life = 2 minutes.

HIGHER TIER ONLY

After 3 half-lives: **1/8 remains**.

Decayed : initial = **7 : 8**.

6 Exposure, uses and precautions

Irradiation: radiation reaches an object.

Contamination: radioactive material gets on/in it; this material keeps emitting.

Irradiation alone does not make it radioactive in these GCSE situations.

Hazard: ionisation can damage cells/DNA. An internal alpha source is strongly ionising close to tissue.

Reduce exposure: less time, more distance, appropriate shielding.

Uses: beta for paper thickness; gamma for sterilising through packaging.

Peer review: scientists check evidence.