**Topics 4.1–4.4**
Full edition:
Topics 1–4

# Paper 1 Revision Booklet

AQA GCSE Physics 8463 · Foundation & Higher




Name _____ Class _____ Target grade _____

| | | | |
|---|---|---|---|
| **4.1** Energy | **4.2** Electricity | **4.3** Particle model of matter | **4.4** Atomic structure |

Work through a topic, then come back to it on the dates in your planner. Little and often beats one long cram.

# Revise like a scientist



This booklet uses six revision techniques that research shows work best. Every activity is labelled with the technique it uses and the grade it targets.

**Retrieval practice**
Pulling ideas out of your memory makes them stick far better than re-reading. Brain dumps, quizzes and cover-and-recall tasks.

**Spaced practice**
Revisit each topic after 2 days, 1 week and 3 weeks. Forgetting a little, then remembering again, strengthens memory.

**Interleaving**
Mixed-topic questions train you to spot which idea a question needs, just like the real exam.

**Dual coding**
Words plus diagrams: graphs, ray diagrams and labelled apparatus give your memory two routes in.

**Elaboration**
Asking 'why?' and 'how?' and linking ideas together turns facts into understanding.

**Worked examples**
I do → We do → You do: study a full solution, finish a half-done one, then do one alone.

KEY

## Grade pathways

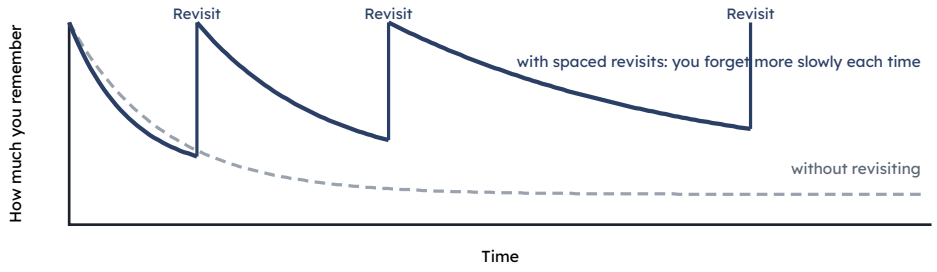
**GRADE 4**
Secure the basics: recall definitions and units, pick the right equation from the equation sheet, and do one-step calculations.

**GRADE 5**
Rearrange equations, convert units, describe practicals and explain in two linked steps.

**GRADE 7+**
Multi-step calculations, evaluate methods and data, and write logical 6-mark answers.

SPACED PRACTICE DUAL CODING

## Why spacing works




SPACED PRACTICE

## My spaced revision planner

Write the date you'll do each session. Tick it off when it's done.

| Topic | First go | +2 days | +1 week | +3 weeks | Before the mock |
|---|---|---|---|---|---|
| 4.1 Energy | | | | | |
| 4.2 Electricity | | | | | |
| 4.3 Particle model of matter | | | | | |
| 4.4 Atomic structure | | | | | |
| Paper 1 mixed quiz | | | | | |

# What's inside




## Topic 1 · Energy (4.1)

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## Paper 1 mixed retrieval

| | |
|---|---|
| Interleaved quiz across all four topics | 58 |


ROUTINE

### The routine for every page

**1. Try it cold.** Answer from memory first, without notes. Struggling a bit is good: it's what makes learning stick.

**2. Check and correct.** Mark it with the answer booklet in a different colour pen. Fix every mistake.

**3. Come back later.** Redo anything you got wrong on your next spaced session.

ONLINE

### Use it with mrsullyphysics.com

**Flashcards** for retrieval practice: cards you get wrong come back until you get them right.

**Quizzes and Aim higher** for extra Grade 5+ and 7+ questions with mark schemes.

**Animations** to see the physics move (dual coding).

# Brain dump and checklist



RETRIEVAL PRACTICE · GRADE 4 · GRADE 5 · GRADE 7

## Brain dump

Set a timer for 5 minutes. Write or draw everything you remember about energy: stores, equations, units, practicals. No notes! Afterwards, add anything you missed in a different colour.

Prompts if you get stuck: stores? · pathways? · Ek, Ep, Ee? · specific heat capacity? · power? · efficiency? · renewables?

METACOGNITION

## How confident am I?

Rate each statement now (before) by shading R, A or G. Rate again at the end of the topic (after).

| I can... | Before | | | After | | |
|---|---|---|---|---|---|---|
| | R | A | G | R | A | G |
| Name the eight energy stores and describe how energy is transferred between them | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Calculate kinetic, gravitational potential and elastic potential energy | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Use $\Delta E = mc\Delta\theta$ and describe the specific heat capacity practical | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Define power and use $P = E \div t$ and $P = W \div t$ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| State the principle of conservation of energy and describe dissipation | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Explain how lubrication and thermal insulation reduce wasted energy | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Explain how thermal conductivity and wall thickness affect the rate of cooling | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Calculate efficiency and rearrange the equation | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Describe the thermal insulation practical (Physics only) | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Compare renewable and non-renewable energy resources | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

## Extra practice

Retrieval · answers in the answer booklet

**1** Fill the gap: Power is the _____ at which energy is transferred. [1]

# Knowledge organiser

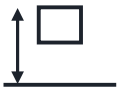


DUAL CODING | GRADE 4 | GRADE 5 | GRADE 7

## THE EIGHT ENERGY STORES



Kinetic



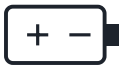
Gravitational potential



Elastic potential



Thermal



Chemical




Magnetic



Electrostatic



Nuclear

## HOW ENERGY IS TRANSFERRED

- **Mechanically:** by a force doing work
- **Electrically:** by an electric current doing work
- **By heating:** because of a temperature difference
- **By radiation:** by waves, e.g. light and sound

## BIG IDEAS

- Energy can be transferred usefully, stored or **dissipated**, but can't be created or destroyed.
- In a **closed system** there is no net change to the total energy.
- Wasted energy is usually dissipated to the surroundings by heating.

## KEY EQUATIONS: ALL GIVEN ON THE PHYSICS EQUATIONS SHEET IN THE EXAM

| Equation (on your equation sheet) | Quantities and units | Watch out |
|---|---|---|
| **$E_k = \frac{1}{2} m v^2$** | kinetic energy (J), mass (kg), speed (m/s) | Square the speed first |
| **$E_p = m g h$** | gravitational potential energy (J), mass (kg), g (N/kg), height (m) | g = 9.8 N/kg is given in the question |
| **$E_e = \frac{1}{2} k e^2$** | elastic potential energy (J), spring constant (N/m), extension (m) | Extension in metres |
| **$\Delta E = m c \Delta\theta$** | change in thermal energy (J), mass (kg), specific heat capacity (J/kg °C), temperature change (°C) | Δθ = final − start temperature |
| **$P = E \div t$** | power (W), energy transferred (J), time (s) | kW → W, minutes → s |
| **$P = W \div t$** | power (W), work done (J), time (s) | Work done = energy transferred |
| **efficiency = useful output energy transfer ÷ total input energy transfer** | no unit (or %); also works with power | Never more than 1 (100%) |

## TURN OVER

Key words, misconceptions and Grade 7+ links are on the next page.

# Knowledge organiser: key words, misconceptions, practicals



ELABORATION | GRADE 4 | GRADE 5 | GRADE 7

## KEY WORDS: LEARN THESE WORD FOR WORD (SAME AS SIDE 2 OF YOUR KNOWLEDGE ORGANISER)

**System:** an object or group of objects.
**Conservation of energy:** energy can be transferred usefully, stored or dissipated, but cannot be created or destroyed.
**Dissipated:** energy transferred to the surroundings so it is stored in less useful ways; often called 'wasted'.
**Specific heat capacity:** the amount of energy required to raise the temperature of 1 kg of a substance by 1 °C.
**Power:** the rate at which energy is transferred, or the rate at which work is done.
**Thermal conductivity:** the higher it is, the higher the rate of energy transfer by conduction across a material.
**Efficiency:** useful output energy transfer ÷ total input energy transfer.
**Renewable resource:** one that is being (or can be) replenished as it is used.

## MISCONCEPTIONS: SPOT THE MISTAKE

| × Common mistake | ✓ What's actually true |
|---|---|
| × Energy gets used up. | ✓ Energy is never used up; it's transferred to other stores, often dissipated. |
| × Heat and temperature are the same. | ✓ Temperature is a measure of hotness; energy is transferred by heating. |
| × A machine can be 100% efficient. | ✓ Some energy is always dissipated, so efficiency is less than 1. |

## REDUCE WASTED ENERGY

**Lubrication:** reduces friction.
**Thermal insulation:** reduces energy transfer by heating.
**Streamlining:** reduces air resistance.
**Thicker walls with low thermal conductivity** slow the rate of cooling of a building.

## RP1: SPECIFIC HEAT CAPACITY

**Aim:** Determine the specific heat capacity of one or more materials, such as aluminium and copper blocks, by linking the energy transferred by the heater (work done) to the increase in temperature and thermal energy stored.
**Change:** Energy transferred (J) · **Measure:** Temperature (°C) · **Control:** Mass of block, insulation, power of heater
**Must include:** Measure mass with a balance; Insulate the block; Measure energy with a joulemeter or E = VIt; Record temperature at regular intervals.
**Common mistake:** Forgetting to convert mass to kg or time to seconds.

## RP2: THERMAL INSULATION (PO)

**Aim:** Investigate the effectiveness of different materials as thermal insulators, and the factors that may affect the thermal insulation properties of a material (such as its thickness).
**Change:** Type of material (or number of layers) · **Measure:** Temperature drop over a fixed time · **Control:** Starting temperature, volume of water, beaker size, time, lid
**Must include:** Investigate a factor such as thickness (number of layers); Control the volume and starting temperature of water; Measure temperature at regular intervals for a fixed time; Use a lid.
**Common mistake:** Starting the timer at different temperatures.

## AIM FOR GRADE 7+

- Combine equations: Ep lost = Ek gained → $v = \sqrt{(2gh)}$.
- Explain why measured specific heat capacity is too high (energy dissipated → smaller $\Delta\theta$).
- Evaluate energy resources: give both sides and a justified conclusion.

RETRIEVAL PRACTICE | SPACED PRACTICE | GRADE 4 | GRADE 5

## Equation sheet skills: which equation, which unit?

You get every equation on the Physics Equations Sheet, but it won't tell you which one a question needs or what unit the answer has. Cover the knowledge organiser and fill in the table. Redo it on another day (spaced!).

| Situation | Which equation? | Unit of the answer | Redo 1 ✓/× | Redo 2 ✓/× |
|---|---|---|---|---|
| A 2 kg trolley is moving at 3 m/s. How much energy is in its kinetic store? | | | | |
| A crate is lifted onto a shelf. How much energy does it gain? | | | | |
| A spring is stretched by 5 cm. How much energy does it store? | | | | |
| A block of copper warms up by 20 °C. How much energy did it take in? | | | | |
| A motor lifts a load in 4 s. How quickly is it transferring energy? | | | | |
| How much of a lamp's input ends up as light? | | | | |

RETRIEVAL PRACTICE | GRADE 4 | GRADE 5

## Fill the gaps

Use the AQA key words. No word bank: that's the point.

1. Energy can be transferred usefully, stored or _____, but cannot be created or destroyed.
2. The amount of energy needed to raise the temperature of 1 kg of a substance by 1 °C is its _____.
3. Power is the _____ at which energy is transferred.
4. One watt is equal to one _____ per second.
5. Wasted energy is usually transferred to the _____ store of the surroundings.

ELABORATION | GRADE 5

## Odd one out

Circle the odd one out in each row and explain why.

1. kinetic · thermal · heating · nuclear

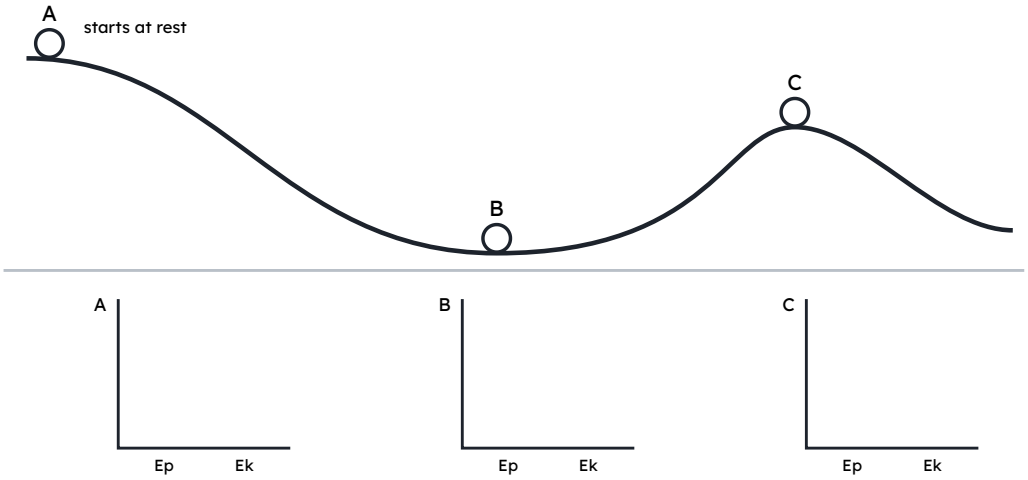
2. watt · joule per second · joule

3. wind · tidal · nuclear · solar

DUAL CODING GRADE 4 GRADE 5

## Roller coaster energy

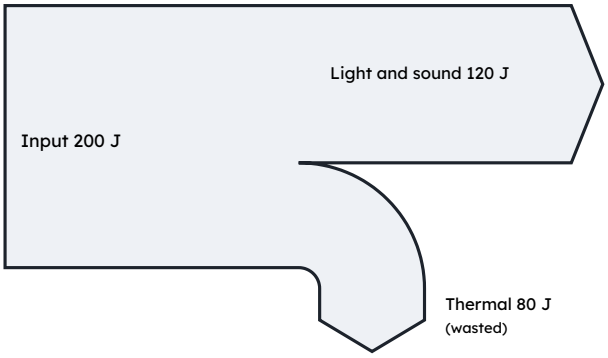
A car starts at rest at A. Ignore friction. Draw bars to show the gravitational potential (Ep) and kinetic (Ek) energy at A, B and C.




DUAL CODING GRADE 4 GRADE 5

## Reading a Sankey diagram

Sankey diagrams show energy transfers to scale. The width of each arrow shows the amount of energy.




**a** How much energy is wasted? [1]

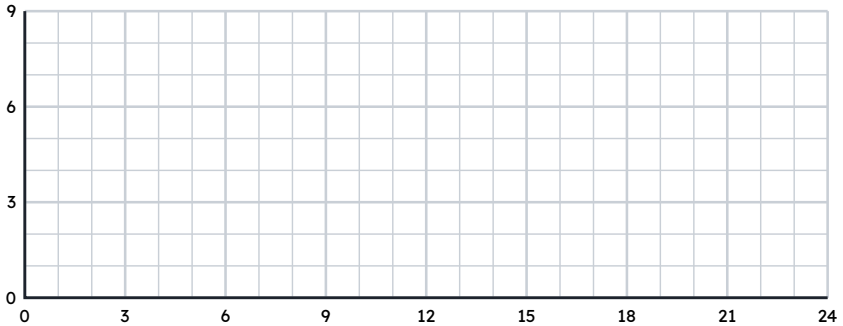
**b** Calculate the efficiency of the TV. [2]

**c** Where does the wasted energy go? [1]

DUAL CODING GRADE 5

## Draw your own Sankey diagram

An energy-saving lamp is supplied with 100 J. It transfers 20 J usefully by light. Draw a Sankey diagram to scale on the grid (1 square = 20 J).



WORKED EXAMPLES | GRADE 4 | GRADE 5

## Kinetic energy

### I do (worked example)

**A 2 kg ball moves at 3 m/s. Calculate Ek.**

1. Write the equation: Ek = ½mv²
2. Substitute: Ek = ½ × 2 × 3²
3. Square first: 3² = 9
4. Ek = ½ × 2 × 9 = **9 J**

### We do (finish it)

**A 60 kg runner moves at 5 m/s.**

1. Ek = ½mv²
2. Ek = ½ × 60 × ___
3. 5² = ___
4. Ek = ___ J

### You do

**A 900 kg car moves at 20 m/s.**

WORKED EXAMPLES | GRADE 4 | GRADE 5

## Gravitational potential energy

### I do (worked example)

**A 3 kg box is lifted 2 m. Calculate Ep. (g = 9.8 N/kg)**

1. Ep = mgh
2. Ep = 3 × 9.8 × 2
3. **Ep = 58.8 J**

Units: kg, N/kg, m → J

### We do (finish it)

**A 50 kg student climbs 4 m.**

1. Ep = mgh
2. Ep = 50 × 9.8 × ___
3. Ep = ___ J

### You do

**A 0.5 kg book is lifted 1.2 m.**

WORKED EXAMPLES | GRADE 7

## Rearranging: the next step

Grade 7+ questions often ask you to rearrange. Use the triangle-free method: write the equation, substitute, then solve.

**1** A 0.2 kg ball is dropped from 1.8 m. Calculate its speed just before it hits the ground (ignore air resistance). [4]

**2** A spring (k = 40 N/m) stores 0.2 J. Calculate its extension. [3]

WORKED EXAMPLES GRADE 4 GRADE 5

## Specific heat capacity

### I do (worked example)

**Heat 0.5 kg of water by 20 °C (c = 4200 J/kg °C).**

1. ΔE = mcΔθ
2. ΔE = 0.5 × 4200 × 20
3. **ΔE = 42 000 J**

Δθ = change in temperature

### We do (finish it)

**Heat 2 kg of oil by 15 °C (c = 2000).**

1. ΔE = mcΔθ
2. ΔE = 2 × ___ × 15
3. ΔE = ___ J

### You do

**Heat 0.25 kg of water from 20 °C to 80 °C.**

WORKED EXAMPLES GRADE 4 GRADE 5

## Power and efficiency

### I do (worked example)

**A 2 kW kettle runs for 2 minutes. Calculate E.**

1. Convert: 2 kW = 2000 W, 2 min = 120 s
2. E = Pt
3. E = 2000 × 120
4. **E = 240 000 J**

### We do (finish it)

**A motor: 500 J in, 400 J useful.**

1. efficiency = useful ÷ total
2. = ___ ÷ 500
3. = ___
4. As a %: ___

### You do

**A 1.5 kW heater runs for 10 min.**

ELABORATION GRADE 5

## Spot the mistake

Each student has made one mistake. Find it and correct it.

**1** Ali: "A 2 kg ball at 4 m/s has Ek = ½ × 2 × 4 = 4 J." [2]

**2** Bea: "A 60 W lamp on for 2 minutes transfers 60 × 2 = 120 J." [2]

**3** Cal: "A machine with an efficiency of 1.2 is very good." [1]

## Extra practice

Retrieval · answers in the answer booklet

**1** True or false? Energy can be created in a power station. Explain. [2]

ELABORATION GRADE 4 GRADE 5 GRADE 7

## Build an explanation

Answer each question in two steps. Use the starter, then push yourself with the Grade 7+ extension.

**1** Why does a car's brakes get hot when it stops?

*Grade 4–5 starter: "The car's kinetic energy store decreases because…"*

*Grade 7+ extension: "This means the energy is… so the total energy…"*

**2** How does loft insulation keep a house warm for longer?

*Grade 4–5 starter: "Insulation has a low thermal conductivity, so…"*

*Grade 7+ extension: "Link to the rate of cooling: the rate depends on…"*

**3** Why is it impossible for any device to be 100% efficient?

*Grade 4–5 starter: "Some energy is always…"*

*Grade 7+ extension: "Use an example and explain where the energy goes."*

ELABORATION GRADE 5

## True or false? Justify it.

Saying why is worth more marks than saying true or false.

**4** "Energy is used up when a battery goes flat." [2]

**5** "A more powerful kettle transfers more energy per second." [1]

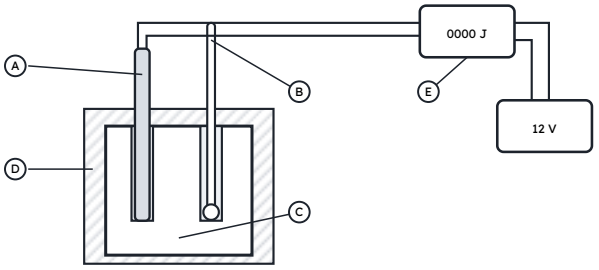
# Required practical 1: specific heat capacity



DUAL CODING GRADE 4

## Label the apparatus

Write the name of each labelled part, A to E.




**A** _____

**B** _____

**C** _____

**D** _____

**E** _____

RETRIEVAL PRACTICE GRADE 4 GRADE 5

## Put the method in order

Write the letters in the right order.

A. Switch on the heater and start the stopwatch.

B. Measure the mass of the aluminium block.

C. Record the temperature and energy every minute for 10 minutes.

D. Wrap the block in insulation and insert the heater and thermometer.

E. Plot temperature against energy and find the gradient.

F. Record the starting temperature.

_____

ELABORATION GRADE 5 GRADE 7

## Why do we...?

**1** ...wrap the block in insulation? [1]

_____

**2** ...put a drop of water in the thermometer hole? [1]

_____

**3** ...usually get a value of c that is higher than the true value? [2]

_____

_____

# RP1: analyse the results

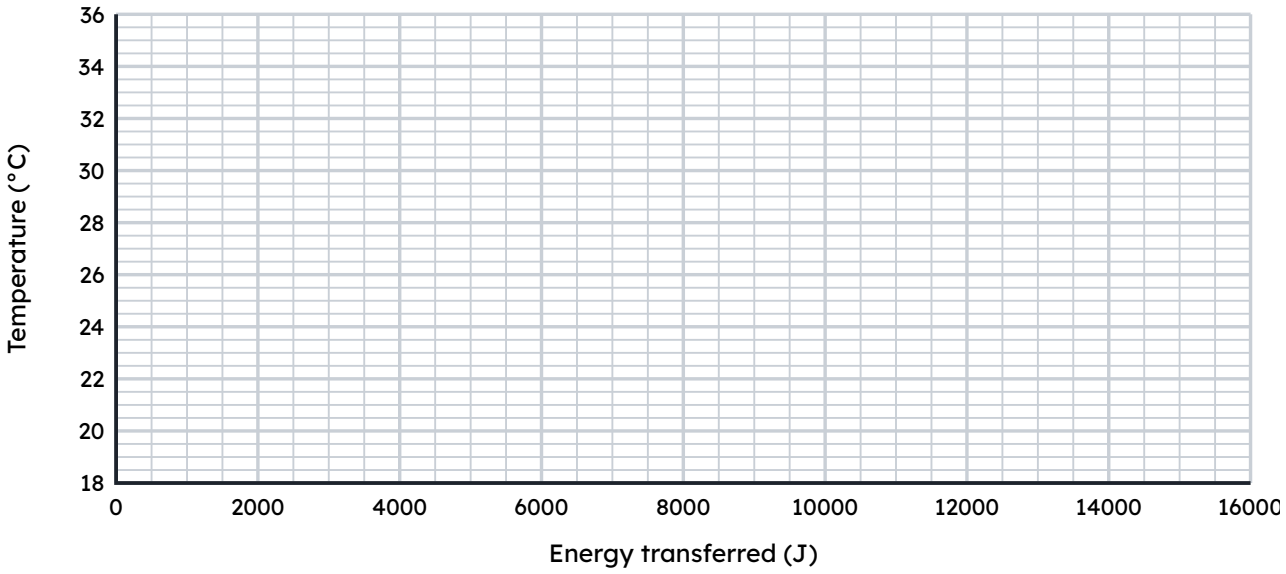


DUAL CODING | WORKED EXAMPLES | GRADE 5 | GRADE 7

## Plot and analyse

A 1.0 kg aluminium block was heated. Plot the results and draw a line of best fit through the straight section.

| Energy (J) | 0 | 3000 | 6000 | 9000 | 12 000 | 15 000 |
|---|---|---|---|---|---|---|
| Temperature (°C) | 20.0 | 22.4 | 25.6 | 28.6 | 31.6 | 34.6 |




**a** Explain why the first point is below the line. [1]

**b** Calculate the gradient of the straight section. [2]

**c** Use c = 1 ÷ (gradient × mass) to calculate the specific heat capacity. [2]

**d** The accepted value is 900 J/kg °C. Suggest one improvement. [1]

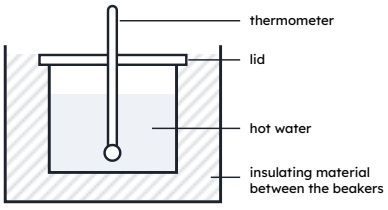
## Extra practice

Retrieval · answers in the answer booklet

**1** Grade 7+ A 0.06 kg tennis ball is hit straight up at 30 m/s. Assuming all its kinetic energy becomes gravitational potential energy, calculate the maximum height it reaches. (g = 9.8 N/kg) [3]

RETRIEVAL PRACTICE GRADE 4 GRADE 5

## Required practical 2: thermal insulation




**a** Independent variable: [1]

**b** Dependent variable: [1]

**c** Two control variables: [2]

**d** Which result shows the best insulator? [1]

RETRIEVAL PRACTICE GRADE 4 GRADE 5

## Compare energy resources

Complete the table from memory, then check.

| Resource | Renewable? | Reliable? | Environmental impact |
|---|---|---|---|
| Coal | | | |
| Nuclear | | | |
| Wind | | | |
| Solar | | | |
| Hydroelectric | | | |
| Tidal | | | |

ELABORATION GRADE 7

## Evaluate

Grade 7+: weigh up both sides and reach a conclusion.

**1** A town council wants to replace its coal power station. Evaluate replacing it with a wind farm. [6]

RETRIEVAL PRACTICE SPACED PRACTICE GRADE 4

## Quick-fire retrieval: Topic 1 so far

Cover the topic pages. Answer in under 3 minutes.

**1** Unit of specific heat capacity?

**2** Unit of power?

**3** Store that increases when a spring is stretched?

**4** Value of g on Earth?

**5** Way to reduce friction?

**6** A reliable renewable resource?

# Exam practice



GRADE RADE 4

## Secure the basics

**1** Which of these is an energy store? Tick one. [1]

☐ heating ☐ chemical ☐ radiation ☐ electrically

**2** A kettle has a power of 2000 W. It is switched on for 60 s. Calculate the energy transferred. [2]

**3** Give one way to reduce unwanted energy transfers in a machine with moving parts. [1]

**4** A lamp is supplied with 50 J of energy and transfers 10 J usefully. Calculate its efficiency. [2]

**5** Name the energy store that decreases when a ball falls. [1]

GRADE RADE 5

## Apply and rearrange

**6** A 1200 kg car travels at 15 m/s. Calculate its kinetic energy. [2]

**7** A motor has an efficiency of 0.6 and a useful output of 300 W. Calculate the input power. [3]

**8** Calculate the energy needed to heat 2.0 kg of water from 15 °C to 65 °C. (c = 4200 J/kg °C) [3]

**9** Explain why a house with thick walls made of a material with a low thermal conductivity cools more slowly. [2]

GRADE RADE 7+

## Stretch

**10** A 2.0 kW heater warms 3.0 kg of liquid from 20 °C to 70 °C in 5 minutes. Calculate the specific heat capacity, assuming no energy is wasted. [4]

**11** Describe how a student could find the specific heat capacity of a metal block. Include how to make the result as accurate as possible. [6]

**Total: _____ / 27**

EXAM TECHNIQUE

## Command words

| Command word | What to do |
|---|---|
| **State / Give / Name** | A short answer; no explanation needed. |
| **Describe** | Say what happens, in order. No need to say why. |
| **Explain** | Say what happens *and why*: use “because” and “so”. |
| **Calculate** | Show the equation, substitution, answer and unit. |
| **Evaluate** | Give points for and against, then a justified conclusion. |

## Extra practice

Retrieval · answers in the answer booklet

**1** Grade 5 0.25 kg of water is heated from 20 °C to 80 °C. Calculate the energy transferred. (c = 4200 J/kg °C) [2]

METACOGNITION

## Re-rate yourself

Go back to the checklist on the first page of this topic and fill in the 'After' column.

METACOGNITION GRADE 4 GRADE 5 GRADE 7

## Exam wrapper: why did I drop marks?

After marking the exam practice, write the question numbers you got wrong in the right row. This tells you what kind of revision you need.

| Reason I lost marks | Question numbers | What to do next |
|---|---|---|
| I didn't know or remember it (knowledge gap) | | Flashcards and brain dumps |
| I knew it but misread the question or command word | | Underline command words |
| Maths slip: units, rearranging, squaring | | Redo the "we do / you do" pages |
| I ran out of time or didn't finish | | Timed practice: 1 mark per minute |

METACOGNITION GRADE 4 GRADE 5 GRADE 7

## Two things I'm now confident about

METACOGNITION

## One thing I still need to work on, and how I'll fix it

e.g. 'Rearranging Ek = ½mv² → redo the Grade 7+ questions in section 1.9 and use the website's Aim higher section.'

SPACED PRACTICE

## Book my next spaced sessions

Write the dates in the planner on page 2: +2 days, +1 week, +3 weeks.

# Brain dump and checklist



RETRIEVAL PRACTICE · GRADE 4 · GRADE 5 · GRADE 7

## Brain dump

Set a timer for 5 minutes. Write or draw everything you remember about electricity. No notes! Afterwards, add anything you missed in a different colour.

Prompts if you get stuck: circuit symbols? · Q = It? · V = IR? · series vs parallel? · I–V graphs? · thermistor and LDR? · a.c. and d.c.? · plug wires? · National Grid? · static?

METACOGNITION

## How confident am I?

Rate each statement now (before) by shading R, A or G. Rate again at the end of the topic (after).

| I can... | Before | | | After | | |
|---|---|---|---|---|---|---|
| | R | A | G | R | A | G |
| Draw and recognise circuit symbols | ○ | ○ | ○ | ○ | ○ | ○ |
| Use Q = It and define current as the rate of flow of charge | ○ | ○ | ○ | ○ | ○ | ○ |
| Use V = IR and describe the resistance practical (RP3) | ○ | ○ | ○ | ○ | ○ | ○ |
| Sketch and explain I–V graphs for a resistor, filament lamp and diode (RP4) | ○ | ○ | ○ | ○ | ○ | ○ |
| Describe how thermistors and LDRs respond to temperature and light | ○ | ○ | ○ | ○ | ○ | ○ |
| State the rules for current, p.d. and resistance in series and parallel | ○ | ○ | ○ | ○ | ○ | ○ |
| Describe a.c. and d.c. and UK mains (230 V, 50 Hz) | ○ | ○ | ○ | ○ | ○ | ○ |
| Name the three wires in a plug and explain why the live wire is dangerous | ○ | ○ | ○ | ○ | ○ | ○ |
| Use P = VI, P = $I^2R$, E = Pt and E = QV | ○ | ○ | ○ | ○ | ○ | ○ |
| Explain how the National Grid uses transformers to reduce the energy wasted in the cables | ○ | ○ | ○ | ○ | ○ | ○ |
| Explain static charge and electric fields (Physics only) | ○ | ○ | ○ | ○ | ○ | ○ |

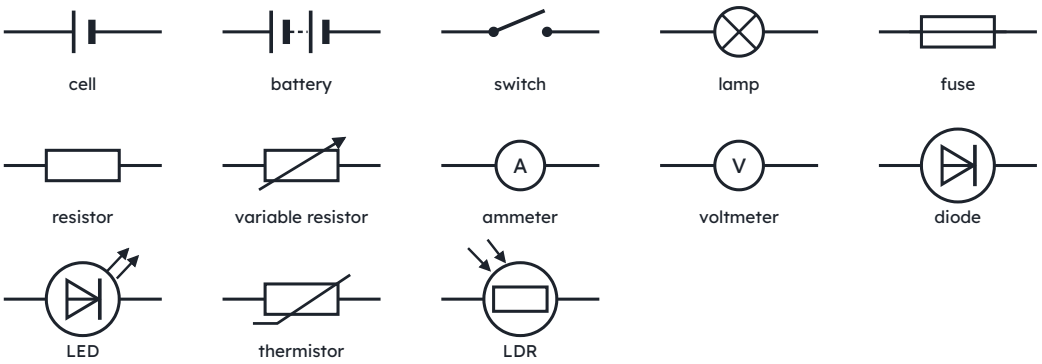
## Extra practice

Retrieval · answers in the answer booklet

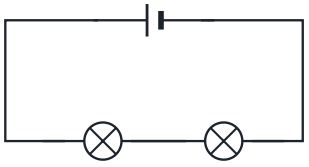
**1** Fill the gap: Mains electricity in the UK has a frequency of _____ Hz. [1]

DUAL CODING | GRADE 4 | GRADE 5 | GRADE 7

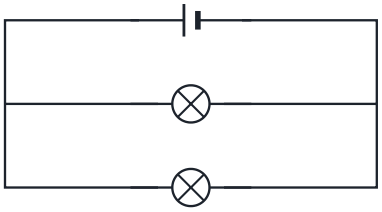
## CIRCUIT SYMBOLS



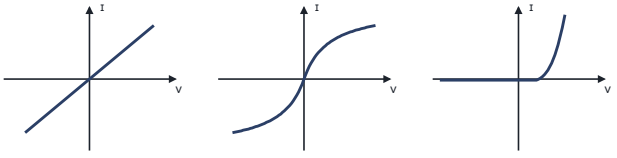

## SERIES AND PARALLEL · I–V GRAPHS



Series: one loop
same current everywhere
p.d. shared; R total = $R_1 + R_2$



Parallel: separate branches
same p.d. across each branch; currents add
total R less than the smallest resistor




Resistor (constant temperature) | Filament lamp | Diode

## KEY EQUATIONS: ALL GIVEN ON THE PHYSICS EQUATIONS SHEET IN THE EXAM

| Equation | Quantities and units | Watch out |
|---|---|---|
| **Q = I t** | charge flow (C), current (A), time (s) | Time in seconds |
| **V = I R** | potential difference (V), current (A), resistance (Ω) | Rearrange: R = V ÷ I |
| **P = V I** | power (W), potential difference (V), current (A) | Mains p.d. ≈ 230 V |
| **P = $I^2$ R** | power (W), current (A), resistance (Ω) | Square the current first |
| **E = P t** | energy transferred (J), power (W), time (s) | kW → W, minutes → s |
| **E = Q V** | energy transferred (J), charge flow (C), potential difference (V) | p.d. = energy per unit charge |

## SERIES AND PARALLEL RULES

**Series:** same current everywhere; p.d. is shared; $R_{total} = R_1 + R_2$.

**Parallel:** same p.d. across each branch; branch currents add up to the total; total resistance is less than the smallest resistor.

## MAINS ELECTRICITY

UK mains is a.c. at 230 V, 50 Hz.
**Live** (brown) 230 V · **neutral** (blue) about 0 V · **earth** (green and yellow stripes) safety wire, only carries current if there is a fault.

## TURN OVER

Key words, misconceptions, required practicals and Grade 7+ links are on the next page.

# Knowledge organiser: key words, misconceptions, practicals



ELABORATION GRADE 4 GRADE 5 GRADE 7

## KEY WORDS: LEARN THESE WORD FOR WORD (SAME AS SIDE 2 OF YOUR KNOWLEDGE ORGANISER)

**Current:** the rate of flow of electrical charge. Same at every point in a single closed loop.
**Potential difference:** the energy transferred per unit charge passed (E = QV).
**Resistance:** the greater it is, the smaller the current for a given p.d.
**Ohmic conductor:** current is directly proportional to p.d. at constant temperature.
**Thermistor:** resistance decreases as temperature increases.
**LDR:** resistance decreases as light intensity increases.
**Direct current (d.c.):** flows in one direction only (cells and batteries).
**Alternating current (a.c.):** keeps changing direction; UK mains is 230 V, 50 Hz.

## MISCONCEPTIONS: SPOT THE MISTAKE

| × Common mistake | ✓ What's actually true |
|---|---|
| × Current gets used up round a circuit. | ✓ Current is the same at every point in a series loop; energy is transferred, not charge. |
| × Adding resistors in parallel increases resistance. | ✓ It decreases the total resistance: more paths for the charge. |
| × The fuse is in the neutral wire. | ✓ The fuse is in the live wire, so a fault disconnects the dangerous supply. |

## RP3: RESISTANCE

**Aim:** Investigate how wire length affects resistance, and how resistors combine in series and parallel.
**Change:** Length of wire · **Measure:** Resistance (from V and I) · **Control:** Material and thickness of wire, temperature, current
**Must include:** Draw and use a correct circuit diagram; Test resistors in series and in parallel and compare total resistance; Ammeter in series, voltmeter in parallel; Calculate R = V ÷ I.
**Common mistake:** Connecting the voltmeter in series or the ammeter in parallel.

## RP4: I–V CHARACTERISTICS

**Aim:** Plot I–V graphs for a filament lamp, a resistor at constant temperature and a diode.
**Change:** Potential difference · **Measure:** Current · **Control:** Component being tested, temperature (for the resistor)
**Must include:** Correct circuit with a variable resistor; Record pairs of V and I readings; Reverse the connections for negative values; Plot I against V for each component.
**Common mistake:** Plotting the axes the wrong way round (AQA uses current on the y-axis).

## AIM FOR GRADE 7+

- Two-step calculations: I = P ÷ V, then R = V ÷ I.
- Explain the filament lamp's I–V curve using temperature and resistance.
- Explain why the National Grid uses high p.d.: $P = I^2R$, so a lower current wastes less power.

## Extra practice

Retrieval · answers in the answer booklet

**1** Grade 7+ A 60 W lamp runs on 230 V mains for 5 minutes. Calculate the charge that flows through it. [4]

RETRIEVAL PRACTICE | SPACED PRACTICE | GRADE 4 | GRADE 5

## Equation sheet skills: which equation, which unit?

Every equation is on the Physics Equations Sheet, but it won't tell you which one a question needs or what unit the answer has. Cover the knowledge organiser and fill in the table. Redo it on another day.

| Situation | Which equation? | Unit of the answer | Redo 1 ✓/× | Redo 2 ✓/× |
|---|---|---|---|---|
| A charge flows through a lamp in 2 minutes. How much charge? | | | | |
| What p.d. drives 0.5 A through a 20 Ω resistor? | | | | |
| A kettle runs on mains and draws 9 A. What is its power? | | | | |
| Power wasted in a cable carrying a large current? | | | | |
| A 2 kW heater is on for 30 minutes. How much energy? | | | | |
| Energy transferred when 50 C moves through 12 V? | | | | |

RETRIEVAL PRACTICE | GRADE 4 | GRADE 5

## Fill the gaps

Use the AQA key words. No word bank: that's the point.

1. Current is the rate of flow of electrical _____.
2. In a series circuit the _____ is the same at every point.
3. The resistance of a thermistor decreases as the _____ increases.
4. The earth wire is green and yellow; the neutral wire is _____.
5. Step-up transformers increase the p.d. so the _____ in the cables is smaller and less energy is wasted.

ELABORATION | GRADE 5

## Odd one out

Circle the odd one out in each row and explain why.

1. ammeter · voltmeter · thermistor · fuse

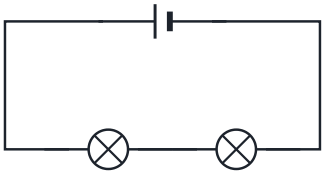
2. Q = It · V = IR · ρ = m ÷ V · P = VI

3. live · neutral · earth · fuse

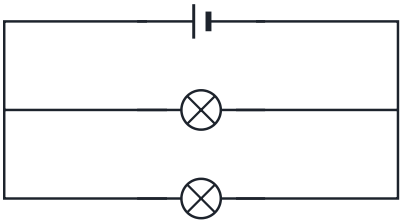
DUAL CODING GRADE 4 GRADE 5

## Read the circuit

Use the circuits to answer.



Series: one loop
same current everywhere
p.d. shared; R total = $R_1 + R_2$



Parallel: separate branches
same p.d. across each branch; currents add
total R less than the smallest resistor

**a** In the series circuit, the cell is 6 V and one lamp has 2 V across it. What is the p.d. across the other lamp? [2]

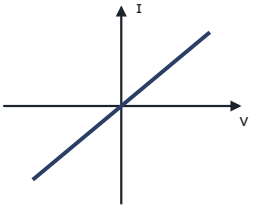
**b** In the parallel circuit, the branch currents are 0.2 A and 0.3 A. What does the ammeter by the cell read? [1]

**c** Which circuit has the lower total resistance? Explain. [2]

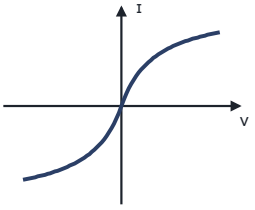
DUAL CODING GRADE 5 GRADE 7

## I–V graphs

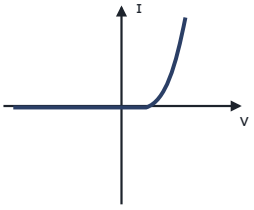
Match each graph to the component and explain its shape.




Resistor (constant temperature)




Filament lamp




Diode

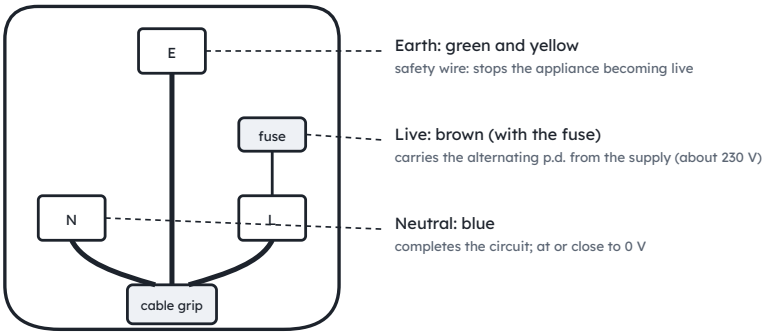
**a** Which graph shows a resistor at constant temperature? How do you know? [2]

**b** Explain why the filament lamp graph curves. [3]

**c** What is special about the diode? [1]

DUAL CODING GRADE 4 GRADE 5 GRADE 7

## Plugs and the National Grid




**a** Why is the live wire dangerous even when a switch is open? [2]

**b** Explain why the National Grid transmits at a very high p.d. [3]

## Extra practice

Retrieval · answers in the answer booklet

**1** Grade 5 Explain why touching the live wire can give you an electric shock. [2]

**2** Grade 7+ Explain why a person who touches the live wire can get an electric shock, even if the appliance's switch is off. [4]

**3** Grade 7+ Fuel flowing through a pipe into an aircraft can produce a spark. Explain why, and how the risk is reduced. [3]

# I do, we do, you do

WORKED EXAMPLES · GRADE 4 · GRADE 5

## Charge and current

### I do (worked example)

**A current of 0.4 A flows for 2 minutes. Calculate the charge.**

1. Q = It
2. t = 2 × 60 = 120 s
3. Q = 0.4 × 120
4. **Q = 48 C**

### We do (finish it)

**3 A for 5 minutes.**

1. t = ___ s
2. Q = 3 × ___
3. Q = ___ C

### You do

**1.5 A for 40 s.**

WORKED EXAMPLES · GRADE 4 · GRADE 5

## V = IR

### I do (worked example)

**A 12 V supply drives 0.3 A through a resistor. Calculate R.**

1. V = IR, so R = V ÷ I
2. R = 12 ÷ 0.3
3. **R = 40 Ω**

Check the units: V ÷ A = Ω

### We do (finish it)

**0.25 A through a 48 Ω resistor. Calculate V.**

1. V = IR
2. V = 0.25 × ___
3. V = ___ V

### You do

**6 V across 30 Ω. Calculate I.**

WORKED EXAMPLES · GRADE 5 · GRADE 7

## Series circuits: two steps

Grade 7+ questions often need the series rules and V = IR together.

**1** A 4 Ω and an 8 Ω resistor are in series with a 6 V battery. Calculate the current and the p.d. across the 8 Ω resistor. [4]

## Extra practice

Retrieval · answers in the answer booklet

**1** Grade 5 State the colour of the neutral wire in a three-core cable and describe what it does. [2]

# I do, we do, you do (continued)



WORKED EXAMPLES | GRADE 4 | GRADE 5

## Power and energy

**I do (worked example)**

**A 230 V toaster draws 4 A for 3 minutes. Calculate the energy.**

1. P = VI = 230 × 4 = 920 W
2. t = 3 × 60 = 180 s
3. E = Pt = 920 × 180
4. **E = 165 600 J**

**We do (finish it)**

**A 60 W lamp on for 10 s.**

1. E = Pt
2. E = 60 × ___
3. E = ___ J

**You do**

**2 A through 15 Ω. Calculate P.**

WORKED EXAMPLES | GRADE 5 | GRADE 7

## E = QV

**I do (worked example)**

**20 C passes through a 9 V battery. Calculate the energy.**

1. E = QV
2. E = 20 × 9
3. **E = 180 J**

p.d. = energy per coulomb

**We do (finish it)**

**500 J transferred by 50 C.**

1. V = E ÷ Q
2. V = 500 ÷ ___
3. V = ___ V

**You do**

**230 V mains, 2 A for 1 s.**

ELABORATION | GRADE 5

## Spot the mistake

Each student has made one mistake. Find it and correct it.

**1** Ana: "A 2 kW heater on for 10 minutes transfers 2 × 10 = 20 J." [2]

**2** Ben: "In parallel, adding another resistor makes the total resistance bigger." [1]

**3** Cara: "$P = I^2R$, so 3 A through 10 Ω gives 3 × 2 × 10 = 60 W." [2]

## Extra practice

Retrieval · answers in the answer booklet

**1** Which wire is brown in a UK plug? [1]

**A** Live **B** Neutral **C** Earth **D** Fuse

# Why? How? Explaining electricity



ELABORATION GRADE 4 GRADE 5 GRADE 7

## Build an explanation

Answer each question in two steps. Use the starter, then push yourself with the Grade 7+ extension.

**1** Explain why the resistance of a filament lamp increases as the current increases.

*Grade 4–5 starter: "As the current increases, the filament…"*

*Grade 7+ extension: "Link to the ions in the metal and the electrons:…"*

**2** Explain how an LDR can switch on a street lamp at night.

*Grade 4–5 starter: "When it gets dark, the resistance of the LDR…"*

*Grade 7+ extension: "Link to how the p.d. is shared in a series circuit:…"*

**3** Explain why a person can get an electric shock from a faulty appliance.

*Grade 4–5 starter: "The live wire is at a high p.d., and the person is at…"*

*Grade 7+ extension: "Link to the earth wire and the fuse:…"*

ELABORATION GRADE 5

## True or false? Justify it.

Saying why is worth more marks than saying true or false.

**4** "Current is used up as it flows round a circuit." [2]

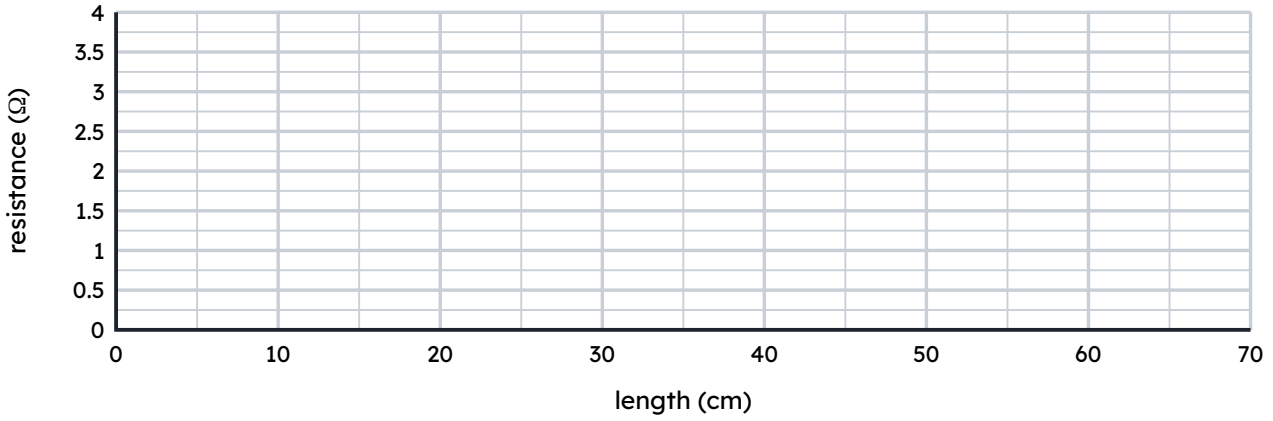
**5** "The earth wire normally carries a current." [1]

DUAL CODING | WORKED EXAMPLES | GRADE 4 | GRADE 5 | GRADE 7

## RP3: resistance of a wire

A student measures the resistance of different lengths of wire using an ammeter and a voltmeter.

| Length (cm) | 10 | 20 | 30 | 40 | 50 | 60 |
|---|---|---|---|---|---|---|
| p.d. (V) | 0.30 | 0.60 | 0.90 | 1.20 | 1.50 | 1.80 |
| Current (A) | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 |
| Resistance (Ω) | | | | | | |




**a** Complete the resistance row (R = V ÷ I) and plot the graph. [3]

**b** Describe the relationship. [1]

**c** Why should the current be kept small? [2]

**d** The line doesn't quite pass through (0, 0) on a real graph. Suggest why. [1]

## Extra practice

Retrieval · answers in the answer booklet

**1** Grade 7+ Two identical 6 Ω resistors are connected in parallel to a 12 V supply. Calculate the total current from the supply and explain why the total resistance is less than 6 Ω. [4]

# RP4: I–V characteristics

RETRIEVAL PRACTICE | ELABORATION | GRADE 4 | GRADE 5 | GRADE 7

## RP4: I–V characteristics

A student uses a variable resistor to change the p.d. across a filament lamp, then reverses the supply.

**a** Draw the circuit she should use. [3]

| p.d. (V) | −6 | −4 | −2 | 0 | 2 | 4 | 6 |
|---|---|---|---|---|---|---|---|
| Current (A) | −0.30 | −0.26 | −0.18 | 0 | 0.18 | 0.26 | 0.30 |

**b** Describe the shape of the I–V graph for these results. [2]

**c** Calculate the resistance of the lamp at 2 V and at 6 V. [3]

**d** Explain the difference in your answers to (c). [2]

**e** How would the graph be different for a diode? [2]

## Extra practice

Retrieval · answers in the answer booklet

**1** Grade 7+ A current of 3 A flows through a cable with a resistance of 5 Ω for 10 minutes. Calculate the energy transferred by heating in the cable. [4]

**2** Grade 7+ A phone charger transfers 18 000 J to a phone in 1 hour at a p.d. of 5 V. Calculate the charge that flows, then the average current. [4]

# Exam practice



GRADE RADE 4

## Secure the basics

**1** Draw the circuit symbol for a thermistor. [1]

**2** State the frequency and p.d. of the UK mains supply. [2]

**3** Calculate the charge that flows when a current of 2 A flows for 30 s. [2]

**4** Name the colour of the live wire in a UK plug. [1]

**5** A resistor has 6 V across it and a current of 0.2 A. Calculate its resistance. [2]

GRADE RADE 5

## Apply and rearrange

**6** A 1.5 kW hairdryer is used for 4 minutes. Calculate the energy transferred. [3]

**7** Explain how the resistance of a thermistor changes as it is heated, and give one use. [2]

**8** A current of 0.5 A flows through a 40 Ω resistor. Calculate the power transferred. [2]

**9** Explain why a lamp in parallel stays on when another branch is switched off. [2]

## Extra practice

Retrieval · answers in the answer booklet

**1** True or false? The resistance of an LDR decreases as light intensity increases. Explain. [2]

GRADE RADE 7+

## Stretch

**10** A 6 V battery is connected to a 10 Ω and a 20 Ω resistor in parallel. Calculate the current from the battery. [4]

**11** Describe how to investigate how the resistance of a wire depends on its length. Include how you would make the results valid. [6]

**Total: _____ / 27**

RETRIEVAL PRACTICE SPACED PRACTICE GRADE 4

## Quick-fire retrieval: Electricity

Cover everything. Answer in under 3 minutes. Redo it on your next spaced session.

**1** Unit of charge?

**2** Unit of resistance?

**3** UK mains p.d. and frequency?

**4** Colour of the neutral wire?

**5** Series: what's the same everywhere?

**6** Parallel: what's the same across each branch?

## Extra practice

Retrieval · answers in the answer booklet

**1** Grade 5 A current of 0.4 A flows for 3 minutes. Calculate the charge that flows. [2]

# Reflect and plan



METACOGNITION

## Re-rate yourself

Go back to the checklist at the start of this topic and fill in the 'After' column.

METACOGNITION GRADE 4 GRADE 5 GRADE 7

## Exam wrapper: why did I drop marks?

After marking the exam practice, write the question numbers you got wrong in the right row.

| Reason I lost marks | Question numbers | What to do next |
|---|---|---|
| I didn't know or remember it (knowledge gap) | | Flashcards and brain dumps |
| I knew it but misread the question or command word | | Underline command words |
| Maths slip: units, rearranging, standard form | | Redo the "we do / you do" pages |
| I ran out of time or didn't finish | | Timed practice: 1 mark per minute |

METACOGNITION

## Two things I'm now confident about

METACOGNITION

## One thing I still need to work on, and how I'll fix it

e.g. 'Rearranging equations → redo the Grade 7+ questions and use the website's Aim higher section.'

SPACED PRACTICE

## Book my next spaced sessions

Write the dates in the planner at the front: +2 days, +1 week, +3 weeks.

## Extra practice

Retrieval · answers in the answer booklet

**1** True or false? A fuse is connected in the neutral wire. Explain. [2]

# Brain dump and checklist



RETRIEVAL PRACTICE · GRADE 4 · GRADE 5 · GRADE 7

## Brain dump

Set a timer for 5 minutes. Write or draw everything you remember about particle model of matter. No notes! Afterwards, add anything you missed in a different colour.

Prompts if you get stuck: density? · ρ = m ÷ V? · solid, liquid, gas? · internal energy? · specific heat capacity? · latent heat? · heating curves? · gas pressure? · pV = constant?

METACOGNITION

## How confident am I?

Rate each statement now (before) by shading R, A or G. Rate again at the end of the topic (after).

| I can... | Before | | | After | | |
|---|---|---|---|---|---|---|
| | R | A | G | R | A | G |
| Use the particle model to explain differences in density of solids, liquids and gases | ○ | ○ | ○ | ○ | ○ | ○ |
| Use ρ = m ÷ V and describe the density practical (RP5) | ○ | ○ | ○ | ○ | ○ | ○ |
| Describe changes of state and explain why mass is conserved | ○ | ○ | ○ | ○ | ○ | ○ |
| Define internal energy as the total kinetic and potential energy of the particles | ○ | ○ | ○ | ○ | ○ | ○ |
| Use ΔE = mcΔθ for temperature changes | ○ | ○ | ○ | ○ | ○ | ○ |
| Define specific latent heat of fusion and vaporisation and use E = mL | ○ | ○ | ○ | ○ | ○ | ○ |
| Interpret heating and cooling graphs | ○ | ○ | ○ | ○ | ○ | ○ |
| Explain gas pressure using particle motion | ○ | ○ | ○ | ○ | ○ | ○ |
| Explain how temperature affects the pressure of a gas at constant volume | ○ | ○ | ○ | ○ | ○ | ○ |
| Use pV = constant for a fixed mass of gas at constant temperature (Physics only) | ○ | ○ | ○ | ○ | ○ | ○ |
| Explain why doing work on a gas increases its temperature (Physics only, Higher) | ○ | ○ | ○ | ○ | ○ | ○ |

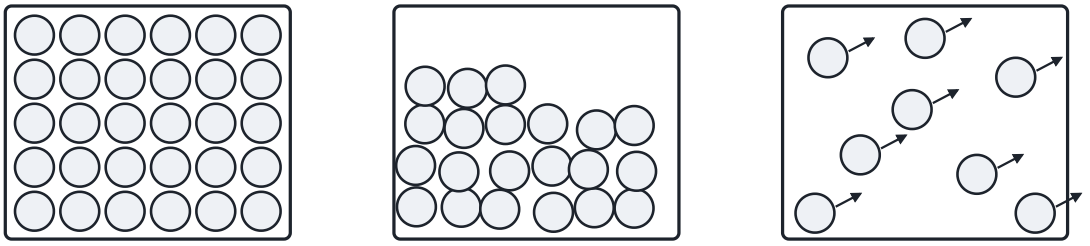
## Extra practice

Retrieval · answers in the answer booklet

**1** True or false? When a substance melts, its mass increases. Explain. [2]

DUAL CODING | GRADE 4 | GRADE 5 | GRADE 7

## STATES OF MATTER

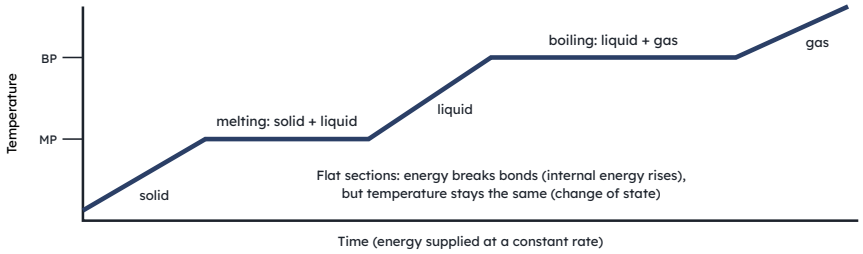


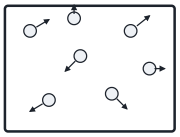
**Solid**
close together, regular pattern, vibrate about fixed positions

**Liquid**
close together, random arrangement, move past each other

**Gas**
far apart, random, move quickly in all directions

## HEATING CURVE · GAS PRESSURE



Particles collide with the walls, exerting a force at right angles: pressure

Higher temperature → particles move faster → hit the walls more often and harder → higher pressure

Smaller volume (constant temperature) → particles hit the walls more often → higher pressure: $pV$ = constant (Physics only)

## KEY EQUATIONS: ALL GIVEN ON THE PHYSICS EQUATIONS SHEET IN THE EXAM

| Equation | Quantities and units | Watch out |
|---|---|---|
| **$\rho = m \div V$** | density (kg/m³), mass (kg), volume (m³) | 1 g/cm³ = 1000 kg/m³ |
| **$\Delta E = m\,c\,\Delta\theta$** | change in thermal energy (J), mass (kg), specific heat capacity (J/kg °C), temperature change (°C) | Used when the temperature changes |
| **$E = m\,L$** | energy for a change of state (J), mass (kg), specific latent heat (J/kg) | Used when the state changes (no temperature change) |
| **$p\,V$ = constant** | pressure (Pa), volume (m³); fixed mass of gas at constant temperature (Physics only) | $p_1V_1 = p_2V_2$ |

## INTERNAL ENERGY

Internal energy is the total kinetic energy and potential energy of all the particles in a system.
Heating either raises the temperature (more kinetic energy) or changes the state (more potential energy), not both at once.

## CHANGES OF STATE

Melting, freezing, boiling, evaporating, condensing and sublimating are **physical changes**: the material recovers its original properties if the change is reversed. Mass is conserved.

## TURN OVER

Key words, misconceptions, required practicals and Grade 7+ links are on the next page.

# Knowledge organiser: key words, misconceptions, practicals



ELABORATION GRADE 4 GRADE 5 GRADE 7

## KEY WORDS: LEARN THESE WORD FOR WORD (SAME AS SIDE 2 OF YOUR KNOWLEDGE ORGANISER)

**Density:** mass per unit volume (ρ = m ÷ V).
**Internal energy:** the total kinetic energy and potential energy of all the particles that make up a system.
**Specific latent heat:** the amount of energy required to change the state of 1 kg of a substance with no change in temperature.
**Latent heat of fusion:** solid ↔ liquid. Latent heat of vaporisation: liquid ↔ gas.
**Physical change:** the material recovers its original properties if the change is reversed; mass is conserved.
**Gas pressure:** particles colliding with the walls exert a net force at right angles to the surface.
**Temperature of a gas:** related to the average kinetic energy of its molecules.

## MISCONCEPTIONS: SPOT THE MISTAKE

| × Common mistake | ✓ What's actually true |
|---|---|
| × Particles expand when heated. | ✓ Particles move faster and further apart; they don't get bigger. |
| × Temperature rises while ice melts. | ✓ Temperature stays constant during a change of state. |
| × Mass changes when a substance melts. | ✓ Mass is conserved in a change of state. |

## RP5: DENSITY

**Aim:** Determine the density of regular and irregular solids and of a liquid.
**Change:** Object or material · **Measure:** Mass and volume · **Control:** Balance and measuring equipment used
**Must include:** Measure mass with a balance; Measure volume correctly for regular and irregular objects; Use a eureka can for irregular objects; Calculate ρ = m ÷ V with units.
**Common mistake:** Forgetting units, or mixing g with $m^3$.

## AIM FOR GRADE 7+

- Heating then melting: add $mc\Delta\theta$ and $mL$ for the total energy.
- Explain flat sections of heating curves using internal energy (potential, not kinetic, increases).
- (PO) pV = constant: compressing a gas at constant temperature increases its pressure.

## Extra practice

Retrieval · answers in the answer booklet

**1** Grade 7+ 0.5 kg of water at 20 °C is heated to 100 °C, and then 0.1 kg of it boils away. Calculate the total energy supplied. (c = 4200 J/kg °C, L = 2 260 000 J/kg) [4]

**2** Grade 5 Name the change of state when (a) a gas turns into a liquid, (b) a solid turns straight into a gas. [2]

RETRIEVAL PRACTICE | SPACED PRACTICE | GRADE 4 | GRADE 5

## Equation sheet skills: which equation, which unit?

Every equation is on the Physics Equations Sheet, but it won't tell you which one a question needs or what unit the answer has. Cover the knowledge organiser and fill in the table. Redo it on another day.

| Situation | Which equation? | Unit of the answer | Redo 1 ✓/× | Redo 2 ✓/× |
|---|---|---|---|---|
| A block of metal has a mass and a measured volume. How dense is it? | | | | |
| Energy to warm 2 kg of water by 30 °C? | | | | |
| Energy to melt 0.5 kg of ice at 0 °C? | | | | |
| Gas compressed slowly at constant temperature: new pressure? | | | | |
| Calculate the mass of air in a room from its volume and density. | | | | |
| Energy given out as steam condenses. | | | | |

RETRIEVAL PRACTICE | GRADE 4 | GRADE 5

## Fill the gaps

Use the AQA key words. No word bank: that's the point.

1. Density is mass per unit _____.
2. Internal energy is the total kinetic and _____ energy of the particles.
3. The energy needed to change the state of 1 kg of a substance with no change in temperature is its specific _____ heat.
4. In a change of state, mass is _____.
5. Gas particles colliding with the walls of a container exert a _____ at right angles to the wall.

ELABORATION | GRADE 5

## Odd one out

Circle the odd one out in each row and explain why.

1. melting · boiling · burning · condensing

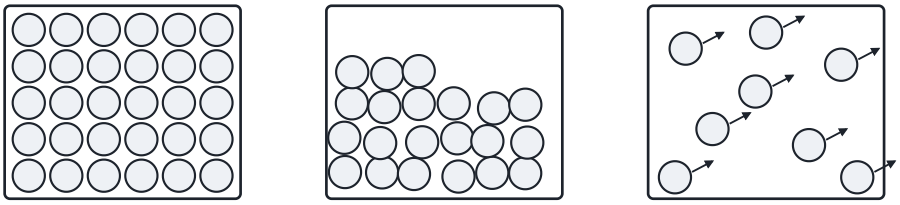
2. fusion · vaporisation · evaporation · density

3. kg/m³ · J/kg · J/kg °C · N/kg

DUAL CODING GRADE 4 GRADE 5

## Particles and density

Use the diagram to answer.



**Solid**
close together, regular pattern, vibrate about fixed positions

**Liquid**
close together, random arrangement, move past each other

**Gas**
far apart, random, move quickly in all directions

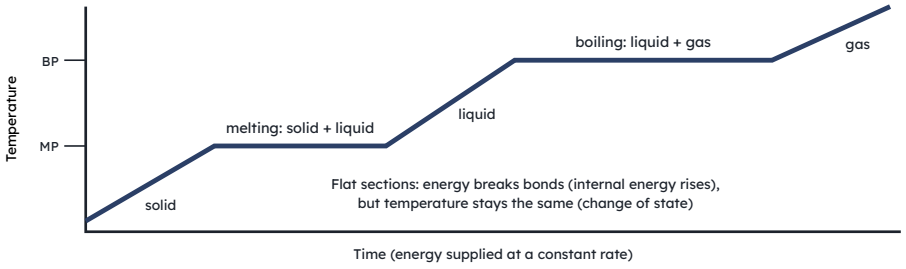
**a** Describe the arrangement and motion of particles in a solid. [2]

**b** Explain why a gas is much less dense than its solid. [2]

DUAL CODING GRADE 5 GRADE 7

## Read the heating curve

Ice is heated steadily from −20 °C until it has all turned to steam.




**a** What is happening at the first flat section? [1]

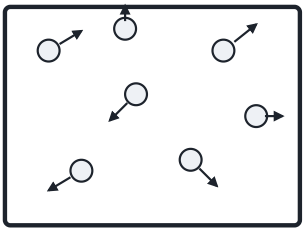
**b** Explain why the temperature doesn't rise while it is melting. [3]

**c** Why is the second flat section longer than the first? [2]

# Picture it (continued)

DUAL CODING GRADE 4 GRADE 5 GRADE 7

## Gas pressure



Particles collide with the walls, exerting a force at right angles: pressure

Higher temperature → particles move faster → hit the walls more often and harder → higher pressure

Smaller volume (constant temperature) → particles hit the walls more often → higher pressure: pV = constant (Physics only)

**a** Explain how gas particles exert a pressure on the walls of a container. [2]

**b** The gas is heated at constant volume. Explain why the pressure increases. [3]

## Extra practice

Retrieval · answers in the answer booklet

**1** Grade 7+ Explain why the temperature of a liquid stays constant while it freezes, even though energy is being transferred away from it. [3]

**2** Grade 5 A block measures 2 cm × 3 cm × 5 cm and has a mass of 81 g. Calculate its density. [3]

**3** Grade 5 A 0.5 kg object has a volume of $2.0 \times 10^{-4}$ m³. Calculate its density. [2]

**4** Fill the gap: Changing straight from a solid to a gas is called _____. [1]

WORKED EXAMPLES GRADE 4 GRADE 5

## Density

| I do (worked example) | We do (finish it) | You do |
|---|---|---|
| **A 0.54 kg block has a volume of 0.0002 m³. Calculate ρ.** | **2 kg of oil, volume 0.0025 m³.** | **Mass of 3 m³ of water (ρ = 1000 kg/m³).** |
| 1. ρ = m ÷ V | 1. ρ = m ÷ V | |
| 2. ρ = 0.54 ÷ 0.0002 | 2. ρ = 2 ÷ ___ | |
| 3. **ρ = 2700 kg/m³** | 3. ρ = ___ kg/m³ | |
| (aluminium) | | |

WORKED EXAMPLES GRADE 4 GRADE 5

## Specific latent heat

| I do (worked example) | We do (finish it) | You do |
|---|---|---|
| **Energy to melt 2 kg of ice. (L = 334 000 J/kg)** | **Boil away 0.3 kg of water. (L = 2 260 000 J/kg)** | **50 000 J melts 0.2 kg of wax. Calculate L.** |
| 1. E = mL | 1. E = mL | |
| 2. E = 2 × 334 000 | 2. E = 0.3 × ___ | |
| 3. **E = 668 000 J** | 3. E = ___ J | |
| No temperature change | | |

WORKED EXAMPLES GRADE 5 GRADE 7

## Units: the next step

Density questions often give g and cm³. Convert first, or work in g/cm³ and convert at the end.

**1** A stone has a mass of 150 g and a volume of 60 cm³. Calculate its density in kg/m³. [3]

## Extra practice

Retrieval · answers in the answer booklet

**1** Grade 5 Explain why the temperature of ice stays at 0 °C while it is melting, even though it is being heated. [3]

WORKED EXAMPLES GRADE 5 GRADE 7

## Heating then melting (two steps)

**I do (worked example)**

**Energy to warm 1 kg of ice from –10 °C to 0 °C, then melt it.**

1. $\Delta E = mc\Delta\theta = 1 \times 2100 \times 10 = 21\,000$ J
2. $E = mL = 1 \times 334\,000 = 334\,000$ J
3. Total = 21 000 + 334 000
4. **355 000 J**

**We do (finish it)**

**0.5 kg of water from 20 °C to 100 °C (c = 4200).**

1. $\Delta E = mc\Delta\theta$
2. $= 0.5 \times 4200 \times$ ___
3. = ___ J

**You do**

**Then boil it all away (L = 2 260 000 J/kg).**

WORKED EXAMPLES GRADE 5 GRADE 7

## pV = constant (Physics only)

**I do (worked example)**

**Gas at 100 kPa, 0.03 m³ is squashed to 0.01 m³.**

1. $p_1V_1 = p_2V_2$
2. $100\,000 \times 0.03 = p_2 \times 0.01$
3. $p_2 = 3000 \div 0.01$
4. **$p_2$ = 300 000 Pa**

**We do (finish it)**

**200 kPa, 2 m³ expands to 4 m³.**

1. $p_1V_1 = p_2V_2$
2. $200\,000 \times 2 = p_2 \times$ ___
3. $p_2$ = ___ Pa

**You do**

**50 kPa, 6 m³ compressed to 1.5 m³.**

ELABORATION GRADE 5

## Spot the mistake

Each student has made one mistake. Find it and correct it.

**1** Dan: “Ice at 0 °C melting into water at 0 °C has gained no energy, because the temperature didn't change.” [2]

**2** Eve: “When water boils away, the mass is destroyed.” [1]

**3** Fay: “ρ = 400 g ÷ 0.0005 m³ = 800 000 kg/m³.” [2]

## Extra practice

Retrieval · answers in the answer booklet

**1** Grade 7+ A gas in a 0.002 m³ cylinder is at a pressure of 100 kPa. It is slowly compressed to 0.0005 m³ at constant temperature. Calculate the new pressure and explain the change in terms of particles. [4]

**2** Grade 7+ A sealed aerosol can is left in strong sunlight. Explain, in terms of particles, why the pressure inside increases and why the can could burst. [3]

# Why? How? Explaining particle model of matter



ELABORATION GRADE 4 GRADE 5 GRADE 7

## Build an explanation

Answer each question in two steps. Use the starter, then push yourself with the Grade 7+ extension.

**1** Explain why a gas exerts more pressure when it is heated in a sealed container.

*Grade 4–5 starter: "Heating the gas increases the kinetic energy of the particles, so…"*

*Grade 7+ extension: "Link to collisions with the walls, force and area:…"*

**2** Explain why sweating cools you down.

*Grade 4–5 starter: "The sweat evaporates, which needs…"*

*Grade 7+ extension: "Link to which particles leave the liquid:…"*

**3** Explain why pumping up a bike tyre makes the pump warm. (Physics only, Higher)

*Grade 4–5 starter: "Pushing the piston does work on the gas…"*

*Grade 7+ extension: "Link work done to internal energy and temperature:…"*

ELABORATION GRADE 5

## True or false? Justify it.

Saying why is worth more marks than saying true or false.

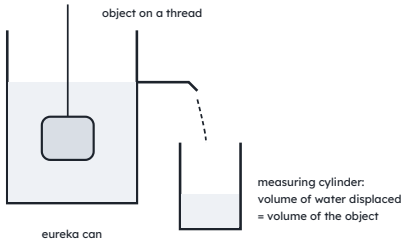
**4** "The temperature of a substance always increases when you heat it." [2]

**5** "Gas particles in a container all move at the same speed." [1]

DUAL CODING | WORKED EXAMPLES | GRADE 4 | GRADE 5 | GRADE 7

## RP5: density of regular and irregular objects

Part 1: a regular block. Part 2: an irregular stone, using a eureka can.




| | Block | Stone |
|---|---|---|
| Mass (g) | 216 | 130 |
| Dimensions / water displaced | 3 cm × 4 cm × 6 .75 cm | 52 cm³ displaced |
| Volume (cm³) | | |
| Density (g/cm³) | | |

**a** Complete the table. [4]

**b** Describe how to measure the volume of the stone using a eureka can. [3]

**c** Convert the density of the stone to kg/m³. [1]

**d** Suggest one source of error and how to reduce it. [2]

**e** How would you find the density of a liquid? [2]

| | Trial 1 | Trial 2 | Trial 3 | Mean |
|---|---|---|---|---|
| Mass of empty cylinder (g) | 84.2 | 84.2 | 84.2 | |
| Mass of cylinder + 50 cm³ oil (g) | 130.1 | 130.4 | 129.9 | |
| Mass of oil (g) | | | | |

**f** Complete the table and calculate the density of the oil in kg/m³. [3]

**g** Why does repeating and calculating a mean improve the result? [1]

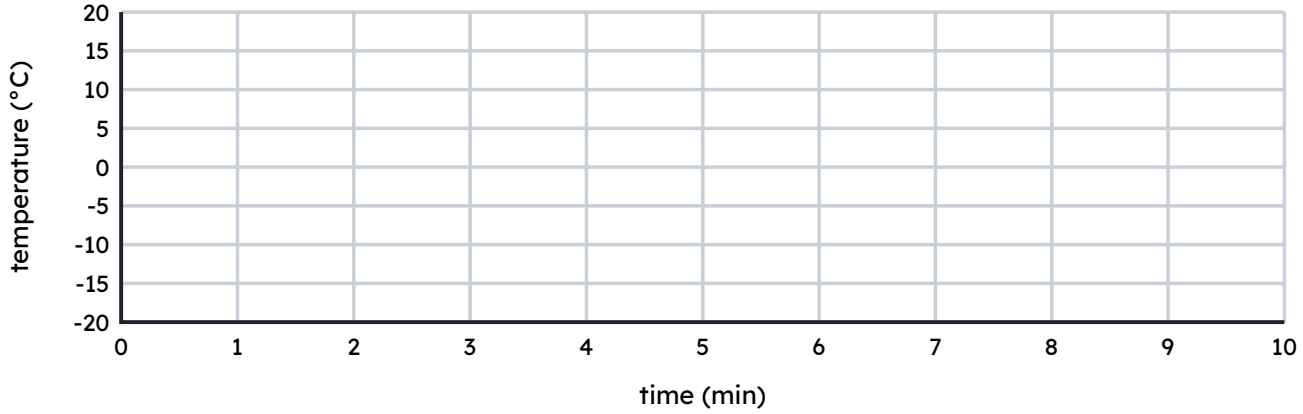
**h** Will the oil float on water (1000 kg/m³)? Explain. [1]

DUAL CODING | ELABORATION | GRADE 5 | GRADE 7

## Specific heat capacity and latent heat: data skills

A student heats 0.2 kg of ice with a 50 W immersion heater and records the temperature every minute.

| Time (min) | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature (°C) | −15 | −8 | −1 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 11 |




**a** Plot the graph. Mark where the ice is melting. [3]

**b** Use the time for melting to estimate the specific latent heat of fusion of ice. [3]

**c** The accepted value is 334 000 J/kg. Suggest why the estimate is so different. [2]

## Extra practice

Retrieval · answers in the answer booklet

**1** Grade 7+ A 2 kW kettle, already at 100 °C, boils away 0.25 kg of water in 5 minutes. Use this to estimate the specific latent heat of vaporisation of water, and explain why the estimate is too high. [4]

# Exam practice



GRADE RADE 4

## Secure the basics

**1** Name the change of state from gas to liquid. [1]

**2** State the unit of density. [1]

**3** A block has a mass of 6 kg and a volume of 0.002 m³. Calculate its density. [2]

**4** Describe the arrangement of particles in a liquid. [2]

**5** What happens to the mass of a substance when it melts? [1]

GRADE RADE 5

## Apply and rearrange

**6** Calculate the energy needed to boil away 0.4 kg of water at 100 °C. [2]
(L = 2 260 000 J/kg)

**7** Define internal energy. [2]

**8** Explain why a balloon left in the sun gets bigger. [3]

## Extra practice

Retrieval · answers in the answer booklet

**1** Grade 5 Oil has a density of 900 kg/m³. Calculate the mass of 0.03 m³ of oil. [2]

# Exam practice (continued)



GRADE RADE 7+

## Stretch

**9** A gas has a volume of 0.6 m³ at a pressure of 120 kPa. It is compressed at constant temperature to 0.2 m³. Calculate the new pressure. (Physics only) [3]

**10** Describe how to find the density of an irregular object and of a liquid. Include the measurements you would take and how you would calculate density. [6]

**Total: _____ / 23**

RETRIEVAL PRACTICE SPACED PRACTICE GRADE 4

## Quick-fire retrieval: Particle model of matter

Cover everything. Answer in under 3 minutes. Redo it on your next spaced session.

**1** Unit of specific latent heat?

**2** Water's density?

**3** Solid → gas directly?

**4** Flat section on a heating curve?

**5** What increases in a gas when it's heated?

**6** Is a change of state physical or chemical?

## Extra practice

Retrieval · answers in the answer booklet

**1** Grade 5 Explain why gases are much less dense than solids. [3]

# Reflect and plan



METACOGNITION

## Re-rate yourself

Go back to the checklist at the start of this topic and fill in the 'After' column.

METACOGNITION GRADE 4 GRADE 5 GRADE 7

## Exam wrapper: why did I drop marks?

After marking the exam practice, write the question numbers you got wrong in the right row.

| Reason I lost marks | Question numbers | What to do next |
|---|---|---|
| I didn't know or remember it (knowledge gap) | | Flashcards and brain dumps |
| I knew it but misread the question or command word | | Underline command words |
| Maths slip: units, rearranging, standard form | | Redo the "we do / you do" pages |
| I ran out of time or didn't finish | | Timed practice: 1 mark per minute |

METACOGNITION

## Two things I'm now confident about

METACOGNITION

## One thing I still need to work on, and how I'll fix it

e.g. 'Rearranging equations → redo the Grade 7+ questions and use the website's Aim higher section.'

SPACED PRACTICE

## Book my next spaced sessions

Write the dates in the planner at the front: +2 days, +1 week, +3 weeks.

## Extra practice

Retrieval · answers in the answer booklet

**1** True or false? Heating ice while it melts increases its internal energy. Explain. [2]

# Brain dump and checklist



RETRIEVAL PRACTICE · GRADE 4 · GRADE 5 · GRADE 7

## Brain dump

Set a timer for 5 minutes. Write or draw everything you remember about atomic structure. No notes! Afterwards, add anything you missed in a different colour.

Prompts if you get stuck: protons, neutrons, electrons? · isotopes? · plum pudding? · alpha scattering? · alpha, beta, gamma? · nuclear equations? · half-life? · contamination? · fission and fusion?

METACOGNITION

## How confident am I?

Rate each statement now (before) by shading R, A or G. Rate again at the end of the topic (after).

| I can... | Before | | | After | | |
|---|---|---|---|---|---|---|
| | R | A | G | R | A | G |
| Describe the structure of the atom and its size (about $1 \times 10^{-10}$ m) | ○ | ○ | ○ | ○ | ○ | ○ |
| Explain how electrons change energy levels by absorbing or emitting EM radiation | ○ | ○ | ○ | ○ | ○ | ○ |
| Use mass number and atomic number; define isotopes | ○ | ○ | ○ | ○ | ○ | ○ |
| Describe how the model of the atom changed: plum pudding, alpha scattering, Bohr, Chadwick | ○ | ○ | ○ | ○ | ○ | ○ |
| Describe alpha, beta and gamma: what they are, how penetrating and how ionising | ○ | ○ | ○ | ○ | ○ | ○ |
| Write balanced nuclear equations for alpha and beta decay | ○ | ○ | ○ | ○ | ○ | ○ |
| Define half-life and find it from a graph | ○ | ○ | ○ | ○ | ○ | ○ |
| Calculate the net decline as a ratio after a number of half-lives (Higher) | ○ | ○ | ○ | ○ | ○ | ○ |
| Explain the difference between contamination and irradiation | ○ | ○ | ○ | ○ | ○ | ○ |
| Describe uses and dangers of nuclear radiation (Physics only) | ○ | ○ | ○ | ○ | ○ | ○ |
| Describe nuclear fission and fusion and chain reactions (Physics only) | ○ | ○ | ○ | ○ | ○ | ○ |

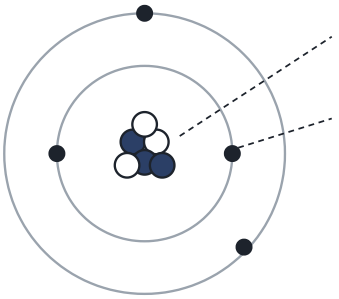
## Extra practice

Retrieval · answers in the answer booklet

**1** True or false? You can predict exactly when a particular nucleus will decay. Explain. [2]

DUAL CODING | GRADE 4 | GRADE 5 | GRADE 7

## THE ATOM · ALPHA SCATTERING

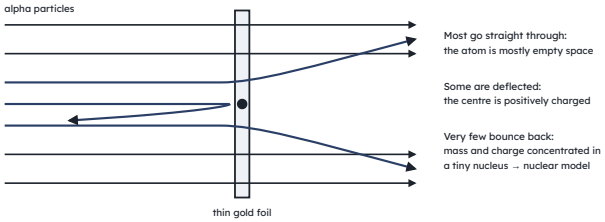


Nucleus: protons (+) and neutrons (0)
tiny: radius less than 1/10 000 of the atom

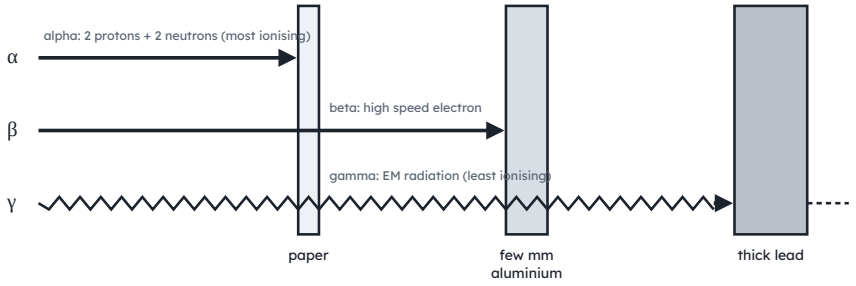
Electrons (–) in energy levels (shells)
absorb EM radiation → move to a higher level
lose an outer electron → positive ion

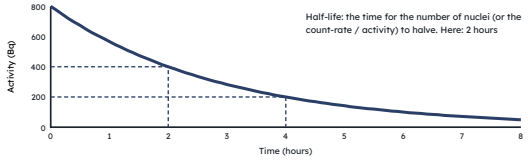
Atom radius about $1 \times 10^{-10}$ m
neutral: number of protons = number of electrons

proton neutron electron




## PENETRATION · HALF-LIFE




## NUCLEAR RADIATION

**Alpha (α):** two neutrons and two protons (a helium nucleus). Most ionising; stopped by paper or a few cm of air.
**Beta (β):** a high speed electron ejected from the nucleus as a neutron turns into a proton. Stopped by a few mm of aluminium.
**Gamma (γ):** electromagnetic radiation from the nucleus. Least ionising; reduced by thick lead or concrete.

## NUCLEAR EQUATIONS

Alpha: $^{219}_{86}Rn \rightarrow {}^{215}_{84}Po + {}^{4}_{2}He$
Beta: $^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e$
Gamma: no change to mass or charge. Mass and atomic numbers balance on both sides.

## TURN OVER

Key words, misconceptions, required practicals and Grade 7+ links are on the next page.

# Knowledge organiser: key words, misconceptions, practicals



ELABORATION GRADE 4 GRADE 5 GRADE 7

## KEY WORDS: LEARN THESE WORD FOR WORD (SAME AS SIDE 2 OF YOUR KNOWLEDGE ORGANISER)

**Isotopes:** atoms of the same element with the same number of protons but different numbers of neutrons.
**Atomic number:** the number of protons. Mass number: protons + neutrons.
**Activity:** the rate at which a source of unstable nuclei decays, in becquerel (Bq).
**Count-rate:** the number of decays recorded each second by a detector (e.g. Geiger-Muller tube).
**Half-life:** the time for the number of nuclei of the isotope in a sample to halve, or for the count-rate (or activity) to fall to half its initial level.
**Contamination:** the unwanted presence of materials containing radioactive atoms on other materials.
**Irradiation:** exposing an object to nuclear radiation; the object does not become radioactive.
**Nuclear fission (PO):** the splitting of a large and unstable nucleus into two smaller nuclei, roughly equal in size.
**Nuclear fusion (PO):** the joining of two light nuclei to form a heavier nucleus.

## MISCONCEPTIONS: SPOT THE MISTAKE

| × Common mistake | ✓ What's actually true |
|---|---|
| × Irradiated food becomes radioactive. | ✓ Irradiation doesn't make things radioactive; contamination is the problem. |
| × Gamma is the most dangerous everywhere. | ✓ Inside the body, alpha is most dangerous because it's most ionising. |
| × Half-life is half the time a sample lasts. | ✓ It's the time for the activity (or number of nuclei) to halve. |

## AIM FOR GRADE 7+

- Balance nuclear equations: mass and atomic numbers must add up on both sides.
- Choose a medical isotope: type of radiation and half-life, with reasons.
- Explain how the model of the atom changed with new evidence.

## Extra practice

Retrieval · answers in the answer booklet

**1** Grade 5 Give two natural sources of background radiation. [2]

**2** Grade 7+ A sample contains 1600 unstable nuclei and has a half-life of 5 days. After 15 days, what is the net decline, as a ratio of the original number? [3]

**3** Grade 7+ Carbon-14 (atomic number 6) decays by beta emission. Write the products and explain what happens inside the nucleus. [3]

RETRIEVAL PRACTICE GRADE 4 GRADE 5

## Order it: how the model of the atom developed

Number the models in the order they were proposed and say what evidence led to each change.

Bohr's electrons in shells · tiny solid spheres · Chadwick's neutron · plum pudding model · nuclear model from alpha scattering

RETRIEVAL PRACTICE GRADE 4 GRADE 5

## Fill the gaps

Use the AQA key words. No word bank: that's the point.

1. Atoms of the same element with different numbers of neutrons are called _____.
2. The time it takes for the count-rate from a sample to fall to half is the _____.
3. A beta particle is a high speed _____ ejected from the nucleus.
4. Exposing an object to nuclear radiation without it becoming radioactive is called _____.
5. The rate at which a source of unstable nuclei decays is its activity, measured in _____ (Bq).

ELABORATION GRADE 5

## Odd one out

Circle the odd one out in each row and explain why.

1. alpha · beta · gamma · neutron

2. proton · neutron · electron · nucleus

3. fission · fusion · chain reaction · red-shift

## Extra practice

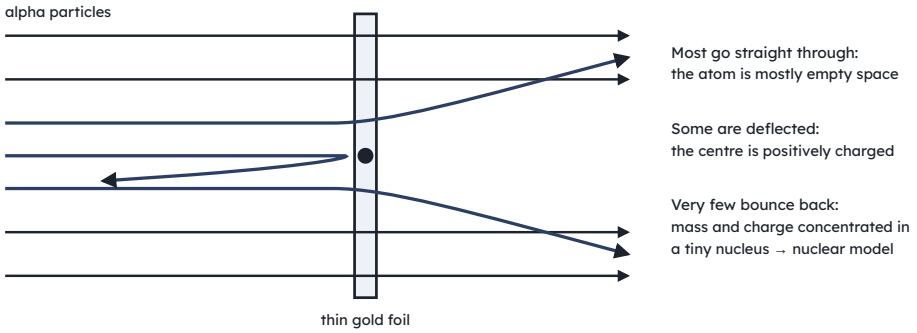
Retrieval · answers in the answer booklet

**1** Grade 7+ Explain how the results of the alpha scattering experiment led to the nuclear model of the atom. [4]

DUAL CODING GRADE 4 GRADE 5 GRADE 7

## The alpha scattering experiment

Alpha particles were fired at thin gold foil.



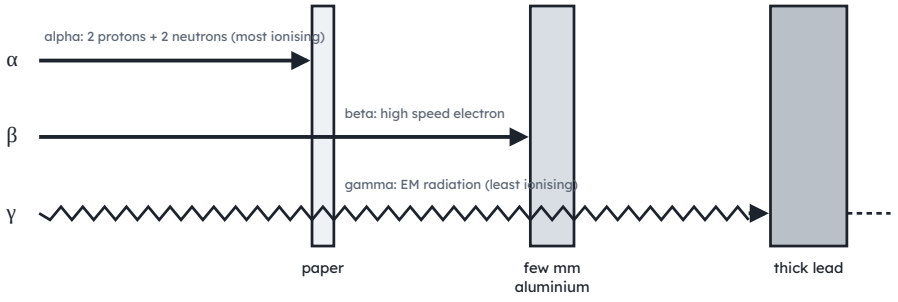

**a** Most alpha particles went straight through. What does this show? [1]

**b** A few were deflected back. What does this show? [2]

**c** Which model did this experiment replace? [1]

DUAL CODING GRADE 4 GRADE 5

## Penetrating power



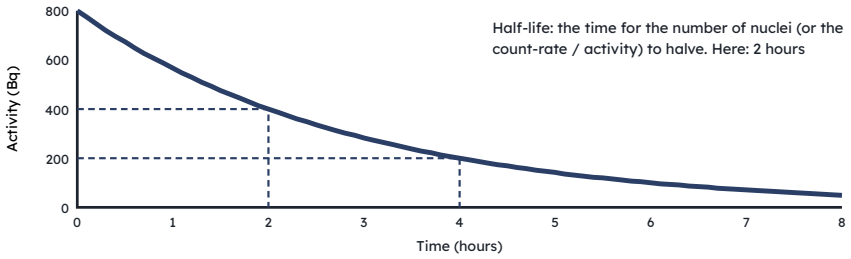

**a** Which radiation is stopped by paper? [1]

**b** Which radiation passes through aluminium but is reduced by thick lead? [1]

**c** Explain why an alpha source is most dangerous inside the body. [2]

DUAL CODING GRADE 5 GRADE 7

## Read the half-life graph




**a** Use the graph to find the half-life. [2]

**b** What fraction of the original count-rate is left after 3 half-lives? [1]

**c** Why is the graph a smooth curve even though decay is random? [2]

## Extra practice

Retrieval · answers in the answer booklet

**1** Grade 7+ Compare nuclear fission and nuclear fusion. [4]

**2** Grade 7+ Explain how a nuclear chain reaction happens and how it is controlled in a nuclear reactor. [4]

**3** Grade 5 What is meant by the half-life of a radioactive isotope? [2]

WORKED EXAMPLES GRADE 4 GRADE 5

## Balancing nuclear equations

| I do (worked example) | We do (finish it) | You do |
|---|---|---|
| **Polonium-210 decays by alpha emission.** | **Carbon-14 (atomic number 6) decays by beta.** | **Uranium-238 (92) decays by alpha.** |
| 1. Alpha = $^{4}_{2}He$ | 1. Beta = $^{0}_{-1}e$ | |
| 2. Mass number: 210 − 4 = 206 | 2. Mass number stays ___ | |
| 3. Atomic number: 84 − 2 = 82 (lead) | 3. Atomic number becomes ___ | |
| 4. $^{210}_{84}Po \rightarrow {}^{206}_{82}Pb + {}^{4}_{2}He$ | | |

WORKED EXAMPLES GRADE 5 GRADE 7

## Half-life

| I do (worked example) | We do (finish it) | You do |
|---|---|---|
| **Activity 800 Bq, half-life 2 days. Activity after 6 days?** | **Count-rate 120 cpm, half-life 5 min. After 15 min?** | **Determine the half-life: 640 Bq falls to 40 Bq in 12 hours.** |
| 1. 6 ÷ 2 = 3 half-lives | 1. Number of half-lives = ___ | |
| 2. 800 → 400 → 200 → 100 | 2. 120 → 60 → ___ → ___ | |
| 3. **100 Bq** | 3. ___ cpm | |
| Halve once per half-life | | |

WORKED EXAMPLES GRADE 7

## Net decline as a ratio (Higher)

**1** A sample has a half-life of 4 years. What fraction of the original unstable nuclei is left after 12 years? Express the net decline as a ratio. [3]

## Extra practice

Retrieval · answers in the answer booklet

**1** Grade 7+ Explain why a medical tracer injected into the body should emit gamma radiation rather than alpha radiation. [4]

**2** Grade 7+ A food company says 'Our irradiated food is not radioactive, but contaminated food can be dangerous.' Explain why the company is correct. [4]

# Why? How? Explaining atomic structure



ELABORATION GRADE 4 GRADE 5 GRADE 7

## Build an explanation

Answer each question in two steps. Use the starter, then push yourself with the Grade 7+ extension.

**1** Explain why the plum pudding model was replaced.

*Grade 4–5 starter: "In the alpha scattering experiment, a few alpha particles…"*

*Grade 7+ extension: "Explain what the plum pudding model predicted instead:…"*

**2** Explain why gamma sources are used as medical tracers rather than alpha sources. (Physics only)

*Grade 4–5 starter: "The radiation must get out of the body to be detected, so…"*

*Grade 7+ extension: "Compare ionisation and choose a suitable half-life:…"*

**3** Explain the difference between contamination and irradiation.

*Grade 4–5 starter: "Contamination is when radioactive atoms…"*

*Grade 7+ extension: "Say which is more dangerous and why:…"*

ELABORATION GRADE 5

## True or false? Justify it.

Saying why is worth more marks than saying true or false.

**4** "A sample with a half-life of 2 hours will have completely decayed after 4 hours." [2]

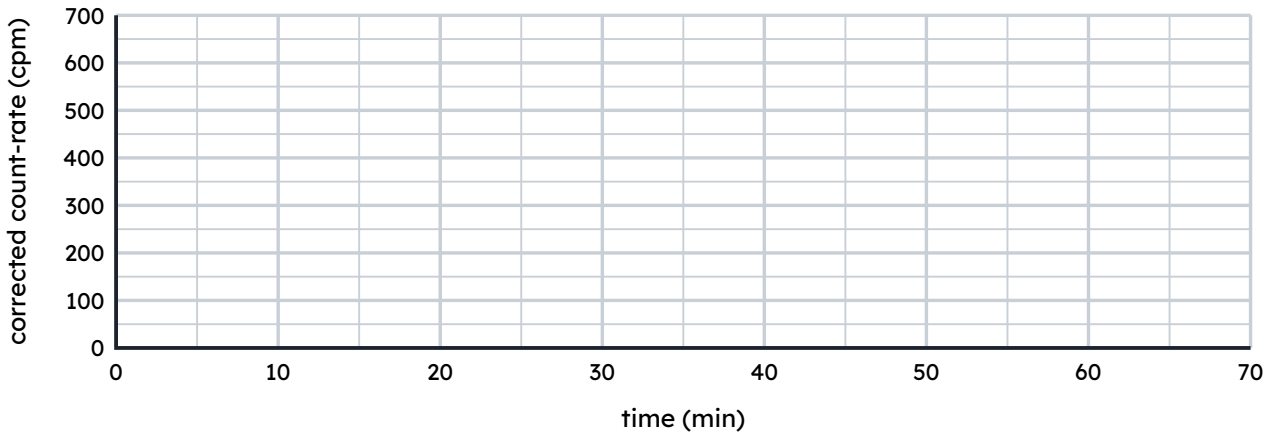
**5** "Isotopes of an element have different numbers of protons." [1]

DUAL CODING ELABORATION GRADE 5 GRADE 7

## Analyse decay data

A student measures the count-rate from a radioactive source every 10 minutes. Background radiation is 20 counts per minute.

| Time (min) | 0 | 10 | 20 | 30 | 40 | 50 | 60 |
|---|---|---|---|---|---|---|---|
| Measured count-rate (cpm) | 660 | 468 | 340 | 260 | 180 | 140 | 100 |
| Corrected count-rate (cpm) | | | | | | | |




**a** Complete the corrected row by subtracting background radiation, then plot the graph. [3]

**b** Use your graph to find the half-life. [2]

**c** Why does the student need to subtract background radiation? [1]

**d** Some points are off the curve. Explain why. [2]

**e** Give two ways the student should protect herself. [2]

## Extra practice

Retrieval · answers in the answer booklet

**1** Grade 5 The activity of a sample falls from 800 Bq to 100 Bq. The half-life is 5 days. How long did this take? [2]

# Exam practice



GRADE RADE 4

## Secure the basics

**1** Name the particle with no charge in the nucleus. [1]

**2** What is the charge on an alpha particle? [1]

**3** Which type of radiation is an electromagnetic wave? [1]

**4** State the unit of activity. [1]

**5** An atom has 6 protons and 8 neutrons. What is its mass number? [1]

**6** Give one source of background radiation. [1]

GRADE RADE 5

## Apply and rearrange

**7** Describe what happens to an electron when an atom absorbs electromagnetic radiation. [2]

**8** A sample has an activity of 1200 Bq and a half-life of 3 hours. Calculate its activity after 9 hours. [2]

**9** Describe nuclear fission. (Physics only) [3]

## Extra practice

Retrieval · answers in the answer booklet

**1** Which radiation is most dangerous inside the body? [1]

**A** Alpha **B** Beta **C** Gamma **D** They're all the same

GRADE RADE 7+

### Stretch

**10** Write the nuclear equation for the beta decay of iodine-131 (atomic number 53) to xenon (Xe). [2]

**11** Describe how scientists' model of the atom has changed over time and explain why it changed. [6]

**Total: _____ / 21**

RETRIEVAL PRACTICE SPACED PRACTICE GRADE 4

### Quick-fire retrieval: Atomic structure

Cover everything. Answer in under 3 minutes. Redo it on your next spaced session.

**1** Radius of an atom?

**2** Most penetrating radiation?

**3** Most ionising radiation?

**4** Who discovered the neutron?

**5** Fusion joins what?

**6** Half-life of a sample: random or predictable?

### Extra practice

Retrieval · answers in the answer booklet

**1** Grade 5 Compare alpha, beta and gamma radiation in terms of penetration and ionising power. [3]

# Reflect and plan



METACOGNITION

## Re-rate yourself

Go back to the checklist at the start of this topic and fill in the 'After' column.

METACOGNITION GRADE 4 GRADE 5 GRADE 7

## Exam wrapper: why did I drop marks?

After marking the exam practice, write the question numbers you got wrong in the right row.

| Reason I lost marks | Question numbers | What to do next |
|---|---|---|
| I didn't know or remember it (knowledge gap) | | Flashcards and brain dumps |
| I knew it but misread the question or command word | | Underline command words |
| Maths slip: units, rearranging, standard form | | Redo the "we do / you do" pages |
| I ran out of time or didn't finish | | Timed practice: 1 mark per minute |

METACOGNITION

## Two things I'm now confident about

_____

_____

METACOGNITION

## One thing I still need to work on, and how I'll fix it

e.g. 'Rearranging equations → redo the Grade 7+ questions and use the website's Aim higher section.'

_____

_____

_____

SPACED PRACTICE

## Book my next spaced sessions

Write the dates in the planner at the front: +2 days, +1 week, +3 weeks.

## Extra practice

Retrieval · answers in the answer booklet

**1** Fill the gap: Radiation dose is measured in _____. [1]

_____

# Interleaved retrieval quiz

Do this a week after finishing a topic

INTERLEAVING · RETRIEVAL PRACTICE · GRADE 4 · GRADE 5 · GRADE 7

## Mixed Paper 1 questions

The questions are mixed up on purpose. First decide which topic each one is from, then answer it. Some questions link two topics, just like the real exam.

**1** (?) Calculate the resistance of a lamp with 12 V across it and 0.4 A through it. [2]

**2** (?) A 2 kg ball moves at 3 m/s. Calculate its kinetic energy. [2]

**3** (?) What is the difference between two isotopes of the same element? [1]

**4** (?) Name the change of state from liquid to gas. [1]

**5** (?) Give two ways to reduce unwanted energy transfers in a machine. [2]

**6** (?) Why does the National Grid use step-up transformers? [2]

**7** (?) Calculate the density of a 4 kg object with a volume of 0.002 $m^3$. [2]

**8** (?) A source's count-rate falls from 400 to 100 cpm in 6 hours. Determine the half-life. [2]

**9** (?) Calculate the energy to warm 0.5 kg of water by 10 °C. (c = 4200 J/kg °C) [2]

**10** (?) A 60 W lamp is on for 1 hour. How much energy does it transfer? [2]

| Q | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Topic | | | | | | | | | | |

## Extra practice

Retrieval · answers in the answer booklet

**1** Define **hydroelectricity**. [1]