Topic 4.3 Particle model of matter Revision Booklet

AQA GCSE Physics 8463 · Foundation & Higher



Name _____ Class _____ Target grade _____

4.3
Particle model of matter

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

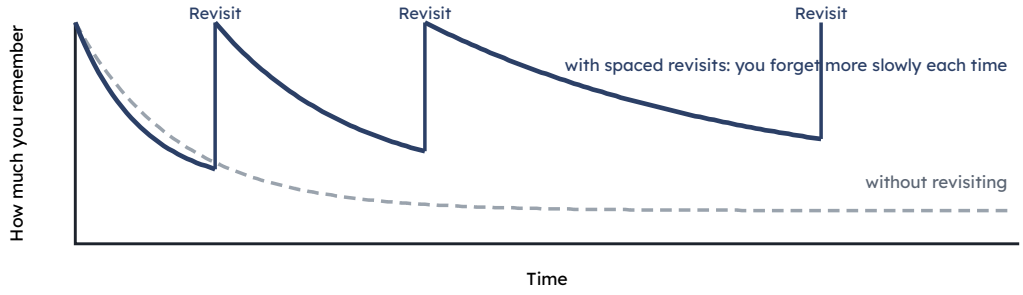
Rearrange equations, convert units, describe practicals and explain in two linked steps.

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
4.3 Particle model of matter					
Final review					

What's inside

Topic 3 · Particle model of matter (4.3)

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Final review

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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).

Extra practice

Retrieval · answers in the answer booklet

1 Grade 5 Describe the arrangement and movement of particles in a solid, a liquid and a gas. [3]

2 Grade 7+ Explain why the temperature of a boiling liquid stays the same even though it is still being heated. [4]

3 Grade 5 Calculate the energy needed to raise the temperature of 0.4 kg of aluminium by 25 °C. (c = 900 J/kg °C) [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)	○	○	○	○	○	○

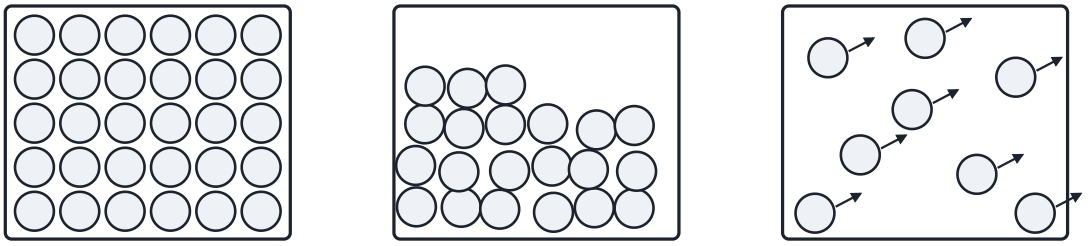
Extra practice

Retrieval · answers in the answer booklet

1 True or false? Temperature and internal energy mean the same thing. Explain. [2]

DUAL CODING | GRADE 4 | GRADE 5 | GRADE 7

STATES OF MATTER

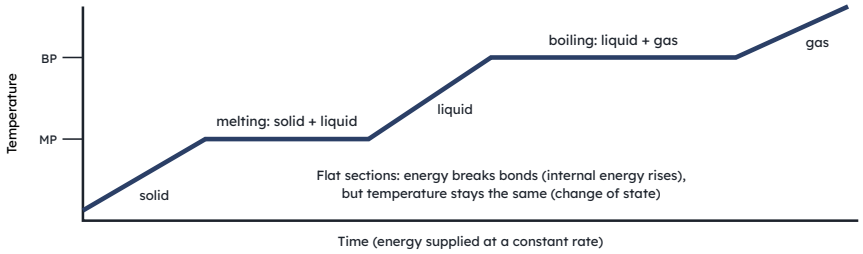


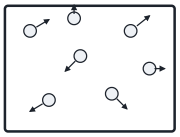
Solid
close together, regular pattern, vibrate about fixed positions

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 ($\rho = m \div V$).
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 $\rho = m \div V$ 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 5 Use the particle model to explain why gases can be compressed but liquids can't (easily). [2]

2 Grade 5 Calculate the energy needed to boil away 2 kg of water that is already at 100 °C. (Specific latent heat of vaporisation = 2 260 000 J/kg) [2]

Cover, recall, check

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 ✓/×
Mass of a block of gold from its volume and density				
Energy to boil away a pan of water at 100 °C				
Temperature rise of a metal block heated by a known energy				
Volume of an irregular stone from its mass and density				
New volume of a gas compressed at constant temperature				
Density of air in a balloon				

RETRIEVAL PRACTICE | GRADE 4 | GRADE 5

Fill the gaps

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

1. In a solid, the particles vibrate about _____ positions.
2. When a substance changes state, its mass is _____.
3. Specific latent heat of _____ is the energy to change 1 kg from liquid to vapour with no change in temperature.
4. Raising the temperature of a gas at constant volume increases its _____.
5. Particles in a gas are in constant _____ motion.

ELABORATION | GRADE 5

Odd one out

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

1. evaporating · condensing · melting · dissolving

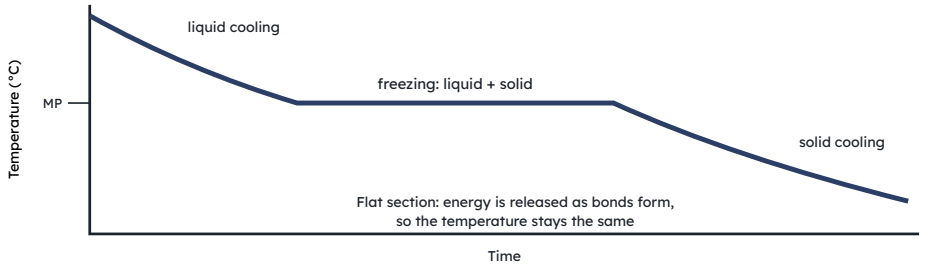
2. density · mass · volume · temperature

3. kinetic · potential · internal · chemical

DUAL CODING GRADE 5 GRADE 7

Cooling curve of stearic acid

Liquid stearic acid cools from 80 °C to 40 °C.



a On a cooling curve, what does the flat section show? [1]

b Explain why the temperature stays constant while it freezes. [3]

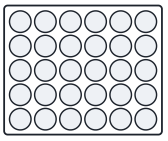
c What happens to the internal energy during freezing? [1]

DUAL CODING GRADE 4

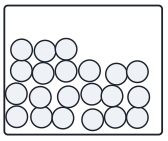
Particle diagrams

Draw the arrangement of particles in a solid, a liquid and a gas.

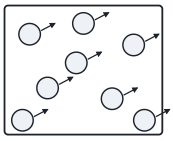
Solid	Liquid	Gas



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 Why can a gas be compressed but a liquid can't (easily)? [2]

Extra practice

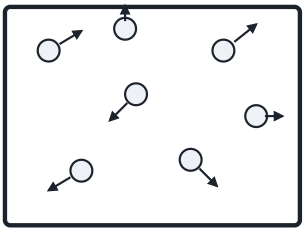
Retrieval · answers in the answer booklet

1 Grade 5 Explain why the mass stays the same when ice melts. [2]

Picture it (continued)

DUAL CODING GRADE 5 GRADE 7

Squashing a gas (Physics only)



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 A syringe of air is slowly pushed in at constant temperature. What happens to the pressure? [1]

b Explain your answer using particles. [3]

c If the piston is pushed in quickly, the air gets warmer. Explain why. (Higher) [2]

Extra practice

Retrieval · answers in the answer booklet

1 Grade 5 Explain why the pressure of a gas in a sealed container increases when it is heated. [3]

2 Grade 5 A 54 g stone is lowered into a measuring cylinder. The water level rises from 50 cm^3 to 70 cm^3. Calculate the density of the stone. [3]

3 Fill the gap: The total kinetic and potential energy of all the particles in a system is its _____ energy. [1]

WORKED EXAMPLES GRADE 4 GRADE 5

Density (rearranging)

I do (worked example)

Calculate the mass of 0.5 m³ of concrete (ρ = 2400 kg/m³).

1. m = ρ V
2. m = 2400 × 0.5
3. **m = 1200 kg**

We do (finish it)

Calculate the volume of 5 kg of oil (ρ = 800 kg/m³).

1. V = m ÷ ρ
2. V = 5 ÷ ___
3. V = ___ m³

You do

An 80 g ring has volume 4 cm³. Calculate ρ in g/cm³.

WORKED EXAMPLES GRADE 4 GRADE 5

Specific heat capacity

I do (worked example)

Energy to heat 0.4 kg of aluminium by 50 °C. (c = 900)

1. ΔE = m c Δθ
2. = 0.4 × 900 × 50
3. **= 18 000 J**

We do (finish it)

2 kg of water warms from 15 °C to 65 °C. (c = 4200)

1. Δθ = ___ °C
2. ΔE = 2 × 4200 × ___
3. ΔE = ___ J

You do

12 000 J raises 0.5 kg of a metal by 60 °C. Calculate c.

WORKED EXAMPLES GRADE 7

Latent heat from a graph (Grade 7+)

1 A 200 W heater melts 0.12 kg of ice at 0 °C in 3 minutes 20 seconds. Calculate the specific latent heat of fusion of ice. Suggest why it is higher than the true value. [4]

Extra practice

Retrieval · answers in the answer booklet

1 Grade 7+ Compare the internal energy of 1 kg of ice at 0 °C with 1 kg of water at 0 °C. [3]

2 What does a flat section on a heating graph show? [1]

A The temperature is rising **B** A change of state **C** The substance is cooling **D** Nothing is happening

WORKED EXAMPLES GRADE 5

E = mL

I do (worked example)

Energy to melt 0.25 kg of lead. (L = 23 000 J/kg)

1. E = m L
2. = 0.25 × 23 000
3. **= 5750 J**

We do (finish it)

Energy released when 0.5 kg of steam condenses. (L = 2 260 000)

1. E = 0.5 × ___
2. E = ___ J

You do

9000 J melts 0.03 kg of solder. Calculate L.

WORKED EXAMPLES GRADE 5 GRADE 7

Gas pressure and volume (Physics only)

I do (worked example)

A gas at 120 kPa in 0.5 m³ expands to 1.5 m³.

1. $p_2 = p_1V_1 \div V_2$
2. = 120 000 × 0.5 ÷ 1.5
3. **= 40 000 Pa**

We do (finish it)

100 kPa, 6 litres compressed to 2 litres.

1. p_2 = 100 × 6 ÷ ___
2. p_2 = ___ kPa

You do

250 kPa, 0.4 m³. Volume when p = 100 kPa?

ELABORATION GRADE 5

Spot the mistake

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

1 Max: “Boiling and evaporation are exactly the same.” [2]

2 Nia: “ΔE = 2 × 4200 × 80 for water heated from 20 °C to 80 °C.” [1]

3 Ola: “Particles expand when a solid is heated.” [1]

Extra practice

Retrieval · answers in the answer booklet

1 True or false? Mass is conserved when a substance changes state. Explain. [2]

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 the pressure in a car tyre is higher after a long journey.

Grade 4–5 starter: "The air in the tyre gets warmer, so…"

Grade 7+ extension: "Link to collisions with the tyre walls:…"

2 Explain why steam at 100 °C causes a worse burn than water at 100 °C.

Grade 4–5 starter: "When steam touches your skin it condenses, so…"

Grade 7+ extension: "Link to latent heat:…"

3 Explain why ice floats on water.

Grade 4–5 starter: "Ice has a lower density than water because…"

Grade 7+ extension: "Link to floating:…"

ELABORATION GRADE 5

True or false? Justify it.

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

4 "Evaporation can only happen at 100 °C." [2]

5 "When a substance melts, its temperature rises." [1]

WORKED EXAMPLES GRADE 4 GRADE 5 GRADE 7

RP5: density of a liquid and of a regular object

Part 1: salt water. Part 2: a rectangular wooden block.

Measurement	Value
Mass of empty measuring cylinder (g)	62.0
Mass of cylinder + 80 cm^3 salt water (g)	150.8
Mass of salt water (g)	
Density of salt water (g/cm^3)	

a Complete the table. [2]

b Convert the density to kg/m^3. [1]

c Why should the reading be taken at eye level from the bottom of the meniscus? [1]

Length (cm)	Width (cm)	Height (cm)	Mass (g)	Volume (cm^3)	Density (g/cm^3)
10.0	5.0	4.0	140		

d Complete the table for the wooden block. [2]

e Which measuring instrument would give the most precise length measurements? [1]

f Will the block float in the salt water? Explain. [1]

Extra practice

Retrieval · answers in the answer booklet

1 Grade 7+ 0.2 kg of ice at 0 °C melts, and the water then warms to 20 °C. Calculate the total energy needed. (L = 334 000 J/kg, c = 4200 J/kg °C) [4]

2 Grade 5 Calculate the energy needed to boil away 0.2 kg of water at 100 °C. (Specific latent heat of vaporisation = 2.26×10^6 J/kg) [2]

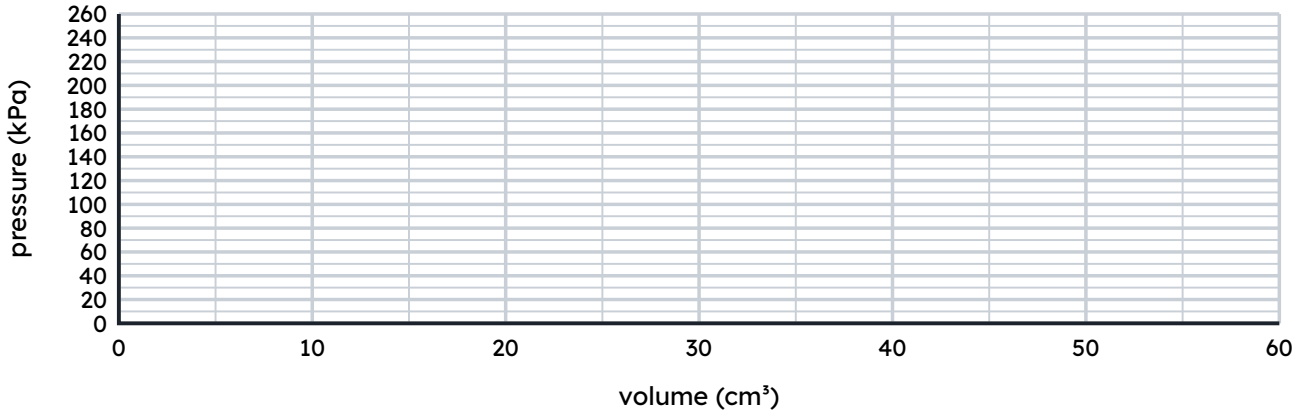
Required practical 5 and heating data (continued)

DUAL CODING | ELABORATION | GRADE 5 | GRADE 7

Gas data: pressure and volume (Physics only)

A student traps air in a syringe connected to a pressure gauge and slowly pushes the plunger in.

Volume (cm³)	50	40	30	25	20
Pressure (kPa)	100	125	167	200	250
p × V (kPa cm³)					



a Complete the p × V row. What do you notice? [2]

b Why must the plunger be pushed in slowly? [2]

c Predict the pressure when the volume is 10 cm³. [1]

Extra practice

Retrieval · answers in the answer booklet

1 Grade 7+ Explain why 1 kg of steam at 100 °C has more internal energy than 1 kg of water at 100 °C. [3]

2 A 2 kg block has a volume of 0.0008 m³. Calculate its density. [2]

Exam practice

GRADE RADE 4

Secure the basics

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

2 Give the unit of specific latent heat. [1]

3 Describe the motion of particles in a gas. [2]

4 What is the density of water in kg/m³? [1]

5 Calculate the density of a 2 kg object with a volume of 0.0005 m³. [2]

GRADE RADE 5

Apply and rearrange

6 Calculate the energy needed to raise the temperature of 0.5 kg of copper by 40 °C. (c = 385 J/kg °C) [2]

7 Explain the difference between specific heat capacity and specific latent heat. [2]

8 Explain why a sealed can of drink might burst if heated. [3]

Extra practice

Retrieval · answers in the answer booklet

1 Grade 7+ Explain why the pump gets warm when you pump up a bicycle tyre quickly. [3]

Exam practice (continued)

GRADE RADE 7+

Stretch

9 Calculate the total energy to turn 0.2 kg of water at 30 °C into steam at 100 °C. (c = 4200 J/kg °C, L = 2 260 000 J/kg) [4]

10 Describe how to find the specific latent heat of fusion of ice. Include the measurements and how you would use them. [6]

Total: _____ / 24

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 Gas → liquid?

2 Unit of pressure?

3 Total KE + PE of particles?

4 Mass during a change of state?

5 Liquid to gas at the surface?

6 Density of oil vs water?

Extra practice

Retrieval · answers in the answer booklet

1 Internal energy is... [1]

A the total kinetic energy only **B** the total kinetic and potential energy of the particles

C the temperature **D** the heat in an object

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 Define **states of matter**. [1]

RETRIEVAL PRACTICE | SPACED PRACTICE | GRADE 4 | GRADE 5 | GRADE 7

Final review: test yourself on the whole topic

Do these without your notes, a week after finishing the booklet. Mark them with the answer booklet and add any you got wrong to your 'still to learn' list on the reflect page.

Each question shows its target grade. Aim to get every Grade 4 and 5 question right before moving on to Grade 7+.

Extra practice

Retrieval · answers in the answer booklet

1 Grade 7+ A 2.0 kW kettle continues to heat boiling water. Calculate how long it takes to boil away 0.1 kg of water. ($L = 2.26 \times 10^6$ J/kg) [4]

2 Grade 7+ A stone has a mass of 81 g. When lowered into a measuring cylinder, the water level rises from 50 cm^3 to 80 cm^3. Calculate the density of the stone in kg/m^3. [3]

3 Grade 7+ A gas occupies 2.0×10^{-3} m^3 at 100 kPa. It is compressed at constant temperature to 5.0×10^{-4} m^3. Calculate the new pressure. [3]

4 Grade 7+ Calculate the total energy needed to turn 0.5 kg of ice at 0 °C into water at 20 °C. (L for fusion = 334 000 J/kg; c of water = 4200 J/kg °C) [4]

5 What happens to particles when a solid melts? [1]

A They gain enough energy to break some bonds and move past each other **B** They get bigger

C They stop moving **D** They become a gas