

Covering teacher guide

Density calculations and units

Start here / subject briefing

Before this lesson: Consolidation after pupils have met density and cuboid volume. They need a calculator. No measuring experiment is required today.

Density compares the mass in an equal volume. Dividing mass by volume gives the mass in one unit of volume. A smaller piece of the same uniform material has the same density: its mass and volume decrease together. Use matching mass and volume units before calculating.

Words and symbols you will need

Term	Plain-English meaning
Density, ρ (rho)	Mass per unit volume, expressed here in g/cm^3 or kg/m^3 .
Mass, m	The amount of matter in the sample, measured here in g or kg.
Volume, V	The space occupied by the sample. A cuboid uses length $\times$ width $\times$ height.
cm^3 and m^3	Cubic centimetres and cubic metres: $1 \text{ cm}^3 = 0.000001 \text{ m}^3$.
Uniform material	The material is the same throughout. Compare samples at the same temperature.

Help pupils choose a method

1. Name the unknown: density = mass $\div$ volume; mass = density $\times$ volume; volume = mass $\div$ density.
2. Match units: use g with cm^3 , or kg with m^3 . Divide cm^3 by one million to obtain m^3 .
3. Show the substitution and final unit. Compare material or liquid values in the same units.

Use the supplied model - pupil page 2

Pupil page 2 supplies the model. Multiply its three dimensions before dividing. Its 9 g in each cm^3 becomes 9000 kg in each m^3 because both the mass and volume units change.

Volume = $3 \times 2 \times 1 = 6 \text{ cm}^3$. Density = $54 \div 6 = 9 \text{ g/cm}^3$. Convert: $9 \times 1000 = 9000 \text{ kg/m}^3$. Check using SI units: mass = 0.054 kg; volume = 0.000006 m^3 ; density = $0.054 \div 0.000006 = 9000 \text{ kg/m}^3$.

If pupils are still stuck

Read the relevant coaching aloud and use its named retry within the replacement time. If it remains insecure, help the pupil write the correct equation or first step, then record the exact difficulty and attempted working for the usual teacher.

Turn to teacher page 2 for the timed run sheet. Keep this guide separate from the pupil booklet.

Run the lesson from this page

Density calculations and units

Download and print one complete seven-page pupil handout per pupil, in order. Double-sided printing is fine; staple each booklet.

Read the subject briefing on teacher page 1. Use the timed run sheet on page 2 and the numbered answers. Each check has Say / Ask / Expect coaching and a fresh retry.

Pupils need a pen, a different-coloured pen and a calculator. All reading, diagram and data are included; no pupil login, devices or practical apparatus are needed.

Min	Pupil page / Q	Read aloud / check	Next action and answer key
0-5	1 / 1-3	"Start on page 1. Work from memory." At 5 minutes check the three answers.	If insecure, Try again A uses the first 2 reading minutes. Answers: teacher page 3. Coaching: page 7.
5-15	2 / reading	"Read the equations and conversions, then follow the worked model."	Check Try again A if used. The equations are supplied; focus on choosing and using them.
15-20	3 / 4	"Choose a letter and show both conversions. Stop at the check."	Check B plus both conversions. If insecure, Try again B replaces 9-10. Answers: teacher page 3. Coaching: page 8.
20-30	3-4 / 5-10	"Work through the calculation questions. Show working and units."	If Try again B was used, leave 9-10 blank. Answers: teacher page 4.
30-33	4 / 11	"Pause and answer question 11 independently."	Separate equation errors from cubic-unit errors. Try again C replaces 15-16. Answers: teacher page 4. Coaching: page 9.
33-45	5-6 / 12-21	"Use the cuboid and tables. Finish the comparisons."	Use the prepared data only. If finished early, strengthen the explanations in 14 and 16. Answers: teacher page 5.
45-55	6 / 22	"Check your practice in a different colour. Explain one correction."	Read the numbered practice answers from this guide. Keep the exit answer hidden. Answers: teacher page 5.
55-60	7 / 23	"Cover the earlier pages. Complete the final question on your own."	Collect every booklet. Check the exit afterwards; D is next lesson only. Answers: teacher page 6. Coaching: page 10.

Estimated route: 5 + 10 + 5 + 25 + 10 + 5 = 60 minutes. Practice is 10 minutes, a 3-minute check and 12 minutes. A uses reading time; B replaces 9-10; C replaces 15-16; D is next lesson only. Timings have not been classroom-trialled.

Checks 1 and 2 - pupil pages 1 and 3

Match the pupil number. Accept equivalent correct wording. Keep this guide separate from pupils.

1. (pupil p1) $0.180 \times 1000 = 180 \text{ g}$.

2. (pupil p1) $V = 2 \times 3 \times 4 = 24 \text{ cm}^3$. Multiply all three perpendicular dimensions.

3. (pupil p1) B. It has the greater mass in the same volume, so its mass per unit volume is greater.

4. (pupil p3) B. $2.4 \text{ g} = 0.0024 \text{ kg}$; $1 \text{ cm}^3 = 0.000001 \text{ m}^3$. Density = $0.0024 \div 0.000001 = 2400 \text{ kg/m}^3$. Both mass and volume units change.

Try again A - pupil page 1

Only if your teacher asks. Use the first 2 reading minutes, then continue on page 2.

(a) 75 g. (b) 10 cm^3 . (c) The 25 g sample: more mass occupies the same volume.

Try again B - pupil page 3

Only if your teacher asks. Complete this instead of questions 9-10, then answer questions 5-8.

$1.6 \text{ g} = 0.0016 \text{ kg}$; $1 \text{ cm}^3 = 0.000001 \text{ m}^3$. Density = $0.0016 \div 0.000001 = 1600 \text{ kg/m}^3$.

Practice and check 3 - pupil pages 3-4

Match the pupil number. Accept equivalent correct wording. Keep this guide separate from pupils.

5. (pupil p3) Density: mass per unit volume, not total mass or weight.

6. (pupil p3) $\rho = m/V = 54.0 \div 20.0 = 2.70 \text{ g/cm}^3$.

7. (pupil p3) $m = \rho V = 2.70 \times 35.0 = 94.5 \text{ g}$.

8. (pupil p4) $V = m/\rho = 121.5 \div 2.70 = 45.0 \text{ cm}^3$.

9. (pupil p4) $6.0 \div 1\,000\,000 = 0.0000060 \text{ m}^3$, or $6.0 \times 10^{-6} \text{ m}^3$.

10. (pupil p4) $2.70 \text{ g} = 0.00270 \text{ kg}$ and $1 \text{ cm}^3 = 0.000001 \text{ m}^3$. $\rho = 0.00270 \div 0.000001 = 2700 \text{ kg/m}^3$.

11. (pupil p4) $25 \text{ cm}^3 = 0.000025 \text{ m}^3$. Use $m = \rho V$: $m = 1200 \times 0.000025 = 0.030 \text{ kg}$. Accept 30 g only if correctly converted to the requested kg.

Try again C - pupil page 4

Only if your teacher asks. Complete this instead of questions 15-16. Then complete questions 12-14 and 17-21.

$V = 40 \div 1\,000\,000 = 0.000040 \text{ m}^3$. $m = \rho V = 1500 \times 0.000040 = 0.060 \text{ kg}$.

Solids, liquids and review - pupil pages 5-6

Match the pupil number. Accept equivalent correct wording. Keep this guide separate from pupils.

12. (pupil p5) $V = 4.0 \times 2.5 \times 1.2 = 12 \text{ cm}^3$.

13. (pupil p5) $\rho = 106.8 \div 12 = 8.9 \text{ g/cm}^3$. Use the pupil's earlier valid volume for consistent follow-through.

14. (pupil p5) Copper: 8.9 g/cm^3 matches the supplied value. Another material or alloy may have a similar density, so this is evidence rather than proof.

15. (pupil p5) $\rho = 26.7 \div 3.0 = 8.9 \text{ g/cm}^3$.

16. (pupil p5) Each has half the original mass and half the original volume. The ratio m/V is unchanged, so density is unchanged. Assume the same material and temperature.

17. (pupil p6) Liquid mass = $140.0 - 64.0 = 76.0 \text{ g}$.

18. (pupil p6) $\rho = 76.0 \div 80.0 = 0.950 \text{ g/cm}^3$.

19. (pupil p6) $0.950 \times 1000 = 950 \text{ kg/m}^3$.

20. (pupil p6) Liquid mass = $149.6 - 64.0 = 85.6 \text{ g}$. Density = $85.6 \div 80.0 = 1.07 \text{ g/cm}^3$.

21. (pupil p6) B passes: $1.07 \text{ g/cm}^3 = 1070 \text{ kg/m}^3$, within 1030-1090. A fails: 950 kg/m^3 is below 1030. This is a density check, not proof of chemical suitability.

22. (pupil p6) Accept an accurate correction with a reason. For a unit error, explain that the centimetre-to-metre length factor is cubed for volume. For a rearrangement, use $m = \rho V$ or $V = m/\rho$ as appropriate. For the all-correct option, mass and volume decrease in the same proportion, so m/V is unchanged.

Exit and next lesson - pupil page 7

Match the pupil number. Accept equivalent correct wording. Keep this guide separate from pupils.

23. (pupil p7) (a) $\rho = 96 \div 12 = 8.0 \text{ g/cm}^3 = 8000 \text{ kg/m}^3$. Alternatively $0.096 \text{ kg} \div 0.000012 \text{ m}^3 = 8000 \text{ kg/m}^3$.
 (b) Each half has mass 48 g and volume 6 cm^3 , so $48 \div 6 = 8.0 \text{ g/cm}^3$: density is unchanged because mass and volume halve together.

Try again D - next lesson - pupil page 7

Leave this today. Your usual teacher may ask you to do it next lesson.

$72 \div 30 = 2.4 \text{ g/cm}^3 = 2400 \text{ kg/m}^3$. The quarter has mass 18 g and volume 7.5 cm^3 . Its density is still 2.4 g/cm^3 because mass and volume both become one quarter.

Collect and follow up

Collect the complete named booklet. Use question 23 to record the objectives demonstrated and the precise next step: equation choice, cubic-unit conversion or unchanged density after cutting. Tell the usual teacher which pupils need Try again D.

Source provenance - for the usual teacher

Pupil question	Original worksheet part / page
5	WS-12 Q1(a) / source p1
6	WS-12 Q1(b) / source p1
7	WS-12 Q1(c) / source p1
8	WS-12 Q1(d) / source p2
9	WS-12 Q1(e) / source p2
10	WS-12 Q1(f) / source p2
12	WS-12 Q2(a) / source p2
13	WS-12 Q2(b) / source p2
14	WS-12 Q2(c) / source p3
15	WS-12 Q2(d) / source p3
16	WS-12 Q2(e) / source p3
17	WS-12 Q5(a) / source p6
18	WS-12 Q5(b) / source p6
19	WS-12 Q5(c) / source p6
20	WS-12 Q5(d) / source p7
21	WS-12 Q5(e) / source p7

Selected practice is reformatted from the maintained PhysicsUK worksheet. Required context is included; unassigned parts are omitted.

[Source worksheet](#) | [Maintained solutions](#) | [Revision notes](#)

Check 1: Entry

Question 1, Question 2, Question 3

Look for: Question 1: 180 g. Question 2: 24 cm³ from all three dimensions. Question 3: B, because equal volumes can be compared by mass.

If secure: Continue to the reading and model on pupil page 2.

If: Question 1 divides by 1000, or question 2 adds dimensions / uses only two.

Likely issue: The pupil needs the direction of the mass conversion or the volume-of-a-cuboid rule.

Say: One kilogram is 1000 grams, so multiply kilograms by 1000. Cuboid volume multiplies three perpendicular lengths; adding lengths cannot give a volume.

Ask: How many grams are in 0.180 kg? What multiplication gives the volume of a 2 cm × 3 cm × 4 cm cuboid?

Expect: 180 g; $2 \times 3 \times 4 = 24 \text{ cm}^3$.

Next: Use page 2: the mass-conversion row and the cuboid-volume sentence. Direct Try again A on page 1 within the first 2 reading minutes. Check all three new responses.

Pupil page 2: conversion table and Same material, different size; Try again A on page 1.

If: Question 3 gives A, or gives B without referring to the equal volumes.

Likely issue: The mass-per-unit-volume comparison is insecure, or the correct choice may be a guess.

Say: Density compares mass in the same volume. When the volumes are equal, the sample with more mass has more mass per unit volume.

Ask: A and B each occupy 10 cm³. Which is denser: A at 20 g or B at 30 g? Why?

Expect: B: greater mass in the same volume. "B is heavier" alone needs the equal-volume reason.

Next: Read the opening definition on page 2. Ask what is held equal, then direct Try again A on page 1. Use reading time and check the independent comparison.

Pupil page 2, opening definition; Try again A on page 1.

If the retry remains insecure, use the support guidance on teacher page 1 and record the precise difficulty for the usual teacher.

Check 2: Hinge

Question 4

Look for: B, with $2.4 \text{ g} = 0.0024 \text{ kg}$ and $1 \text{ cm}^3 = 0.000001 \text{ m}^3$, giving 2400 kg/m^3 . A correct letter alone does not demonstrate the method.

If secure: Start questions 5-10. If only the letter is correct, request both conversions before judging the method secure.

If: A leaves the value unchanged; C converts grams only.

Likely issue: The density unit is a ratio: both numerator and denominator need conversion.

Say: Density is a mass divided by a volume. To change g/cm^3 into kg/m^3 , change both units, then divide the converted mass by the converted volume.

Ask: For question 4, what do 2.4 g and 1 cm^3 become in kg and m^3 ?

Expect: 0.0024 kg and 0.000001 m^3 . Their ratio is 2400 kg/m^3 , option B.

Next: Use the g/cm^3 -to- kg/m^3 row on page 2. Direct Try again B on page 3, replacing questions 9-10. Check both converted quantities and the final division.

Pupil page 2, final conversion row; Try again B on page 3.

If: D changes the volume unit but keeps grams as though they were kilograms, or uses 0.01 m^3 for 1 cm^3 .

Likely issue: One conversion has been omitted, or a length factor has been used for volume.

Say: A cubic centimetre has three lengths of 0.01 metres. Cube that length factor for volume. The mass must also change from grams to kilograms.

Ask: What is $0.01 \times 0.01 \times 0.01$? What is 2.4 g in kilograms?

Expect: 0.000001 m^3 for 1 cm^3 ; $2.4 \text{ g} = 0.0024 \text{ kg}$. Using 0.01 m^3 converts only one length.

Next: Use "Convert volume as a cube" on page 2. Cube 0.01 , then check the mass conversion. Direct Try again B instead of questions 9-10.

Pupil page 2, cubic-volume row and model; Try again B on page 3.

If: B with missing working or incompatible converted quantities.

Likely issue: The choice may be guessed; the conversion method is not yet evidenced.

Say: A correct letter needs a checkable method. Write the mass in kilograms above the sample volume in cubic metres, then divide.

Ask: Talk through the two conversions and the division that give your answer to question 4.

Expect: $2.4 \text{ g} = 0.0024 \text{ kg}$; $1 \text{ cm}^3 = 0.000001 \text{ m}^3$; divide to obtain 2400 kg/m^3 .

Next: Ask the pupil to show the mass and cubic-volume conversions. If either is insecure, use the page 2 conversion rows and Try again B instead of questions 9-10.

Pupil pages 2-3, conversion rows and Try again B.

If the retry remains insecure, use the support guidance on teacher page 1 and record the precise difficulty for the usual teacher.

Check 3: Mid Practice

Question 11

Look for: $25 \text{ cm}^3 = 0.000025 \text{ m}^3$; $m = \rho V = 1200 \times 0.000025 = 0.030 \text{ kg}$. Check equation choice separately from conversion.

If secure: Continue with the cuboid and liquid applications, questions 12-21.

If: The volume conversion is correct, but divides density by volume or uses mass = volume/density.

Likely issue: The requested quantity has not been connected to the correct rearrangement.

Say: Density tells us the mass in one unit of volume. To find the mass in several units of volume, multiply density by volume.

Ask: Which equation finds mass? Use it with the converted volume in question 11.

Expect: $m = \rho V$; $1200 \times 0.000025 = 0.030 \text{ kg}$. Dividing density by volume does not find mass.

Next: Use the "Mass, m" row on page 2. Direct Try again C on page 4 instead of questions 15-16. Require the equation before substitution.

Pupil page 2, mass equation; Try again C on page 4.

If: Uses $m = \rho V$ but substitutes 25, 0.25 or 0.025 as a volume in m^3 .

Likely issue: The equation is appropriate; the cubic-unit conversion is the error.

Say: The equation is correct. The volume must be in cubic metres to match kg/m^3 . Divide a value in cm^3 by one million.

Ask: Convert the 25 cm^3 in question 11 to m^3 before multiplying.

Expect: $25 \div 1\,000\,000 = 0.000025 \text{ m}^3$. Then $1200 \times 0.000025 = 0.030 \text{ kg}$.

Next: Use the cm^3 -to- m^3 row on page 2. Ask the pupil to label both units, then complete Try again C instead of questions 15-16.

Pupil page 2, cubic-volume conversion; Try again C on page 4.

If: Equation and conversion are correct but the multiplication or final unit is wrong.

Likely issue: This is an arithmetic/unit slip rather than a wrong density model.

Say: Keep the correct equation and volume conversion. Enter the whole decimal volume in the calculator. kg/m^3 multiplied by m^3 leaves kilograms.

Ask: What is 1200×0.000025 , and which unit remains?

Expect: 0.030 kg . A correctly obtained 30 g must be converted to the requested kg .

Next: Keep the valid method. Check the calculator entry and that $\text{kg/m}^3 \times \text{m}^3$ leaves kg . Complete Try again C independently instead of questions 15-16.

Pupil page 2, mass equation and units; Try again C on page 4.

If the retry remains insecure, use the support guidance on teacher page 1 and record the precise difficulty for the usual teacher.

Check 4: Exit

Question 23

Look for: $8.0 \text{ g/cm}^3 = 8000 \text{ kg/m}^3$. Each half: 48 g and 6 cm^3 , so density remains 8.0 g/cm^3 . Require the mass/volume ratio explanation.

If secure: Record the calculation, conversion and same-material comparison objectives as secure where the evidence supports them.

If: Gives 8 kg/m^3 , reverses the density equation or makes a cubic-unit error.

Likely issue: Equation choice or conversion still needs an independent follow-up.

Say: Density is mass divided by volume. Grams divided by cm^3 give g/cm^3 ; multiply that density by 1000 to obtain kg/m^3 .

Ask: In question 23, what unit belongs to $96 \div 12$? What is the same density in kg/m^3 ?

Expect: 8.0 g/cm^3 , equivalent to 8000 kg/m^3 . The value 8 alone is not 8 kg/m^3 .

Next: Next lesson, revisit the equation/conversion tables and cuboid model on page 2. Then pupils cover the reading and complete Try again D on page 7. Compare with the key.

Pupil page 2, equations and conversions; Try again D on page 7, next lesson only.

If: Says each half is less dense because it has less mass, or gives unchanged density without a mass-and-volume reason.

Likely issue: Sample size is being confused with the ratio defining density, or the reason is missing.

Say: Cutting the uniform sample halves both mass and volume. Density is their ratio, so it stays the same when both halve.

Ask: What are the mass and volume of each half in question 23? Divide them.

Expect: 48 g and 6 cm^3 ; $48 \div 6 = 8.0 \text{ g/cm}^3$, unchanged. Less mass alone does not establish less density.

Next: Next lesson, use "Same material, different size" on page 2. Halve mass and volume together, then direct Try again D independently.

Pupil page 2, Same material, different size; Try again D on page 7, next lesson only.

If the retry remains insecure, use the support guidance on teacher page 1 and record the precise difficulty for the usual teacher.

Specification and review

AQA 8463: 4.3.1.1 | AQA 8464: 6.3.1.1. Density, mass and volume calculations, cubic-unit conversions and comparisons of uniform samples. Both courses and tiers use the same selection. Detailed measurement methods, displacement, particle-state comparisons and practical completion are reserved for other lessons.

PhysicsUK original cover lesson. Reviewed 2026-10-31. Timings estimated.