Density of solids and liquids

Answers, marking points and revision notes | AQA Combined Science 8464 and AQA GCSE Physics 8463

GCSE science required practicals

This practical online

Answers

1 Name the measuring instrument Ruby should use to find:

a. the mass of the aluminium block

b. the length of each side of the block.

(2 marks)

a) A top-pan balance.

b) A ruler marked in millimetres (or vernier callipers).

Marking points

- Balance (top-pan or electronic)
- Ruler (mm scale) or callipers

2 Describe how Ruby used the displacement can to find the volume of the granite pebble. (2 marks)

She filled the can with water until it ran out of the spout and waited for the dripping to stop. Then she put an empty measuring cylinder under the spout, lowered the pebble in gently on a thread, and read the volume of water collected in the cylinder. This volume equals the volume of the pebble.

Marking points

- Fill the can to the spout (until dripping stops) before adding the pebble
- Collect the displaced water in a measuring cylinder: its volume is the pebble's volume

3 Explain how Ruby should read the measuring cylinder to get an accurate volume. (2 marks)

She should put the cylinder on a flat bench and read the scale at the bottom of the curved surface of the water (the meniscus), with her eye level with it. Looking from above or below would give a parallax error.

Marking points

- Read at the bottom of the meniscus
- Eye level with the surface to avoid parallax error

4 Give one hazard in this practical and describe how to reduce the risk. (2 marks)

Water spilling from the displacement can could make the floor slippery. Ruby should stand the can in a tray and wipe up any spills straight away.

Marking points

- Hazard: spilled water (slips, near the balance), dropped heavy block, or broken glass
- Matching control, e.g. tray and wipe spills, lower objects on a thread, use plastic cylinders

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5 Calculate the values of X and Y for the brass cube. Show your working. (3 marks)

X: volume = 2.0 × 2.0 × 2.0 = 8.0 cm^3.

Y: density = 68.0 ÷ 8.0 = 8.5 g/cm^3.

volume = length × width × height

volume = 2.0 × 2.0 × 2.0

X = 8.0 cm^3

density = mass ÷ volume

density = 68.0 ÷ 8.0

Y = 8.5 g/cm^3

Marking points

- Volume = 2.0 × 2.0 × 2.0
- X = 8.0 cm^3
- Y = 8.5 g/cm^3

6 Calculate the value of Z, the density of the granite pebble. Give your answer to 3 significant figures. (2 marks)

Density = 48.6 ÷ 18.5 = 2.627 g/cm^3, which is 2.63 g/cm^3 to 3 significant figures.

density = mass ÷ volume

density = 48.6 ÷ 18.5

density = 2.627 g/cm^3

Z = 2.63 g/cm^3 (3 s.f.)

Marking points

- Density = 48.6 ÷ 18.5
- 2.63 g/cm^3

7 Mohammed measured the density of cooking oil. He wrote down:

mass of empty measuring cylinder = 62.4 g
mass of measuring cylinder with oil = 108.4 g
volume of oil = 50.0 cm^3

Calculate the density of the cooking oil. Show your working. (3 marks)

Mass of oil = 108.4 - 62.4 = 46.0 g.

Density = 46.0 ÷ 50.0 = 0.92 g/cm^3.

mass of oil = 108.4 - 62.4

mass of oil = 46.0 g

density = mass ÷ volume

density = 46.0 ÷ 50.0

density = 0.92 g/cm^3

Marking points

- Subtracts the cylinder: mass of oil = 46.0 g
- Density = 46.0 ÷ 50.0
- 0.92 g/cm^3

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8 The density of the aluminium block is 2.71 g/cm^3. Write this density in kg/m^3. (2 marks)

1 g/cm^3 = 1000 kg/m^3, so 2.71 × 1000 = 2710 kg/m^3.

$1\ g/cm^3 = 1000\ kg/m^3$

$density = 2.71 \times 1000$

$density = 2710\ kg/m^3$

Marking points

- Multiplies by 1000
- 2710 kg/m^3

9 **Higher tier**

A brass weight is a cuboid measuring 45 mm by 30 mm by 12 mm. Its mass is 0.137 kg.

Calculate its density in kg/m^3. Give your answer to 3 significant figures. Show your working. (4 marks)

In metres the sides are 0.045 m, 0.030 m and 0.012 m.

Volume = 0.045 × 0.030 × 0.012 = 1.62 × 10^{-5} m^3.

Density = 0.137 ÷ (1.62 × 10^{-5}) = 8457 kg/m^3, which is 8460 kg/m^3 to 3 significant figures.

$45\ mm = 0.045\ m$

$30\ mm = 0.030\ m$

$12\ mm = 0.012\ m$

$V = 0.045 \times 0.030 \times 0.012$

$V = 1.62 \times 10^{-5}\ m^3$

$\rho = m \div V$

$\rho = 0.137 \div (1.62 \times 10^{-5})$

$\rho = 8456.8\ kg/m^3$

$\rho = 8460\ kg/m^3\ (3\ s.f.)$

Marking points

- Converts lengths to metres
- Volume = 1.62 × 10^{-5} m^3
- Density = mass ÷ volume
- 8460 kg/m^3

10 Ruby measured the volume of the pebble three times with the displacement can. She got 18.5 cm^3, 18.0 cm^3 and 19.0 cm^3.

Calculate the mean volume and say whether her readings are repeatable. (2 marks)

Mean = (18.5 + 18.0 + 19.0) ÷ 3 = 18.5 cm^3. The readings are close together (within 1.0 cm^3 of each other), so they are repeatable.

Marking points

- Mean = 18.5 cm^3
- Repeatable, because the readings are close together (small spread)

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11 Ruby's first try with the displacement can gave a pebble volume that was too small. Suggest one reason why, and how she could stop it happening. (2 marks)

She may not have filled the can right up to the spout, so the first water pushed up just filled the can instead of coming out. She should fill it until it overflows and wait for the dripping to stop before putting the cylinder under the spout.

Marking points

- A sensible reason: can not full to the spout, drops left in the spout, water splashed out when the pebble was dropped in
- A matching fix: fill until it drips and wait, lower the pebble gently on a thread, tap the spout

12 **Higher tier**

Ruby measured each side of the 2.0 cm brass cube with a ruler marked in millimetres. Explain why her value for its density could be quite far from the true value, and suggest a better instrument. (2 marks)

The ruler's resolution is 1 mm, which is 5% of a 20 mm side, and the volume uses the side three times, so a small error in reading each length becomes a large error in the volume and so the density. Vernier callipers or a micrometer have a much smaller resolution (0.1 mm or less), so the volume is more accurate.

Marking points

- Resolution of 1 mm is large compared with a 20 mm side, and the error is multiplied three times in the volume
- Use vernier callipers or a micrometer (smaller resolution)

13 Ruby wants to find the volume of a cork using a measuring cylinder of water. The cork floats. Describe how she could still find its volume. (2 marks)

Tie the cork to a heavy sinker, such as a metal nut. First lower just the sinker into the water and read the volume. Then lower the sinker and cork together until both are under the water and read again. The difference between the two readings is the volume of the cork.

Marking points

- Use a sinker (or push it under with a thin pin) so the cork is fully under water
- Volume of cork = reading with cork and sinker - reading with sinker only

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14 Plan an investigation to find out how the density of salt water depends on the mass of salt dissolved in it.

(6 marks)

Measure 100 cm^3 of water into a beaker with a measuring cylinder. Weigh out 5 g of salt on a balance, add it to the water and stir until it has all dissolved. Repeat to make solutions with 0 g, 10 g, 15 g, 20 g and 25 g of salt in 100 cm^3 of water. For each solution, put an empty 50 cm^3 measuring cylinder on the balance and press tare. Pour in the salt water until the bottom of the meniscus is on the 50.0 cm^3 mark, reading with my eye level with it, and record the mass of the liquid shown on the balance. Calculate density = mass ÷ volume. Rinse and dry the cylinder between solutions and keep all the solutions at room temperature. Repeat each measurement three times and find the mean density. Plot a graph of density against mass of salt to see the pattern; I would expect the density to increase as more salt is dissolved. Wipe up any spills so no one slips and the balance stays dry.

Marking points (any 6, with the method in a logical order)

- Same volume of water for each solution, measured with a measuring cylinder
- Measure different masses of salt on a balance and dissolve completely
- Tare the balance with the empty cylinder (or subtract its mass)
- Measure a fixed volume of each solution, reading the meniscus at eye level
- Record the mass of the solution only
- Calculate density = mass ÷ volume
- Keep temperature the same; rinse and dry the cylinder between solutions
- Repeat and calculate a mean for each solution
- Plot density against mass of salt, or a sensible safety point

How it is marked

- 5-6 marks: a clear, logical plan that makes a range of solutions, measures the mass and volume of each correctly, calculates density and says how the results will be compared.
- 3-4 marks: a workable plan to measure mass and volume of the solutions, but parts are missing, such as how the cylinder's mass is removed or which variables are kept the same.
- 1-2 marks: some relevant steps such as weighing or measuring volume, but no clear sequence and it would not give a density for each solution.

Revision notes: the method

Aim: To find the density of regular solids, irregular solids and a liquid by measuring their mass and volume.

Equipment

- Top-pan balance (reading to 0.1 g)
- Ruler marked in mm, or vernier callipers
- Regularly shaped solids (for example a metal cuboid and cube)
- Irregular objects (for example a pebble and a rubber stopper)
- Displacement (eureka) can
- Measuring cylinders (10 cm^3, 50 cm^3 and 100 cm^3)
- Beaker of water
- Thread
- The liquid to be tested (for example cooking oil)
- Paper towels

Method

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1. Regular solid: measure its mass on the balance.
2. Measure its length, width and height with a ruler (or callipers), and work out the volume as length × width × height.
3. Irregular solid that fits in a measuring cylinder: half fill the cylinder with water and read the volume at the bottom of the meniscus, with your eye level with it.
4. Tie the object to a thread, lower it gently into the water until it is covered, and read the new volume; the difference is the volume of the object.
5. Larger irregular solid: fill a displacement can with water until it drips from the spout, wait for it to stop, and put an empty measuring cylinder under the spout.
6. Lower the object gently into the can on a thread and collect all the water that comes out; its volume is the volume of the object.
7. Measure the mass of each object on the balance, drying it first if it has been in water.
8. Liquid: put an empty measuring cylinder on the balance and press tare (or record its mass).
9. Pour in a measured volume of the liquid, such as 50.0 cm^3, and record the mass of the liquid alone.
10. Calculate each density using density = mass ÷ volume, and repeat each measurement to find a mean.

Variables

- **Independent:** The object or liquid being tested.
- **Dependent:** The density, calculated from the mass (balance) and the volume (ruler, measuring cylinder or displacement can).
- **Control:** Use water at room temperature in the cylinder and can; Fill the displacement can to the spout every time; Read every measuring cylinder at the bottom of the meniscus, at eye level; Use the same balance, zeroed before each reading

Hazards

Hazard	What could happen	How to reduce the risk
Spilled water on the floor or bench	Someone slips, or water reaches the electric balance	Stand the displacement can in a tray, wipe up spills straight away and keep the balance away from the water.
Heavy metal blocks	Injury to feet or breaking glassware if dropped	Lower objects gently on a thread and keep them near the middle of the bench.
Glass measuring cylinders	Cuts if one is knocked over and breaks	Use plastic cylinders where possible and do not drop objects into them.

Key points

- Density = mass ÷ volume; in g/cm^3 use grams and cm^3, in kg/m^3 use kg and m^3.
- To change g/cm^3 to kg/m^3, multiply by 1000.
- For a liquid, subtract the mass of the empty cylinder (or tare it): you want the mass of the liquid only.
- Volume by displacement = new reading - starting reading, not the new reading on its own.
- Read measuring cylinders at the bottom of the meniscus with your eye level with it.
- Wait for the displacement can to stop dripping before you start and after you add the object.

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