Exercise walk-through

Density ▪ 1.4

eXercise

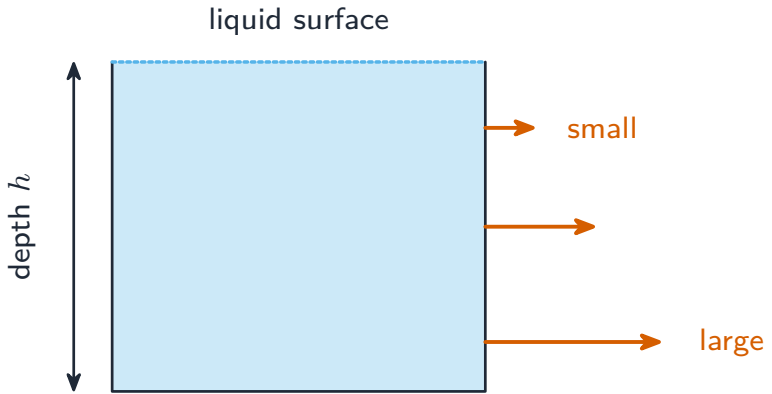
You must be able to

- use $\rho = \dfrac{m}{V}$ with consistent units
- find the volume of a regular and an irregular solid
- predict floating or sinking from densities

Method — Density and the displacement method

Stone, mass 54 g, water rises $20 \to 40$ cm^3: volume $= 20$ cm^3;
$\rho = \dfrac{54}{20} = 2.7$ g/cm^3.
Float/sink: floats if its density $<$ the liquid's density.

Method — Density and the displacement method



A tank of liquid; pressure pushing the wall increases with depth

Method — Which floats, and finding the density of a liquid

An object **floats** in a liquid when its density is **less** than the liquid's density, and sinks when it is greater. The same rule decides which of two liquids floats on the other, provided they do not mix: the less dense liquid lies on top. Oil (≈ 800 kg/m^3) floats on water (1000 kg/m^3).

Density of a liquid. Weigh an empty measuring cylinder; pour in the liquid and read its volume; weigh again. The mass of the liquid is the difference between the two readings, and $\rho = \dfrac{m}{V}$.

Worked example. An empty cylinder has a mass of 84.0 g. With 50 cm^3 of a liquid it has a mass of 124.0 g. Mass of liquid $= 124.0 - 84.0 = 40.0$ g, so $\rho = \dfrac{40.0}{50} = 0.80$ g/cm^3. This liquid floats on water, whose density is 1.0 g/cm^3.

$\triangle$ Watch the units: 1 g/cm$^3 = 1000$ kg/m^3, because 1 m$^3 = 10^6$ cm^3 and 1 kg $= 1000$ g.

Practice 2.1 ▪ 2 marks

A block has mass 240 g and volume 30 cm^3. Find its density.

Solution 2.1

Worked steps

$$\rho = \frac{m}{V} = \frac{240}{30} = 8.0\ \text{g/cm}^3$$ M1 A1.

Practice 2.2 ▪ 1 mark

State how to find the volume of a small irregular stone.

Solution 2.2

Method: Density and the displacement method

Worked steps

lower it into water in a measuring cylinder; the rise in water level is its volume B1.

Practice 2.3 ▪ 2 marks

Four liquids that do not mix have densities 0.79, 1.00, 1.26 and 0.92 g/cm^3. State the order in which they settle, from the top of the container downwards.

Solution 2.3

Method: Which floats, and finding the density of a liquid

Worked steps

0.79, 0.92, 1.00, 1.26 g/cm^3 from the top down **B1**; the least dense liquid floats on top of the denser ones **B1**.

Practice 2.4 ▪ 2 marks

Convert a density of 2.7 g/cm^3 into kg/m^3.

Solution 2.4

Worked steps

$2.7\ \mathrm{g/cm^3} \times 1000$ M1 $= 2700\ \mathrm{kg/m^3}$ A1.

Exam-style 3.1 ▪ 1 mark

An object floats on water (density 1.0 g/cm^3) if its density is:

A greater than 1.0 g/cm^3

B less than 1.0 g/cm^3

C exactly 1.0 g/cm^3 only

D any value

Solution 3.1

Method: Which floats, and finding the density of a liquid

A greater than $1.0\ \mathrm{g/cm^3}$

B less than $1.0\ \mathrm{g/cm^3}$ ✓

C exactly $1.0\ \mathrm{g/cm^3}$ only

D any value

Worked steps

B. It floats if its density is less than that of water.

Exam-style 3.2 ▪ 1 mark

A rectangular metal block measures 2.0 cm $\times$ 3.0 cm $\times$ 5.0 cm and has mass 216 g.
(a) Find its volume.
(b) Find its density.

Solution 3.2

Worked steps

(a) $V = 2.0 \times 3.0 \times 5.0 = 30\ \text{cm}^3$ **B1**.

(b) $\rho = \dfrac{216}{30} = 7.2\ \text{g/cm}^3$ **M1** **A1**.

Exam-style 3.3 ▪ 2 marks

A liquid of density $0.80\ \text{g/cm}^3$ is poured onto water. State, with a reason, which liquid floats on top.

Solution 3.3

Worked steps

(a) Measure the mass of the empty measuring cylinder B1; pour in the liquid and read its volume from the scale, at the bottom of the meniscus with the eye level B1; measure the mass again and subtract to get the mass of the liquid, then divide mass by volume B1.

(b) Mass of liquid $= 140.0 - 76.0 = 64.0$ g B1; $\rho = \dfrac{64.0}{80}$ M1 $= 0.80$ g/cm^3 A1.

(c) Volume of the metal $= 105 - 80 = 25$ cm^3 B1; mass of the metal $= 337.5 - 140.0 = 197.5$ g B1; $\rho = \dfrac{197.5}{25} = 7.9$ g/cm^3 A1.

(d) No, it sinks B1: its density of 7.9 g/cm^3 is far greater than the liquid's 0.80 g/cm^3 B1.

(e) Sugar dissolves in the liquid, so the level would not give its volume B1.

Exam-style 3.3 ▪ 3 marks

A student finds the density of a liquid and of an irregular metal object.
(a) Describe how she finds the density of the liquid, naming her measurements.
(b) Her empty measuring cylinder has a mass of 76.0 g. With 80 cm^3 of the liquid it has a mass of 140.0 g. Calculate the density of the liquid.
(c) She lowers the metal object into the cylinder. The level rises from 80 cm^3 to 105 cm^3 and the balance now reads 337.5 g. Calculate the density of the metal.
(d) State, with a reason, whether the metal would float in the liquid.
(e) Explain why the displacement method could not be used for a small cube of sugar.

Solution 3.3

Worked steps

(a) Measure the mass of the empty measuring cylinder B1; pour in the liquid and read its volume from the scale, at the bottom of the meniscus with the eye level B1; measure the mass again and subtract to get the mass of the liquid, then divide mass by volume B1.

(b) Mass of liquid $= 140.0 - 76.0 = 64.0$ g B1; $\rho = \dfrac{64.0}{80}$ M1 $= 0.80$ g/cm^3 A1.

(c) Volume of the metal $= 105 - 80 = 25$ cm^3 B1; mass of the metal $= 337.5 - 140.0 = 197.5$ g B1; $\rho = \dfrac{197.5}{25} = 7.9$ g/cm^3 A1.

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(e) Sugar dissolves in the liquid, so the level would not give its volume B1.