1.4 Density

Name: _____ Class: _____ Date: _____ **Total: 28 marks**

0 Vocabulary

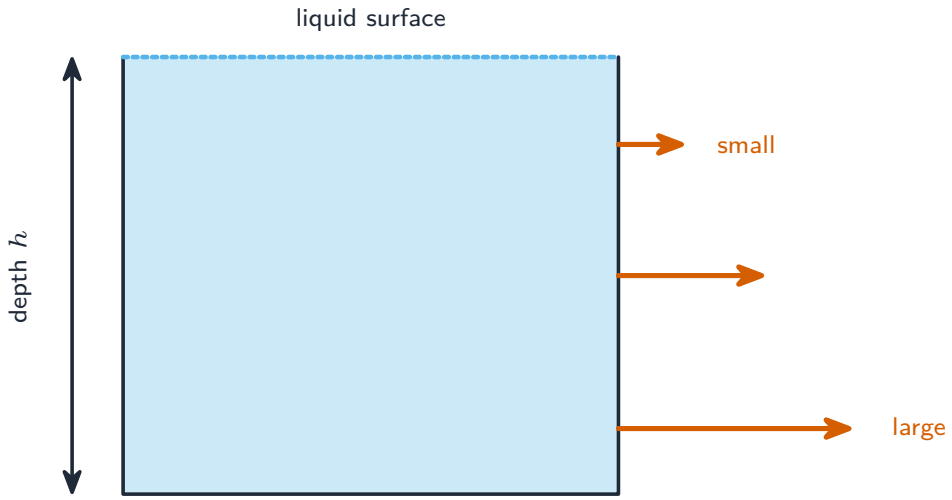
Word	Example
measurement /ˈmeʒəmənt/ 测量	Repeat each **measurement** three times. 每次**测量**重复三遍。
measuring cylinder 量筒 /ˈmeʒərɪŋ ˈsɪlɪndə/	A **measuring cylinder** measures a rough volume of liquid. **量筒**可以粗略测量液体体积。
meniscus /ˈmenɪskəs/ 弯月面	Read the volume at the bottom of the **meniscus**. 读取**弯月面**底部对应的体积。
magnitude /ˈmægnɪtjuːd/ 大小	The force has a **magnitude** of 20 N. 这个力的**大小**是 20 N。
regular solid /ˈregjʊlə ˈsɒlɪd/ 规则固体	A cube is a **regular solid**: you can work out its volume with a ruler. 立方体是**规则固体**：你可以用直尺测量并计算它的体积。
irregular solid 不规则固体 /ɪˈregjʊlə ˈsɒlɪd/	A stone is an **irregular solid**. 石头是**不规则固体**。
displacement method 排水法 /dɪˈspleɪsmənt ˈmeθəd/	Use the **displacement method** to find a stone's volume. 用**排水法**测量石头的体积。
floats /fləʊts/ 漂浮	A cork **floats** on water. 软木塞**漂浮**在水面上。
spring constant 弹簧常数 /sprɪŋ ˈkɒnstənt/	A stiff spring has a large **spring constant**. 硬弹簧的**劲度系数**大。
pivot /ˈpɪvət/ 支点	The see-saw turns about its **pivot**. 跷跷板绕着它的**支点**转动。
scale /skeɪl/ 规模	A large dam is a big-**scale** energy project. 一座大坝是一个大**规模**的能源项目。

1 Key knowledge and worked examples

■ Density

Density 密度 is mass per unit volume: $\rho = \dfrac{m}{V}$, in g/cm^3 or kg/m^3. Rearranged: $m = \rho V$ and $V = \dfrac{m}{\rho}$.

what you need	regular solid	irregular solid	liquid
mass	balance	balance	balance: full minus empty cylinder
volume	measure sides; $V = l \times w \times h$	rise in a measuring cylinder	read the measuring cylinder



Density ρ is mass per unit volume; a denser liquid also gives a greater pressure with depth

- An object **floats** in a liquid when its density is **less** than the liquid's; it sinks when greater.
- Liquids that do not mix settle in order of density: the least dense on top. Oil (800 kg/m^3) floats on water (1000 kg/m^3).
- 1 g/cm^3 = 1000 kg/m^3, because 1 m^3 = 10^6 cm^3 and 1 kg = 1000 g.

■ Worked example 1: an irregular solid by displacement

A stone of mass 54 g is lowered into a measuring cylinder. The water rises from 20 cm^3 to 40 cm^3. Find the density of the stone.

1. The stone pushes aside its own volume of water: $V = 40\ cm^3 - 20\ cm^3 = 20\ cm^3$.
2. Density is mass per unit volume, $\rho = \frac{m}{V}$:

$$\rho = \frac{m}{V} = \frac{54\ g}{20\ cm^3} = \mathbf{2.7}\ g/cm^3$$

■ Worked example 2: the density of a liquid

An empty measuring cylinder has a mass of 84.0 g. With 50 cm^3 of a liquid in it the mass is 124.0 g. Find the density of the liquid, and say whether it floats on water.

1. Mass of the liquid alone: $m = 124.0\ g - 84.0\ g = 40.0\ g$.
2. $$\rho = \frac{m}{V} = \frac{40.0\ g}{50\ cm^3} = \mathbf{0.80}\ g/cm^3$$
3. 0.80 g/cm^3 is less than water's 1.0 g/cm^3, so the liquid floats on water.

■ Worked example 3: SI units for a regular solid

A concrete slab measures 2.0 m × 0.50 m × 0.10 m and has a mass of 230 kg. Find its density in kg/m^3.

1. Volume of a cuboid: $V = l \times w \times h = 2.0\ m \times 0.50\ m \times 0.10\ m = 0.10\ m^3$.
2. $$\rho = \frac{m}{V} = \frac{230\ kg}{0.10\ m^3} = \mathbf{2300}\ kg/m^3$$

2 Practice

2.1 A block has mass 240 g and volume 30 cm^3. Find its density. [2]



2.2 State how to find the volume of a small irregular stone. [1]



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2.3 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. [2]

0.79 1.00 1.26 0.92 g/cm^3

2.4 Convert a density of 2.7 g/cm^3 into kg/m^3. [2]

2.7 g/cm^3

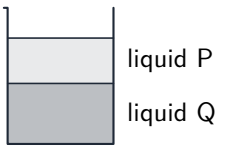
3 Exam-style questions

3.1 An object floats on water (density 1.0 g/cm^3) if its density is: [1]



- **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

3.2 Liquid P floats on top of liquid Q. The liquids do not mix. Which statement explains why P floats on Q? [1]

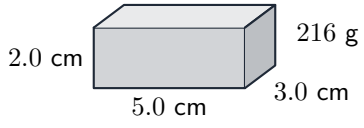


- **A** The mass of liquid Q is greater than the mass of liquid P.
- **B** The mass of 1 cm^3 of liquid Q is greater than the mass of 1 cm^3 of liquid P.
- **C** The volume of liquid Q is greater than the volume of liquid P.
- **D** The volume of 1 g of liquid Q is greater than the volume of 1 g of liquid P.

3.3 A rectangular metal block measures 2.0 cm × 3.0 cm × 5.0 cm and has mass 216 g.

(a) Find its volume. [1]

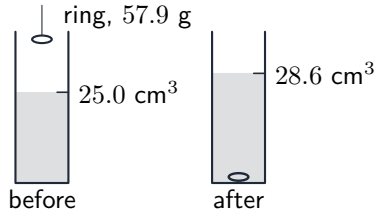
(b) Find its density. [2]



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3.4 A jeweller is given a ring said to be pure gold. Its mass is 57.9 g. When it is lowered into a measuring cylinder of water, the level rises from 25.0 cm^3 to 28.6 cm^3. The density of pure gold is 19.3 g/cm^3.

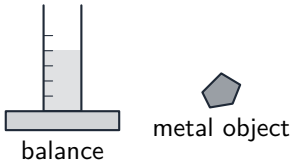
(a) Calculate the density of the ring. [3]



(b) State whether the ring is pure gold, and give a reason. [1]

3.5 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. [3]



(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. [3]

(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. [3]

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(d) State, with a reason, whether the metal would float in the liquid. [2]

(e) Explain why the displacement method could not be used for a small cube of sugar. [1]

Solutions

Each answer shows the steps, then the **result**.

2.1

- $\rho = m/V$

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

2.2

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

2.3

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

2.4

- $\times 1000$ to convert g/cm^3 to kg/m^3

$$2.7\ \text{g/cm}^3 \times 1000 = \mathbf{2700}\ \text{kg/m}^{\mathbf{3}}$$

3.1 B

- it floats if its density is less than that of water

3.2 B

- liquid Q has the greater density (more mass in each cm^3), so it sinks below P; A and C compare whole amounts, not density

3.3

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

(b) $\rho = m/V$

$$\rho = \frac{m}{V} = \frac{216\ \text{g}}{30\ \text{cm}^3} = \mathbf{7.2}\ \text{g/cm}^{\mathbf{3}}$$

3.4

(a)

- volume by displacement: $V = 28.6\ \text{cm}^3 - 25.0\ \text{cm}^3 = 3.6\ \text{cm}^3$
- density is mass per unit volume, $\rho = \dfrac{m}{V}$

$$\rho = \frac{m}{V} = \frac{57.9\ \text{g}}{3.6\ \text{cm}^3} = \mathbf{16}\ \text{g/cm}^3$$

(b)

- not pure gold: its density (16 g/cm^3) is less than that of pure gold (19.3 g/cm^3)

3.5

(a) measure the mass of the empty measuring cylinder

- pour in the liquid and read its volume from the scale, at the bottom of the meniscus with the eye level
- measure the mass again and subtract to get the mass of the liquid, then divide mass by volume

(b) mass of liquid $m = m_{\text{full}} - m_{\text{empty}} = 140.0\ \text{g} - 76.0\ \text{g} = 64.0\ \text{g}$

- $\rho = m/V$

$$\rho = \frac{m}{V} = \frac{64.0\ \text{g}}{80\ \text{cm}^3} = \mathbf{0.80}\ \text{g/cm}^{\mathbf{3}}$$

(c) volume of the metal $V = V_2 - V_1 = 105\ \text{cm}^3 - 80\ \text{cm}^3 = 25\ \text{cm}^3$

- mass of the metal $m = m_2 - m_1 = 337.5\ \text{g} - 140.0\ \text{g} = 197.5\ \text{g}$

$$\rho = \frac{m}{V} = \frac{197.5\ \text{g}}{25\ \text{cm}^3} = \mathbf{7.9}\ \text{g/cm}^{\mathbf{3}}$$

(d) **no**, it sinks

- its density of 7.9 g/cm^3 is far greater than the liquid's 0.80 g/cm^3

(e) sugar dissolves in the liquid, so the level would not give its volume