## DENSITY AND REQUIRED PRACTICAL 5

1

A student investigated the density of different fruits.

The table below shows the results.

| Fruit | Density in g/cm$^3$ |
|---|---|
| Apple | 0.68 |
| Kiwi | 1.03 |
| Lemon | 0.95 |
| Lime | 1.05 |

(a) The student determined the volume of each fruit using a displacement can and a measuring cylinder.

What other piece of equipment would the student need to determine the density of each fruit?

___________________________________________

**(1)**

(b) Write down the equation which links density ($\rho$), mass ($m$) and volume ($V$).

___________________________________________

**(1)**

(c) The mass of the apple was 85 g.

The density of the apple was 0.68 g/cm$^3$.

Calculate the volume of the apple.

Give your answer in cm$^3$.

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Volume = ________________ cm$^3$

**(3)**

(d) The student only measured the volume of each fruit once.

The volume measurements **cannot** be used to show that the method to measure volume gives precise readings.

Give the reason why.

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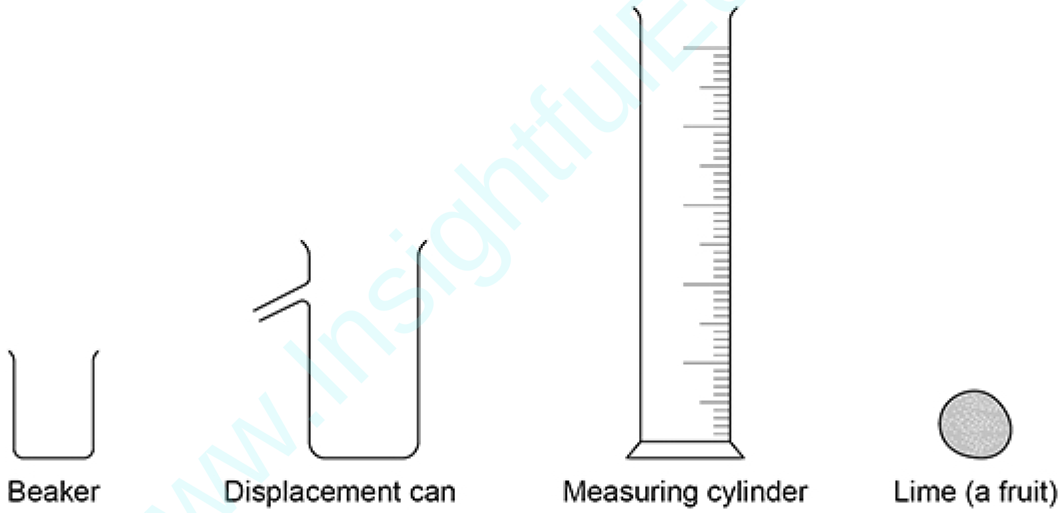
**(1)**
**(Total 6 marks)**

2

A student investigated the density of different fruits.

To determine the density of each fruit, the student measured the volume of each fruit.

The figure below shows the equipment the student could have used.




(a) Describe a method the student could have used to measure the volume of the lime.

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**(4)**

(b) The student measured the volume of each fruit three times and then calculated a mean value.

The three measurements for a grape were

$2.1\ cm^3$ $2.1\ cm^3$ $2.4\ cm^3$

Calculate the mean value.

Mean value = ______________ $cm^3$

**(2)**

(c) What are the advantages of taking three measurements and calculating a mean value?

Tick (✓) **two** boxes.

| | |
|---|---|
| Allows anomalous results to be identified and ignored. | ☐ |
| Improves the resolution of the volume measurement. | ☐ |
| Increases the precision of the measured volumes. | ☐ |
| Reduces the effect of random errors when using the equipment. | ☐ |
| Stops all types of error when using the equipment. | ☐ |

**(2)**

(d) The mass of an apple was 84.0 g.

The volume of the apple was 120 $cm^3$.

Calculate the density of the apple.

Give your answer in $g/cm^3$.

Use the equation:

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

____________________________________________________________

____________________________________________________________

____________________________________________________________

Density = _______________ $g/cm^3$

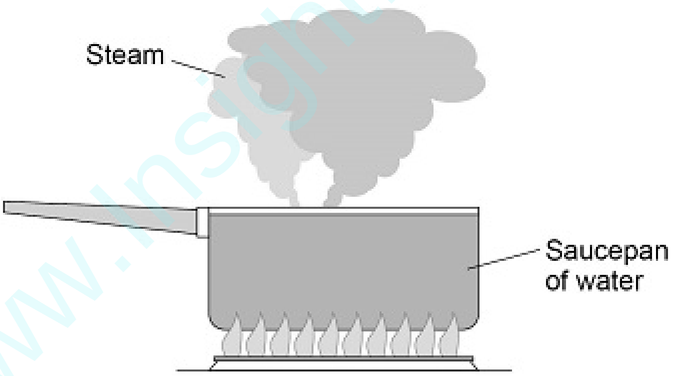
**(2)**

**(Total 10 marks)**

3

**Figure 1** shows water being heated. Eventually the water changed into steam.

**Figure 1**




(a) Complete the sentences.

Choose answers from the box.

Each answer may be used once, more than once or not at all.

| | | |
|---|---|---|
| **greater than** | **less than** | **the same as** |

The distance between the particles in steam is __________________________ the

distance between the particles in liquid water.

The density of steam is ___________________________ the density of liquid water.

**(2)**

(b) The mass of the steam was 0.063 kg

The volume of the steam was 0.105 $m^3$

Calculate the density of steam.

Use the equation:

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

Choose the unit from the box.

| | | |
|---|---|---|
| **kg** | **$m^3$ / kg** | **kg / $m^3$** |

___________________________________________________________

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Density = ________________________ Unit __________________

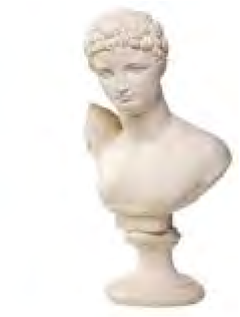
**(3)**

4

A student wants to calculate the density of the two objects shown in the figure below.

**Metal cube**





**Small statue**



Describe the methods that the student should use to calculate the densities of the two objects.

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**(Total 6 marks)**

5

The diagram below shows a wind turbine.

(a) At a particular wind speed, a volume of $2.3 \times 10^4$ $m^3$ of air passes the blades each second.

The density of air is 1.2 kg/$m^3$.

Calculate the mass of air passing the blades per second.

___________________________________________

___________________________________________

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Mass of air per second = ____________________ kg

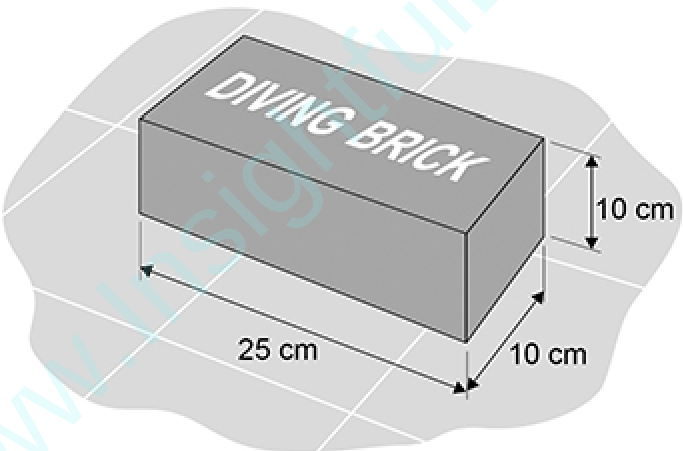
**(3)**

6

Diving bricks sink to the bottom of a swimming pool.

**Figure 1** shows a diving brick.

**Figure 1**




Swimmers practise diving to the bottom of the swimming pool to pick up the diving brick

(b) When the brick from **Figure 1** is at the bottom of the pool, the top surface of the brick is 2.50 m below the surface of the water.

The force acting on the top surface of the brick due to the weight of the water is 637 N.

gravitational field strength = 9.8 N/kg

Calculate the density of the water in the swimming pool.

Use the Physics Equations Sheet.

Density of water = ___________ kg/m$^3$

**(6)**

**7**

A student wanted to determine the density of a small piece of rock.

(a) Describe how the student could measure the volume of the piece of rock.

**(4)**

(b) The volume of the piece of rock was 18.0 cm³.

The student measured the mass of the piece of rock as 48.6 g.

Calculate the density of the rock in g/cm³.

Use the equation:

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

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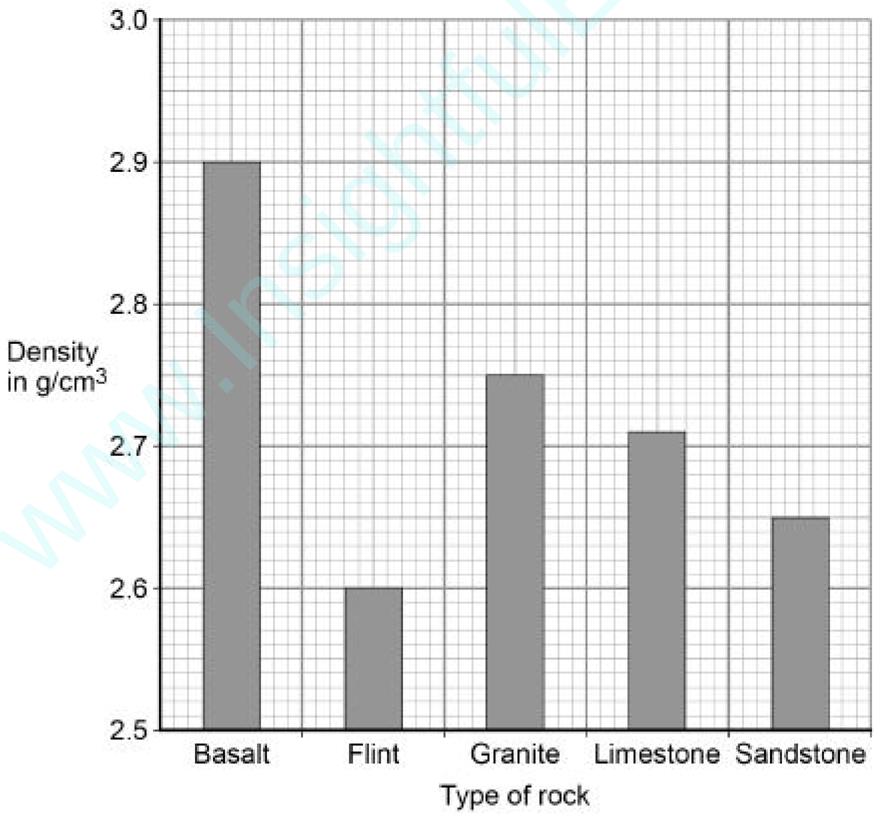
___________________________________________

___________________________________________

Density = ______________________ g/cm³

**(2)**

The graph below shows the densities of different types of rock.



(c) What is the most likely type of rock that the student had?

Tick **one** box.

Basalt ☐

Flint ☐

Granite ☐

Limestone ☐

Sandstone ☐

**(1)**

(d) Give **one** source of error that may have occurred when the student measured the volume of the rock.

___

___

**(1)**

(e) How would the error you described in part **(d)** affect the measured volume of the rock?

___

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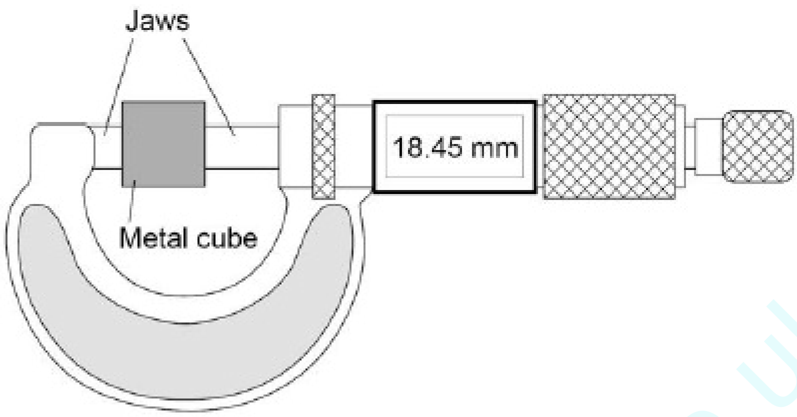
**(1)**

**(Total 9 marks)**

8

A student measured the width of a solid metal cube using a digital micrometer.

The figure below shows the micrometer.




(a) The resolution of the micrometer is 0.01 mm

The student could have used a metre rule to measure the width of the cube.

Explain how using a metre rule would have affected the accuracy of the student's measurement of width.

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**(2)**

(b) The mass of the metal cube was measured using a top pan balance.

The balance had a zero error.

Explain how the zero error may be corrected after readings had been taken from the balance.

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**(2)**

(c) The width of the cube was 18.45 mm. The density of the cube was $8.0 \times 10^3$ kg/m$^3$

Calculate the mass of the cube.

Mass = ______________________________ kg

**(5)**

**(Total 9 marks)**

9

The figure below shows a rock found by a student on a beach.

To help identify the type of rock, the student took measurements to determine its density.

(a) Describe a method the student could use to determine the density of the rock.

________________________________________________________________

**(6)**

The student determined the density of the rock to be 2.55 ± 0.10 $g/cm^3$.

(b) What are the maximum and minimum values for the density of the rock?

Maximum density = ______________________ $g/cm^3$

Minimum density = ______________________ $g/cm^3$

**(1)**

(c) The table below gives the density of five different types of rock.

| **Type of rock** | **Density in $g/cm^3$** |
| --- | --- |
| Basalt | 2.90 ± 0.10 |
| Chalk | 2.35 ± 0.15 |
| Flint | 2.60 ± 0.10 |
| Sandstone | 2.20 ± 0.20 |
| Slate | 2.90 ± 0.20 |

Which two types of rock in above table could be the type of rock the student had?

Tick (✓) **one** box.

| | |
|---|---|
| Basalt or chalk | ☐ |
| Chalk or flint | ☐ |
| Flint or sandstone | ☐ |
| Sandstone or slate | ☐ |

**(1)**

(d) The student only took one set of measurements to determine the density of the rock.

Explain why taking the measurements more than once may improve the accuracy of the density value.

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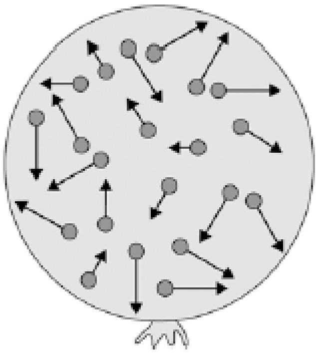
**(2)**

**(Total 10 marks)**

**10**

The figure below shows a balloon filled with helium gas.



(a) The helium in the balloon has a mass of 0.00254 kg.

The balloon has a volume of 0.0141 $m^3$.

Calculate the density of helium. Choose the correct unit from the box.

| | | |
|---|---|---|
| **$m^3$ / kg** | **kg / $m^3$** | **kg $m^3$** |

___________________________________________

___________________________________________

___________________________________________

___________________________________________

Density = ____________________ Unit __________

**(3)**

Mark Scheme - Answers

1

(a) balance / scales 1

(b) $\text{density} = \frac{\text{mass}}{\text{volume}}$

**or**

$\rho = \frac{m}{V}$ 1

(c) $0.68 = \frac{85}{V}$ 1

$V = \frac{85}{0.68}$ 1

$V$ = 125 (cm$^3$) 1

(d) repeat readings (of volume) need taking (of each fruit) to show that the readings are close together

*allow 'the same' for 'close together'* 1

**[6]**

2

(a) **Level 2**: The method would lead to the production of a valid outcome. The key steps are identified and logically sequenced. 3–4

**Level 1:** The method would not necessarily lead to a valid outcome. Some steps are identified, but the method is not fully logically sequenced. 1–2

No relevant content 0

**Indicative content**

- use a eureka/displacement can
- fill the eureka/displacement can with water
- fill the eureka/displacement can up to the spout
- place lime in eureka/displacement can
- collect water that overflows
- use a measuring cylinder to measure volume of water

**OR**

- use a measuring cylinder
- part fill the measuring cylinder with water
- measure the initial volume of water
- place lime in measuring cylinder
- record new volume of water
- volume of lime = new volume – initial volume

(b) mean = $\frac{(2.1+2.1+2.4)}{3}$ **1**

mean = 2.2 ($cm^3$) **1**

(c) allows anomalous results to be identified and ignored **1**

reduces the effect of random errors when using the equipment **1**

(d) density = $\frac{84}{120}$ **1**

density = 0.70 ($g/cm^3$) **1**

**[10]**

3

(a) greater than **1**

less than **1**

*in this order only* **1**

(b)

*an answer of 0.6 scores **2** marks*

density = $\frac{0.063}{0.105}$ **1**

density = 0.6 **1**

$kg / m^3$ **1**

4

**Level 3 (5–6 marks):**
Clear and coherent description of both methods including equation needed to calculate density. Steps are logically ordered and could be followed by someone else to obtain valid results.

**Level 2 (3–4 marks):**

Clear description of one method to measure density **or** partial description of both methods. Steps may not be logically ordered.

**Level 1 (1–2 marks):**
Basic description of measurements needed with no indication of how to use them.

**0 marks:**
No relevant content.

**Indicative content**

**For both:**
- measure mass using a balance
- calculate density using ρ = m / V

**Metal cube:**
- measure length of cube's sides using a ruler
- calculate volume

**Small statue:**
- immerse in water
- measure volume / mass of water displaced
- volume of water displaced = volume of small statue

**[6]**

5

(a) $1.2 = \frac{m}{2.3 \times 10^4}$

1

m = 1.2 × 2.3 × $10^4$

1

m = 27 600 (kg)

*allow an answer of 28 000 (kg) or 2.8 × $10^4$ (kg)*

**or**

m = 2.76 × $10^4$ (kg)

1

*an answer of 27 600 (kg) scores **3** marks*

6

(b) $A = 0.25 \times 0.10 = 0.025$ m$^2$

**1**

$$P = \frac{637}{0.025}$$

*allow correct substitution of incorrectly calculated value of A*

**1**

$P$ = 25 480 (Pa)

*allow correct calculation using an incorrectly calculated value of A*

*to gain further marks, P = F/A or an incorrect rearrangement of P = F/A must have been used with the given data*

**1**

25 480 = <u>2.5</u> × $\rho$ × 9.8

*allow correct substitution of incorrectly calculated value of P*

**1**

$$\rho = \frac{25\,480}{9.8 \times 2.5}$$

*allow correct rearrangement using an incorrectly calculated value of P*

*allow use of h = 2.6 (m)*

**1**

$\rho$ = 1040 kg/m$^3$

*allow correct calculation using an incorrectly calculated value of P*

*allow use of h = 2.6 (m)*

**1**

**Alternative method**

$A = 0.25 \times 0.10 = 0.025$ (m$^2$)

**1**

volume of water column
($V$) = 0.025 × 2.5

*allow use of an incorrectly calculated value of A*

**1**

$V$ = 0.0625 (m$^3$)

*allow use of an incorrectly calculated value of A*

**1**

$m \left(= \frac{637}{9.8}\right) = 65 \text{ (kg)}$ 1

$\rho = \frac{65}{0.0625}$

*allow use of an incorrectly calculated value of V* 1

$\rho$ = 1040 (kg/m$^3$) 1

7

(a) **Level 2:** The method would lead to the production of a valid outcome. Key steps are identified and logically sequenced. 3−4

**Level 1:** The method would not necessarily lead to a valid outcome. Some relevant steps are identified, but links are not made clear. 1−2

**No relevant content** 0

**Indicative content**

- part fill a measuring cylinder with water
- measure initial volume
- place object in water
- measure final volume
- volume of object = final volume − initial volume

- fill a displacement / eureka can with water
- water level with spout
- place object in water
- collect displaced water
- measuring cylinder used to determine volume of displaced water

(b) $\text{density} = \frac{48.6}{18.0}$ 1

density = 2.70 (g/cm$^3$) 1

*an answer of 2.70 (g/cm$^3$) scores **2** marks*

(c) limestone 1

(d) eye position when using measuring cylinder

**or**
water level in can (at start) not at level of spout
**or**
not all water displaced by stone is collected in container
1

(e) volume would be lower / higher
1

[9]

8

(a) metre rule has a lower resolution

*allow metre rule has a resolution of 1 mm / 1 cm*

*fewer decimal places is insufficient*
1

so is less accurate (than the micrometer screw gauge)
1

(b) record the value of the zero error when there is no object on the balance

subtract / add the value of the zero error
1

subtract / add the value of the zero error
1

(c)

*an answer of 0.0502 (kg) scores **5** marks*

$V = (18.45 \times 10^{-3})^3$
**or**
$V = 0.01845^3$

*this mark may be awarded if width is incorrectly / not converted*
1

$V = 6.28 \times 10^{-6}$ ($m^3$)

*this answer only*
1

$8.0 \times 10^3 = \frac{m}{6.28 \times 10^{-6}}$

*allow*

$8.0 \times 10^3 = \frac{m}{\text{their calculated V}}$
1

$m = 8.0 \times 10^3 \times 6.28 \times 10^{-6}$

*allow $m = 8.0 \times 10^3 \times$ their calculated V*
1

m = 0.0502 (kg)

*allow an answer consistent with their calculated V*

1

[9]

9

(a) **Level 3**: The method would lead to the production of a valid outcome. All key steps are identified and logically sequenced. 5−6

**Level 2:** The method would not necessarily lead to a valid outcome. Most steps are identified, but the method is not fully logically sequenced. 3−4

**Level 1**: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear. 1−2

**No relevant content** 0

**Indicative content:**

- measure mass using a balance / scales

- part fill a measuring cylinder with water and measure initial volume
- place rock in water and measure final volume
- volume of rock = final volume − initial volume

- fill a displacement / eureka can with water level with spout
- place rock in water and collect displaced water
- measuring cylinder used to determine volume of displaced water
- volume of rock = volume of displaced water

- use mass and volume to calculate density

- use of: density = $\frac{\text{mass}}{\text{volume}}$

(b) maximum density = 2.65 (g/cm$^3$)

*both required*

minimum density = 2.45 (g/cm$^3$)

1

(c) chalk or flint

1

(d) a mean can be calculated

1

which reduces the effect of random errors

*allow anomalies can be identified / removed*

1

**[10]**

**10**

(a)

0.00254 / 0.0141

1

0.18

1

*accept 0.18 with no working shown for the **2** calculation marks*

kg / $m^3$

1

**[7]**