DENSITY OF WATER

1 The IGCSE students are carrying out measurements in order to determine the density of water using two methods.

(a) Method 1

Fig. 1.1 shows an empty measuring cylinder on a balance and Fig. 1.2 shows the measuring cylinder containing water.

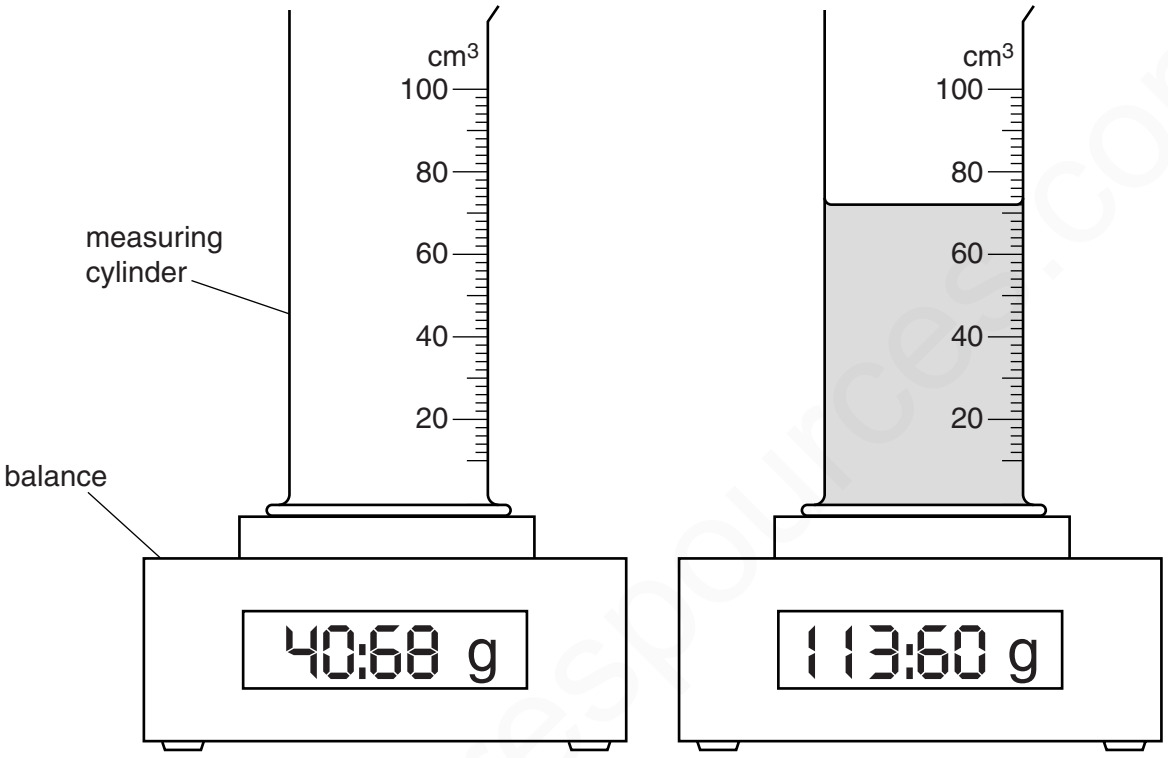

Fig. 1.1 **Fig. 1.2**

(i) Read and record the mass m_1 of the empty measuring cylinder.

m_1 = ... g

(ii) Read and record the mass m_2 of the measuring cylinder and water.

m_2 = ... g

(iii) Read and record the volume V_1 of water, as shown in Fig. 1.2.

V_1 = ... cm^3

(iv) Calculate a value ρ_1 for the density of water using your readings from **(a)(i)**, **(ii)** and **(iii)** and the equation $\rho_1 = \frac{m_2 - m_1}{V_1}$. Give an appropriate unit.

ρ_1 = ...

[3]

(b) Method 2

In this method, a test-tube is floated in the water left in the measuring cylinder from Method 1 and the change in water level is measured.

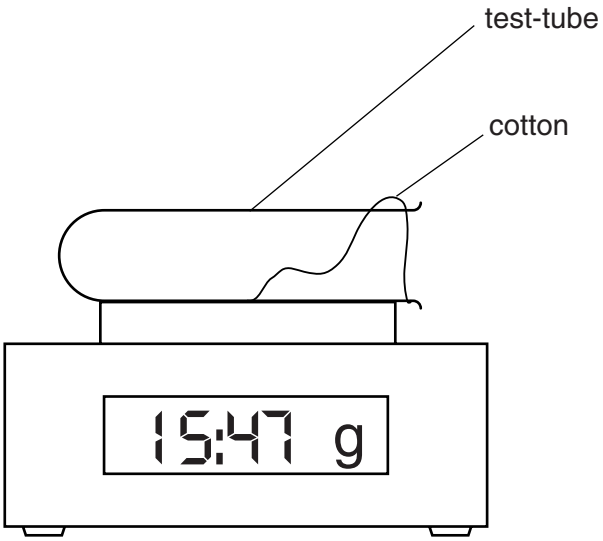

Fig. 1.3

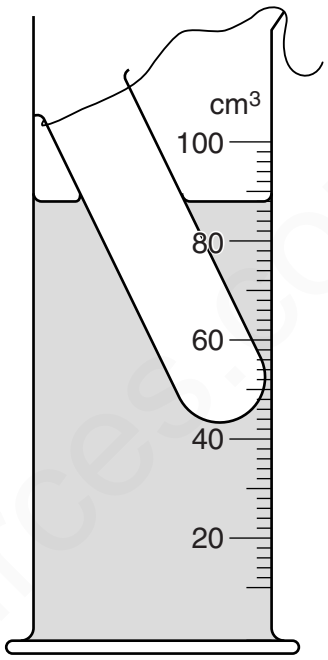

Fig. 1.4

(i) Read and record the mass m_3 of the test-tube, as shown in Fig. 1.3.

m_3 = ...

(ii) The test-tube is carefully lowered, by means of a piece of cotton, into the measuring cylinder until it floats as shown in Fig. 1.4. Read and record the new water level V_2 in the measuring cylinder.

V_2 = ...

(iii) Using your results from **(a)(iii)** and **(b)(ii)**, calculate V_3, the change in the water level, where $V_3 = (V_2 - V_1)$.

V_3 = ...

(iv) Calculate and record a value ρ_2 for the density of water using the equation $\rho_2 = \frac{m_3}{V_3}$.

ρ_2 = ...
[3]

(c) Calculate an average value ρ_{AV} for the density of water using your results from **(a)(iv)** and **(b)(iv)**.

ρ_{AV} = ... [1]

(d) Suggest a precaution that should be taken in **Method 1** to ensure that the volume reading is as accurate as possible.

.....

.....

.....[1]

(e) Suggest a possible source of experimental inaccuracy in **Method 2**, other than with the volume reading.

State and explain the effect that this would have on your value for ρ_2.

suggestion .....

.....

effect and explanation .....

.....

[2]

[Total: 10]

(a)(i)(ii) $m_1 = 40.68\,(g)$ and $m_2 = 113.60\,(g)$
correct answer only (not 40:68, 113:60) [1]

(iii) $V_1 = 72\,(cm^3)$ correct answer only [1]

(iv) ρ_1 with unit of g/cm^3 or kg/m^3 seen in **(a)**, **(b)** or **(c)** and not contradicted
(unit must match value) [1]

(b)(i)(ii) $m_3 = 15.47\,(g)$ and $V_2 = 88\,(cm^3)$ correct answer only [1]

(iii) $V_3 = 16\,(cm^3)$/ecf [1]

(iv) ρ_2 to 2/3 sig. figs. [1]

(c) ρ_{AV} 0.99(1) (g/cm^3) **or** 991/990 (kg/m^3) **or** ecf from **(a)** and **(b)** [1]

(d) any one from:
- take reading perpendicularly/at right angles to scale
- read bottom of meniscus
- other suitable precaution [1]

(e) appropriate source of inaccuracy, other than in **(d)**
e.g. balance not at zero/test-tube catches on side of measuring cylinder [1]

matching effect on ρ with explanation
e.g. ρ greater as mass reading larger/ρ greater as volume smaller [1]

[Total: 10]

2 A student is determining the density of water by two methods.

Method 1

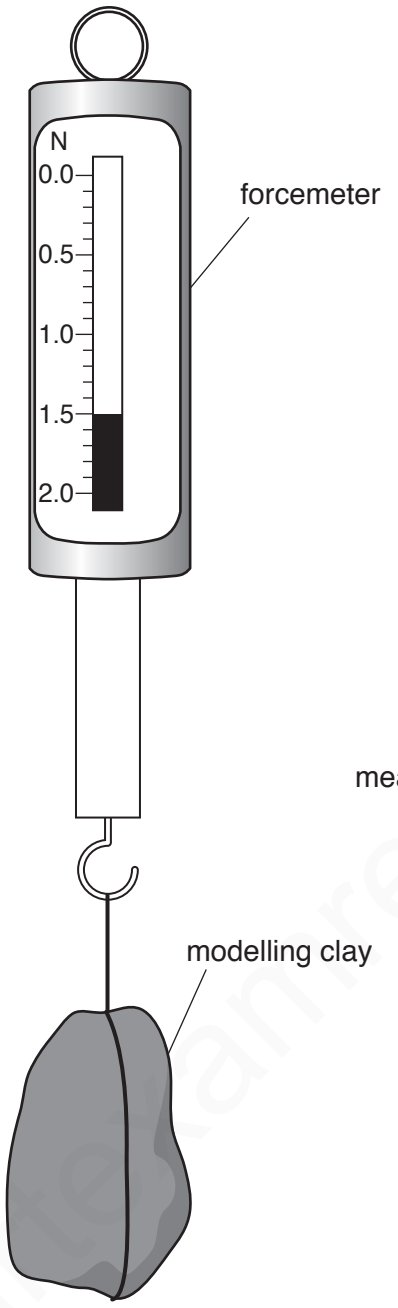

Fig. 1.1

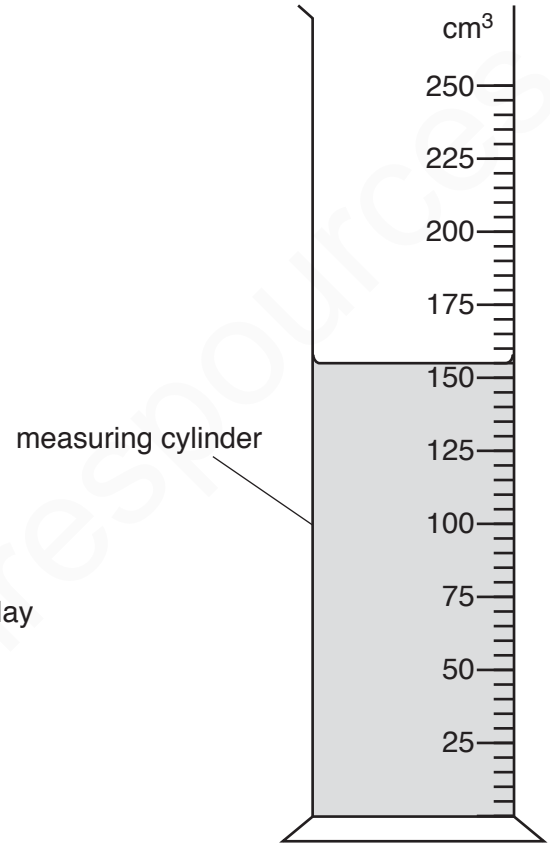

Fig. 1.2

(a) Record the weight W_1 of the piece of modelling clay shown in Fig. 1.1.

W_1 = ... N [1]

(b) (i) Record the volume V_1 of the water in the measuring cylinder shown in Fig. 1.2.

V_1 = ... cm^3 [1]

(ii) Describe briefly how a measuring cylinder is read to obtain an accurate value for the volume of water. You may draw a diagram.

.....

.....

.....[2]

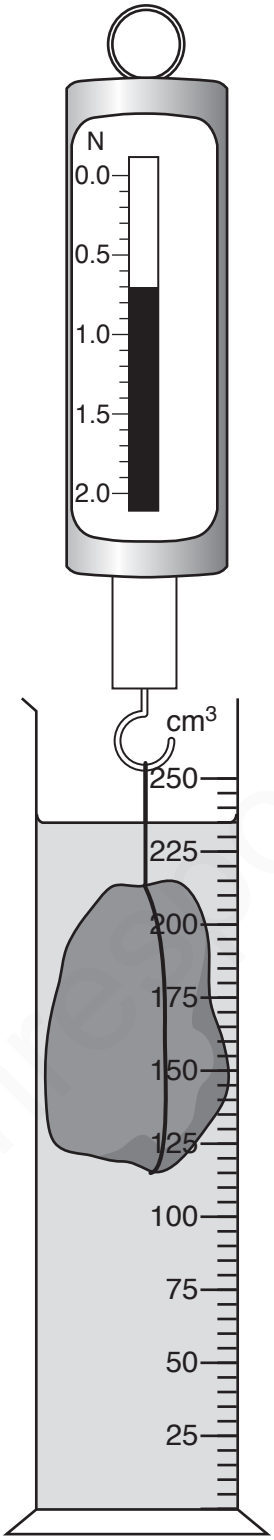

Fig. 1.3

(c) The student lowers the modelling clay into the water, as shown in Fig. 1.3.

- Record the new reading W_2 of the forcemeter.

W_2 = ... N

- Record the new reading V_2 of the measuring cylinder, with the piece of modelling clay in the water.

V_2 = ... cm^3
[1]

(d) Calculate a value ρ_1 for the density of water, using your readings from **(a)**, **(b)** and **(c)** and the equation

$$\rho_1 = \frac{(W_1 - W_2)}{(V_2 - V_1)} \times k$$

where $k = 100\,g/N$.

ρ_1 = ...[2]

Method 2

(e) The student removes the modelling clay from the water and places the measuring cylinder on a balance.

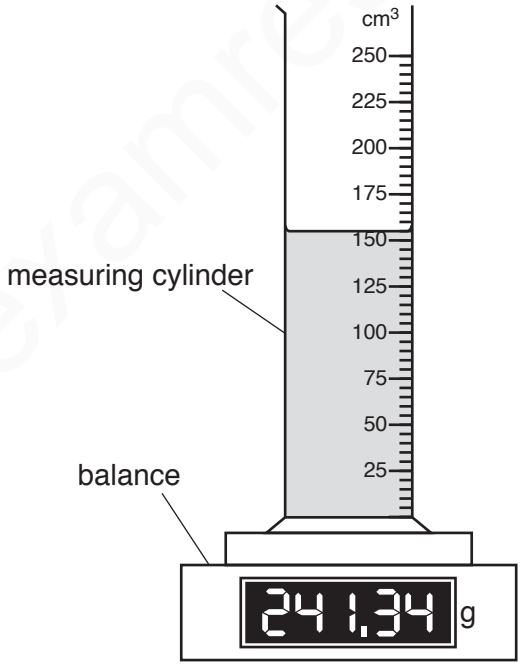

Fig. 1.4

The reading for the mass m_1 of the measuring cylinder and water is shown in Fig. 1.4.

Record m_1 to the nearest gram.

m_1 = ...[1]

(f) The student pours the water out of the measuring cylinder and measures the mass m_2 of the empty measuring cylinder.

m_2 = ...93.....g

- Calculate a second value ρ_2 for the density of water, using your readings from **(b)**, **(e)** and **(f)** and the equation

$$\rho_2 = \frac{(m_1 - m_2)}{V_1} .$$

ρ_2 = ...

- Calculate an average value ρ_{AV} for the density of water, using your results for ρ_1 and ρ_2.

ρ_{AV} = ...
[1]

(g) Suggest a possible source of inaccuracy in either **Method 1** or **Method 2**, even when they are carried out carefully.

Explain how an improvement might be made to reduce this inaccuracy.

suggestion .....

.....

improvement .....

.....
[2]

[Total: 11]

MARKING SCHEME

(a)	W_1 = 1.5 (N)	1
(b)(i)	V_1 = 155 (cm^3)	1
(b)(ii)	line of sight perpendicular	1
	to bottom of meniscus	1
(c)	W_2 = 0.7 (N) and V_2 = 235 (cm^3)	1
(d)	ρ_1 = 1.0 or ecf	1
	unit g/cm^3	1
(e)	m_1 = 241 (g)	1
(f)	ρ_{AV} 0.978 / 0.977(g/cm^3)	1
(g)	appropriate cause of inaccuracy: e.g: • some water still in empty measuring cylinder • water spilled, splashed when putty put in water • water drops on putty when removed • air bubbles on putty	1
	suitable improvement: e.g: • measure m_2 at start (when cylinder dry) • measure new volume in Method OR refill to correct value • shake putty to remove air / smooth surface to minimise bubbles	1
	Total:	**11**

3 A student is determining the density of water. She is provided with a plastic cup, shown in Fig. 1.1.

Fig. 1.1

(a) She draws around the base of the cup. Her drawing is shown in Fig. 1.2.

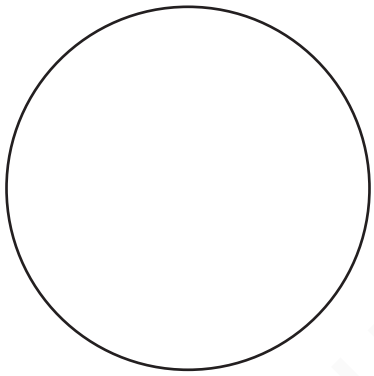

Fig. 1.2

(i) From Fig. 1.2, take and record measurements to determine an accurate value for the diameter D_B of the base of the cup.

D_B = ... cm [2]

(ii) The student places the cup upside down and draws around the rim of the cup.
She determines the diameter D_T of the rim of the cup.

D_T = 7.2 cm

Calculate the average diameter D of the cup using the equation $D = \frac{D_B + D_T}{2}$.

D = ... cm [1]

(b) On Fig. 1.3, measure the vertical height h of the cup.

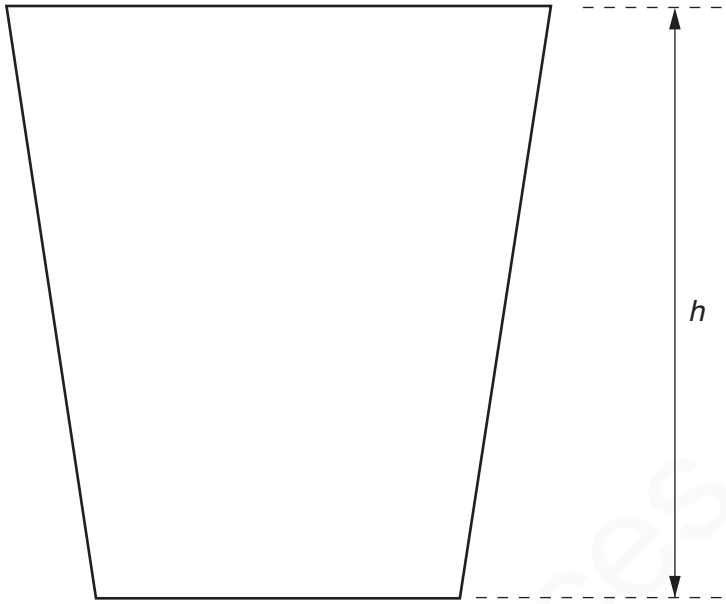

Fig. 1.3

h = ... cm

Calculate the volume V of the cup using the equation $V = 0.785\,D^2\,h$.

V = ... cm^3
[1]

(c) The student fills the cup with water. The mass of the cup with the water is shown in Fig. 1.4.

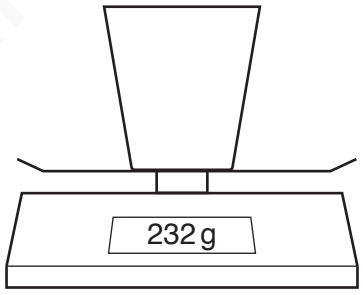

Fig. 1.4

Determine the density ρ of water using the equation $\rho = \frac{m}{V}$ and your value from **(b)2**.

Give your answer to a suitable number of significant figures for this experiment. Include the unit.

ρ = ... [3]

(d) Suggest, with a reason, a part of the procedure **(a)**, **(b)** or **(c)** that could give an unreliable result for the density of water.

part .....

reason .....

.....

[1]

(e) The student pours the water from the cup into a measuring cylinder.

Draw a diagram to show water in a measuring cylinder. Show clearly the meniscus and the line of sight the student should use to obtain an accurate value for the volume of the water.

[2]

[Total: 10]

MARKING SCHEME

(a)(i)	2 or more measurements seen	**1**
	D_B = 4.8 ± 0.1 (cm)	**1**
(a)(ii)	D = 6.0 (cm)	**1**
(b)	1 h = 7.8 (cm) **AND** 2 V = 220(.428) (cm^3)	**1**
(c)	ρ = 1 / 1.1 / 1.05(.....)	**1**
	2 or 3 significant figures	**1**
	g / cm^3	**1**
(d)	any **one** from: part **(a)** drawn circle not exact / thickness of rim or cup / thickness of the pencil line part **(b)** difficult to measure the height (in practice) / D^2 increases inaccuracy in D part **(c)** mass of cup has been ignored	**1**
(e)	diagram showing clearly:	
	line of sight perpendicular to measuring cylinder	**1**
	to the bottom of the meniscus	**1**