1(a).

(i) Define density.

-- [1]

(ii) A volume of air measuring 3.0 m^3 has a mass of 3.9 kg.

Calculate its density.

___________ kg/m^3 [2]

(b). Georgina does an experiment to test the hypothesis *'the reason why a solid floats or sinks in a liquid depends upon both the density of the solid and the density of the liquid'*.

She was given blocks of rubber and wood and bottles of maple syrup and baby oil.

Material	**Density (g/cm^3)**
Rubber	1.52
Wood	0.85
Maple Syrup	1.37
Baby Oil	0.80

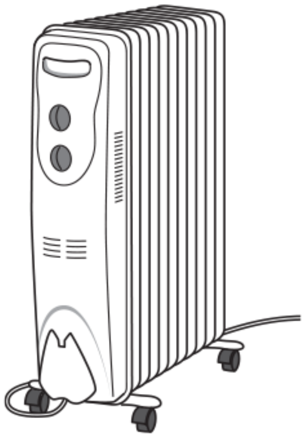
Material	**Floats in Maple Syrup**	**Floats in Baby Oil**
Rubber	No	No
Wood	Yes	No

Georgina concludes that the density of both the solid and the liquid affects whether it floats or sinks.

Use the data to justify Georgina's conclusion.

-- [2]

2(a). The diagram shows a common type of electric heater. It contains oil which is heated by an electrical element.



The table shows some information about the heater.

Electrical power	1500 W
230 V	Voltage rating
Specific heat capacity of oil	1600 J / kg °C
Mass of oil	4.5 kg

Show that more than 700 000 J of energy is needed to heat the oil from 20 °C to 120 °C.

Use the equation:
change in internal energy = mass × specific heat capacity × change in temperature

[2]

(b).

(i) Use your answer to **(a)** to calculate the minimum time for the oil to reach a temperature of 120 °C, starting at 20 °C.

Minimum time = ... s **[3]**

(ii) In practice, it will take longer than this for the heater to reach 120 °C.

State the reason for this.

____

____ **[1]**

3. Sarah carries out an experiment to measure the specific latent heat of vaporisation of water. She does this by finding the energy needed to evaporate a known mass of water.

The apparatus she uses is shown in **Fig. 9.1**.

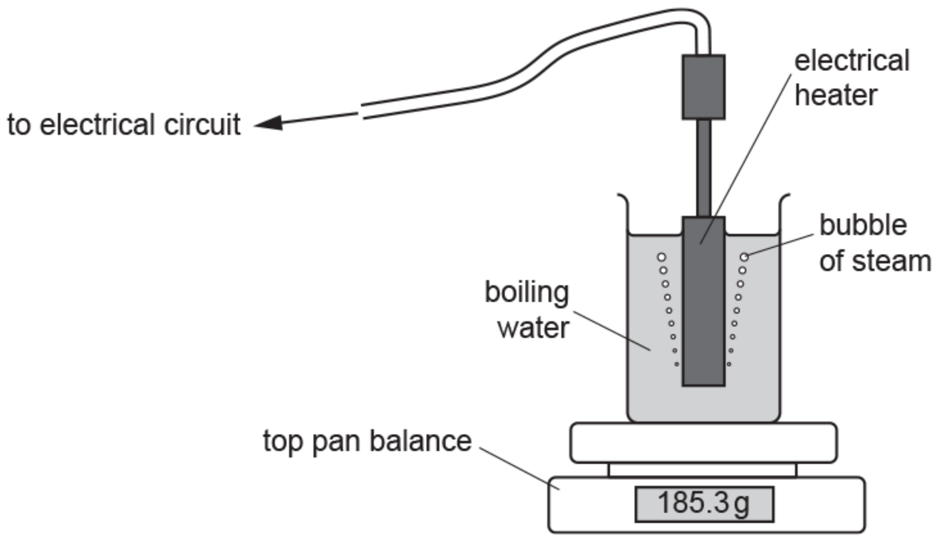


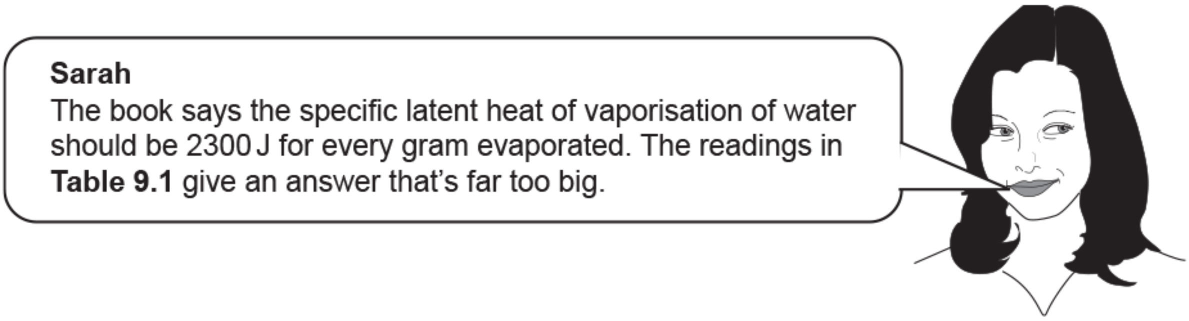
Fig. 9.1

Using this apparatus, Sarah takes these readings.

	Measured value
current	3.0 A
potential difference	12 V
time	150 s
balance reading at start	185.3 g
balance reading at the end	184.3 g

Table 9.1

* Sarah is not happy with her results.



Is Sarah right?

What could Sarah do to get an accurate value of the specific latent heat of vaporisation of water from her experiment?

[6]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1	a	i	Density = mass ÷ volume (1)	1	
		ii	**FIRST CHECK ANSWER ON ANSWER LINE** **If answer = 1.3 (kg / m^3) award 2 marks** 3.9 ÷ 3.0 (1) = 1.3 (kg / m^3) (1)	2	
	b		She is correct: Density of solid > density of liquid → solid sinks (1) Quotes data from the table in support of claim (1)	2	(No mark for just stating Georgina is correct) **allow** Rubber greater density than both liquids so does not float **ora** **allow** wood density 0.85 floats in maple syrup > density of 1.37 but sinks in baby oil < density of 0.80
			Total	5	
2	a		FIRST CHECK THE ANSWER **If answer = 720 000 (J) award 2 marks** substitution 4.5 × 1600 × (120–20) ✓ = 720 000 (J) ✓	2 (AO 2.1) (AO 2.1)	**ALLOW** 20 or 120 for ΔT to give 144 000 or 864 000 Does not need comparison with 700 000 for the mark <u>Examiner's Comments</u> On the whole candidates were able to substitute the correct numbers into the given equation, and nearly all of them realised that it was the temperature change which was needed. This question was well answered.

Question			Answer/Indicative content	Marks	Guidance
	b	i	FIRST CHECK THE ANSWER ON ANSWER LINE **If answer = 480 (s) award 3 marks** recall **and** rearrange: time = energy / power ✓ substitution 720 000 / 1500 ✓ = 480 (s) ✓	3 (AO 1.2) (AO 2.1) (AO 2.1)	ECF (a) or energy = 700 000 (J) ALLOW for 2 marks '48' or '4800' as a transcription error. Examiner's Comments Candidates found this question difficult as it required use of the data given on the previous page. The question stem referred to the rise in temperature so many candidates divided the value calculated in the previous part by the temperature difference as they were unable to recall and rearrange the equation.
		ii	energy transferred to the metal radiator / in the wires ✓	1 (AO 1.1)	ALLOW 'energy is lost to the surroundings' IGNORE it heats up the room / ignore efficiency arguments DO NOT ALLOW 'loss' on its own Examiner's Comments This question was not well answered. Most candidates simply stated that the heater would not start at 20° C for instance or that the calculation was only approximate.
			Total	6	

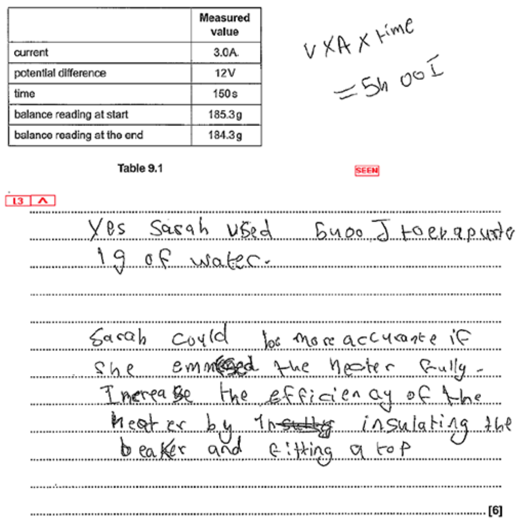
Question			Answer/Indicative content	Marks	Guidance
3			*Please refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** Correct calculation to check whether the value of SLH is greater than 2300 J/g **AND** specific evaluation / development. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Correct calculation to check whether the value of SLH is greater than 2300 J/g **OR** Identifies at least one shortcoming of Sarah's experiment **OR** suggests at least one valid improvement. *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** May attempt to use data to check statement **OR** Makes generic suggestion(s) to improve the procedure, e.g. repeat readings, use a more accurate balance. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*	6 (AO 2.2 × 2) (AO 3.1b × 2) (AO 3.3a × 2)	**Indicative scientific points may include:** **AO2.2 Calculation of SLH** • P = 3.0 A × 12 V = 36 W • $\Delta E = Pt$ = 36 W × 150 s = 5400 J • Δm = {185.3 g – 184.3 g} = 1.0 g • $L = \Delta E/\Delta m$ = 5400 J/1.0 g = 5400 J/g **AO3.1b Evaluation of experiment** • Heat losses constitute the (most) significant shortcomings • Not all of heater in the water • Thermal energy will dissipate through sides and bottom of beaker • Thermal energy will dissipate from the water surface • Relatively low mass of water evaporated **AO3.3a Development of experimental procedure** • Ensure water level is above top of heater. • Surround beaker sides and bottom with insulating material • Cover top of beaker to limit convection losses (but still allow water vapour to escape) • Use higher powered heater to evaporate more water in the same time • Make sure water is boiling before starting measurements. • Longer time/higher current/voltage to evaporate more water. <u>Examiner's Comments</u> Candidates who did well on this question used the data to calculate the specific latent heat. They considered whether a reason for Sarah's value being so high might be because of energy transfers to the surroundings environment and not just to the water. Finally they suggested how Sarah might minimise the unwanted energy transfers.

Question			Answer/Indicative content	Marks	Guidance

Only a very few candidates calculated the specific latent heat, although some wrote that Sarah should have calculated the value for it. Level 3 responses were expected to compare Sarah's calculated vale with the expected value. Candidates were expected to know that this quantitative comparison would be required in order to find how accurate Sarah's value for latent heat of vaporisation was.

Many candidates thought as the value for latent heat was too large it could be reduced by heating for a shorter time, with a lower powered heater, or with less water. Improvements such as repeating the experiment, checking for anomalous observations, and calculating a mean, were common suggestions. These should be standard scientific practice and these suggestions allowed lower ability candidates to be credited at the top of the Level 2 band.

Exemplar 7



	Measured value
current	3.0A
potential difference	12V
time	150 s
balance reading at start	185.3 g
balance reading at the end	184.3 g

Table 9.1

V x A x time = 5400 J

SEEN

L3 ^

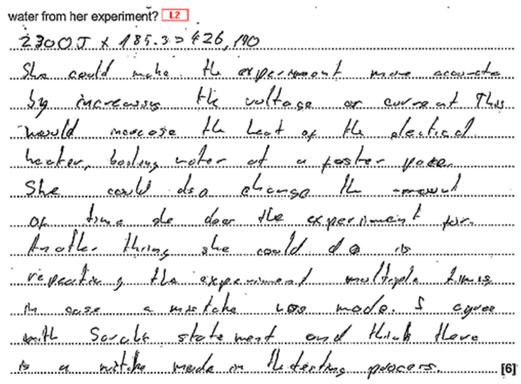
Yes Sarah used 5400 J to evaporate 1g of water.

Sarah could be more accurate if she emmersed the heater fully. Increase the efficiency of the heater by insulating the beaker and fitting a top

[6]

Exemplar 7 is a top of band Level 3 response. At first sight the answer may seem very brief. However the candidate has demonstrated all the criteria for a full mark response:

Question			Answer/Indicative content	Marks	Guidance

					• calculates the specific latent heat
					• suggests three improvements:
					   ◦ ensuring the heater is immersed in the water
					   ◦ insulating the beaker
					   ◦ putting a top on the beaker.
					
					Exemplar 8
					
					
					water from her experiment? L2
					2300J x 185.3 = 426,190
					She could make the experiment more accurate by increasing the voltage or current. This would increase the heat of the electrical heater, boiling water at a faster rate. She could also change the amount of time she does the experiment for. Another thing she could do is repeating the experiment multiple times in case a mistake was made. I agree with Sarah's statement and think there is a mistake made in the testing process. [6]
					
					Exemplar 8 is a top of band Level 2 response. The candidate's attempted calculation is not helpful, but the suggestion to increase the heater output so the water heats at a faster rate would improve the accuracy. Changing the time confirms Level 2, but it would not be specific enough on its own.

			Total	6	