ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Physics

PHA3/B3/X Investigate and Practical Skills in AS Physics

Mark Scheme

2009 examination - June series

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GCE Physics, PHA3/B3/X, Investigative and Practical Skills in AS Physics

Section A, Task 1

Question 1			
(a)	accuracy:	raw readings of d_1, d_2 and h to 0.1 mm, values sensible ✓ d_1 and/or d_2 from repeated readings ✓ (accept readings to 0.01 mm for digital callipers)	**2**
(b)	accuracy:	V, max 4 sf, in range 34.8 cm^3 to 38.5 cm^3, 36 cm^3, 37 cm^3 or 38 cm^3 ✓✓ [in range 33.0 cm^3 to 40.3 cm^3, 34 cm^3, 35 cm^3 or 39 cm^3 ✓] **adjust ranges if type 23 stopper has been provided* (penalise 5 or more sf in final answer)	**2**
(c)	explanation:	*either* the jaws of the callipers may not lie in the same plane as the dimension being measured so the reading may not be correct ✓ *or* it was difficult to prevent the jaws of the callipers from deforming the stopper and changing the reading to be measured ✓ (reject ideas that only refer to some property of the stopper)	**1**
		Total	**5**

Question 2				
(a)	(i) (ii) (iii) (iv)	accuracy: explanation:	p and q to nearest mm ✓ m in g to SV ± 5 g ✓ (for missing SV values use 48.5 g to 58.5 g; (penalise 5 or more sf in final answer)) measure (vertical) height to ruler from bench at each end [at two or more points]; (adjust position of mass) to make sure (vertical) heights are the same ✓	**3**
(b)	(i) (ii) (iii)	accuracy/ deduction: explanation:	r to nearest mm, $r < q$ ✓ ρ_S in range 1300 to 1600 kg m^{-3} ✓ r contains the greatest (percentage) uncertainty because this is the smallest dimension ✓	**3**
(c)		deduction:	V from $\frac{m}{\rho}$ (accept eow) ✓ V, 3 sf or 4 sf, in range 33.9 to 39.4 cm^3 [2 sf in range 35 to 39 cm^3] ✓✓ [31.1 to 42.1 cm^3, 2 sf in range 32 to 34 or 40 or 41 cm^3 ✓] (mixed units leading to power of ten error can earn 1 max; no ecf from false ρ_S) **adjust ranges if type 23 stopper has been provided* (penalise 5 or more sf in final answer)	**3**
			Total	**9**

Section A, Task 2

Question 1			
(a) (i) (ii) (iii)	accuracy: estimation:	d recorded to nearest mm, $20.0 \le d \le 30.0$ cm, L recorded to nearest mm, $40.0 \le L \le 60.0$ cm ✓ (absolute) uncertainty, ΔL, in mm, in range 2 mm to 5 mm ✓	**2**
(b)	tabulation: results: significant figures: quality:	m /g d /mm ✓✓ deduct ½ for each missing separator, rounding down; bald d and m is worth 1 mark penalise if m/g is not in the left-hand column of the table or if the tabulation is poor 5 **additional** sets of m and d ✓ m range ≥ 50 g ✓ no credit for false data all m to nearest g and all (tabulated) d to nearest mm ✓ at least 5 points to ± 2 mm of straight line of positive gradient (judge from graph, providing this is suitably-scaled) ✓ [allow ecf if appropriate curve has been drawn]	**6**
(c)	axes: scales: points: line:	d (vertical) against m (horizontal) or 0/2; each axis earns 1 mark providing valid unit and separator are given ✓✓ [bald d (vertical) and m (horizontal) ✓] deduct a mark if the interval between the numerical values is marked on either axis with a frequency of > 5 cm points should cover at least half the grid horizontally ✓ **and** half the grid vertically ✓ (if necessary, a false origin should be used to meet these criteria; either or both marks may be lost for use of a difficult, backwards or non-linear scale) 6 points plotted correctly (check at least three including any anomalous points) ✓✓✓ 1 mark is deducted for every point missing and for every point > 1 mm from the correct position deduct 1 mark if any point is poorly marked; no credit for false data **straight** best fit line (ruled) of positive gradient ✓ withhold the mark if the line is poorly marked (allow a smooth curve if accurately plotted points justify this; if false data used eg backwards graph, give credit if a reasonable line is drawn)	**8**
		Total	**16**

Section B

Question 1		
(a)	a valid attempt must be mad at the gradient calculation or 0/2, *y*-step and *x*-step both to be at least 8 semi-major grid squares ✓ (if a poorly-scaled graph is drawn the hypotenuse of the gradient triangle should be extended to meet the 8 × 8 criteria) correct transfer of *y*-step and *x*-step data between graph and calculation ✓ (mark is withheld if points used to determine either step > 1 mm from correct position on grid; if tabulated points are used these must lie on the line)	**2**
(b)	$\frac{L}{G}$, in range 190 g to 210 g [0.20 kg] ✓✓ [180 g to 220 g or 0.19 kg or 0.21 kg ✓] (penalise 5 or more sf in final answer)	**2**
	Total	**4**

Question 2		
(a)	correct method using data from 1 (a) (ii) and 1 (a) (iii) Task 2, eg $\frac{\Delta L}{L} \times 100$ ✓	**1**
(b)	correct method, ie 3 × answer to 2 (a), correctly evaluated ✓	**1**
	Total	**2**

Question 3		
	use a plumb line [metre ruler, checked with set square] to obtain the vertical **from the rod** ✓ use a **set square** to obtain the horizontal from this vertical (hence establish the direction along which to measure) [allow ecf for 'vertical clamp stand'] ✓ (credit relevant detail if shown in sketch)	**2**
	Total	**2**

Question 4		
	mass of water that just fills the bottle = **44.12 – 18.07** (= 26.05 g) ✓ mass of liquid that just fills the bottle = **45.20 – 18.07** (= 27.13 g) ✓ clarity of working, eg expect **26.05** (g) and **27.13** (g) and clear layout ✓ density liquid/g cm^{-3} = 27.13 ÷ 26.05 ✓ [density liquid/kg m^{-3} = (27.13 × 10^{3} ÷ 26.05 × 10^{-5}) ✓] (withhold mark if 26.05 is truncated to 2 sf, but tolerate 3 sf) final answer in kg m^{-3}, evaluated to **at least 4 sf**, (expect 1041 or 1042, reject 1040; 5 or more sf are allowed here if rounding is correct) ✓ [reverse argument using density to prove volume of water = volume of liquid can earn full credit, eg for$_4$ ✓ = volume of water that fills bottle (= $\frac{26.05 \times 10^{-3}}{1000}$) and volume of liquid that fills bottle (= $\frac{27.13 \times 10^{-3}}{1040}$); for $_5$ ✓ both expressions = 2.61 × 10^{-5} m^{3}]	**5**
	Total	**5**

Question 5		
(a)	the **fifth** row [h_L = 37.7, h_W = 36.0] is suspect ✓ this is the only set where $h_L > h_W$ ✓	**2**
(b) (i)	$_1$M: rejects errant set and calculates any $\frac{h_W}{h_L}$ ✓ $_2$M: evaluates $\frac{h_W}{h_L}$ using all 5 valid data sets ✓ $_3$M: calculates average $\frac{h_W}{h_L}$ using at least 2 valid sets (expect 1.046) ✓ $_4$M: density of liquid = $1000 \times \frac{h_W}{h_L}$ ✓ $_1$M: rejects errant set and calculates average h_W and average h_L ✓ $_2$M: as above using all 5 valid data sets (accept eow, eg 52.9(2) cm and 50.6(2) cm) ✓ $_3$M: calculates $\frac{h_W}{h_L}$ using average values of h_W and h_L derived from at least 2 valid sets (expect 1.045) ✓ $_4$M: as first method ✓ $_{12}$M: rejecting errant set, calculates liquid density using any $1000 \times \frac{h_W}{h_L}$ ✓✓ $_3$M: calculates liquid density for each of the 5 valid data sets ✓ $_4$M: calculates average of $1000 \times \frac{h_W}{h_L}$ ✓ density of liquid = 1045 kg m^{-3} or 1046 kg m^{-3} [accept 3 sf 1.050 kg m^{-3}] ✓ (penalise 5 or more sf in final answer)	**8**
(b) (ii)	plot a graph of h_w (↑) against h_L (→); measure the gradient ✓ density of liquid = gradient × density of water ✓ [plot $\rho_W h_w$ (↑) against h_L (→); measure gradient ✓ density of liquid = gradient ✓]	
(b) (iii)	errant data set is shown by point (significantly) off the best-fit line ✓ (tolerate 'anomalous point would be an *outlier*')	
(c)	**parallax** error when judging level of (bottom of) the meniscus against scale on ruler ✓ valid procedure described to describe how *h* is read at eye level eg use of a mirror placed behind the tube or with a set-square [look along set square placed in contact with vertical face of ruler] ✓ [the ruler may not be **vertical** ✓ avoid by aligning with a plumb line or with a set-square with one edge on the bench or by comparing with a known vertical (eg a door frame) ✓ may not measure to **bottom** of meniscus consistently ✓ avoid by reading h with eye level with bottom of meniscus (procedure described as above) ✓] (credit relevant detail if shown in sketch) ✓] (reject 'leaky clip' as this will lead to changing levels)	**2**
	Total	**12**