Oxford Cambridge and RSA

GCE

Physics B

Unit **H557/03:** Practical skills in physics

Advanced GCE

Mark Scheme for June 2018

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

Annotations

Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

Note about significant figures:

If the data given in a question is to 2 sf, then allow to 2 or <u>more</u> significant figures.
If an answer is given to fewer than 2 sf, then penalise once only in the <u>entire</u> paper.
Any exception to this rule will be mentioned in the Additional Guidance.

Question			Answer	Marks	Guidance
1	a	i	Potential divider formula ✓ For example: $R_Y \div R_X = V_Y \div V_X$ or $R_Y \div (R_X + R_Y) = V_Y \div V_T$ R_Y= (4 x 3.4) ÷ 8 = **1.7** Ω ✓ **OR** Current (through resistor) = 8 ÷ 3.4 = 2.4 A ✓ R_Y = 4 ÷ 2.4 = **1.7**Ω ✓	2	Potential divider equation with numbers or symbols $R_Y \div 3.4 = 4 \div 8$ or $R_Y \div (3.4 + R_Y) = V_Y \div 12$. Accept reverse argument eg: calculate V = 4.4 V for R = 2Ω
		ii	Area = π d^2 / 4 = **1.7×10^{-9}** m^2 ✓ **EITHER** Maximum and/or minimum method ✓ Maximum = 1.8×10^{-9} m^2 and/or minimum = 1.5×10^{-9} m^2✓ Absolute error in area = [½ (max – min) OR max – actual OR actual - min] = **0.1 or 0.2×10^{-9} m^2** ✓ **OR** % error in diameter measurement = 2÷46 = 0.043 or 4.3% ✓ % error in area = 2 × % error in d = 8.6% or 8.7% giving **0.1(4)×10^{-9} m^2** ✓	3	Use of r = 0.046 mm gives A = 6.6×10^{-9} m^2. Two marks for uncertainty are independent. ecf incorrect area used to calculate uncertainty. [±0.6×10^{-9} for A = 6.6×10^{-9} m^2] Ignore sf in final answer but must be rounded correctly.
		iii	Use of [$G = \sigma A/L$ and $G = 1/R$ to give] $R = L/\sigma A$ or $\sigma = L/AR$ ✓ Substitution σ [= 0.2/(1.7×10^{-9} × 1.7)] = **6.9×10^{7}** Sm^{-1} ✓ Assumption: ✓ that the filament provides the only resistance in the bulb the filament is of constant diameter that the filament is at normal (operating) temperature/temperature of filament not affecting resistance/resistivity/conductivity	3	ALLOW σ = 5.9×10^{7}, 6(.0)×10^{7} or 7.1×10^{7}. ALLOW ecf of incorrect area calculated in part (ii). ONLY ALLOW ecf of incorrect R from part (i) if it rounds to 2Ω.

Question			Answer	Marks	Guidance
	b		**Level 3 (5-6 marks)** ✓✓ Clear calculation with reference to student's hypothesis to aid macroscopic explanation **AND** discussion of microscopic reasons for variation of resistance of a bulb with temperature and current. *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)** ✓✓ Some macroscopic **AND** microscopic explanation of variation of resistance with temperature **AND** current. Correct calculation of either a relevant potential difference or resistance is required as part of the macroscopic explanation. *There is a line of reasoning presented with some structure. The information presented is in the most part relevant and supported by some evidence.* **Level 1 (1-2 marks)** ✓✓ Attempted calculation **OR** some macroscopic **OR** microscopic explanation of resistance (relating to temperature OR current). *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	**Indicative scientific points may include:** **Macroscopic explanation.** • student's calculation of 6.0 V assumes that resistance of bulb is about 6.9 Ω; • voltage across resistor with R = 1.7 Ω is 9.6 V (or R = 2 Ω gives V = 9.3 V) (accept correct across bulb of approx. 2.5V); • with a higher total resistance in the circuit the current will be less; • lower current means less power/energy dissipated as heat in filament; • filament will be at lower temperature; • higher conductivity / lower resistivity of filament in bulb; • bulb will have R less (than 1.7 Ω); • larger proportion of the p.d. will be across the resistor; • therefore the p.d. across resistor will be larger (than 9.6V). **Microscopic explanation (does not to relate to this specific case)** • Electrons flowing through lattice of metal atoms/ions; • Electrons collide with metal atoms/ions; • Electrons transfer (kinetic) energy to atoms/ions; • as current is less metal atoms/ions have less KE / vibrate less (ora); • less obstruction to moving electrons (ora); • Temperature of filament reduces due to less frequent collisions of electrons with metal atoms/ions (ora); • metal atoms/ions vibrate less (ora); • fewer collisions between electrons and metal atoms/ions in lattice (ora).
			Question total	**14**	

Question			Answer	Marks	Guidance
2	a		Any 2 of: ✓✓ Handle with tongs/tweezers/forceps/gloves; Direct away from body Only use for a short period of time / record usage Shield/store in lead container	2	NOT keep your distance or wtte
	b	i	3.6, 1.8 ✓ Background radiation count needs to be subtracted from all experimental readings ✓	2	Look at data written in 3rd column of table only.
		ii	1.06, 0.79 ✓	1	Rounding errors penalised. 2dp necessary. Look at data written in 4th column of table only.
		iii	Both points plotted to within half a small square ✓ Straight line of best fit drawn with reasonable balance of points either side of line and extends across all plotted points✓	2	ALLOW ecf from (b)(ii). Plots must be < half a small square in diameter. ALLOW ecf from plotting. Expect to see. y-intercept 3 squares from the top (within ½ small square) x-intercept 2 to 3 squares from the right (within ½ small square)

Question			Answer	Marks	Guidance
		iv	**Level 3 (5-6 marks)** ✓✓ Clearly worked half-life calculation from gradient including linearisation of equation **AND** detailed comparison of logarithmic and exponential graphs. *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)** ✓✓ Calculation of half-life (by an appropriate method) or decay constant or gradient and some comparison of logarithmic and exponential graphs **OR** clearly worked half-life calculation from gradient including linearisation of equation **OR** detailed comparison of logarithmic and exponential graphs. *There is a line of reasoning presented with some structure. The information presented is in the most part relevant and supported by some evidence.* **Level 1 (1-2 marks)** ✓✓ Attempted calculation of half-life **AND/OR** or some comparison of logarithmic and exponential graphs. *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	**Indicative scientific points may include:** **Determination of half life** • Calculation of gradient using 2 points on the line (at least half the length of the line apart) • Gradient in range -9×10^{-3} to -10×10^{-3}. • Allow ecf of gradient from their line. • Calculation of half-life = - ln 2 ÷ gradient • Half-life in range 69s to 77s • Rearrangement of $A = A_0 e^{-\lambda t}$ to $\ln A = \ln A_0 - \lambda t$ • Explanation that this is a y = mx + c type straight line with gradient = $-\lambda$ and intercept = $\ln A_0$. • Approximate decay constant could be calculated from table data or single point on graph and substituted into exponential/logarithmic equation. • Approximate half-life could be determined purely from table data. **Comparison of logarithmic and exponential graphs:** • Exponential plot will give a decay curve; • Curve line is more difficult to draw; • Easier to see anomalies with a straight line. • On an exponential scale - Need to find several values of half-life in different parts of curve and average. • Logarithmic graphs compress the scale so it is easier to see variation across all values of *A*. • Finding half-life from curve with smaller values of *A* will be more inaccurate than for large values of *A*. • Radioactive decay is a random process and at small values of A the randomness will affect readings more. • Logarithm graph reduces the effect of random nature/ value determined for half-life is more reliable. • Easier to average out random error in the points by drawing a straight line of best fit.
			Question total	**13**	

Question			Answer	Marks	Guidance
3	a		When (apparent) weight force is equal and opposite to air resistance/drag force✓ no <u>resultant/net</u> force ✓ there is no acceleration ✓	3	IGNORE any reference to electric force F =Eq ALLOW forces are in equilibrium for second marking point. **ALLOW** it is travelling at <u>terminal</u> velocity for third marking point.
	b	i	Field strength = $V \div d = 390 \div 6\times10^{-3} = \mathbf{6.5\times10^{4}}$ ✓ V m^{-1} or N C^{-1} ✓	2	
		ii	$F = Eq$ **or** $F = mg$ ✓ Equate forces and rearrange to *give* $q = mg \div E$ ✓ Charge q (= $2.15\times10^{-15} \times 9.81 \div 6.5\times10^{4}$) = $\mathbf{3.2\times10^{-19}}$ C ✓	3	ALLOW ecf of incorrect value for E from part (i). Second mark can be implicit in the calculation Bald correct answer gains three marks
		iii	Causing apparent weight of the oil drop to be less than actual weight / electric force can be smaller ✓ Calculated value is higher than actual value.✓	2	ALLOW $F_E + F_B = mg$ / $F_E = mg – F_B$. ALLOW actual charge is lower or calculated charge is too high.
	c		The weight and the electric forces are acting downwards/in the same direction. ✓ Oil drop will accelerate towards bottom/positive plate. ✓	2	 ALLOW The oil drop will reach a higher/faster terminal velocity.
			Question total	**14**	
			SECTION TOTAL	**39**	

Question			Answer	Marks	Guidance
4	a	i	Mean value = [(0.247 + 0.248 + (4 × 0.249) + (2 × 0.250) + (3 × 0.251) + (2 × 0.252) + 0.253) ÷ 14 = 3.501 ÷ 14] = **0.250** mm ✓ Spread = ± ½ range ✓ [= ± ½ (0.253 - 0.247] = 0.003) % uncertainty = (0.003 ÷ 0.250) x 100 = **1(.2)%** ✓	3	Mean must be to 3sf. ecf incorrect mean used to calculate %uncertainty, but not ecf incorrect spread.
		ii	Area = π d^2 ÷ 4 = **4.9(1)×10⁻⁸**m^2 ✓ **EITHER** % error in area measurement (= 2 × % error in d) = 2.4%✓ Absolute uncertainty = [4.9(1)×10^{-8} x 0.024 =] **1(.2)×10^{-9}** m^2 ✓ **OR** Maximum = 5.03 x 10^{-8} m^2 and/or minimum = 4.79 x 10^{-8} m^2 ✓ Absolute error in area = [½ (max – min) OR max – actual OR actual - min] = ± **0.1(2)×10^{-8}** m^2✓	3	Use of r = 0.250 mm gives A = 1.96×10^{-7} m^2. ALLOW % uncertainty is twice % uncertainty in diameter calculated in (a)(i). ALLOW ecf for uncertainty on incorrect calculation of A. [±4.8×10^{-9} for A = 1.96×10^{-7} m^2]
	b	i	x-error bars at ± 0.5 ✓ y-error bars at ± 0.2 ✓	4	At least 6 correct to ½small square in total line length. At least 6 correct to ½small square in total line length
			Elastic region labelled at the straight section of the graph (F ≤ 7 N by eye) **AND** Plastic region labelled at the curved section of the graph (F ≥ 7 N by eye) ✓		Both correct for a mark. Can be labelled anywhere on the graph.
			Straight LoBF drawn with a fair spread of **their** points above and below the line by eye, extending as least as far as 6 N. ✓		LoBF should not use top 3 plots. Ignore any line drawn at F > 7 N Line drawn should not cross the x axis and there should be similar number of points either side of line.

Question			Answer	Marks	Guidance
		ii	Calculate gradient using two points on **their line** which are at least half the length of **their line** apart. ✓ Use of Young Modulus = *Fl/Ax* or stress/strain [= gradient x (*l/A*)]✓ Calculate value of Young Modulus using value of *A* from **(a)(ii)** and *l* = 4.00 m and <u>gradient</u>. ✓ Correct units (Pa or N m^{-2}). ✓ Answer has correct POT for their units. ✓	5	Look for ΔF ≥ 5.0 if full height line drawn. If a single data point is used to find gradient check drawn line goes through both origin and data point and F is greater than half height of line. Gradient should be in range 1.3×10^3 to 1.7×10^3. Ignore POT in gradient calc. ALLOW ecf from incorrect lbf. If E calculated from data point values or stress over strain; max 3 marks (not first or third marking point). Expect $1 \times 10^{11} \geq E \geq 1.4 \times 10^{11}$ Pa. ALLOW ecf of incorrect A in part (a)(ii). [If A = 1.96×10^{-7} m^2 then E will be a quarter the value above – approx 3×10^{10} Pa.]

	c		**Level 3 (5-6 marks)** ✓✓
			• Combines their %uncertainties correctly to find overall %uncertainty in *E.*
			• Identifies (with reason) that extension provides the greatest source of uncertainty
			• Justifies improvement for any two sources of uncertainty.
			
			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) ✓✓
			Minimum 2 of:
			• Calculation of reasonable %uncertainty in variable(s) (not area) or *E*.
			• Comparison of two or more %uncertainties or complete set of uncertainties listed (*A, l, F* and *x* **OR** *A, l* and gradient).
			• Identifies reasons for at least two sources of uncertainty.
			• Suggest improvements to mitigate at least two sources of uncertainty.
			
			There is a line of reasoning presented with some structure. The information presented is in the most part relevant and supported by some evidence.
				6	**Indicative scientific points may include:**
					
					Determining the uncertainty in *E*:
					• 'worst fit' line drawn using error bars.
					• Gradient of worst fit line calculated correctly.
					• % uncertainty in gradient worked out.
					• Addition of % uncertainties in gradient, area and length for overall % uncertainty in *E*.
					• Max value for *E* calculated using max gradient, max length and min area AND/OR min value for *E* from min gradient, min length and max area.
					• % uncertainty in *E* worked out.
					• Expect % uncertainties as follows:
					  ○ *E* in region of 30%
					  ○ Gradient in region of 20 to 25%
					  ○ Area 2.4% (ecf from (a)(ii))
					  ○ Length 0.5%
					  ○ Force up to 20% (depending on value)
					  ○ Extension up to 100% (depending on value)

Question			Answer	Marks	Guidance

			Level 1 (1-2 marks) ✓✓
			Minimum 2 of:
			• Identifies reason for source of uncertainty;
			• Suggests improvement for at least one source of uncertainty
			• Attempts to calculate % uncertainty for at least one variable other than area.
			
			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.
					• Use data point value to estimate % uncertainty in *F* (using smallest value of *F* to give largest uncertainty)
					• Use data point value to estimate % uncertainty in *F* (using smallest value of *x* to give largest uncertainty).
					• Finding max and min values of *E* from equation $E = Fl \div Ax$ and appropriate substitution.
					
					Identifying sources of uncertainty and improvements:
					• Uncertainties in load:
					  o variation in 100g masses
					  o weigh masses individually on scales/balance
					• Uncertainty in area/diameter.
					  o variation in thickness of wire
					  o not cylindrical/ not circular cross section.
					  o uncertainty in diameter give larger uncertainty in area as it is squared.
					  o Diameter measured in different <u>planes/directions</u> (NOT different places along wire).
					  o Use of thicker wire will reduce % uncertainty in diameter
					• Uncertainty in length
					  o kinked wire
					  o not initially straight/taut
					  o use fresh wire
					  o pre-load wire (to remove kinks)
					• Uncertainty in extension
					  o small measurement so large % uncertainty
					  o Explanation of zero errors
					  o Extension provides the largest source of error.
					  o longer wire so larger extensions
					  o use of travelling microscope/Vernier scale.
					• if thicker wire used then extension will be smaller so % uncertainty increases in extension.
					• Measure extension loading and unloading (for elastic deformation only).

			Question total	**21**	
			SECTION B TOTAL	**21**	

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