Oxford Cambridge and RSA

GCE

Physics B

H557/03: Practical skills in physics

Advanced GCE

Mark Scheme for November 2020

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.

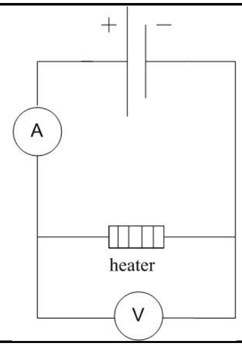
Mark schemes should be read in conjunction with the published question papers and the report on the examination.

Annotations

Annotation	Meaning
BOD	Benefit of doubt given
CON	Contradiction
✗	Incorrect response
ECF	Error carried forward
L1	Level 1
L2	Level 2
L3	Level 3
TE	Transcription error
NBOD	Benefit of doubt not given
POT	Power of 10 error
^	Omission mark
SF	Error in number of significant figures
✓	Correct response
?	Wrong physics or equation

Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

Annotation	Meaning
/	alternative and acceptable answers for the same marking point
reject	Answers which are not worthy of credit
not	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

Question			Solution	Marks	Guidance
1	a		EITHER Stir the liquid ✓ To ensure temperature is the same throughout✓ OR Fully immerse a heater or completely fill the calorimeter✓ So energy is not wasted/used/dissipated heating up the air ✓ OR Start at temp below room temp and heat to similar temp above room temperature Heat loss cancelled by heat gain from surroundings or wtte.	 1 1	 ALLOW To ensure that the thermal energy/heat (energy)/temperature is distributed throughout the liquid. ALLOW shorter heater ALLOW heat (energy). Ignore reference to frequency of temperature readings and insulation.
	b	i	Circuit with <u>a power source</u> drawn with correct symbols ammeter in series to measure current through heater ✓ voltmeter would give pd across heater ✓	 1 1	 If only one unlabelled component in circuit allow use of resistor symbol for heater. If two fixed resistors are shown, heater must be labelled to get second mark.

	b	ii	Power = V I = 10.5 × 2.3 = 24 W ✓ Power per unit mass = 24 ÷ 0.2 = 120 or 121 W kg^{-1}. ✓ Either: Max power ÷ min mass = (10.7 x 2.5) ÷ 0.195 = 137 W kg^{-1} and/or min power ÷ max mass = (10.3 x 2.1) ÷ 0.205 = 106 W kg^{-1} ✓ Uncertainty = ½(max value – min value) or max value – calculated value or calculated value – min value ✓ Or: relative uncertainty = (0.2/10.5) + (0.2/2.3) + (5/200) = 0.131 ✓ Absolute uncertainty = 0.131 × 120 = 16, so uncertainty = 20 W kg^{-1} ✓	1 1 1 1	Actual value = 24.15 W Actual value = 120.75 W kg^{-1}, ALLOW any value which rounds to 121. Expect to see uncertainty of 16 or 17, so uncertainty = 20W kg^{-1} . Check method not value. ALLOW ecf in uncertainty calculation for candidates who omit the mass uncertainty in calculation. Eg (10.7 × 2.5) ÷ 0.2 = 134 W kg^{-1} or ((0.2/10.5) + (0.2/2.3)) x 121 gives uncertainty = 13 W kg^{-1} for a maximum of 3 marks. If total power (24.2W) on answer line, then one mark can be awarded for correct calculation of absolute uncertainty in total power (≈3W). Max 2 marks available. Ideally the answer should be given to 2sf and the uncertainty should be quoted to 1sf, but allow uncertainty to no more than 2sf.
	c	i	ANY 2 of: (Initially) constant rate of temp increase OR temp (change) proportional to time✓ (because) constant/steady power input✓ Negligible/no heat lost to surroundings during linear region✓ (After approx 3 mins) Rate of increase of temperature decreases ✓ Because the temperature difference with the surroundings increases (so more thermal energy is lost to the surroundings at a higher rate.)✓	2	NOT just a linear relationship without referring to the variables IGNORE any reference to change of state

	c	ii	Straight line of best fit drawn through the first 5 plots ✓	1	Line should extend to at least 2 large squares across the grid. A line through first 5 plots (± half a small square) should pass directly through all 5 plots and will be just to the right of the 6^{th} plot. A straight line taken from 1^{st} to 7^{th} plot is the shallowest acceptable line. Any line which attempts to go through 8 or more plots will not be acceptable
	c	iii	Energy supplied = Power × Δt $P\ \Delta t = m\ c\ \Delta\theta$ ✓ Gradient = $\Delta\theta / \Delta t = P/mc$ and *P and m* are constant ✓ ($\Delta\theta / \Delta t = Z/c$)	 1 1	ALLOW *IV* to be substituted for *P* throughout. Any subject
	c	iv	Use of two suitable data points on the line read off correctly ✓ (Correct) calculation of gradient ✓ Specific heat capacity = 120 ÷ calculated gradient ✓ OR Use of two suitable data points on the line read off correctly ✓ Substitute read offs into $V\ I\ \Delta t = m\ c\ \Delta\theta$ or $P\ \Delta t = m\ c\ \Delta\theta$ ✓ Subsequent calculation for c. ✓	1 1 1	$\Delta t \geq 120$s;. Read offs should be to ± small square $\Delta t \geq 120$s Read offs should be to ± small square ALLOW ecf of value of Power per unit mass from 1(b)(ii) Gradient should be approx 0.06 °C s^{-1}. This gives c ≈ 2000 J kg^{-1} K^{-1}.
			Question total	**16**	

Question			Solution	Marks	Guidance
2	a		Radius of larger circle is twice that of the smaller one (by similar triangles). ✓ Show that circular area is therefore 4× as big. ✓ Using equation to show that intensity is ¼L_x.	1 1	$L_{2x} = \frac{E}{t\pi(2r)^2}$ gets first mark $L_{2x} = \frac{E}{4t\pi r^2}$ gets second mark IGNORE use of x instead of r.
	b	i	(Increased light intensity will) increase conductivity / reduce resistance of LDR. ✓ Therefore, the p.d. across the LDR will decrease (total p.d. is constant) so the p.d. across the fixed resistor must increase ✓ OR Therefore, larger proportion of voltage will be across fixed resistor. OR Total resistance decreases, so current increases, so pd across fixed resistor increases.	1 1	Ignore references to inverse proportion or direct proportion. Potential divider equation could be used to show proportion.
	b	ii	22, 10 ✓ Both points plotted correctly (within half a small square) ✓ Acceptable curve drawn through points on graph ✓	1 1 1	± half a small square give range 21-23 and 9-11. ecf whatever values are in the table. Line should have a positive (> 0) intensity at V = 2.0, and should not be too hairy or thick and should pass through or close to all plotted points.

	c		**Level 3 (5-6 marks)** ✓✓ Clear and correct numerical interpretation. AND identified correct shift for graph with some explanation. *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 numerical interpretation. OR explain shift of graph with background illumination using correct scientific ideas. *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)** ✓✓ Partial or incorrect numerical interpretation AND/OR qualitative comparison of effect of background illumination *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:** • Calculation of distance of the torch when output is 5.0V (CHECK candidate's approx read offs) o Read off graph fig 2.4 at 5.0V to be (*40* Wm^{-2}) o Read off graph fig 2.3 to find $1/x^2$ to be (*45* m^{-2}). o This gives x = (*0.15* m) • Calculation of intensity if torch is at x = 25 cm o $1/x^2$ = **16** o Read off graph fig 2.3 gives intensity of **14 Wm^{-2}** • Calculation of distance of torch when output is 5.0 V with background intensity of 14 Wm^{-2} (check candidate's approx read offs) o Torch intensity = *40* – 14 = *26* Wm^{-2} o Use fig 2.3 to give $1/x^2$ to be *29* m^{-2} o This give x = *0.186* m • What happens to the curve: o When there is no light from the torch; total intensity = 14 Wm^{-2} o From fig 2.4 this will mean that the output = *4.0 V* o Hence the graph will cross the x-axis at (*4.0*, 0) (no light from torch) o Graph will also go through (5.0, *26*) o Same shape graph but all points lower by **14 Wm^{-2}.** o Light intensity from torch = total light intensity – background intensity. o With background illumination the LDR will be more conductive/less resistive for all values of x. o Voltage output for all values of x will be higher. o Curve is shifted right. o Light intensity from torch will be less for the same output. o When output = 5.0 V the torch will be dimmer because some light from background so further away. o Torch will be further away for the same output. IGNORE statements saying that the graph will move upwards – this is because the candidate has misinterpreted the y axis as total light intensity rather than intensity from the torch alone.

Question			Solution	Marks	Guidance
3	a	i	ANY 4 of: Sound wave travels down the tube and reflects at the end; ✓ Waves travelling in opposite direction superpose/ interfere; ✓ Two waves have same wavelength or frequency and similar amplitudes. ✓ Node is formed where waves meet in antiphase / antinode formed where waves meet in phase. ✓ Node at water surface ✓ Antinode at open end of tube ✓	4	ALLOW constructive interference for antinode, destructive for node Marks could be awarded from a labelled diagram.
	a	ii	Combine equation with v = fλ To give $L_1 + x = v \div 4f$, (and rearranged to give $L_1 = (v/4f) - x$) ✓	1	
	b	i	Speed of sound = 4 × 83 = 330 m s^{-1}. ✓ Worst line drawn through error bars. ✓ Gradient of worst line found using co-ordinates at least half the length of the drawn line apart. ✓ Method for percentage uncertainty calculated: ✓ eg: $\lvert$worst gradient – 83$\rvert$ ÷ 83 x 100 (steepest gradient – shallowest gradient)/2 ÷ 83 x 100	1 1 1 1	Actual value = 332 Steepest line from (0.0039, 0.32) to (0.00188, 0.14) (m≈89) Shallowest line from (0.0040,0.318) to (0.0018, 0.144) (m≈79) Coordinates of end point ±half a small square Percentage uncertainty could also be calculated from calculated values for speed of sound. Expect final value in the region of 4% - 7% but actual value will depend on the line drawn.

	b	ii	substituting coordinates of a point on the line into "y = 83x + c" ✓ OR Use coordinates of a point on the line; eg (0.0026, 0.205) Substitute into L_1 = (v/4f) – x); eg 0.205 = (330×0.0026/4) – *x* ✓ Correct calculation of x or -c and D = x/0.3 (= 0.009/0.3 = 0.03 m (3 cm) ✓	1 1	Intercept, c ≈ 0.009. Accept any answers which would round to 3 cm to 1sf.
			Question total	**11**	

Question			Solution	Marks	Guidance
4	**a**	**i**	V_{peak} = 1.5V✓	**1**	1500 mV
		ii	f = 1/0.02 = 50 Hz✓	**1**	
	b	**i**	Recall $\frac{V_1}{V_2} = \frac{N_1}{N_2}$ ✓ Correct ratio of voltages or squares ie $\frac{V_1}{V_2} = \frac{1.5}{1} = \frac{3squares}{2squares}$, (hence $\frac{N_1}{N_2} = \frac{3}{2}$)✓	**1** **1**	 DO not accept 3/2 without justification. ACCEPT any correct justified voltage ratio eg rms, peak, max-min.
		ii	Suggestion for one mark✓ Consequence of suggestion for second mark. ✓ For example: Eddy currents (in the core) Heat or energy lost in core / opposing flux OR Small leakage of flux into the air Reduced flux in secondary coil OR Resistance in electrical circuit heat or energy lost in wires / pd lost in wires	**1** **1**	Ignore reference to efficiency ACCEPT electrical current induced in core as a description of eddy current. ALLOW hysteresis in core ✓ Causing heat loss in core ✓
	c		$I_1V_1 = I_2V_2$ Hence $\frac{V_1}{V_2} = \frac{I_2}{I_1}$ Substituted into $\frac{V_1}{V_2} = \frac{N_1}{N_2}$ and rearranged to give $I_2 = \frac{N_1 I_1}{N_2}$ ✓ Assumption: Transformer is 100% efficient / ideal transformer✓	 **1** **1**	 ALLOW any correct reason for efficiency. ALLOW no energy loss or no power loss or power input = power output.

	d	i	Use of $\varepsilon = -N\frac{\Delta\phi}{\Delta t}$ ✓ *OR* State $\Delta\Phi$ is the area under the ($\varepsilon - t$) graph divided by *N* (wtte) Δt = ¼T (time taken from zero to max) ✓ OR Estimate area under graph for ¼ cycle of Fig 4.2 as triangle so area = ½ (0.005)(2.0) Final calculated value by dividing value by N. ✓ $\Delta\Phi = \frac{2.0 \times 0.005}{200}$ = 5 × 10^{-5} Wb $\Delta\Phi = \frac{½ \times 2.0 \times 0.005}{200}$ = 2.5 × 10^{-5} Wb (for area method)	1 1 1	Either: Rearrange to give the integral; $\Delta\phi = -\frac{1}{N}\ \varepsilon\ \Delta t$ Or: substitute $\varepsilon = 2.0$, *N* = 200 into the equation $2.0 = -200\frac{\Delta\phi}{\Delta t}$ allow ecf from answer for *f* in (a)(ii). Using calculus to give an answer of 3.2 × 10^{-5} Wb will gain full credit.
		ii	Two (or more) correct complete loops within the core ✓ Clockwise arrow showing the flow of flux. ✓	1 1	IGNORE any lines outside the core. Flux lines must not cross. ALLOW one correct arrow
		iii	ANY one of: • decreases permeance (of the core) ✓ • decreases magnetic flux (in the core) ✓ • decreases the output voltage (if a second coil was used) ✓	1	ALLOW increase in magnetic resistance or decrease magnetic conductance for first marking point. ACCEPT decreases strength of magnetic field

		iv	**Level 3 (5-6 marks)** ✓✓ Detailed and correct explanation of both the effect of the air gap on permeance and of eddy currents in laminations compared to solid cores or other lamination orientation. *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)** ✓✓ Mainly correct explanation of both the effect of the air gap on permeance and of eddy currents in laminations compared to solid cores or other lamination orientation. May be lacking in detail. *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)** ✓✓ Limited or incorrect explanation of the effect of the air gap and/or of the laminations on the performance of a magnetic circuit. Use of terminology may be confused. *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:** Explanation of effect of the air gap • air has a lower permeability than iron/the core • permeability of air is much lower than iron • air gap decreases overall permeance of the magnetic circuit • a small gap has a very large effect • permeance is analogous to conductance in an electric circuit • flux in core depends on permeance • flux will be decreased Explanation for the stacked laminations • Eddy currents are formed/induced in the core • they produce a flux that opposes the flux induced by the primary coil • Eddy currents that form in iron core are reduced in size by vertical laminations • Eddy currents induced at right angles to the flux • Glue is an electrical insulator • Eddy currents can only go as deep at the thickness of the vertically laminated sheets. • Vertical laminations provide a high resistance /small cross-sectional area in the direction of eddy currents • Horizontal laminations /solid block would allow larger eddy currents. • Vertical laminations do not impede the flux in the core / horizontal ones do. • Solid block is best for flux but worst for eddy currents • ALLOW reference in the written answer to correct eddy currents drawn on to Fig 4.4 or sketches within the written answer
			Question Total	**20**	

OCR (Oxford Cambridge and RSA Examinations)
The Triangle Building
Shaftesbury Road
Cambridge
CB2 8EA

OCR Customer Contact Centre

Education and Learning
Telephone: 01223 553998
Facsimile: 01223 552627
Email: general.qualifications@ocr.org.uk

www.ocr.org.uk