OCR
Oxford Cambridge and RSA

GCE

Physics A

Unit **H556/03:** Unified physics

Advanced GCE

Mark Scheme for June 2017

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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.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

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Annotations available in Scoris

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
(1)	Separates marking points
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

CATEGORISATION OF MARKS

The marking schemes categorise marks on the MACB scheme.

B marks: These are awarded as independent marks, which do not depend on other marks. For a **B**-mark to be scored, the point to which it refers must be seen specifically in the candidate's answers.

M marks: These are method marks upon which **A**-marks (accuracy marks) later depend. For an **M**-mark to be scored, the point to which it refers must be seen in the candidate's answers. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.

C marks: These are compensatory method marks which can be scored even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known it. For example, if an equation carries a **C**-mark and the candidate does not write down the actual equation but does correct working which shows the candidate knew the equation, then the **C**-mark is given.

A marks: These are accuracy or answer marks, which either depend on an **M**-mark, or allow a **C**-mark to be scored.

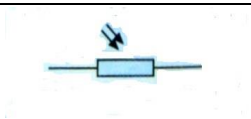
Note about significant figures:

If the data given in a question is to 2 sf, then allow to 2 or more significant figures.
If an answer is given to fewer than 2 sf, then penalise once only in the entire paper (except for Q3 where SF are examined).
Any exception to this rule will be mentioned in the Additional Guidance.

Question			Answer	Marks	Guidance
1	(		$^{238}_{92}U \rightarrow {}^{234}_{90}Th$ + ...	B1	**allow** proton and/or nucleon number to the right of symbol
			$^{4}_{2}He$ or $^{4}_{2}\alpha$	B1	**allow** γ-photon; zero for any other extra particle
	(b)		$mv = (4.00 - 0.0665) \times 10^{-25} \times 2.40 \times 10^{5} = 9.44 \times 10^{-20}$	C1	**allow** 0.07×10^{-25} for α-particle mass
			$v = 9.44 \times 10^{-20} / 6.65 \times 10^{-27} = 1.42 \times 10^{7}$	C1	**max** 3 if use 4.00 instead of 3.93 in momentum eq'n **allow** ratio of masses 234 and 4 **or** calculations using 234u and 4u
			k.e. = ½ x 6.65×10^{-27} x $(1.42 \times 10^{7})^2$ = 6.70×10^{-13} (J)	A1	**allow** $p^2/2m$ calculation for k.e.
			$6.70 \times 10^{-13} / 1.60 \times 10^{-13}$ = 4.19 (MeV)	B1	**accept** 4.0 to 4.2; **ecf** (calculated value of k.e. in J)/e **N.B.** the correct answer automatically gains all 4 marks
	(c)		$\Delta A = 32 = 4n_{\alpha}$ so n_{α} = 8	B1	**allow** 8 (decays), i.e no mention of α particles
			$\Delta Z = 10 = 2n_{\alpha} - n_{\beta}$ so n_{β} = 6	B1	**allow** 10 – 16 = - 6; **NOT** 14 – 8 = 6; **must state** β(-) particles
			argument/reasoning given for both n_{α} and n_{β}	B1	e.g. change in mass number caused by α decay, change in proton number combination of α and β
			Total	9	

Question			Answer	Marks	Guidance
2	(		F = Bev **and** F = eE E = V/a **or** F=(eE) = eV/a Bev = eV/a giving V = Bva	**B1** **B1** **B1**	**allow** Q or q for e
	(b)	**(i)**	I = nAev; v = 60 x 10^{-3}/1.2 x 10^{23} x 1.6 x 10^{-19} x 5.0 x 0.2 x10^{-6} v = 3.1 (m s^{-1})	**C1** **C1** **A1**	**allow** any subject
		(ii)	V = 80 x 10^{-3} x 3.1 x 5.0 x 10^{-3} = 1.2 x 10^{-3} (V)	**A1**	**ecf (b)(i)**; **allow** 1.2 mV; 1.3 x 10^{-3} (V)
	(c)	**(i)**	Hall probe only compares B-fields/AW **or** V will be too small/less than 1 mV so not easy to measure	**B1**	allow any sensible comment, e.g. how do you convert the measured V into a B value
		(ii)	find B using F = BIl; F is measured by weighing magnets (e.g. placed on top pan balance assuming wire is fixed); graph of F against I to find B(l) from gradient/AW; greatest uncertainty: measurement of l in B-field sensible reason/justification for choosing l **or** small masses	**B1** **B1** **B1** **B1** **B1**	**max** 4 of the 5 marking points **alt** measure F by adding small masses to wire to return it to zero current position **or** use readings of F at several I to find average F/I, etc. **or** measurement of small masses in alt. method,etc quantitative suggestion about % error i.e. l small (1 mm in 60) leading to large % uncertainty **or** difficulty in determining edge/end of B-field
			Total	**12**	

Question			Answer	Marks	Guidance
3	(a)		Take ln to give $\ln V = -(t/C).1/R + \ln V_0$ gradient (m) = (-) t/C where t = 15	M1 A1	**allow** $\ln (V/V_0) = -(t/C).1/R$
	(b)	(i)	1.10 ± 0.07	B1	value plus uncertainty required for the mark
		(ii)	two points plotted correctly to within ½ small square on x-axis; line of best fit	B1 B1	**ignore** accuracy of length of error bar; **ecf bi** value **or both** worst acceptable lines drawn
		(iii)	gradient (= 15/C) = 6.6 (x 10^4); C = 15 / 6.6 x 10^4 = 2.3 x 10^{-4} (F) worst acceptable straight line drawn (C) ± 0.3 x 10^{-4} F	C1 A1 B1 B1	**accept** 6.4 to 6.8 **ignore** power of 10 **accept** 2.3 ± 0.1 x 10^{-4} **allow ecf** for the point calculated incorrectly in **b(ii)**; steepest or shallowest possible line that passes through <u>all</u> the error bars; should pass from top of top error bar to bottom of bottom error bar **or** bottom of top error bar to top of bottom error bar **allow** e.g. (C) ± 0.2 x 10^{-4}; **allow** value of C to 4 SF **but N.B**. the uncertainty and the value of C **must be** to the same number of decimal places **allow** 230 ± 30 μF etc **allow** equivalent unit including s Ω^{-1}, C V^{-1}, A s V^{-1}
	(c)		ln(0.1) = -15/RC **or** R = -15/C ln(0.1) **or** R = 0.65/C R = 0.65/2.3 x 10^{-4} giving R = 28 kΩ	C1 A1	ln(0.1) = -2.30 **ecf (b)(iii)**
			Total	11	

Question			Answer	Marks	Guidance
4			**see page 12**	**B1 x 6**	
	(b)	**(i)**		**B1**	two arrows needed **not** across resistor; allow a surrounding circle with arrows outside circle
		(ii)1	from graph 3.0 (kΩ) $I = 4.0/3.0 = 1.33 \times 10^{-3}$ A **or** $R = 2.0/4.0 \times 3.0 \times 10^{3}$ $R = (6.0 - 4.0)/1.33 \times 10^{-3} = 1.5 \times 10^{3}$ (Ω)	**B1** **C1** **A1**	**allow** 3.1 ± 0.1 (kΩ) **accept** 1.3 mA; **accept** potential divider argument **allow** 1.5 kΩ; **special case:** using 2.4 V in place of 4.0 V gives R = 4.5 kΩ; give 1 mark out of 2
		(ii)2	at 2.4 V R_{LDR} = 1.0 kΩ giving 2.5 (W m^{-2})	**M1** **A1**	**ecf (b)(ii); allow** potential divider or I = 2.4 mA; **for special case:** R_{LDR} = 9.0 kΩ ; give 1 mark out of 2 allow 2.4 to 2.6 W m^{-2} **N.B. remember to record a mark out of 5 here**
			Total	**12**	

Question			Answer	Marks	Guidance
4	(a)		**Level 3 (5 - 6 marks)** Clear planning and correct identification of terminals and position of components *There is a well-developed line of reasoning which is clear and logically structured. The information presented is clear relevant and substantiated.* **Level 2 (3 – 4 marks)** Clear planning and correct identification of some components / terminals *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)** Some planning and/or an attempt at identifying component / terminals *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.*	**B1 x 6**	**Use level of response annotations in RM Assessor, e.g. L2 for 4 marks, L2^ for 3 marks, etc.** **Indicative scientific points may include:** **Planning** • suitable circuit arrangements/diagrams drawn between two points which could be connected to the box terminals • use of R to limit current, e.g. to find CD terminals • logical plan of connection across terminals e.g. connect circuit to each pair of terminals in turn • identify terminals C and D as the circuit with the largest current/smallest resistance • A and B identified because CD known **or** the circuit including terminals AC/D has the smallest current/largest resistance **Identifying** • $V = IR$ quoted or used in calculations • $R_T = \Sigma R$ used to determine the 220 Ω or the 470 Ω resistors • For 220 Ω resistor (between AB or BC/D) current is 27 (mA) A **or** 19 (mA) with R • For 470 Ω resistor (between AB or BC/D) current is 13 (mA) **or** 11 (mA) with R • For both resistors (between AC/D) current is 8.7 (mA) **or** 7.6 (mA) with R • For wire (between CD) current is 0.060 A	

Question			Answer	Marks	Guidance
5		(i)	sin **or** cos wave with 1.5 wavelengths (between **C** and **R**) y-axis showing scale ,i.e. (amplitude) 2.(0) x 10^{-6} (m) correct scale on x-axis showing λ = 0.2 (m) **X** and **Y** labelled at adjacent intercepts on x-axis	**B1** **B1** **B1** **B1**	 unit must be present, e.g 10^{-6} m **NOT** if axis labelled time
		(ii)1	v = Aω **or** 2πfA v = (2 x 10^{-6} x 2 x 3.14 x 1.7 x 10^{3} =) 2.1 x 10^{-2} (m s^{-1}.)	**C1** **A1**	
		(ii)2	½Mv^2 = 3/2 RT and T = 290 v = √(3 x 8.31 x 290/0.029) v = 5(.0) x 10^{2} (m s^{-1}.)	**C1** **A1**	**or** ½mv^2 = 3/2 kT so v^2 = 3 (k/m) 290 **N.B. remember to record a mark out of 4 here**
	(b)		**see page 14**	**B1 x 6**	
			Total	**14**	

Question			Answer	Marks	Guidance
5	(b)		**Level 3 (5 - 6 marks)** Clear description and explanation for **both** experiments **and** some discussion of uncertainty *There is a well-developed line of reasoning which is clear and logically structured. The information presented is clear relevant and substantiated.* **Level 2 (3 – 4 marks)** Some description and explanation for **both** experiments **or** clear description and explanation for **one** experiment **and** some discussion 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.* **Level 1 (1 – 2 marks)** Limited description and explanation for **one** experiment *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.*	**B1 x 6**	**Use level of response annotations in RM Assessor, e.g. L2 for 4 marks, L2^ for 3 marks, etc.** **Indicative scientific points may include:** **Description and explanation** **Experiment (a)** • Coherent signals/(sound) waves • Interference / superposition • Maximum signal / minimum signal • Idea of how wavelength is determined (e.g. distance between adjacent max positions = λ) • $v = f \times \lambda$ **Experiment (b)** • Stationary/standing wave produced • Superposition of waves travelling in opposite directions • Nodes / antinodes • Idea of how wavelength is determined (e.g. distance between adjacent nodes = $\lambda/2$) • $v = f \times \lambda$ **Uncertainty** • Measure multiples of λ • to reduce % uncertainty (by factor n) • move from minimum signal to minimum signal • so can increase sensitivity of scope to get better fix on each minimum position/ increase loudness from speaker • Lower frequency from signal generator • so increases λ with (%) uncertainty reduced • Do experiment outside • to reduce background reflections from room (so that sharper minima should be observed)

Question			Answer	Marks	Guidance
6			arrow down through centre of ball labelled weight **or** W **or** mg **or** 1.2 N	 **B1**	zero if any other arrows or forces present
	(b)	**(i)**	(horizontally) mv^2/r (**or** $mr\omega^2$) = T sin θ **and** (vertically) W **or** mg = T cos θ (tan θ = v^2/rg **or** $r\omega^2/g$) tan θ = 0.045 x 4 x 9.87 x 2.2/9.81 **or** 0.48/1.2 (= 0.40) θ = 22°	 **M1** **A1** **A0**	**accept** figures in place of algebra, r = 0.045 m v = 0.42 m s^{-1} ω = 3π rad s^{-1}; $r\omega^2$ = 4.0 m s^{-2} ; W = 1.2 N and m = 0.12 kg and $mr\omega^2$ = 0.48 N **accept** labelled triangle of forces diagram **N.B.** this is a *show that Q* ; sufficient calculation must be present to indicate that the candidate has not worked back from the answer
		(ii)	k = (mg/x_0 = 1.2 / 0.050) = 24 (N m^{-1}) (T = mg / cos θ = kx giving) x = 1.2 / 24 cos 22 x = 0.054 (m)	**C1** **C1** **A1**	**or** solution by ratios
	(c)		($y = ½gt^2$ =) 0.18 = 0.5 x 9.81 x t^2 giving t = 0.19 (s) (x = vt =) 0.42 x 0.19 = 0.08 (m) distance = $\sqrt{(r^2 + x^2)}$ = $\sqrt{(0.0020 + 0.0064)}$ = 0.092 (m)	**C1** **C1** **C1** **A1**	**alt**: projectile motion: x = vt, $y = ½gt^2$ $y = ½g(x/v)^2$ **ecf (b)i** for v; $x^2 = 2yv^2/g = 2 \times 0.18 \times 0.42^2/9.81$
	(d)		T increases **or** string stretches **or** angle θ increases to provide/create a larger centripetal force	**M1** **A1**	 **allow** mv^2/r **or** $mr\omega^2$ in place of *centripetal force* causality must be implied to gain the A mark
			Total	**12**	

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