OCR
Oxford Cambridge and RSA

GCE

Physics A

Unit **H556/02:** Exploring 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 RM Assessor

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

MARKING INSTRUCTIONS

Generic version as supplied by OCR Sciences

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.
Any exception to this rule will be mentioned in the Additional Guidance.

SECTION A

Question	Answer	Marks	Guidance
1	B	1	
2	C	1	
3	D	1	
4	B	1	
5	A	1	
6	C	1	
7	A	1	
8	D	1	
9	D	1	
10	C	1	
11	D	1	
12	A	1	
13	D	1	
14	B	1	
15	B	1	
	Total	15	

SECTION B

Question			Answer	Marks	Guidance
16	(a)		(When two or more waves meet at a point in space) the resultant (displacement) is equal to the (vector) sum of the individual displacements of waves (meeting at a point)	B1	**Allow** total / Σ / net for resultant **Not** amplitude for displacement
	(b)	(i)	Clear evidence of at least two fringe separations used to determine *x* **and** *x* in the range 7.0 to 9.0 mm	B1	**Expect** 8 (mm)
			$\lambda = \frac{0.25\times10^{-3}\times8\times10^{-3}}{4.25}$ (Allow any subject)	C1	**Allow** ecf for incorrect value of *x*
			$\lambda = 4.7 \times 10^{-7}$ (m)	A1	
		(ii)	Red light has longer wavelength / λ **and** separation between fringes increases (AW)	M1	
			Separation between fringes justified in terms of $x \propto \lambda$ or $x = \lambda D/a$, *D* and *a* are constants	A1	**Allow** other acceptable labels for *D* and *a*
			Total	6	

Question			Answer	Marks	Guidance
17	(a)		Any <u>one</u> from: current, temperature, light intensity and amount of substance / matter	B1	**Not**: ampere, kelvin, candela and mole **Not** correct quantity with its unit, e.g. current in <u>A</u> or current (A)
	(b)	(i)	$R = \frac{\rho L}{A}$ **and** $A = \pi\left(\frac{d}{2}\right)^2$ $R_X = \frac{4\rho L}{\pi d^2}$ and $R_Y = \frac{8\rho L}{\pi d^2}$ Clear steps leading to $R = \frac{12\rho L}{\pi d^2}$	M1 A1	
		(ii)1	Ruler / tape measure (for L) **and** micrometer (for d)	B1	**Allow** (vernier / digital) calipers or travelling microscope for micrometer
		(ii)2	R = 2.3(4) (Ω) $\frac{0.1}{9.5}$ or $2\times\frac{0.003}{0.270}$ $\frac{0.1}{9.5}+2\times\frac{0.003}{0.270}$ or 0.0327 or 3.27% absolute uncertainty in R = 0.0327× 2.34 = 0.077 R = 2.3 ± 0.1 (Ω)	C1 C1 C1 A1	**Allow** other correct methods for getting 2.3 ± 0.1 (Ω) **Allow** 2 or more sf for this C1 mark **Note** 0.0105 or 1.05% or 0.0222 or 2.22% scores this mark, allow 2sf or more **Allow**: 2.34 ± 0.08 (Ω) **Note** use of R_X or R_Y instead of R can score the second and third C1 marks only
		(ii)3	(The actual) R is large(r) **because** (the actual) d is small(er) or (the actual) A is small(er) or $R \propto 1/d^2$	B1	**Allow**: The <u>calculated</u> R is small(er) **because** (the measured) A is large(r) or $R \propto 1/d^2$
			Total	9	

Question			Answer	Marks	Guidance
18	(a)	(i)	Resistance of parallel combination = 40 (Ω) $I = \frac{4.2 - 1.5}{40 + 33}$ I = 0.037 (A)	C1 C1 A1	**Allow** $(1/60 + 1/120)^{-1}$ **Allow** 2 marks for $I = \frac{4.2 + 1.5}{40 + 33} = 0.078$ (A)
		(ii)	Any <u>two</u> from: The current decreases up to 1.5 V The current is zero at 1.5 V The current changes direction / is negative when < 1.5 V The current increases below 1.5 V	B1×2	**Allow** 'current is zero when the e.m.f.s are the same'

Question	Answer	Marks	Guidance
(b)*	**Level 3 (5–6 marks)** Clear description including a reasonable estimate of *r* **and** clear limitations *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 description with an attempt to estimate *r* **and** some limitations *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 *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.*	**B1×6**	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 estimation** • Correct circuit with (variable) resistor, ammeter and voltmeter • Correct symbols used for all the components • *R* changed to get different values for *P* • $R = V/I$ (using ammeter and voltmeter readings) or *R* measured directly using an ohmmeter with the variable resistor isolated from the circuit or *R* read directly from a resistance box • Power calculated using $P = V^2/R$ or $P = VI$ or $P = I^2R$ • The value of *r* is between 1.0 to 3.0 Ω • A smooth curve drawn on Fig. 18.2 (to determine *r)* • A better approximation from sketched graph or *r* is between 1.5 and 2.7 Ω • Any attempt at using $E = V + Ir$, with or without the power equation(s) to determine *r* - even if the value is incorrect **Limitations** • 'More data' required • Data point necessary at R = 2.0 Ω / More data (points) needed between 1 to 3 Ω • No evidence of averaging / Error bars necessary (for both *P* and *R* values)
	Total	**11**	

Question			Answer	Marks	Guidance
19	(a)		Photon(s) mentioned	B1	
			One-to-one interaction between photons and electrons	B1	**Allow** 'photon absorbed by an electron' **Allow**: collide etc. for interaction
			Energy of photon is independent of intensity / intensity is to do with <u>rate</u> (of photons / photoelectric emission) / photon energy depends on frequency / energy of photon depends on wavelength / photon energy $\propto$ frequency / photon energy $\propto 1/\lambda$	B1	**Allow** $E = hf$ or $E = hc/\lambda$
			energy of uv photon(s) > work function (of zinc) / frequency of uv > threshold frequency	B1	**Allow** energy of light photon(s) < work function (of zinc) / frequency of light < threshold frequency **Allow** $\geq$ instead of > here **Not** $f > f_0$
	(b)		$\phi = \frac{6.63\times10^{-34}\times3.0\times10^{8}}{2.9\times10^{-7}}$ or 6.86×10^{-19} (J)	C1	
			$E = 5.1 \times 1.60 \times 10^{-19}$ or 8.16×10^{-19} (J) max kinetic energy = $(8.16 - 6.86) \times 10^{-19}$	C1	**Note**: Using 5.1 and not 8.16×10^{-19} cannot score this mark or the next mark
			max kinetic energy = 1.3×10^{-19} (J)	A1	**Allow** 2 marks for 0.81 eV
	(c)		Any <u>three</u> from: The electrons are repelled by **C** / electrons travel against the electric field (AW) The electrons are emitted with a 'range' of speed / velocity / kinetic energy (AW) As V increases the slow(er) electrons do not reach **C and** hence I decreases maximum KE in the range 2.1 <u>eV</u> to 2.2 <u>eV</u> or 3.36×10^{-19} <u>J</u> to 3.52×10^{-19} <u>J</u>	B1×3	**Note** 'range' can be implied by 'highest' or 'lowest' **Allow** 'find p.d. when current is (just) zero, and then KE = $e \times V$'
			Total	10	

Question			Answer	Marks	Guidance
20	(a)		Correct pattern	B1	**Note**: At least five field lines must be drawn and of these, two must be perpendicular (by eye) to the surface of the sphere and plate
			Correct direction of the field	B1	**Note**: This may be shown on just one line
	(b)		(Electric potential) is the work done per (unit) charge in bringing a positive charge from infinity (to the point).	B1	**Allow**: work done / energy required to bring a unit positive charge from infinity (to the point)
	(c)	(i)	$V = Q/4\pi\varepsilon_0 r$ (Allow any subject)	C1	**Note** using $\boldsymbol{E = V/d}$ with $E = Q/4\pi\varepsilon_0 r^2$ is wrong physics and hence scores zero
			$Q = 4\pi \times 8.85 \times 10^{-12} \times 0.015 \times 5000$	C1	**Note** if the value of ε_0 is not given here, it could be implied in the correct 3sf answer **Allow** any subject here if the answer is given to more than 2sf **Allow** the use of $1/4\pi\varepsilon_0 = 9 \times 10^9$
			$Q = 8.3(4) \times 10^{-9}$ (C)	A0	
		(ii)1	(electric force =) $1.7 \times 10^{-2} \times \tan 4.0$ (Allow any subject)	M1	**Not** $1.7 \times 10^{-2} \sin 4$ or $1.7 \times 10^{-2} \cos 86$ **Allow** $1.7 \times 10^{-2} \times \sin 4/\cos 4$
			(electric force = 1.19×10^{-3} N)	(A0)	
		(ii)2	$E = 1.2 \times 10^{-3}/8.3(4) \times 10^{-9}$	C1	
			$E = 1.4 \times 10^5$ (N C^{-1})	A1	**Allow** 2 marks for 1.45×10^5 (N C^{-1}), 8.3×10^{-9} used **Allow** 2 marks for 1.43×10^5 (N C^{-1}), 1.19×10^{-3} (N) used
			Total	8	

Question			Answer	Marks	Guidance
21	(a)		$\varepsilon = 7.2 \times 10^{-12} \times 1.2 \times 10^{-3}/4.0 \times 10^{-4}$ permittivity = 2.2×10^{-11} (F m^{-1})	C1 A1	**Allow** any subject **Allow** ε_o instead of ε **Note** answer to 3 sf is 2.16×10^{-11} (F m^{-1}) **Allow** 1 mark for bald 2.4; relative permittivity calculated
	(b)	(i)	capacitance of two capacitors in series = 500 (μF) C = 1000 + 500 C = 1500 (μF)	C1 A1	
		(ii)	$V = 1.5 \times e^{-12/15}$ V = 0.67 (V)	C1 A1	Possible ecf from **(i)** **Allow** 1 mark for 0.83 V, $V = 1.5[1 - e^{-12/15}]$ used
			Total	6	

Question			Answer	Marks	Guidance
22	(a)*		**Level 3 (5–6 marks)** Clear evaluation of Fig. 22.1 **and** clear analysis *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 evaluation of Fig. 22.1 **and** some analysis *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 evaluation of Fig. 22.1 **or** limited analysis *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.*	**B1×6**	Use level of response annotations in RM Assessor, e.g. L2 for 4 marks, L2^ for 3 marks, etc. **Ignore** incorrect references to the terms precision and accuracy **Indicative scientific points may include:** **Evaluation of Fig. 22.1** • Comment on the line • The straight line misses one error bar / anomalous point ringed or indicated • Too few data points plotted • The triangle used to calculate the gradient is (too) small • Some plots should have been repeated / checked • No error bars for current • 'Not regular intervals' (for current) • No origin shown (AW) **Evaluation of analysis** • The value of *B* is close to the accepted value • The difference of only 7% • No absolute or percentage uncertainty in *B* shown (AW) • Worst-fit line or maximum / minimum gradient line could have been used to determine the (absolute or percentage) uncertainty in *B* • *F* against I graph should be a straight line or • *BL* = gradient (any subject)

Question			Answer	Marks	Guidance
	(b)	(i)	There is a changing / fluctuating (magnetic) field / flux (linkage) (magnetic) field / flux (linkage) in core and secondary (coil) Statement of Faraday's law: e.m.f. (induced) $\propto$ rate of change of (magnetic) flux linkage	M1 A1 B1	**Note**: This changing flux can be anywhere **Allow** 'the direction of the field oscillates' **Allow** 'the core helps to link the flux to the secondary coil' **Allow** 'equal to / =' **Ignore** 'cutting of flux' **Not** just $E = (-)\Delta(N\phi)/\Delta t$
		(ii)1	(I_S =) 24/12 or 2.0 (A) (I_P =) $\frac{20}{400} \times 2.0$ (current in primary =) 0.10 (A) or (V_P =) 12×20 or 240 (V) (I_P =) $\frac{24}{240}$ (current in primary =) 0.10 (A)	C1 A1 C1 A1	 **Allow** 1 sf answer **Allow** 1 sf answer
		(ii)2	Idea of changing / increasing (magnetic) field / flux / current (in primary) at the start Eventually current and flux (linkage) are constant, therefore no e.m.f.	B1 B1	**Note**: Any labels used must be clearly defined
			Total	13	

Question			Answer	Marks	Guidance
23	(a)		Any <u>two</u> from: It acts between quarks / nucleons / hadrons 'Short-range' force Repulsive below (about) 0.5 fm Attractive up to (about) 3 fm	B1×2	**Allow** any correctly named particle **Allow** any value between 0.5 fm and 5 fm
	(b)	(i)	proton = u u d or neutron = u d d	B1	
		(ii)	$d \rightarrow u + {}^{0}_{-1}e$ $+ \bar{\nu}_{(e)}$	M1 A1	**Allow** the equation expressed in words **Allow** $udd \rightarrow uud + {}^{0}_{-1}e$ **Allow** ${}^{0}_{-1}\beta$ **Not** e^- for electron **Allow** this mark if electron written as e^- or β^-
	(c)		mass (of nucleus) $\propto A$ volume (of nucleus) $\propto$ radius^3 $\propto A$ **and** clears steps using $\rho = m/V$ to show density is (about) the same	B1 B1	**Allow** mass = Am, mass = Au, etc. **Allow** r or R for radius **Allow** any sensible constant in front of the r^3
			Total	7	

Question			Answer	Marks	Guidance
24	(a)		$^{2}_{1}\mathrm{H}$ has two nucleons binding energy per nucleon = 1.1 MeV (per nucleon)	B1 B1	 **Allow** 1.76×10^{-13} J (per nucleon)
	(b)		The protons / nuclei repel each other (At high temperature) particles have more KE **and** hence can get close (enough to fuse)	B1 B1	**Not** atoms / particles **Allow** 'enough KE to get close' **Not** atoms or ions
	(c)		$E = hc/\lambda$ **and** $E = mc^2$ or $E = 2 \times mc^2$ $\lambda = \dfrac{6.63\times10^{-34}}{\mathbf{2}\times9.11\times10^{-31}\times3.0\times10^{8}}$ maximum wavelength = 1.2×10^{-12} (m)	C1 C1 A1	**Allow** $hc/\lambda = 2mc^2$ with or without the factor of 2 **Note**: The mass must be $2m_e$ to score this and the next mark **Not** de Broglie equation $\lambda = h/mv$ with speed of c; which gives 2.4×10^{-12} (m) **Allow** 2 marks for 6.6×10^{-16} (m); mass of neutron or proton used instead **Allow** the following marks for 1.02 MeV recalled: $E = 1.63 \times 10^{-13}$ (J) C1 $\lambda = \dfrac{6.63\times10^{-34}\times3.0\times10^{8}}{1.63\times10^{-13}}$ C1 maximum wavelength $= 1.2 \times 10^{-12}$ (m) A1
			Total	**7**	

Question			Answer	Marks	Guidance
25	(a)		The patient is surrounded by (gamma) detectors or Increased activity is where F-18 accumulates (AW)	B1	**Allow** 'diametrically opposite detectors'
			The positrons (from the F-18) annihilate electrons (inside the patient)	B1	
			Each annihilation produces two gamma photons travelling in opposite directions	B1	**Not** gamma rays / radiation
			The arrival times are used to locate position (of increased activity)	B1	**Allow** 'delay time'
	(b)		λ = ln2/110 or 6.3×10^{-3} (min^{-1})	C1	**Allow** 1.05×10^{-4} (s^{-1})
			$0.30 = e^{-6.3\times10^{-3}t}$		This is the same as $0.30 = e^{-1.05\times10^{-4}t}$
			$t = \dfrac{\ln(0.30)}{-6.3\times10^{-3}}$	C1	**Note**: This mark is for a **ln** expression (any subject)
			t = 190 (minutes)	A1	**Allow** 2 marks for 1.15×10^{4} (s) as the final answer
	(c)		Any sensible suggestion, e.g. 'post-code' lottery, some patients may not get the treatment because of where they live, longer waiting lists, etc.	B1	
			Total	8	

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