OCR
Oxford Cambridge and RSA

GCE

Physics A

Unit **G482**: Electrons, Waves and Photons

Advanced Subsidiary 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.

Annotations

Annotation	Meaning
BOD	Benefit of doubt given
CON	Contradiction
	Incorrect response
ECF	Error carried forward
FT	Follow through
NAQ	Not answered question
NBOD	Benefit of doubt not given
POT	Power of 10 error
^	Omission mark
RE	Rounding error ONLY APPLIED ONCE IN THE PAPER; also use as Repeated error
SF	Error in number of significant figures ONLY APPLIED ONCE IN THE PAPER
	Correct response
AE	Arithmetic error
	Wrong physics or equation
/	alternative and acceptable answers for the same marking point
(1)	Separates marking points
reject	Answers which are not worthy of credit

Annotation	Meaning
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

Subject-specific Marking Instructions

CATEGORISATION OF MARKS

The marking scheme categorises marks on the MABC scheme

B marks: These are awarded as <u>independent</u> 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 answer.

M marks: These are <u>method</u> 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 answer. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.

C marks: These are <u>compensatory</u> 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 that the candidate knew the equation, then the **C**-mark is given.

A marks: These are <u>accuracy</u> or <u>answer</u> 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 answers to 2 or more sf.
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 Guidance.
Please put a tick for every mark awarded in the body of the text at the point where the mark is given.

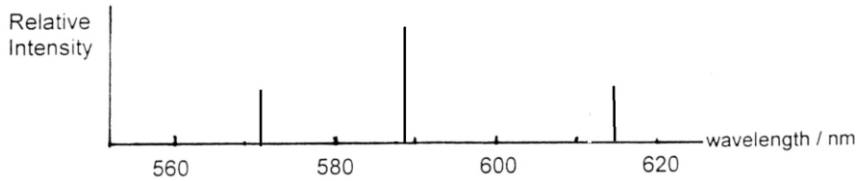
Question			Answer	M	Guidance
1					
	a	i	P = VI I = 60/230 = 0.26 (A)	C1 A1	 **allow** 0.261, etc.
		ii	R = V/I = 230/ 0.26 = 882 (Ω)	A1	**ecf ai; allow** 880 Ω to 885 Ω **or** 890 Ω
	b	i	ρ = RA/l or R = ρl/A l = 885 x 4.8 x 10^{-8}/ 7.0 x 10^{-5} ρ = 0.61 (m)	C1 C1 A1	 **ecf aii** **accept** 0.60 to 0.61
		ii	resistivity of filament is temperature dependent/ R of filament is much less/low when cold so initial I large heating effect is I^2R so more likely to melt	B1 B1 B1	**allow** resistance is proportional to temperature/AW
	c		I = P/V = 8.7/230 = 0.038 A Q = It = 0.038 x 3.0 x 3600 = 410 unit C	C1 A1 B1	**allow** 38 mA accept 408, 409 **accept** A s
	d		power difference 51.3 W power cost = 51.3 x 15 x 0.12 = £92.34 9 extra bulbs required = £9.00 so total is £101.34	C1 C1 A1	**alt** bulb £108, LED £15.66; difference; add in £9 **allow** ± 10p **accept** answer to 2 sf
			Total question 1	**15**	

Question			Answer	M	Guidance
2					
	a	**i**	$I_1 = V/R$ $I_1 = 120 / 750 = 0.16$ (A)	C1 A1	allow V = IR
		ii	$I_2 = 0.40 – 0.16$ (= 0.24) $0.24(320 + R) = 120$ $R = 180$ (Ω)	C1 A1	**ecf ai** but not if $I_2<0$ or $I_2= I_1$. **alt** $R_{tot} = 300$; $1/300 = 1/750 + 1/(320 + R)$
	b	**i**	$V_X = 0.16 \times 500 = 80.0$; $V_Y = 0.24 \times 320 = 76.8$ $V_{XY} = 3.2$ (V)	C1 A1	**ecf a; allow** 0.16 x 250 = 40; 0.24 x 180 = 43.2
		ii	I_1 is unchanged as same resistance across supply/AW I_2 increases as (branch) resistance falls (and supply p.d. is constant)/AW V_{XY} decreases as p.d. across 320 Ω increases **or** potential at Y increases (and p.d. at X is constant)	M1 M1 A1	no M mark without justification **ignore** M status of marks above if I_1 is unchanged and I_2 increases have been stated
	c	**i**	correct symbol	B1	
		ii1	$R_{200} = 575$ Ω; $R_{220} = 445$ Ω $I_{200} = 0.21$ A; $I_{220} = 0.27$ A so $\Delta I/\Delta\theta = 0.06/20$ (= 3 mA K^{-1})	C1 M1 A1	tolerance ± 5 Ω; **allow** 255 Ω and 125 Ω for 1 mark using I = 120/R **accept** answers which become 3 mA K^{-1} to 1 SF
		ii2	$\Delta V/\Delta\theta = 320\ \Delta I/\Delta\theta$ $\Delta V/\Delta\theta = 320 \times 0.003 = 0.96$ (V K^{-1})	M1 A1	$V_{Y200} = 67.2$ V with $V_{XY200} = 12.8$ V; $V_{Y220} = 86.4$ V with $V_{XY220} = -6.4$ V giving $\Delta V/\Delta\theta = 19.2/20$ **accept ecf cii1** x 320
		ii3	fsd of ammeter must be 300 mA so 1/100 of fsd change per K/AW fsd for voltmeter can be ± 10 V so 1/10 of fsd change per K/AW so measurement of V_{XY} better	 B1 B1 A0	**allow** one mark for a simpler/qualitative answer which contrasts the ability to detect a small temperature change using an ammeter or voltmeter.
		•	• **Total question 2**	**17**	

Question			Answer	M	Guidance
3					
	(a)	(i)	energy transferred from source/changed from some form to electrical energy; per unit charge (to drive charge round a complete circuit)	M1 A1	
		(ii)	(some) energy is transferred into thermal energy /lost as heat in (driving charge through) the battery/cell/supply (which behaves as if it has a resistance inside)	B1	**allow** there is a voltage drop across/decrease in voltage from the battery when a current is drawn from it/AW **or** any description which uses E = V + Ir but not just the formula alone.
	b		**1.**cell across variable resistor R ammeter in series and voltmeter in parallel across R or cell **2.** y-intercept of graph of V against I gives E **3.** the gradient of line on this graph gives the magnitude of r **4**. range of ammeter 0 to 3 (A**)** **5.** range of voltmeter 0 to 6 (V)	B1 B1 B1 B1 B1	QWC only given if marking points **2** and **3** are present **ignore** sign of gradient in determining r **allow** 0 to 5 A **or** just I_{max} = 3 A **allow** 0 to 10 V **or** just V_{max} = 6 V
	c	i	ammeter in series with lamp across terminals voltmeter in parallel with lamp	B1 B1	correct symbols must be used **allow** across lamp and ammeter
		ii	straight line through origin and 300,6 appreciation that current is the same in both components appreciation that p.d.s across components add to 6 V I = 0.16 to 0.17 (A) V = 2.7 ± 0.1 (V)	B1 B1 B1 B1 B1	if wrong line drawn **allow ecf** for rest of answer **accept** answers in terms of lines drawn on fig.3.1 **or** description of using ruler horizontally on graph and adding squares across graph,etc. **allow** 165 ± 5 x 10^{-3} (A) **or** 165 m(A) **allow** mark for consistent values of V for incorrect I
		•	• **Total question 3**	15	

Question			Answer	M	Guidance
4					
	a	i	f = 1000/0.5 f = 2000 (Hz)	C1 A1	**give** 1 mark for 2 (POT error) **allow** 2 kHz or 2 x 10^3 Hz; no SF penalty
		ii	v = fλ giving 340 = 2000 x λ λ = 0.17 (m)	C1 A1	**ecf(a)(i)**
	b		displacement/oscillation (of particles) is normal/perpendicular to direction of energy transfer in transverse wave displacement/oscillation (of particles) is parallel to direction of energy transfer in longitudinal wave	 B1 B1	**allow** vibrations **allow** direction of <u>wave</u> motion/propagation/velocity/travel **NOT** transverse wave can travel through a vacuum give max 1 mark for 2 similar poor definitions, e.g. direction of travel, waves oscillate, etc. (two such errors scores zero)
	c	i	relates to (the oscillation of) <u>two points</u> on the <u>same wave</u> how far 'out of step' one <u>oscillation</u> is from the other/AW	B1 B1	 **allow** terms like the angular separation of the oscillations
		ii	identical curve with any phase shift correct phase, i.e. y= - 2 x 10^{-6} at t = 0	M1 A1	**do not** penalise if curve is not drawn the full width of the diagram, e.g. curve starts on x-axis after 1/4 cycle
		iii	90 degrees or π/2 rad	A1	**accept** symbols for units; **allow** 91^o or 1.6 rad
	d	i	two coherent/identical waves travelling in opposite directions <u>interfere/superpose</u> to produce a resultant wave with nodes and antinodes	B1 B1	**allow** with the same speed and frequency/wavelength in place of coherent/identical
		ii	nodes (or antinodes) are λ/2 apart 0.085 (m)	B1 B1	**ecf aii** **allow** 8.5 cm, 85 mm, etc.
		iii	the path lengths from each speaker to microphone are equal the speaker connections to the signal generator cause their vibrations/oscillations to be in phase or in antiphase AW in phase will produce a maximum; in antiphase a minimum	B1 B1 B1	 **allow** rotate one loudspeaker 180^o; facing maximum, opposed minimum
			Total question 4	**18**	

Question			Answer	M	Guidance
5					
	a		travel through a vacuum **and/or** at the speed of light c **or** are caused by accelerating charges	B1	
	b		B are X-rays F are microwaves	B1 B1	if answers are reversed score 1 mark
	c	i	**1** Reflected sunbeam/light is (partially plane) polarised **2** Light transmitted by the filter will vary between max and min **3** Two max & min per rotation **4** Max with axis of transmission of filter parallel to glass plate **5** because amplitude of light in plane of glass unaffected by reflection **6** Min with axis of transmission of filter in plane of light beam **7** because amplitude of light perpendicular to plane of glass is diminished	B1 B1 B1 B1	**max** 4 marks from 7 marking points one of which (QWC) must be **4** or **6**
		ii	Polaroid sunglasses reduce glare (reflected sunlight from sea/surfaces) **or** ground acts like glass plate in Fig. 5.2 (so) axis of transmission of (lens) filter in plane of light beam **or** in direction to minimise light reaching eye from glare/reflection	B1 B1	
	d	i	UV-B is more energetic/shorter wavelength than UV-A UV-C is absorbed by the atmosphere (so does NOT reach the skin)	B1 B1	**accept** any two suitable statements **allow** one mark out of two for **A** and **C** reversed
		ii	filters out/blocks/reflects/absorbs UV(-B)	B1	**allow** chemicals prevent sunburn/skin cancer **not** stops UV penetrating skin
	e		energy = eV = $1.6 \times 10^{-19} \times 500 = 8.0 \times 10^{-17}$ J $\frac{1}{2}mv^2 = 8.0 \times 10^{-17}$ $v^2 = 1.76 \times 10^{+14}$ $v = 1.3(2) \times 10^7$ m s^{-1} $\lambda = h/mv$ $\lambda = 6.63 \times 10^{-34}/(9.11 \times 10^{-31} \times 1.3 \times 10^7)$ $= 5.5 \times 10^{-11} = 55$ (pm)	C1 C1 C1 C1 A1	**accept** $eV = p^2/2m$; $\lambda = h/p = h/\sqrt{(2meV)}$ **ecf** with incorrect (sensible) energy; e.g. not values giving v > c or very small v last mark for answer in pm, accept 56
			• **Total question 5**	**17**	

Question			Answer	M	Guidance
6					
	a		A spectrum containing only a (few) discrete wavelengths or colours	B1	**accept** some idea of discreteness, e.g. mechanism: atomic state changes, energy level changes, fingerprint of element idea
	b		 Sketch with correct positions; and relative intensities	B2	**allow** only a few nm for width of lines if not drawn as sharp vertical lines; otherwise max 1 mark. **ignore** requirement for labels
	c		$E = hc/\lambda$ + attempt to use; **or** $E_g/E_y = \lambda_y/\lambda_g$ Ratio= 589/570 = 1.03	C1 A1	 **require** at least 3 SF
	d		from left to right on diagram **G**, **R** and **Y**	B1 B1	**allow** 1 mark for only 1 correct
	e	i	$\lambda = d \sin\theta$ $615 \times 10^{-9} = 1.67 \times 10^{-6} \sin\theta$ gives $\theta = 21.61^o$ $570 \times 10^{-9} = 1.67 \times 10^{-6} \sin\theta$ gives $\theta = 19.96^o$ $\Delta\theta = 1.65^o$.	C1 C1 C1 A1	 for θ rounded to 20.0^o allow $\Delta\theta = 1.6^o$; **allow** answer to 2 SF
		ii	$n\lambda = d \sin\theta$ with $\theta = 90^o$ or $\sin\theta = 1$ $n = 1.67 \times 10^{-6} / 615 \times 10^{-9} = 2.7$ so answer is 4	C1 B1	 no marks if no working shown
	f	i	the energy of some of the photons of the sodium light are greater than the work function of the cathode (surface) any of these photons absorbed by a (surface) electron can release it from the metal (surface) photoelectrons are attracted to the positive (collector) electrode, completing the circuit /causing a current	B1 B1 B1	**alt** photon(s) absorbed by (surface) electron(s) (in metal surface); electron (can be) emitted when (photon) energy is greater than work function (**allow** symbol for w.f.); released electron(s) complete(s) circuit/AW
		ii	red light has the least <u>energy</u> as it has the longest wavelength/lowest frequency (and hence the least probability of releasing electrons)	B1 B1	**allow R** or 615 nm
			Total question 6	**18**	

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