OCR
RECOGNISING ACHIEVEMENT

GCE

Physics A

Advanced Subsidiary GCE

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

Mark Scheme for June 2012

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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.

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Annotations

Annotation	Meaning
	Benefit of doubt given
	Contradiction
	Incorrect response
	Error carried forward
	Follow through
	Not answered question
	Benefit of doubt not given
	Power of 10 error
	Omission mark
	Rounding error or repeated error
	Error in number of significant figures
	Correct response
	Arithmetic error
	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

Subject-specific Marking Instructions

CATEGORISATION OF MARKS

The marking scheme categorises marks on the MABC 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 answer.

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 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 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 that 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 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 ticks and crosses against all sub-sections marked AAA (7 in total)

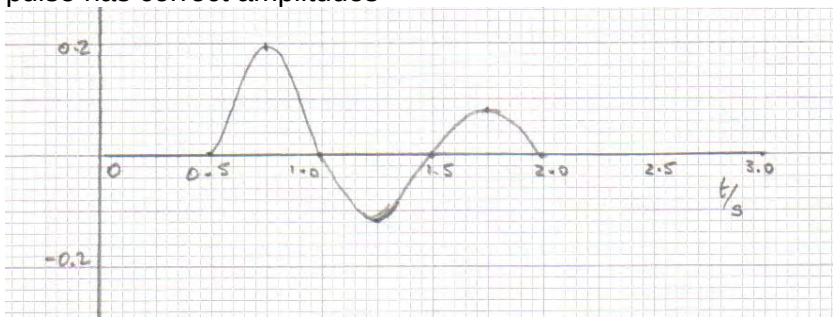
Question			Answer	Marks	Guidance
1	(a)		Work done/energy <u>transfer</u>(red) per unit time	**B1**	**accept** per second **or** rate of energy transfer / rate of doing work **or** energy transfer / time taken
	(b)	(i)	using P = VI I = 40/230 = 0.17(4) (A)	**C1** **A1**	 accept 4/23
	(b)	(ii)	R = 230/0.17 = 1400 (Ω)	**B1**	**possible ecf b(i);** expect and **accept** 1322 or 1353 Ω **accept** 40 = 230^2/R giving R = 52900/40 = 1322 Ω
	(c)		l = RA/ρ l = 1.3 x 10^3 x 3.0 x 10^{-8} /7.0 x 10^{-5} I = 0.56 (m)	**C1** **C1** **A1**	Choosing R = ρl/A substitution; **ecf b(ii)** evaluation; **allow** 0.57 m (using R = 1322 Ω) and 0.58 m (using 1353 Ω) and 0.6 m (using 1400 Ω)
A **A** **A**	(d)		larger power needs larger I so smaller R (for same V) smaller R (but same length) so larger A / thicker	**B1** **B1** **B1**	**accept** P = V^2/R **or** calculation I = 0.26 A giving R **=** 880 or 890 Ω NB if R calculated correctly here, give first 2 marks hence smaller R (but same length) so larger A / thicker
	(e)	(i)	Q = It = 0.17 x 8 x 60 x 60 Q = 4900 (C)	**C1** **A1**	**ecf b(i)** **allow** 4896; or 5000 or 5011 if using I = 0.174 A give 1 mark for 1.36 or 81.6
		(ii)1	(a unit of) <u>energy</u> equal to 3.6 MJ **or** 1 kW for 1 h/AW	**B1**	**eg** 1000 W for 3600 s or similar
		(ii)2	40 x 8 = 320 Wh / 0.32 kWh 0.32 x 22 = 7.0(4) p	**C1** **A1**	 **accept** 7 p (no SF error); allow 7000p (7040) for 1 mark
			Total	**15**	

Question			Answer	Marks	Guidance
2	(a)	(i)1	infinity	**B1**	accept symbol
	(a)	(i)2	R = 1.8/10 x 10^{-3} R =180 Ω	**C1** **A1**	0.18 Ω scores 1 mark
A **A** **A**	(a)	(ii)	resistance decreases because I increases more than V therefore since R = V/I value decreases/AW	**B1** **B1** **B1**	**accept** calculation at second value, e.g. at 2.0 R = 53 Ω, with comparison **OR** at two other values **QWC mark** for second marking point
A **A** **A**	(b)		correct symbol and direction for LED R in series with LED across XY ammeter in series voltmeter in parallel with LED only	**B1** **B1** **B1** **B1**	circle not essential, internal line optional no variable resistor
	(c)		torch; car brake/rear light/ traffic light, etc. torch: draws a lower current / light lasts longer before battery discharged/AW **or** LEDs (much) more efficient (at converting electrical energy into light)/AW **or** if one LED fails remainder still lit/AW	**M1** **A1**	suitable example **accept** any **one** sensible statement, include longer life, more durable contradictory statements score zero
			Total	**12**	

Question			Answer	Marks	Guidance
3 A A A	(a)		R <u>of thermistor</u> decreases as temperature increases supply V is constant/ <u>total</u> R is smaller current increases <u>as V = IR</u>/AW	B1 B1 B1	**accept** more free e's as temperature rises using I = nAev current increases as v decrease very small/AW
	(b)		R_{th} = 40 Ω at 240 ^{o}C (stated or used in calculation) total R in circuit = 240 Ω I = 6/240 = 0.025 A V = 200 x 0.025 = 5.0 V	B1 C1 C1 A1	**apply ecf** if wrong value of R read from graph **allow** V = (200/240)6 so V = 5.0 V **accept** 5 V (no SF error)
	(c)	(i)	correct symbol for LDR	B1	no circle required
		(ii)	R <u>of LDR</u> decreases/current in circuit increases so V increases <u>across fixed</u>/<u>200 Ω resistor</u>/AW	M1 A1	 **accept** simple potential divider argument **accept** voltmeter reading increases
			Total	10	

Question			Answer	Marks	Guidance
4	(a)		R's in parallel have same V/AW so 4.0 x 0.30 = 6.0 x 0.20	**M1** **A1**	**allow** I splits in inverse ratio to R **or** AW; hence I in 6 ohm = 4 / 6 x 0.3 = 0.2 A
	(b)	(i)	sum of/total current into a junction equals the sum of/total current out **or** total algebraic sum of currents is zero	**B1**	**allow** Kirchhoff's first law
		(ii)	0.50 (A)	**A1**	**accept** 0.5 (A) (no SF error)
	(c)		correct formula for R_p and substitution R_p = 2.4 Ω R_s = 8.0 (Ω)	**C1** **C1** **A1**	 **apply ecf** to R_p for second mark **accept** 8 (Ω) (no SF error)
	(d)	(i)	energy transferred from source/changed from some form to electrical energy; per unit charge (to drive charge round a complete circuit)	**M1** **A1**	**allow** form as e.g. light/chemical/heat **allow** energy divided by charge
		(ii)	V = IR = 0.50 x 8.0 =4.0 (V)	**A1**	**ecf b(ii),c** i.e. answer = b(ii) x c **accept** 4 (V) (no SF error)
		(iii)	E – V = Ir giving 5.0 – 4.0 = 0.50 r r = 2.0 (Ω)	**C1** **A1**	**ecf b(ii)** **accept** 2 (Ω) (no SF error); give max of 1 mark for r = 3.3 Ω , i.e. using I = 0.3 A
			Total	**12**	

Question			Answer	Marks	Guidance
5	(a)		electrons have mass, photons have zero mass electrons have charge, photons are uncharged photons travel at <u>speed of light</u>	**B1** **B1**	**max** 2 marks from 3 marking points lower speed of electrons **not** required for mark
	(b)	(i)	energy = eV = $1.6 \times 10^{-19} \times 5000 = 8.0 \times 10^{-16}$ (J)	**C1** **A1**	 **accept** 8×10^{-16} (J) (no SF error)
		(ii)	$\frac{1}{2}mv^2 = 8.0 \times 10^{-16}$ $v^2 = 1.76 \times 10^{+15}$ $v = 4.2 \times 10^{7}$ (m s^{-1})	**C1** **C1** **A1**	 evidence of calculation required
	(c)	(i)	electron wavelength depends on its speed/momentum	**B1**	**accept** de Broglie equation with labels defined
		(ii)	$\lambda = h/mv$ $\lambda = 6.63 \times 10^{-34}/(9.1 \times 10^{-31} \times 4.2 \times 10^{7})$ $= 1.7 \times 10^{-11}$ (m)	**C1** **C1** **A1**	select formula substitution; **allow** 4×10^{7} **allow** 1.8×10^{-11} (m)
	(d)		$E = hc/\lambda$ $\lambda = 6.63 \times 10^{-34} \times 3.0 \times 10^{8}/8.0 \times 10^{-16}$ $= 2.5 \times 10^{-10}$ (m)	**C1** **C1** **A1**	select equation substitute and manipulate answer 2.49×10^{-10} (m)
	(e)	(i)	photoelectric effect / emission	**B1**	
		(ii)	$KE_{max} = hf - \varphi$ or $hf = \varphi + KE_{max}$ $9.0 \times 10^{-19} - 7.2 \times 10^{-19} = 1.8 \times 10^{-19}$ (J)	**C1** **A1**	can be copied from data sheet
		(iii)	Electrons in the metal have a range of energies most require more than the w.f. energy to escape from the surface/AW	**B1** **B1**	w.f. is <u>minimum</u> energy to escape from surface /AW <u>max</u> k.e. given when w.f. subtracted from photon energy **or** photon gives all of its energy to one electron
			Total	**19**	

Question			Answer	Marks	Guidance
6	(a)	(i)	*displacement :* (any) distance moved from equilibrium of a point/particle on a wave *amplitude* maximum displacement (caused by wave motion)	**B1** **B1**	**allow** rest, zero, mean position
	(a)	(ii)	*frequency* number of wavelengths passing a point /vibrations at a point per unit time/second or produced by the wave source /AW *phase difference* between two points on the same wave/waves of the same frequency, how far through the cycle one point is compared to the other	**B1** **B1**	**allow** number of oscillations / cycles per second **accept** in one second **allow** suitable descriptions of in phase and out of phase; **or** an angular measurement of how much a wave leads or lags/AW
A **A** **A**	(b)		pulse starts at 0.5 s ends at 2.0 s pulse shape is reversed from Fig 6.1 pulse has correct amplitudes  	**B1** **B1** **B1** **B1**	 ie amplitude decreasing from L to R over 1.5s accept inversion in time axis NB if extra loops, probably only first marking point available if diagram looks like a coiled spring rather than a smooth curve, 1st, 2nd and 4th marking points are possible
			Total	**8**	

Question			Answer	Marks	Guidance
7 A A A	(a)	(i)	(atom releases energy when) electron moves from high to low level energy released is in form of a photon possible transitions are between n = 3 and n = 1, n = 3 and n = 2, n = 2 and n= 1	B1 B1 B1	can be illustrated on diagram by downward arrow connecting levels can be illustrated on diagram
	(a)	(ii)1	$\varepsilon = hc/\lambda$ $= 6.63 \times 10^{-34} \times 3.0 \times 10^{8} / 6.56 \times 10^{-7}$ $= 3.0(3) \times 10^{-19}$ (J)	 C1 A1	choosing formula and substitution answer accept 3×10^{-19} (J) (no SF error)
	(a)	(ii)2	from n = 3 to n = 2	B1	**allow** between n = 3 and n = 2 **allow** n = 2 to n = 3 or between n = 2 and n = 3 **if** there is no contradiction with answer given in 7ai
	(b)	(i)1	$d \sin \theta = \lambda \qquad d \sin 11.4^{o} = 6.56 \times 10^{-7}$ $d = 6.56 \times 10^{-7}/0.198$ $d = 3.3 \times 10^{-6}$ (m)	C1 C1 A1	choosing formula and substitution manipulation and $\sin 11.4^{o} = 0.198$
	(b)	(i)2	$1/d = 3 \times 10^{5}\ m^{-1} = 300\ mm^{-1}$	A1	**ecf b(i)1**; allow 301 or 302 as data given to 3 sig figs
	(b)	(ii)	**2** rays, one either side of normal to grating at about 8^{o}, say	B1	**accept** any sensible angle
			Total	**11**	

Question			Answer	Marks	Guidance
8	(a)		travel in a vacuum same speed (in vacuum)/at c caused by accelerating charges are (oscillating) electric and magnetic fields	B1 B1	**max** 2 marks from 4 marking points for any one incorrect property, max of 1/2 if 2 incorrect properties, score 0
	(b)		10^{-4} microwaves; 10^{-6} ir; 10^{-8} uv; 10^{-12} gamma	B1 B1	4 correct 2 marks 2 correct 1 mark
	(c)	(i)	the incident wave is reflected at the sheet to produce return wave <u>of same frequency</u>/AW reflected wave is weaker **OR** the reflected wave has travelled a greater distance	 B1 B1	**accept** incident and reflected waves are from same source/of same wavelength/AW **allow** wave amplitude decreases with distance
A A A	(c)	(ii)	reflected wave interferes/superposes with the incident wave constructive interference occurs (**or** waves add) to give maxima/AW **and** destructive interference occurs (**or** waves add) to give minima/AW detail given, e.g. waves add in phase for max/out of phase for min **or** path difference nλ for max (2n +1)/2 λ for min	B1 M1 A1	if <u>incident</u> and <u>reflected</u> waves identified in (c)(i) **accept** "the waves interfere / superpose" **QWC mark** for second marking point **accept** antinodes for maxima and nodes for minima
	(c)	(iii)	λ/4 = 7.5 mm; λ = 30 mm	B1	
	(c)	(iv)	appreciation that I is proportional to a^2 ratio = $(0.8 +0.6)^2/(0.8-0.6)^2$ = $(1.4/0.2)^2 = 7^2 = 49$	C1 C1 A1	
			NOW SCROLL DOWN TO CHECK PAGE 18 IS BLANK		
			Total	13	

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