

**Physics A**

Advanced Subsidiary GCE

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

**Mark Scheme for January 2011**

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Question		Expected Answers	M	Additional Guidance
1	a	use of $R = \rho l/A$ $= 2.4 \times 12 \times 10^{-3}/9.0 \times 10^{-6}$ $= 3.2 \times 10^3 (\Omega)$	C1 M1 A0	
	b	$V^2 = PR$ $= 0.125 \times 3.2 \times 10^3$ $V = 20(V)$	C1 M1 A0	<b>allow</b> $V = \sqrt{(0.125 \times 3.2 \times 10^3)}$ <b>allow</b> substituting $V = 20$ to prove $P = 0.125 \text{ W}$
	c	i	B1 B1	<b>do not allow</b> any reference to values of $V$ or $P$ , etc in answer
		ii	B1 B1	<b>accept</b> $P = 40^2/3.2 \text{ k} = 0.50 \text{ W}$ so $P$ per resistor = $0.50/4 = 0.125 \text{ W}$ <b>do not accept</b> $P_{\text{total}} = 0.50 \text{ W}$ without proof – scores zero
	d	i	M1 A1	<b>accept</b> figures $24 \times 10^{-3} \text{ m}$ and $36 \times 10^{-6} \text{ m}^2$ to give $1.6 \times 10^3 \Omega$
		ii	B1 M1 A1	<b>allow</b> $P = V^2/R$ ; $V_X = 2V_Y$ etc. <b>allow</b> 1 mark only for using $P = V^2/R$ or $IV$ and $V$ is larger across $X$ (i.e. not quantitative) so $X$ has larger $P$
		<b>Total question 1</b>	<b>13</b>	

Question			Expected Answers	M	Additional Guidance
2	a	i	ions	B1	
		ii	<u>positive</u> ions	B1	<b>allow</b> <u>positive</u> charges / cations
		iii	electrons	B1	
	b	i	the battery has an internal resistance/AW some of the emf is across the (internal) resistance (leaving a smaller p.d. across motor)	B1 B1	<b>accept</b> connecting leads have resistance <b>accept</b> $V = E - Ir$ or 'lost volts'/p.d. across r
		ii	use $E = V + Ir$ giving $12 = 8 + 40r$ $r = (12 - 8)/40$ <b>or</b> $4/40$ $= 0.10 \Omega$	C1 M1 M1 A0	<b>accept</b> reverse solution, $0.10 \Omega \rightarrow 8 \text{ V} \rightarrow 12 \text{ V}$ substitution and or solution showing working
		iii	$Q = It = 40 \times 1.2$ $I = 48 \text{ (C)}$	C1 A1	
	c	i	The current heats the filament The resistance/resistivity (of the metal filament) increases (with temperature).	B1 B1	no mention of temperature increase or heating scores zero
		ii	4.5 to 8 A in <u>each (parallel) arm</u> <b>or</b> 9 to 16 A for both together needs to be great enough to cover initial surge/current <b>or</b> use antisurge fuses	B1 B1	no mark if fuse value outside range
		iii	e.g. the starter motor draws 40 A so would need a bigger fuse than headlamp circuit so need different fuses for different situations <b>or</b> if battery used for starter motor with lights on will need too large a fuse – damage occurs before fuse blows/AW	B1	<b>accept</b> headlamp circuit damaged before fuse blows if 40 A fuse only used <b>or</b> fuse blows in starter circuit if 10 A used, etc.
<b>Total question 2</b>				<b>15</b>	

Question		Expected Answers	M	Additional Guidance
3				
a	i	V J C <sup>-1</sup> R V A <sup>-1</sup> P J s <sup>-1</sup> I C s <sup>-1</sup> .	B1 B1 B1	4 correct 3 marks; 2 correct 2 marks 1 correct 1 mark
b	i	using $V_{out} = R_2/(R_1 + R_2) V_{in}$ : $V_{out} = 3.6$ V $3.6 = R_2/(560 + R_2) 6$ $R_2 = 840$ ( $\Omega$ )	alt: $2.4 = I \times 560$ so $I = 4.3$ mA $3.6 = I R_2$	C1 C1 A1 <b>accept</b> $R_2 = (3.6/2.4) \times 560$ or $2.4 = 560/(560 + R_2) 6$
	ii	$I = 4.3 \times 10^{-3}$ (A)	B1	<b>accept</b> 4.3 m(A) or 3/700 (A) <b>ecf (b)(i)</b> i.e. $I = 6/(560 + R_2)$
c	i	$20 \pm 2$ ( $^{\circ}$ C)	B1	
	ii	$R_{Th}$ will fall/ resistance will fall giving greater share of supply V across fixed R/AW  causing the voltage across (fixed) R/voltmeter reading to rise	B1 B1 B1	<b>accept</b> explanation in terms of potential divider equation <b>or</b> current increases <b>or</b> current same in both resistors/resistors in series
	iii	$\Delta R$ is large for small $\Delta T$ at low temperatures/AW in terms of gradient  so thermistor is better in circuit to control low temp, refrigerator	M2 A1	<b>accept</b> sensitivity greater at low temperature <b>or</b> vice versa <b>or</b> $\Delta R$ is small for small $\Delta T$ at high temperatures scores 1 out of 2
		<b>Total question 3</b>	<b>14</b>	

Question		Expected Answers	M	Additional Guidance	
4					
	a	same frequency / period different amplitude / phase	B1 B1	<b>accept</b> wavelength / sinusoidal /AW <b>accept</b> + sine and – sine for 2 marks	
	b	because the waves have a <u>constant</u> phase relationship <b>or</b> are <u>continuous</u> and have the <u>same</u> f/period/ $\lambda$ they are coherent	M1 A1	<b>accept</b> same phase relationship for 1 mark only	
	c	use of 3 ms as period $f = 1/3.0 \times 10^{-3} = 330$ (Hz) using $v = f\lambda$ $340 = 330 \lambda$ $\lambda = 1.0(2)$ (m)	C1 A1 C1 A1	<b>ecf</b> for f possible e.g. $\lambda = 1020$ (m) <b>accept</b> 1.03 (m) <b>no</b> SF error here	
	d	i	0	B1	
		ii	1.0 ( $\mu\text{m}$ )	B1	<b>look for</b> SF error i.e. zero for 1 ( $\mu\text{m}$ )
	e	i	Intensity $\propto$ (amplitude) <sup>2</sup> so ratio is $(3/2)^2 = 9/4$ (giving 2.25 I)	C1 A1	<b>allow</b> $I \propto A^2$
		ii	resultant $A = A_S + A_T = (\pm) 1$ so ratio is $(1/2)^2$ giving 0.25 I	C1 A1	<b>ecf</b> from (d)(ii)
	f	i	phase shift of $\pi$ or $180^\circ$ required <b>or</b> movement of $\lambda/2$ $1.02/2 = 0.51$ (m)	B1 B1	<b>ecf</b> from (c); <b>accept</b> $(2n + 1)/2 \lambda$ <b>accept</b> 0.50 m
		ii	intensity increases to the maximum value	B1 B1	<b>accept</b> quantitative answers, i.e. from 0.25 I to 6.25 I
		<b>Total question 4</b>		<b>18</b>	

Question			Expected Answers	M	Additional Guidance
5					
	a	i	(sum of/total) current into a junction equals the (sum of/total) current out conservation of charge	B1 B1	total vector sum of currents is zero
		ii	(sum of) e.m.f.s = (sum /total of) p.d.s/sum of voltages in/around a (closed) loop (in a circuit) energy is conserved	B1 B1	
	b		a photon is absorbed by an electron (in a metal surface); causing electron to be emitted (from surface). Energy is conserved (in the interaction).	B1 B1 B1	<b>not</b> hits QWC mark
			Only photons with energy/frequency above the work function energy/threshold frequency will cause emission Reference to Einstein's photoelectric energy equation (energy of photon) = (work function of metal) + (maximum possible kinetic energy of emitted electron) work function energy is the <u>minimum</u> energy to release an electron from the surface Number of electrons emitted also depends on light intensity Emission is instantaneous	B1 B2 B1 B1 B1	3 marks from 6 marking points in symbols only scores 1 mark out of 2, i.e. selects from formula sheet
			<b>Total question 5</b>	<b>10</b>	

Question		Expected Answers	M	Additional Guidance
6				
	a	an eV is the <u>energy</u> acquired by an electron accelerated/moves through a p.d. of 1 V 1 eV = $1.6 \times 10^{-19}$ J	B1 B1	
	b	i	B1 B1	1 mark if write correct answers on wrong lines <b>ecf</b> for (first answer) $\times 1.6 \times 10^{-19}$ e.g. $7.68 \times 10^{-36}$ using $4.8 \times 10^{-17}$
		ii	M1 A1	<b>allow</b> 1 mark only for $v^2 = 2 \times \mathbf{b(i)}/9.1 \times 10^{-31}$ if <b>b(i)</b> incorrect <b>allow</b> $1.0 \times 10^7$ , $1 \times 10^7$ is not acceptable
	c	i	B1 B1	<b>accept</b> by being diffracted (by a crystal lattice)/AW <b>accept</b> de Broglie eqn with m,v or p defined
		ii	C1 A1	<b>allow</b> 1 mark for $3.9$ or $4.0 \times 10^{-14}$ (m) caused by subs $m_p$ for m <b>allow</b> $7.3 \times 10^{-11}$ (m)
		<b>Total question 6</b>	<b>10</b>	



Question		Expected Answers	M	Additional Guidance
<b>7</b>				
	<b>a</b>	<b>i</b> a quantum/lump/unit/packet/particle of (e-m) energy/light	B1	
		<b>ii</b> <u>all</u> wavelengths/frequencies are present (in the radiation)/AW	B1	<b>accept</b> colours
	<b>b</b>	<b>i</b> <b>1</b> infra red <b>2</b> the bulb of the lamp is <b>hot</b>	B1 B1	
		<b>ii</b> $5/100 \times 24 = 1.2 \text{ W}$ $n = 1.2/4 \times 10^{-19}$ $= 3.0 \times 10^{18}$	C1 C1 A1	<b>allow</b> 2 marks if forgotten 5% and obtain $6 \times 10^{19}$ allow $3 \times 10^{18}$ – no SF as estimate
	<b>c</b>	<b>i</b> $7^\circ$ violet/blue $12^\circ$ red	B1 B1	<b>not</b> purple
		<b>ii</b> $d = 1/3 \times 10^5 = 3.3 \times 10^{-6} \text{ m}$ $\sin \theta = \lambda/d = 5.4 \times 10^{-7}/3.3 \times 10^{-6} (= 0.162)$ $\theta = 9.3^\circ$ or $9.4^\circ$ do not accept $9^\circ$	B1 M1 A1	with $d = 3 \times 10^{-6} \text{ m}$ $\theta = 10.4^\circ$ give 2 out of 3 <b>ecf</b> incorrect value of d substituted correctly, scores 1 out of 3
		<b>Total question 7</b>	<b>12</b>	
Question		Expected Answers	M	Additional Guidance
<b>8</b>				
	<b>a</b>	<b>i</b> vertical arrow upwards from ground state to zero level or above	B1	
		<b>ii</b> $21.8 \times 10^{-19} \text{ (J)}$	B1	<b>no ecf</b> from (i); ignore sign
	<b>b</b>	<b>i</b> $E = hc/\lambda = 6.63 \times 10^{-34} \times 3.0 \times 10^8/4.9 \times 10^{-7}$ $= 4.06 \times 10^{-19} \text{ (J)}$ <b>or</b> $4.1 \times 10^{-19} \text{ (J)}$	M1 A1	<b>accept</b> use of 6.6 instead of 6.63 which can round down answer to 4.0(4)
		<b>ii</b> vertical arrow downwards between $n = 4$ to $n = 2$ levels	B1	
	<b>c</b>	some photons will be <u>absorbed</u> hydrogen atoms become excited (excited) hydrogen atoms re-emit photons the photon energy is equal to the transition <u><math>n = 1</math> to <math>n = 3</math></u>	B1 B1 B1 B2	<b>not</b> hits <b>allow</b> electron moves up energy levels <b>NB</b> full marks = lines 1 + 4 or 1 + 2 + 3
		<b>Total question 8</b>	<b>8</b>	

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