



GCE

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	$\text{use of } R = \rho l/A$ $= 2.4 \times 12 \times 10^{-3}/9.0 \times 10^{-6}$ $= 3.2 \times 10^3 (\Omega)$	C1 M1 A0	
	b	$V^2 = PR$ $= 0.125 \times 3.2 \times 10^3$ $V = 20(V)$	C1 M1 A0	allow $V = \sqrt{(0.125 \times 3.2 \times 10^3)}$ allow substituting $V = 20$ to prove $P = 0.125 \text{ W}$
	c	i	B1 B1	do not allow any reference to values of V or P , etc in answer
		ii	B1 B1	accept $P = 40^2/3.2 \text{ k} = 0.50 \text{ W}$ so P per resistor = $0.50/4 = 0.125 \text{ W}$ do not accept $P_{\text{total}} = 0.50 \text{ W}$ without proof – scores zero
	d	i	M1 A1	accept 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	allow $P = V^2/R$; $V_X = 2V_Y$ etc. allow 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
Total question 1			13	

Question			Expected Answers	M	Additional Guidance
2	a	i	ions	B1	
		ii	<u>positive</u> ions	B1	allow <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	accept connecting leads have resistance accept $V = E - Ir$ or 'lost volts'/p.d. across r
		ii	use $E = V + Ir$ giving $12 = 8 + 40r$ $r = (12 - 8)/40$ or $4/40$ $= 0.10 \Omega$	C1 M1 M1 A0	accept reverse solution, $0.10 \Omega \rightarrow 8 V \rightarrow 12 V$ substitution and or solution showing working
		iii	$Q = It = 40 \times 1.2$ $I = 48 (C)$	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> or 9 to 16 A for both together needs to be great enough to cover initial surge/current or 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 or if battery used for starter motor with lights on will need too large a fuse – damage occurs before fuse blows/AW	B1	accept headlamp circuit damaged before fuse blows if 40 A fuse only used or fuse blows in starter circuit if 10 A used, etc.
Total question 2				15	

Question		Expected Answers	M	Additional Guidance
3				
a	i	$V \quad J C^{-1}$ $R \quad V A^{-1}$ $P \quad J s^{-1}$ $I \quad C s^{-1}$	B1 B1 B1	4 correct 3 marks; 2 correct 2 marks 1 correct 1 mark
b	i	using $V_{out} = R_2/(R_1 + R_2) V_{in}$: alt: $2.4 = I \times 560$ $V_{out} = 3.6 V$ so $I = 4.3 mA$ $3.6 = R_2/(560 + R_2) 6$ $3.6 = I R_2$ $R_2 = 840 (\Omega)$	C1 C1 A1	accept $R_2 = (3.6/2.4) \times 560$ or $2.4 = 560/(560 + R_2) 6$
	ii	$I = 4.3 \times 10^{-3} (A)$	B1	accept 4.3 m(A) or 3/700 (A) ecf (b)(i) 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	accept explanation in terms of potential divider equation or current increases or current same in both resistors/resistors in series
	iii	ΔR is large for small ΔT at low temperatures/AW in terms of gradient so thermistor is better in circuit to control low temp, refrigerator	M2 A1	accept sensitivity greater at low temperature or vice versa or ΔR is small for small ΔT at high temperatures scores 1 out of 2
Total question 3			14	

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

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	not 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
			Total question 5	10	

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 = 1.6×10^{-19} J	B1 B1	
	b	i 300 (eV) 4.8×10^{-17} (J)	B1 B1	1 mark if write correct answers on wrong lines ecf for (first answer) $\times 1.6 \times 10^{-19}$ e.g. 7.68×10^{-36} using 4.8×10^{-17}
		ii $\frac{1}{2}mv^2 = 4.8 \times 10^{-17} \Rightarrow v^2 = 9.6 \times 10^{-17} / 9.1 \times 10^{-31} (= 1.06 \times 10^{14})$ $v = 1.03 \times 10^7$ (m s ⁻¹)	M1 A1	allow 1 mark only for $v^2 = 2 \times \mathbf{b(i)} / 9.1 \times 10^{-31}$ if b(i) incorrect allow 1.0×10^7 , 1×10^7 is not acceptable
	c	i Electrons are observed to behave as waves/show wavelike properties where the electron wavelength depends on its speed/momentum	B1 B1	accept by being diffracted (by a crystal lattice)/AW accept de Broglie eqn with m,v or p defined
		ii $\lambda = h/mv = 6.63 \times 10^{-34} / (9.1 \times 10^{-31} \times 1.03 \times 10^7)$ $= 7.1 \times 10^{-11}$ (m)	C1 A1	allow 1 mark for 3.9 or 4.0×10^{-14} (m) caused by subs m_p for m allow 7.3×10^{-11} (m)
		Total question 6	10	

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

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