RECOGNISING ACHIEVEMENT

GCE

Physics A

Advanced Subsidiary GCE

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

Mark Scheme for January 2011

Oxford Cambridge and RSA Examinations

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Question			Expected Answers	M	Additional Guidance
1	**a**		use of $R = \rho l/A$ $= 2.4 \times 12 \times 10^{-3}/9.0 \times 10^{-6}$ $= 3.2 \times 10^{3}$ (Ω)	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 W
	c	**i**	adding resistors in series and then in parallel to show that total resistance is 3.2 kΩ	B1 B1	**do not allow** any reference to values of V or P, etc in answer
		ii	p.d across each resistor is 20 V so power dissipated is 0.125 W	B1 B1	**accept** $P = 40^2/3.2\text{ k} = 0.50$ W so P per resistor = 0.50/4 = 0.125 W **do not accept** P_{total} = 0.50 W without proof – scores zero
	d	**i**	using $R_X = \rho l/A$; $A \rightarrow 4A$ and $l \rightarrow 2l$ $R_Y = \rho 2l/4A = \rho l/2A = R_X/2$	M1 A1	**accept** figures 24×10^{-3} m and 36×10^{-6} m^2 to give 1.6×10^{3} Ω
		ii	same current in X and Y (as in series) power dissipated is I^2R **or** IV where $V_X = 2V_Y$ so X has larger P (dissipation)	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	positive ions	B1	**allow** positive 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 Ω	C1 M1 M1 A0	**accept** reverse solution, 0.10 Ω → 8 V→ 12 V substitution and or solution showing working
		iii	Q = It = 40 x 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 each (parallel) arm **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 J C^{-1} R V A^{-1} P J s^{-1} I 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 x 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 (Ω)	C1 C1 A1	 **accept** R_2 = (3.6/2.4) x 560 or .2.4 = 560/(560 + R_2) 6
		ii	I = 4.3 x 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 ± 2 (^{o}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. λ = 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 α $(\text{amplitude})^2$ so ratio is $(3/2)^2 = 9/4$ (giving 2.25 I)	C1 A1	**allow** $I \alpha A^2$
		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^o required **or** movement of λ/2 1.02/2 = 0.51 (m)	B1 B1	**ecf** from **(c); accept** (2n + 1)/2 λ **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) x 1.6×10^{-19} e.g. 7.68×10^{-36} using 4.8×10^{-17}
		ii	$½mv^2 = 4.8 \times 10^{-17} \Rightarrow v^2 = 9.6 \times 10^{-17} / 9.1 \times 10^{-31}$ (= 1.06×10^{14}) $v = 1.03 \times 10^7$ (m s^{-1})	M1 A1	**allow** 1 mark only for v^2 = 2 x **b(i)**/ 9.1×10^{-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 x 24 = 1.2 W n = 1.2/4 x 10^{-19} = 3.0 x 10^{18}	C1 C1 A1	**allow** 2 marks if forgotten 5% and obtain 6 x 10^{19} allow 3 x 10^{18} – no SF as estimate
	c	**i**	7^{o} violet/blue 12^{o} red	B1 B1	**not** purple
		ii	d = 1/3 x 10^{5} = 3.3 x 10^{-6} m sin θ = λ/d = 5.4 x 10^{-7}/3.3 x 10^{-6} (= 0.162) θ = 9.3^{o} or 9.4^{o} do not accept 9^{o}	B1 M1 A1	with d = 3 x 10^{-6} m θ = 10.4^{o} 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 x 10^{-19} (J)	B1	**no ecf** from (i); ignore sign
	b	**i**	E = hc/ λ = 6.63 x 10^{-34} x 3.0 x 10^{8}/4.9 x 10^{-7} = 4.06 x 10^{-19} (J) **or** 4.1 x 10^{-19} (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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