OCR
RECOGNISING ACHIEVEMENT

GCE

Physics A

Advanced Subsidiary GCE

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

Mark Scheme for January 2011

Oxford Cambridge and RSA Examinations

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of pupils of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, OCR Nationals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

It is also responsible for developing new specifications to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support which keep pace with the changing needs of today's society.

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.

Any enquiries about publications should be addressed to:

OCR Publications
PO Box 5050
Annesley
NOTTINGHAM
NG15 0DL

Telephone: 0870 770 6622
Facsimile: 01223 552610
E-mail: publications@ocr.org.uk

Question			Expected Answers	M	Additional Guidance
1	a		use of R = ρl/A = 2.4 x 12 x 10^{-3}/9.0 x 10^{-6} = 3.2 x 10^{3} (Ω)	C1 M1 A0	
	b		V^2 = PR = 0.125 x 3.2 x 10^{3} V = 20(V)	C1 M1 A0	**allow** V = √(0.125 x 3.2 x 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 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 = ρl/A; A → 4A and l → 2l R_Y = ρ2l/4A = ρl/2A = R_X/2	M1 A1	**accept** figures 24 x 10^{-3} m and 36 x 10^{-6} m^2 to give 1.6 x 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
		ii i	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 (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° 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 $v^2 = 2 \times$ **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	all 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 absorbed hydrogen atoms become excited (excited) hydrogen atoms re-emit photons the photon energy is equal to the transition n = 1 to n = 3	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**	

OCR (Oxford Cambridge and RSA Examinations)
1 Hills Road
Cambridge
CB1 2EU

OCR Customer Contact Centre

14 – 19 Qualifications (General)
Telephone: 01223 553998
Facsimile: 01223 552627
Email: general.qualifications@ocr.org.uk

www.ocr.org.uk

For staff training purposes and as part of our quality assurance programme your call may be recorded or monitored

Oxford Cambridge and RSA Examinations
is a Company Limited by Guarantee
Registered in England
Registered Office; 1 Hills Road, Cambridge, CB1 2EU
Registered Company Number: 3484466
OCR is an exempt Charity

OCR (Oxford Cambridge and RSA Examinations)
Head office
Telephone: 01223 552552
Facsimile: 01223 552553