OCR
RECOGNISING ACHIEVEMENT

GCE

Physics A

Advanced Subsidiary GCE

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

Mark Scheme for January 2012

Oxford Cambridge and RSA Examinations

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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 available in SCORIS

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 ONLY APPLIED ONCE IN THE PAPER; also use as Repeated error
	Error in number of significant figures ONLY APPLIED ONCE IN THE PAPER
	Correct response
	Arithmetic error
	Wrong physics or equation
/	alternative and acceptable answers for the same marking point
(1)	Separates marking points
reject	Answers which are not worthy of credit

Annotations in detailed mark schemes

Annotation	Meaning
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.

Question			Answer	Marks	Guidance
1	(a)		resistivity = resistance x area (of cross-section)/length	B1	**accept** equation with *resistance* as subject **allow** *over* for divide by; do **NOT** allow formula with a word for each symbol
	(b)	(i)	$R = \rho l/A = 1.7 \times 10^{-8} / 6.4 \times 10^{-3}$ $= 2.7 \times 10^{-6}$ (Ω)	C1 A1	**accept** 2.66×10^{-6} (Ω)
		(ii)	$P = I^2R$ $= 8000^2 \times 2.7 \times 10^{-6}$ = 170 W	C1 C1 A1	select formula**;** can use P = VI & V = IR **ecf b(i)** 173 (2.7), 170 (2.66)
		(iii)	170 x 9.0 = 1530 W **or** 170 x 24 = 4080 W 1.5 x 24 = 36 (kW h) 4.08 x 9 = 36.7 (kWh)	B1 B1	**ecf b(ii)**; 1 mark for X 9 **or** 1 mark for X 24
		(iv)	36 x 15 = 540 p	B1	**ecf b(iii)** 551(36.7), 555 (37)
	(c)		I = nAev $8000 = 8.4 \times 10^{28} \times 6.4 \times 10^{-3} \times 1.6 \times 10^{-19} v$ $v = 9.3 \times 10^{-5}$ (m s^{-1})	C1 C1 A1	select formula correct substitution
			Total	**12**	

			Answer	Marks	Guidance
2	(a)	(i)1	360 (Ω)	B1	
		(i)2	Current	B1	**not** symbol only; **not** unit only
		(ii)1	1/10 + 1/20 + 1/40 = 1/R R = 5.7 (Ω)	C1 A1	1/R = 0.175 **accept** 40/7
		(ii)2	potential difference	B1	**accept** p.d. or voltage **not** e.m.f.; **not** symbol only; **not** unit only
	(b)	(i)	**p.d./voltage must be proportional to current** as long as temperature and/or (other) physical conditions remain constant **R** line is straight and <u>through the origin</u>	**M1** A1 B1	symbols may be used but must be defined
		(ii)1	(same current so) at 0.6 A have 4.5 V + 4.5 V (=9.0 V)	B1 B1	**accept** resistors in series (so V's add); i.e recognise that at 0.6 A each component has 4.5 V across it.
		(ii)2	add currents so at 3.0 V have 0.2 A + 0.4 A = 0.6 A	B1 B1	**accept** attempt to add currents for 1 mark (i.e. method mark)
		(iii)	thermistor heats up/temperature increases resistance (of thermistor/circuit) decreases (so current rises) temperature/resistance becomes constant (after 2 s) because thermal equilibrium reached	B1 B1 B1 B1	**max** 3 marks **accept** thermal energy frees more charge carriers/AW **accept** energy/power/heat in/generated = energy/power/heat out/lost
			Total	**15**	

Question			Answer	Marks	Guidance
3	(a)	(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 energy divided by charge
		(ii)	any source has an internal resistance where energy is transferred into thermal energy /lost as heat	B1 B1	 there will be 'lost' volts (across the cell when a current is drawn) **or** V = E – Ir explained
	(b)	(i)	V = IR 1.2 = 0.2 R R = 6.0 Ω	C1 A1	substitution needed to score mark **allow** 6 Ω
		(ii)	1.6 – 1.2 = 0.4 = 0.2 r r = 2.0 Ω	C1 A1	 **allow** 2 Ω
	(c)	(i)1	Q = It = 0.20 x 3600 x 1.5 =1100 correct unit,	C1 A1 B1	substitution needed to score mark 1080 **allow** 1 mark max for 0.3 or 18 **allow** C, kC, A s **exception** 0.3 A h or 18 A min scores 3 marks
		(i)2	energy = QV = 1100 x 1.2 **or** $I^2Rt = 0.2^2$ x 6 x5400 = 1320 (J)	C1 A1	**ecf (c)(i)1** substitution needed to score mark 1296(1080) **allow** 1 mark for 1728 (using 1.6)
		(ii)	I is constant for about 9 to 10 hours because internal resistance remains constant/cell operates at constant emf I falls rapidly/towards zero over last hour or so because cell's/chemical energy is used up (so E falls)	B1 B1 B1 B1	QWC must have link between observation and reason to score full marks **accept** r of cell increases causing fall in V or I
			Total	**17**	

Question			Answer	Marks	Guidance
4	(a)		**is a transfer of energy** as a result of oscillations (of the source/medium/particles through which energy is travelling)	**M1** A1	**allow** carries **allow** information **accept** without the transfer of the medium/particles/matter
	(b)		displacement/oscillation (of particles) is normal/perpendicular to direction of energy transfer in transverse wave displacement/oscillation (of particles) is parallel to direction of energy transfer in longitudinal wave	B1 B1	**allow** vibrations **allow** to direction of <u>wave</u> motion/propagation/velocity/travel **NOT** transverse wave can travel through a vacuum give max 1 mark for 2 similar poor definitions, e.g. direction of travel, waves oscillate, etc. (two such errors scores zero)
	(c)	(i)	wavefronts/paths spread out after passing through a gap or around an obstacle/AW	B1	**NOT** wave changes direction
		(ii)	use a slit/hole/ barrier width of gap/position beyond barrier comparable to wavelength microphone/observer's ear suitably placed sound detected/heard outside 'geometrical shadow' region (showing diffraction)	B1 B1 B1 B1	**accept** doorway/end of wall **accept** position of detector beyond doorway **N.B.** good diagram can illustrate first 3 marking points **allow** 'hears sound' in suitable context only observation mark which is QWC mark must be in words 2 marks max for double slit experiment(1^{st} and 3^{rd} m.p.)
	(d)	(i)	$v = f\lambda$ giving $340 = 1200 \times \lambda$ $\lambda = 0.28$ (m)	C1 A1	substitution needed to score mark POT error for using 1.2 kHz giving 280 m **N.B.** $\lambda = 0.3$ SF error (remember apply only once)
		(ii)	waves superpose/interfere at points along **PQ** (constructively and destructively) path difference from sources of nλ for maximum/loud sound/intensity path difference of $(2n + 1)\lambda/2$ for minimum/quiet sound/intensity	B1 B1 B1	**max** 2/3 for writing phase difference is nλ or path difference is 2π i.e. mixing path and phase consistently through answer **allow** waves arrive in phase (0, 2π, 360^o, etc) **allow** waves arrive in anti-phase (π, 180^o, etc) **do not allow** waves arrive out of phase **or** answers in terms of peaks and troughs for 2^{nd} and 3^{rd} marks
		(iii)	$a = \lambda D/x$ giving $a = 0.28 \times 3.0/0.50$ $a = 1.7$ m	C1 A1	**ecf (d)(i)** substitution needed to score mark
		(iv)	intensity of sound (at maxima) unchanged/AW <u>positions</u> of maxima and minima <u>reversed</u>/AW	B1 B1	**allow** volume or amplitude
			Total	**18**	

Question			Answer	Marks	Guidance
5	(a)		energy is trapped in pockets/ where the shape or energy does not move along/energy is stored/AW there are nodes/positions of zero amplitude/motion there are positions where there is max. amplitude/antinodes different/adjacent points have different amplitudes/AW all points between nodes in phase/all points in adjacent λ/2's in anti-phase/AW	B1 B1 B1 B1 B1	**accept** any **two** sensible but different features **allow** there are nodes and antinodes as 1 marking point **penalise** displacement for amplitude once only
	(b)		incident wave is reflected (at the fixed end of the string) and the reflected wave (or it) interferes/superposes with the incident wave (to produce the stationary wave)	B1 B1	
	(c)	(i)	**points which are the same distance from the nodes will have the same amplitude** so **Y** (has the same amplitude as **X**)	**M1** A1	**N.B**. some will add **Z** stating it is the same distance from the node – these candidates can score the first mark
		(ii)	**all points on the string oscillate with the same frequency** so **Y** and **Z** (have the same f as **X**)	**M1** A1	
		(iii)	**all points in alternate segments of the string oscillate in phase/AW** so **Z** (is in phase with **X**)	**M1** A1	**accept** e.g. have positive displacement at the same time
			Total	**10**	

Question			Answer	Marks	Guidance
6	(a)	(i)	gamma rays, u.v., visible/light, i.r., microwaves	B1	**two** out of five needed for mark
		(ii)	*similarity*: travel in a vacuum/same speed (in vacuum)/at c/transverse (wave)/can be polarised/caused by accelerating charges/are oscillating electric and magnetic fields	B1	any **one** for mark **NOT** can be reflected/refracted/diffracted/interfere,etc.
			difference: different λ, f, (photon) energy	B1	any **one** for mark
		(iii)	wavelength of X-rays is close to atomic spacing/AW **or** wavelength of radio waves many/million times the atomic separation	B1	
			maximum/significant diffraction occurs when radiation wavelength ~ spacing (between diffracting planes) within material	B1	
	(b)		**advantage** produces vitamin D (in skin cells) **disadvantage** damage DNA/cause cancer/sunburn, etc.	B1 B1	**allow** any sensible use, e.g. sterilise equipment, forensic science, disco lighting, etc. **NOT** tanning, photosynthesis
	(c)	(i)	2×10^{-10} m	B1	
		(ii)	$E = hc/\lambda$ $= 6.63 \times 10^{-34} \times 3.0 \times 10^{8}/2 \times 10^{-10}$ $= 9.9(5) \times 10^{-16}$ number = 1×10^{9}	C1 C1 A1 B1	Select equation and attempt to apply it **ecf (c)(i)** accept 1×10^{-15}, i.e 1 SF mark scored for 1×10^{-6}/value of E
	(d)	(i)	diode symbol all three components in series	B1 B1	**allow** LED symbol; basic requirement is triangle along wire direction with bar, with or without circle and line through **ecf** for diode symbol
		(ii)	maximum ammeter reading when aerials in line/parallel zero signal/current when aerials at 90^{o} to each other at 180^{o} same signal/ammeter reading as at 0^{o} quoting $I = I_o\cos^2\theta$ to indicate variation through 180^{0}	B1 B1 B1 B1	**accept** ammeter reading falls as aerial is rotated **accept** minimum **allow** full marks for answers in terms of only ammeter reading or signal strength max 3 out of 4 marking points
			Total	**17**	

Question			Answer	Marks	Guidance
7	(a)	(i)	photoelectric effect (experiment) **or** (discrete) counting of gamma rays **or** Compton effect	B1	**NOT** the gold leaf/ the zinc plate experiment, etc.
		(ii)	Young's slits (experiment)	B1	**accept** any interference/diffraction experiment, e.g. using a diffraction grating, a double slit experiment, etc.
	(b)	(i)	φ is the minimum energy required to release an electron from the metal/surface	B1	**allow** escape from
		(ii)	$KE_{max} = hf - \varphi$ or $hf = \varphi + KE_{max}$ **the straight line equation is y = mx + c (where m is the gradient and c the y-intercept)** hence giving c = (-) φ and m = h	B1 **M1** A1	can be copied from the data sheet
		(iii)1	**h = 32 x 10^{-20}/5 x 10^{14} or 40 x 10^{-20}/6.25 x 10^{14} or 20 x 10^{-20}/3 x 10^{14} etc** = 6.4 x 10^{-34} (J s)	**M1** A1	any sensible attempt at gradient gains 1 mark check that answer is consistent with figures and not just quoted, e.g. 6.7 for third set of data above
		(iii)2	8.75 ± 0.25 x 10^{14} (Hz)	B1	tolerance is to within the grid square **N.B**. SF applies i.e answer must be 9.0 NOT 9
		(iii)3	φ = 6.4 x 10^{-34} x 8.75 x 10^{14} = 5.6 x 10^{-19} (J)	C1 A1	**ecf (b)(iii)1,2 or ecf b(iii) 2** x 6.6(3) x 10^{-34} ans = **1** x **2**; 5.8 x 10^{-19} (J) if use h = 6.6 x 10^{-34} **allow** use of $\varphi = hf - KE_{max}$ at (15,40) for example
			Total	**11**	

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