G482 Electrons, Waves and Photons

CATEGORISATION OF MARKS

The marking schemes categorise marks on the MACB 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 answers.

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 answers. 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 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			Expected Answers	Marks	Additional Guidance
1	(a)		resistance = p.d./current	B1	**accept** voltage instead of p.d.; ratio of voltage to current; voltage per (unit) current **not** R = V/I or p.d. = current x resistance or p.d. per amp or answer in units or voltage over current
	(b)	(i)	6 V	B1	
		(ii)	R = V/I = 6/0.25 = 24 (Ω)	C1 A1	**ecf (b)(i)** 240 V gives 960 Ω **award** 0.024 Ω 1 mark only (POT error)
	(c)	(i)	6 V supply with potential divider 'input' across it and lamp across p.d. 'output' ammeter in series with lamp voltmeter across lamp	B1 B1 B1	**accept** 0 – 6 V variable supply with lamp across it **not** variable R in series with supply circuit with no battery present can only score voltmeter mark
		(ii)	non-zero intercept line indicating increasing value of R with current	B1 B1	curve must reach y-axis **accept** straight line or upward curve
		(iii)	resistivity/resistance of filament wire increases with temperature the temperature of the lamp increases with current/voltage increase more frequent electron-ion/atom collisions/AW increased ion vibrations	B1 B1	**accept** any two of the four statements **accept** AW, e.g the lamp heats up because of the current
	(d)	(i)	lamps do not light	B1	**ignore** reasons unless too contrary
			remaining lamps are lit with qualification	B1	qualification could be more dimly or sensible explanation
		(ii)	using resistors in parallel formula to obtain a value of R per unit R per unit = 19.4 Ω or R total = 774 Ω I = 6/19.4 or 240/774 = 0.31 A	C1 C1 A1	eg takes R of bulb = 10 Ω giving R per unit = 9.1 Ω gains first mark only **ecf (b)(i)(ii)** **accept** R of resistors = 4000 Ω; current in chain = 0.06 A; total current = 0.06 + 0.25 = 0.31 A 0.3 A is SF error so gains 2 marks only apply **SF error only once** in paper
			Total question 1	**16**	

Question			Expected Answers	Marks	Additional Guidance
2	**(a)**		$E = I(R + r)$	B1	
	(b)	**(i) 1**	0.80 Ω	B1	
		2	6.4 V	B1	
		(ii)	(sum of) e.m.f.s = sum /total of p.d.s/sum of voltages (in a loop)	B1	
		(iii)	$6.4 = 0.80I$ $I = 8.0$ A	C1 A1	**can be 2 ecf** from **(b)(i),** eg 21.6/0.8 = 27 A (1 ecf) or 21.8/0.68 = 31.8 A (2 ecf)
	(c)	**(i)**	$Q = It = 2.5 \times 6 \times 60 \times 60$ $= 54000$ (C)	C1 A1	**allow** 1 mark if forgets one or two 60's giving 900 C or 15 C
		(ii)	energy = $QE = 54000 \times 14$ $= 756000$ (J)	C1 A1	**allow** (use of 12 V gives) 648000 J for 1 mark
		(iii)	energy loss = $I^2Rt = VIt = 2 \times 2.5 \times 6.0 \times 60 \times 60 = 108000$ J percentage = (108000/756000) x 100 = 14%	C1 A1	**accept** $Q\Delta V = 54000 \times 2.0 = 108000$ J **accept** $Q\Delta V/QE = 2.0/14.0 = 14\%$ **not** 756000/54000 = 14%
			Total question 2	**12**	

Question			Expected Answers	Marks	Additional Guidance
3	(a)	(i)	I = V/R = 8.0/200 I = 0.040 (A)	C1 A1	
		(ii)	V = 24 – 8 = 16 (V)	B1	
		(iii)	R = 16/0.04 giving R = 400 (Ω)	C1 A1	**accept** ratio of p.d.s to ratio of Rs **ecf** from **(i)** & **(ii)** ie **(a)(ii)/(a)(i)**
		(iv)	$P = VI = I^2R = V^2/R$ P = 0.640 (W)	C1 A1	**ecf** from **(i)** & **(ii)** **accept** 640 mW
	(b)	(i)	the thermistor has heated up/ its temperature has increased so its resistance has dropped so the ratio of the voltages across the potential divider changes/AW	B1 M1 A1	 **accept** so the current increases **accept** so IR of fixed resistor increases
		(ii)	voltages are equal so resistances are equal	B1	
	(c)	(ii)	straight line through origin labelled R passing through 0.06,12	B1 B1	**allow** correct lines with no labels
		(ii)	upward curve below straight line through origin labelled T passing through 0.06,12	B1 B1	
			Total question 3	**15**	

Question			Expected Answers	Marks	Additional Guidance
4	(a)	(i)	diffraction or refraction or superposition or interference	B2	**accept** any two from the four listed
		(ii)	only transverse waves can be polarised	B1	**accept** sound is a longitudinal wave or e-m waves are transverse
		(iii)	place transmitter and receiver facing each other	B1	**accept** from diagram **allow** (metal) grille/polarising filter to polarise microwaves
			rotate either transmitter or receiver through 90^o about axis joining aerials **or** use two polarising filters and rotate from parallel to crossed	B1	**accept** place (metal) grille/polarising filter [**not** Polaroid] between transmitter and receiver and rotate through 90^o
			observe signal fall to zero/minimum from initial high value on meter monitoring output of receiver	B1	
			explanation of observations/link between observations and polarisation	B1	QWC mark
	(b)	(i) 1	0.3 (mm)	B1	tolerance ±0.02 mm ie 0.28 – 0.32 (mm)
		2	T = 4.0 ms	C1	
			F = 1/T = 250 (Hz)	A1	**allow** 0.25 Hz or any other POT error for 1 mark
		(ii)	realisation that intensity is proportional to $(\text{amplitude})^2$	B1	
			giving amplitude increase by $\sqrt{2}$, ie4(.2) mm	B1	
			sine wave of same frequency with any increased amplitude	B1	
		(iii)	microphone (to transfer mechanical motion to electrical signal/voltage)	B1	
			oscilloscope to display oscillation/wave for measurement (of period)/AW	B1	**accept** computer/datalogger/frequency meter with qualification as for oscilloscope
			Total question 4	**15**	

Question			Expected Answers	Marks	Additional Guidance
5	(a)	(i)	node occurs where the amplitude/displacement is (always) zero	B1	**accept** displacement for amplitude for **(i)** only
		(ii)	antinode occurs where the amplitude (of the standing wave) takes the maximum (possible) value	B1	
	(b)	(i)	wave travels to end and is reflected	B1	
			reflected wave <u>interferes/superposes</u> with incident wave	B1	**accept** 2 waves of same f travelling in opposite directions <u>interfere</u> with no reference to reflection
			always destructively at certain points to produce nodes **or** always constructively at certain points to produce antinodes	B1	
		(ii)	A and N points labelled correctly	B1	
		(iii)	3	B1	
		(iv)	30 cm = $\lambda/2$ or λ = 60 cm	C1	**allow** 1 mark for correct calculation using $v = f\lambda$ with wrong wavelength if method/reasoning clear
			$v = f\lambda = 120 \times 0.6$	C1	
			$v = 72$ (m s^{-1})	A1	
	(c)		v = 2k becomes v = 3k (k = 36)	B1	**accept** v increases by 3/2 or v = 108 m s^{-1}
			wavelength increases by 3/2 (as frequency unchanged)	B1	**accept** wavelength becomes 90 cm
			2 half wavelengths fit on the string so standing wave is set up/AW	B1	**allow ecf** correct conclusion with wrong λ
			Total question 5	**13**	

Question			Expected Answers	Marks	Additional Guidance
6	(a)	(i)	line spacing d = 1/(300 x 1000) (= 3.3×10^{-6} (m))	B1	look for clear reasoning to award mark
		(ii)	sin θ = λ/d = $6.3 \times 10^{-7}/3.3 \times 10^{-6} = 0.19$ θ = 11 degrees	C1 C1 A1	 rounding error of 0.2 here gives 11.9^{o} 11.9^{o} gets 2 marks
		(iii)	spots can be seen where n = d sin θ/λ maximum n when sin θ = 1 (giving n = 5.3) so n =5 can be seen thus 5 spots on either side of straight through + straight through = 11	B1 B1 B1	**accept** basic idea of orders for first mark N.B. calculation not necessary
	(b)	(i)	ε = hc/λ = $6.6 \times 10^{-34} \times 3.0 \times 10^{8}/6.3 \times 10^{-7}$ = 3.14×10^{-19} (J)	C1 A1	 **accept** 3.2×10^{-19} (J)
		(ii)	$5.0 \times 10^{-4}/3.14 \times 10^{-19}$ = 1.6×10^{15}	C1 A1	**ecf** from **b(i)1**
	(c)	(i)	Electrons behave as waves/have a wavelength diffraction observable because gaps/atoms are similar to wavelength of electrons regular pattern of atoms acts as a grating allowing constructive interference to produce pattern on screen/AW rings occur because atomic 'crystals' at all possible orientations to beam/AW	B1 B1 B1 B1 B1	max 2 out of next 4 marking points **can** gain first 'waves' mark here as well as second mark if first line not written explicitly
		(ii) **1**	λ = h/mv = $6.63 \times 10^{-34}/9.1 \times 10^{-31}$v v = $6.63 \times 10^{-34}/9.1 \times 10^{-31} \times 5.0 \times 10^{-11}$ v = 1.5×10^{7} (m s^{-1})	C1 A1	 using 6.6 instead of 6.63 gives 1.45×10^{7}
		2	½mv^2 = eV ½ x $9.1 \times 10^{-31} \times 2.25 \times 10^{14} = 1.6 \times 10^{-19}$V V = 6.4×10^{2} (V)	C1 C1 A1	 using v =1.45×10^{7} gives 600 V
			Total question 6	**19**	

Question			Expected Answers	Marks	Additional Guidance
7	a		A (clean) zinc plate mounted on the cap of a gold-leaf electroscope. Plate initially charged negatively A u-v lamp shining on plate The gold leaf collapses as the charge leaks away from the plate (when ultra-violet light is incident on the zinc plate) so experiment indicates the emission of negative charge/electrons	B1 B1 B1 B1 B1	first 3 marks can be awarded from diagram or description QWC mark
		Or	A simple photocell, eg two plates in a vacuum envelope A (12 V) dc supply is connected to the photocell and (nano)ammeter. A suitable frequency/u-v lamp shining on one plate The presence of u-v /blue light causes a current in the circuit. so experiment indicates the emission of negative charge/electrons	B1 B1 B1 B1 B1	**accept** photocell made of clean magnesium ribbon surrounded by fine copper gauze first 3 marks can be awarded from diagram or description **ignore** polarity of supply QWC mark
		Or	A (potassium) photocell connected across a (high impedance) voltmeter. Incident light of different frequencies; produced either by white light source and colour filters of known spectral range or by using a diffraction grating or prism to produce a first order spectrum. Different p.d.s are set up across the electrodes of the photocell (when the photocathode is illuminated with light of different frequencies). so experiment indicates the emission of negative charge	B1 B1 B1 B1 B1	first 3 marks can be awarded from diagram or description QWC mark
	b		Individual photons are absorbed by individual electrons in the metal surface. These electrons must have absorbed sufficient energy to overcome the work function energy of the metal/to reach the minimum energy to release an electron from the surface **or** only photons with energies above the work function energy will cause photoelectron emission Concept of instantaneous emission Number of electrons emitted also depends on light intensity Einstein's photoelectric energy equation in symbols with symbols explained, ie (energy of photon) = (work function of metal) + (maximum possible kinetic energy of emitted electron)	 B1 B1 B1 B1 B1 B1	**stop marking after the first five marking points, ie ticks and crosses** **not** photons are absorbed by electrons; 1 to 1 relationship must be implied **accept** definition of work function energy **accept** shorter λ/higher f photon causes higher (kinetic) energy electron **accept** full word equation without symbols for 2 marks maximum 5 marks
			Total question 7	**10**	