

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 2 0.80 Ω 6.4 V	B1 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 x 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 = $(108000/756000) \times 100 = 14\%$	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	
		(iii)	place transmitter and receiver facing each other	B1	accept from diagram allow (metal) grille/polarising filter to polarise microwaves accept place (metal) grille/polarising filter [not Polaroid] between transmitter and receiver and rotate through 90° QWC mark
			rotate either transmitter or receiver through 90° about axis joining aerials or use two polarising filters and rotate from parallel to crossed	B1	
			observe signal fall to zero/minimum from initial high value on meter monitoring output of receiver explanation of observations/link between observations and polarisation	B1 B1	
	(b)	(i) 1	0.3 (mm)	B1	
		2	T = 4.0 ms F = 1/T = 250 (Hz)	C1 A1	allow 0.25 Hz or any other POT error for 1 mark
		(ii)	realisation that intensity is proportional to (amplitude) ² giving amplitude increase by $\sqrt{2}$, ie 4(.2) mm sine wave of same frequency with any increased amplitude	B1 B1 B1	
		(iii)	microphone (to transfer mechanical motion to electrical signal/voltage) oscilloscope to display oscillation/wave for measurement (of period)/AW	B1 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 reflected wave <u>interferes/superposes</u> with incident wave	B1 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 $\lambda = 60$ 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	
			$v = 72 \text{ (m s}^{-1}\text{)}$	A1	
	(c)		$v = 2k$ becomes $v = 3k$ ($k = 36$)	B1	accept v increases by 3/2 or $v = 108 \text{ m s}^{-1}$ accept wavelength becomes 90 cm allow ecf correct conclusion with wrong λ
			wavelength increases by 3/2 (as frequency unchanged)	B1	
			2 half wavelengths fit on the string so standing wave is set up/AW	B1	
Total question 5				13	

Question			Expected Answers	Marks	Additional Guidance
6	(a)	(i)	line spacing $d = 1/(300 \times 1000)$ ($= 3.3 \times 10^{-6}$ (m))	B1	look for clear reasoning to award mark
		(ii)	$\sin \theta = \lambda/d$ $= 6.3 \times 10^{-7}/3.3 \times 10^{-6} = 0.19$ $\theta = 11$ degrees	C1 C1 A1	rounding error of 0.2 here gives 11.9° 11.9° gets 2 marks
		(iii)	spots can be seen where $n = d \sin \theta/\lambda$ maximum n when $\sin \theta = 1$ (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)	$\epsilon = hc/\lambda = 6.6 \times 10^{-34} \times 3.0 \times 10^8/6.3 \times 10^{-7}$ $= 3.14 \times 10^{-19}$ (J)	C1 A1	accept 3.2×10^{-19} (J) ecf from b(i)1
		(ii)	$5.0 \times 10^{-4}/3.14 \times 10^{-19}$ $= 1.6 \times 10^{15}$	C1 A1	
	(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	$\lambda = h/mv = 6.63 \times 10^{-34}/9.1 \times 10^{-31}v$ $v = 6.63 \times 10^{-34}/9.1 \times 10^{-31} \times 5.0 \times 10^{-11}$ $v = 1.5 \times 10^7$ (m s ⁻¹)	C1	using 6.6 instead of 6.63 gives 1.45×10^7 using $v = 1.45 \times 10^7$ gives 600 V
		2	$\frac{1}{2}mv^2 = eV$ $\frac{1}{2} \times 9.1 \times 10^{-31} \times 2.25 \times 10^{14} = 1.6 \times 10^{-19}V$ $V = 6.4 \times 10^2$ (V)	A1 C1 C1 A1	
Total question 6				19	

Question		Expected Answers	Marks	Additional Guidance
7	a	<p>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</p>	<p>B1 B1 B1 B1 B1</p>	<p>first 3 marks can be awarded from diagram or description QWC mark</p>
		<p>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</p> <p>The presence of u-v /blue light causes a current in the circuit. so experiment indicates the emission of negative charge/electrons</p>	<p>B1 B1 B1 B1 B1</p>	<p>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</p>
		<p>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</p>	<p>B1 B1 B1 B1 B1</p>	<p>first 3 marks can be awarded from diagram or description QWC mark</p>
	b	<p>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)</p>	<p>B1 B1 B1 B1 B1</p>	<p>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</p>
Total question 7			10	