AS UNIT 2 – Electricity and Light

MARK SCHEME

GENERAL INSTRUCTIONS

The mark scheme should be applied precisely and no departure made from it.

Recording of marks

Examiners must mark in red ink.

One tick must equate to one mark (except for the extended response questions).

Question totals should be written in the box at the end of the question.

Question totals should be entered onto the grid on the front cover and these should be added to give the script total for each candidate.

Marking rules

All work should be seen to have been marked.

Marking schemes will indicate when explicit working is deemed to be a necessary part of a correct answer.

Crossed out responses not replaced should be marked.

Credit will be given for correct and relevant alternative responses which are not recorded in the mark scheme.

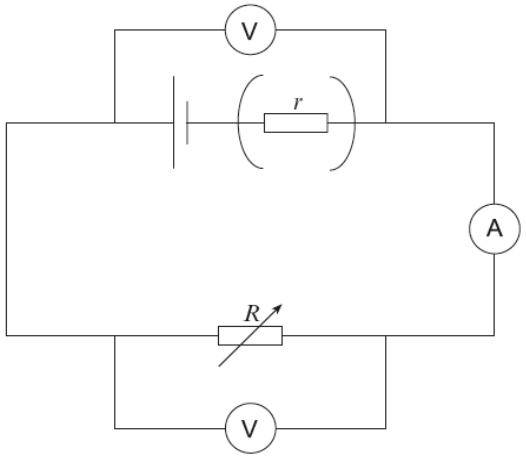
Extended response question

A level of response mark scheme is used. Before applying the mark scheme please read through the whole answer from start to finish. Firstly, decide which level descriptor matches best with the candidate's response: remember that you should be considering the overall quality of the response. Then decide which mark to award within the level. Award the higher mark in the level if there is a good match with both the content statements and the communication statement.

Marking abbreviations

The following may be used in marking schemes or in the marking of scripts to indicate reasons for the marks awarded.

cao = correct answer only
ecf = error carried forward
bod = benefit of doubt

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
1	*(a)*			 Ammeter and either voltmeter correct (1) Variable resistor in series / R in series but stated that it can be changed (1)	1 1			2		2
	(b)			Read V and I, adjust variable resistor, [read V and I etc.]	1			1		1
	(c)	(i)		Straight line drawn through points and judged by eye to be the best possible fit (1) y - intercept between 3.15 - 3.25 [V] (1) Gradient between 0.30 – 0.34 [Ω] (1)		3		3	3	3
		(ii)		Gradient = r (1) y - intercept = emf (1)	2			2		2
	(d)			**Any 2 × (1) from:** • Points lie close to straight line therefore quality acceptable • Extra points needed with lower current (or higher R or higher V) • Extra points needed with higher current (or lower R or lower V)			2	2		2
	(e)			3.20 [V] (**or** initial voltmeter reading) is emf **and** is in good agreement						

				(**ecf**) with (*c*) (1) $I = \frac{2.62}{1.50}$ = 1.75 A [± 0.05 A] **or** $R + r$ = 1.8[2] Ω (1) Argument clearly set out with conclusion (1) Valid arguments include check of $V = E - Ir$, **or** $V = \frac{ER}{R+r}$ **or** $\frac{V}{R} = \frac{E}{R+r}$			3	3	2	3
				Question 1 total	**5**	**3**	**5**	**13**	**5**	**13**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
2	*(a)*			Current proportional to pd (1) Provided temperature is constant (1)	1 1			2		
	(b)			pd across S = 4.2 [V] or by implication (1) Use of $V = IR$ (1) S = 280 [Ω] (1) **Alternative solution:** R_{LED} = 120 [Ω] or by implication (1) R_{total} = 420 [Ω] or by implication (1) S = 280 [Ω] (1)	 1	1 1		3	3	
	(c)	(i)		Use of $A = \pi r^2$ (1) n = 18[.0] × 10^{28} m^{-3} (1) v = 4.1 × 10^{-5} m s^{-1} (1) Penalise wrong powers of 10 or 2 or factor of 3 omitted in n once only	1	 1 1		3	3	
		(ii)		12 [A]		1		1		
	(d)			$R = \frac{28.2 \times 10^{-9} \times 70}{2.54 \times 10^{-6}}$ **ecf** on A **or** by implication (1) R = 0.78 [Ω] **ecf** on A **or** by implication (1) V = 2.3 [V] **ecf** on A and arithmetic slips in finding R (1)		 3		3	3	
				Question 2 total	**4**	**8**	**0**	**12**	**9**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
3	*(a)*	(i)	(I)	λ = 0.20 [m] or by implication (1) 10 m s^{-1} **unit mark ecf** on λ (1)		1 1		2		
			(II)	0.020 [s]		1		1		
			(III)	Attempt at sinusoid **and** same amplitude (1) Wave shifted 0.05 m to the right (1)		2		2	2	
		(ii)		Direction of displacement (or oscillation or particle movement or equivalent) and direction of wave (or energy) travel (1) are at right angles to each other (1)	2			2		
	(b)	(i)		Progressive wave: energy travels. Stationary wave: it doesn't	1			1		
		(ii)		Progressive wave: amplitude constant **or** falls steadily (1) stationary wave: amplitude varies periodically **or** sinusoidally **or** goes up and down [regularly] **or** equivalent (1)	2			2		
				Question 3 total	**5**	**5**	**0**	**10**	**2**	**0**

Question				Marking details	Marks available					
					AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
4	*(a)*	(i)		Same point in cycle at same time **or** equivalent	1			1		
		(ii)		Path difference = 36 mm (1) which is 3λ [accept $n\lambda$] so therefore constructive interference (1)			2	2		
		(iii)		[Path difference does not change so] always constructive (1) [But] signal strength will decrease as we go further from sources (1)			2	2		
	(b)			Use of equation: $y = \frac{12\text{x}360}{36}$ even if units confused (1) y = 120 mm **unit mark** (1)		1 1		2	2	
	(c)			Use of $d\sin\theta = n\lambda$ (1) 24° (1) 53° **or** both angles wrong but because of same arithmetic error (1) **Either** 0° **or** ± 24° and ± 53° **or** equivalent (1)	1	 1 1 1		4	3	
				Question 4 total	**2**	**5**	**4**	**11**	**5**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
5	*(a)*			Measure angles (50° and 27°) (1) Application of $n_1 \sin\theta_1 = n_2 \sin\theta_2$ (1) Answer = 1.69 (1)	1	 1 1		 3	 2	 3
	(b)	(i)		Angle of incidence at **P** = 65° (1) Calculation of critical angle = 41° **or** 1.52 sin 65° = 1.37 **or** 1.52 sin 65° > 1 (1) 65° > 41° **or** no possible angle of refraction into air (1)			 3	 3	 2	
		(ii)		One further reflection on bottom surface at some point **Q**, such that **AQ** < ½ **BP**, and ray emerges from AB bent away from normal		1		1		
		(iii)		Incident and emergent rays marked as parallel (1) First and last portions inside glass marked as parallel (1)		2		2		
	(c)	(i)		Light travelling by different paths takes different times (1) because some paths shorter (or straighter) than others **or** equiv (1)	2			2		
		(ii)		Pulses may overlap **or** equivalent		1		1		
				Question 5 total	**3**	**6**	**3**	**12**	**4**	**3**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
6	*(a)*	(i)		3.0×10^{-19} J [accept the work function] is the [minimum] energy needed to eject an electron from caesium [**or** the surface **or** the metal **not** caesium atom]	1			1		
		(ii)		Correct transposition, equivalent to $f = \frac{E_{k\max} + \phi}{h}$ at any stage (1) $f = 1.4 \times 10^{15}$ [Hz] (1)		2		2	2	
		(iii)		More electrons ejected per second, $E_{k\max}$ unaffected (1) More electrons per second because more photons per second (1) Same $E_{k\max}$ because individual photon energies unaffected (1)	1 1	1		3		
	(b)			P1 – Controversial because different / disagreed with current (then) theory. P2 – Many experiments on photoelectrons since 1902. P3 – Show excellent agreement with new theory. P4 – Old theories cannot explain observations. P5 – Old theory predicted that if enough energy was given, electrons would be emitted. P6 – New theory – light comes in packets of energy (photons). **3 - 4 marks** Expect 4 or more points from P1 – P6 with a sequenced discussion **1 - 2 marks** Expect 1 – 3 points from P1 – P6 with a more fragmented argument.			4	4		
				Question 6 total	**3**	**3**	**4**	**10**	**2**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
7	*(a)*	(i)		Application of $E = \frac{hc}{\lambda}$ **or** $E = hf$ and $c = f\lambda$ ***or*** equivalent **or** $f = 4.7 \times 10^{14}$ [Hz] (1) $\lambda = 630$ [nm] (1)		1 1		2	2	
		(ii)		Downward arrow between top two levels		1		1		
	(b)	(i)		Reflected 7×10^{14} [s^{-1}], transmitted 6.3×10^{15} [s^{-1}]		1		1		
		(ii)		Attempt based on number of photons per second × E_{phot} (1) 2.0 mW **unit mark** (1)		2		2	2	
	(c)			**Energy levels** E0 – More electrons in higher energy levels than lower energy levels. E1 – Population inversion mentioned. E2 – Population inversion between U and L. E3 – L is initially (nearly) empty. E4 – Transition from P to U is instantaneous. E5 – U is a metastable state **or** long lived. E6 – Transition from L to the ground state is instantaneous. **Stimulated emission** S1 – Incident photon causes an electron to drop. S2 – Photon emitted when an electron drops. S3 – Stimulated emission mentioned. S4 – After stimulated emission there are 2 photons instead of 1 photon. S5 – Incident photon of correct energy **or** frequency **or** wavelength is required. S6 – Intensity **or** number (can increase exponentially). **Cavity** C0 – One mirror slightly transparent. C1 – Light / photons traverse the cavity many times. C2 – Intensity increases in cavity.						

				5-6 marks All of E0 – E3 and 1 from E4 – E6 are present. All of S1 – S6 are present. 1 from C0 – C2 is present. There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured. **3-4 marks** 2 or 3 from E0 – E3 are present. 3 from S1 – S6 are present. There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure. **1-2 marks** 1 from E0 – E3 is present. 1 or 2 from S1 – S6 are present. There is a basic line of reasoning which is not coherent, largely irrelevant, supported by limited evidence and with very little structure. **0 marks** No attempt made or no response worthy of credit.	6			6		
				Question 7 total	**6**	**6**	**0**	**12**	**4**	**0**

AS UNIT 2: Electricity and Light - SUMMARY OF ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	5	3	5	13	5	13
2	4	8	0	12	9	0
3	5	5	0	10	2	0
4	2	5	4	11	5	0
5	3	6	3	12	4	3
6	3	3	4	10	2	0
7	6	6	0	12	4	0
TOTAL	**28**	**36**	**16**	**80**	**31**	**16**