Photons - Mark Scheme

Q1.

Question Number	Answer	Mark
	This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The following table shows how the marks should be awarded for indicative content.	

Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points
6	4
5–4	3
3–2	2
1	1
0	0

The following table shows how the marks should be awarded for structure and lines of reasoning.

	Number of marks awarded for structure of answer and sustained line of reasoning
Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2
Answer is partially structured with some linkages and lines of reasoning	1
Answer has no linkages between points and is unstructured	0

Indicative content

- Minimum / threshold frequency required to release electrons.
- For waves, any frequency would be able to release electrons.
- Release of electrons is instantaneous.
- If the wave model were correct, (energy) would take time to build up before electrons were released.
- (Kinetic) energy of released electrons dependent on frequency.
- If the wave model were correct, the (kinetic) energy of the released electrons would be dependent on the intensity.

		6
	Total for question	**6**

Q2.

Question Number	Answer		Mark
	Use of $E = hf$ Converts J to eV Transition from (−) 0.54eV to (−) 0.85eV **Example of calculation** $E = hf = (6.63 \times 10^{-34}$ Js$) \times (7.48 \times 10^{13}$ Hz$) = 4.96 \times 10^{-20}$ J 4.96×10^{-20} J / $(1.60 \times 10^{-19}$ J eV$^{-1}) = 0.31$ eV	(1) (1) (1)	(3)
	Total for question		**3**

Q3.

Question Number	Answer		Mark
a	(Sodium) electrons/atoms gain/absorb energy And electrons move to higher energy levels (Sodium) electrons drop to lower energy levels, releasing photons (For MP2 & MP3, allow excited and de-excited) (For MP2 & MP3, do not allow "atoms" for "electrons") (For "levels" accept shells, orbitals, states)	(1) (1) (1)	**3**
b	Use of $c = f\lambda$ **and** Use of $E=hf$ Converts J to eV Energy = 2.11eV Example of calculation $f = (3.00 \times 10^{8}$ m s$^{-1}) / (589 \times 10^{-9}$ m$) = 5.09 \times 10^{14}$ Hz $E = (6.63 \times 10^{-34}$ Js$) \times (5.09 \times 10^{14}$ Hz$) = 3.38 \times 10^{-19}$ J E (in eV) $= (3.38 \times 10^{-19}$ J$) / (1.60 \times 10^{-19}$ J eV$^{-1}) = 2.11$eV	(1) (1) (1)	**3**
c	Uses $\tan\theta = s / D$ Use of $n\lambda = d\sin\theta$ with $n = 1$ Grating has 301 lines / mm, so the label is correct. **OR** Uses $sin\theta = \frac{s}{\sqrt{(s^2+D^2}}$ Use of $n\lambda = d\sin\theta$ with $n = 1$ Grating has 301 lines / mm, so the label is correct. (Use of double slit or single slit equations does not gain any credit) (Allow reverse calculation to show that 300 lines per mm leads to a value of λ that is close to the given value or that 300 lines per mm leads to a value of d or θ that is close to a value calculated). Example of calculation $\tan\theta = 0.234$ m / 1.30 m = 0.18 $\theta = 10.2°$ $n\lambda = d\sin\theta$, so d = 589×10^{-9} m / sin 10.2° = 3.33×10^{-6} m lines per mm = 1 / 3.33×10^{-3} m = 301.	(1) (1) (1) (1) (1) (1)	**3**
	Total for question		**9**

Q4.

Question Number	Answer		Mark
a	Minimum energy required to release/emit a (photo)electron (from the surface of the metal)	(1)	**(1)**
b	Ultraviolet has a higher (photon) energy (than visible light) Ultraviolet (photons) have an energy greater than the work function **Or** Visible light (photons) have an energy less than the work function **OR** Ultraviolet has a higher frequency (than visible light) Ultraviolet has a frequency greater than the threshold frequency **Or** Visible light has a frequency less than the threshold frequency (Allow converse statements for MP1)	(1) (1) (1) (1)	**(2)**
ci	(Increased intensity means) more <u>photons</u> per second (More photons leads to) more electrons emitted (per second) Reading on ammeter is increased **Or** Current is increased (For MP1 there needs to be an indication of rate e.g. "per unit time")	(1) (1) (1)	**(3)**
ii	Use of $E = hf$ Use of $V = W/Q$ Use of $hf = \Phi + \frac{1}{2} mv^2_{max}$ Work function = 7.6×10^{-19} (J) **<u>Example of Calculation</u>** $hf = \Phi + \frac{1}{2} mv^2_{max} = hf = \Phi + QV$ $hf = (6.63 \times 10^{-34}\ \text{Js})(2.00 \times 10^{15}\ \text{Hz}) = 1.33 \times 10^{-18}$ J $QV/eV = (1.60 \times 10^{-19}\ \text{C})(3.59\ \text{V}) = 5.74 \times 10^{-19}$ J $hf - eV = 7.56 \times 10^{-19}$ J	(1) (1) (1) (1)	**(4)**

Q5.

Question Number	Answer	Mark
	B is the correct answer ($hf = \Phi + KE_{max}$ so increasing f increases KE_{max}) A is not the correct answer as electrons are released instantaneously C is not the correct answer as increasing intensity only increases the number of electrons released and each electron still has the same kinetic energy D is not the correct answer as it is higher frequency, not wavelength, that eventually passes a threshold value to release electrons	**(1)**