Photoelectric Effect MS1

Question Number	Answer	Mark
1(a)	Energy of the photon is less than the work function (of lithium) **OR** frequency of photons is below the threshold frequency (of lithium) (1) Work function is the minimum energy for electrons to be released **OR** No electrons are emitted **OR** no (electron) emission occurs (1) 'There is not enough energy for (electron) emission to occur' scores 1/2	**2**
(b)	Energy 1.8 eV current 0 (1) Energy 3.8 eV current 2.0×10^{-11} (1)	**2**
(c)(i)	Use of 1.6×10^{-19} (1) Energy = 3.7×10^{-19} J (1)	**2**
(c)(ii)	Use of $hf = \varphi + ½ mv^2_{max}$ (1) ecf (c)(i) KE = 4.4×10^{-18} J (1) Use of KE = ½ mv^2 (1) Speed = 3.1×10^6 m s^{-1} (1) **Example of calculation** KE = 4.8×10^{-18} J - 3.68×10^{-19} J = 4.4×10^{-18} J $v^2 = 2 \times 4.4 \times 10^{-18}$ J ÷ 9.11×10^{-31} kg $v = 3.1 \times 10^6$ m s^{-1}	**4**
	Total for question	**10**

Question Number	Answer	Mark
2	**QOWC** **Work must be clear and organised in a logical sequence** **Particle theory** Reference to $E=hf$ or quanta of energy /packets of energy/photons (1) Increased f means more energy of photon (1) Release of electron requires minimum energy /work function (1) One photon releases one electron (1) Greater energy of photon means greater KE of electrons (1) More intense light means more photons, therefore more electrons (1) **Wave theory** Wave energy depends on intensity (1) More intense light should give greater K.E of electrons (1) Energy is spread over the whole wave (1) If exposed for long enough photons eventually released, doesn't happen. (1) **Max 4 for particles and max 2 for waves.**	**6**
	Total for question	**6**

Question Number	Answer	Mark
3(a)(i)	(The) photoelectric (effect) (1)	**1**
3(a)(ii)	3×10^{8}(ms^{-1}) **OR** speed of light **OR** speed of electromagnetic radiation (1)	**1**
3(a)(iii)	(Work function) is the (minimum) amount of energy that a surface electron needs to break free/be released (1) (There must be some reference to surface. Do not credit electrons plural or 'electron and photon')	**1**
3(b)(i)	Attempt to subtract energy values (1) Multiply by 1.6×10^{-19} (1) 1.8×10^{-19}(J) (1) (Alternative method :multiplying by e first and then subtracting Will see 8.64×10^{-19} and 6.88×10^{-19}) <u>Example of calculation</u> Energy = (5.4 eV – 4.3 eV) $\times 1.6 \times 10^{-19}$ Energy = 1.8×10^{-19} J	**3**
3(b)(ii)	Use of KE = ½ m v^2 using their energy value and $m_e = 9.11 \times 10^{-31}$ kg (1) Max speed = 6.2×10^{5} m s^{-1} or correct value using their energy (1) (allowing a full e.c.f even if speed > speed of light) <u>Example of calculation</u> 1.8×10^{-19} J = ½ (9.11×10^{-31} kg $\times v^2$) $v = \sqrt{}$ ($2 \times 1.8 \times 10^{-19}$ J / 9.11×10^{-31} kg $v = 6.2 \times 10^{5}$ m s^{-1}	**2**
3(c)	No change (1)	**1**
	Total for question	**9**

Question Number	Answer		Mark
4(a)	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Reference to photons (may be descriptive, e.g. quantum of energy / light arrives in small packets / light particles …) Energy of photon greater than or equal to work function (of zinc) / $hf \geq \varphi$ Results in electron being emitted So (electroscope) loses charge / charge decreases (and leaf falls)	**(1)** **(1)** **(1)** **(1)**	**4**
4(b)	Photon energy (for visible light) is less than the work function OR frequency (of visible light) less than threshold frequency	**(1)**	**1**
4(c)	Use of $c = f\lambda$ to find frequency (award if hc/λ used) Use of $hf = \Phi + ½ m v^2$ to find KE Use of ke equation with m_e $v = 8.20 \times 10^5$ m s^{-1} <u>Example of calculation</u> KE = $(6.63 \times 10^{-34} \times 3 \times 10^8)/200 \times 10^{-9} - 6.88 \times 10^{-19}$ KE = 3.07×10^{-19} J $v = \sqrt{(2 \times 3.07 \times 10^{-19})/9.11 \times 10^{-31}}$ $v = 8.20 \times 10^5$ m s^{-1}	**(1)** **(1)** **(1)** **(1)**	**4**
4(d)	No change Photon energy doesn't change (with distance) **Or** photon energy depends (only) on frequency/wavelength	**(1)** **(1)**	**2**
	Total for question		**11**

Question Number	Answer	Mark
5	Addition of words (order essential) photon metal energy (allow mass, charge, momentum) (photo)electron work function (of the metal)	 **1** **1** **1** **1** **1**
	Total for question	**5**

Question Number	Answer	Mark
***6(a)(i)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Photon energy greater than the work function (of the metal) **Or** Electrons gain energy greater than the work function (of the metal) **(1)** (so that) electrons are emitted (from the surface of the metal) **(1)** **For Positive p.d**: The electrons are accelerated/attracted towards Q (creating a current) **(1)** **For negative p.d:** The idea that the (released) electrons need (kinetic) energy to reach Q **Or** The electrons decelerated/repelled by Q **(1)** At V_s no electrons have sufficient energy to reach Q (so no current) **(1)**	**5**
6(a)(ii)	Intensity related to number of photons per second **(1)** Double the electrons (per second) **(1)**	**2**
6(b)	Use of $hf = \varphi + ½ mv^2_{max}$ **(1)** Conversion eV to J (See 6.82×10^{-19} (J) or $4.26 \times 1.6\ 10^{-19}$) **(1)** $V_S = 0.71$ V **(1)** <u>Example of calculation</u> Max ke = $(6.63 \times 10^{-34}$ Js $\times 1.2 \times 10^{15}$ Hz) − $(4.26 \times 1.6 \times 10^{-19}$ C) = 7.96×10^{-19} J – 6.82×10^{-19} J = 1.14×10^{-19} J Max ke = 1.14×10^{-19} J ÷ 1.6×10^{-19} C $V_S = 0.71$ V	**3**
	Total for question	**10**

Question Number	Answer		Mark
7(a)	a discrete/specific/allowed energy of an <u>electron</u>	(1)	**1**
7(b)(i)	An electron/atom gains energy and is excited **Or** An electron/atom gains energy and moves to a higher level	(1)	
	The electron/atom (subsequently) falls to a lower level emitting energy in the form of a <u>photon</u>	(1)	**2**
7(b) (ii)	use of $E = hf$	(1)	
	use of $\div 1.6 \times 10^{-19}$ J eV^{-1}	(1)	
	add calculated E to -5.14 eV (no ue)	(1)	
	add level -3.03 eV above -5.14 eV and label	(1)	**4**
	<u>Example of calculation</u> $E = 6.63 \times 10^{-34}$ J s $\times 5.1 \times 10^{14}$ Hz $= 3.38 \times 10^{-19}$ J $= 3.38 \times 10^{-19}$ J $\div 1.6 \times 10^{-19}$ J eV^{-1} = 2.11 eV E level = -5.14 eV + 2.11 eV = -3.03 eV		
7(c)	Different elements have different <u>differences</u> in energy levels	(1)	
	so photons/light of different energies/frequencies/wavelength are emitted	(1)	**2**
	Total for question		**9**