Energy Level Calculations Mark Scheme

Q1.

Question Number	Answer	Mark
	B	1

Q2.

Question Number	Answer	Mark
	The only correct answer is A **B** *is not correct because* the equation is arranged incorrectly **C** *is not correct because* the equation is arranged incorrectly **D** *is not correct because* the equation is arranged incorrectly	1

Q3.

Question Number	Answer	Mark
	C	1

Q4.

Question Number	Answer	Mark
	D shortest arrow pointing to ground state	1
	Incorrect Answers: **A** – shortest wavelength absorbed **B** – longest wavelength absorbed **C** – shortest wavelength emitted	

Q5.

Question Number	Answer	Mark
	B ground state to level 2	1
	Incorrect Answers: A – incorrect change in energy C – incorrect change in energy and direction D – incorrect direction	

Q6.

Question Number	Answer	Mark
	D	**1**
	Incorrect Answers: A – absorption of the longest wavelength B – emission with the longest wavelength C – absorption of the shortest wavelength	

Q7.

(b)(i)	Use of $E = hf$ Use of conversion factor to eV Energy of photon = 1.91 (eV) Identify levels 3.41 (eV) and 1.51 (eV) **Or** levels 1 and 2 Example of calculation $E = 6.63 \times 10^{-34}$ J s $\times$ 4.6×10^{14} Hz (= 3.05×10^{-19} J) $E = 6.63 \times 10^{-34}$ J s $\times$ 4.6×10^{14} Hz $\div$ 1.6×10^{-19} J s = 1.91 eV = 3.41 eV − 1.51 eV (1.90 eV) as the closest match	(1) (1) (1) (1)	**4**
(b)(ii)	Just-free electrons have zero energy state **Or** energy value of level $n = \infty$ is 0 (Bound) electrons need to gain energy to attain this state **Or** electrons need to gain energy to move to a higher level (Accept Because they must gain energy to move up for second mark) (accept answers in terms of ionisation energy)	(1) (1)	**2**

Q8.

Question Number	Answer	Additional Guidance	Mark
	Use of $E = hf$ **and** $v = f\lambda$ (1) Conversion eV to J (1) $\lambda = 2.9 \times 10^{-7}$ m (1)	Example of calculation $\lambda = \frac{6.63\times10^{-34}\text{J s} \times 3.0\times10^{8}\text{m s}^{-1}}{4.3\text{ eV}\times 1.6\times10^{-19}\text{ C}} = 289$ nm	**3**

Q9.

Question Number	Answer		Mark
(a)	Photon – quantum/packet of something relevant e.g. light, radiation, any other named e-m radiation, energy	(1)	
	(quantum/packet) of <u>electromagnetic</u> energy/radiation/waves (dependent mark)	(1)	2
(b)	Use of $(20.66 - 18.70) \times 1.6 \times 10^{-19}$	(1)	
	Use of $E = hf$ (with energy in eV or J)	(1)	
	$f = 4.7 \times 10^{14}$ Hz	(1)	3
	<u>Example of calculation</u> $f = (20.66 - 18.70) \times 1.6 \times 10^{-19} / 6.63 \times 10^{-34}$ $f = 4.73 \times 10^{14}$ Hz		
(c)	From kinetic energy of atoms	(1)	1

Q10.

Question Number	Acceptable answers		Additional guidance	Mark
	• Use of $E = hf$ and $c = f\lambda$	(1)	<u>Example of calculation</u>	
	• Convert J to eV	(1)	$E = 6.63 \times 10^{-34}$ Js $\times 3.00 \times 10^{8}$ m s^{-1} / 5.89×10^{-7} m	
	• 2.1 eV	(1)	$= 3.38 \times 10^{-19}$ J	
	• Arrow drawn on diagram from −3.04 eV to −5.14 eV	(1)	3.38×10^{-19} J / 1.60×10^{-19} C = 2.11 eV	4

Q11.

Question Number	Acceptable Answers	Additional Guidance	Mark
	• use of difference in energy levels in eV and use of $W = QV$ for conversion to Joule **(1)**	Example of calculation:	
	• use of $E = hf$ **(1)**	difference in energy levels $= -0.55$ eV $- (-0.85$ eV$) = 0.3$ eV $= 0.3$ V $\times 1.6 \times 10^{-19}$ C $= 4.8 \times 10^{-20}$ J	
	• frequency $= 7.2 \times 10^{13}$ Hz **(1)**	$f = 4.8 \times 10^{-20}$ J $\div 6.63 \times 10^{-34}$ Js $= 7.2 \times 10^{13}$ Hz	3

Q12.

Question Number	Acceptable answers	Additional guidance	Mark
	• Use of $c = f\lambda$ **(1)** • Use of $\Delta E = hf$ **(1)** • Use of 1 eV = 1.6 x 10^{-19} J **(1)** • Change in energy equal to 1.89 eV and transition from **(1)** energy level 2 to energy level 3	Example of calculation f = 3.00 × 10^{8} m s^{-1} / 656.46 ×10^{-9} m = 4.57 × 10^{14} Hz E = 6.63 × 10^{-34} J s × 4.57 × 10^{14} Hz = 3.03 × 10^{-19} J = 3.03 × 10^{-19} J / 1.60 × 10^{-19} = 1.89 eV 1.89 eV – 3.40 eV = – 1.51 eV = level 3	**4**

Q13.

Question Number	Acceptable answers	Additional guidance	Mark
	• Use of $E=hf$ **(1)** • Use of $c = f\lambda$ **(1)** • Apply conversion factor of 1.6 × 10^{-19} for photon energy from J to eV **(1)** • Level = -5.74 (eV) **(1)**	Example of calculation f = 3.00 × 10^{8} m s^{-1} / 6.1 × 10^{-7} m = 4.91 × 10^{14} Hz E = 6.63 × 10^{-34} J s × 4.91 × 10^{14} Hz = 3.26 × 10^{-19} J 3.26 × 10^{-19} J / 1.6 × 10^{-19} C = 2.04 eV Level = -3.71 eV - 2.04 eV = -5.75 eV	**4**

Q14.

Question Number	Acceptable Answers	Additional guidance	Mark
	• Use of $E = hf$ and $v = f\lambda$ (1) • Converts between eV to J (1) • $\lambda = 2.0 \times 10^{-7}$ (m) **and** conclusion that superradiance can occur (1)	Example of calculation E=6.2 eV × 1.6 × 10^{-19} C $E = \frac{6.63 \times 10^{-34}\ \text{Js} \times\ 3.0 \times 10^{8}\ \text{ms}^{-1}}{\lambda}$ λ = 201 nm so superradiance can occur	**3**

Q15.

Question Number	Acceptable Answers	Additional Guidance	Mark
	• Use of $E = \frac{1}{2}mv^2$ (1) • Use of $E = hf$ and $c = f\lambda$ (1) • $\lambda = (2.4 - 2.5) \times 10^{-7}$(m) (1) • leading to a conclusion that radiation is ultraviolet **Or** conclusion consistent with their value for wavelength (1)	MP4 dependent on MP2 Example of Calculation $\Delta E_k = \frac{1}{2} \times 9.11 \times 10^{-31}\,\text{kg} \times ((2.5 \times 10^6\,\text{m s}^{-1})^2 - (2.1 \times 10^6\,\text{m s}^{-1})^2)$ $\Delta E_k = 8.4 \times 10^{-19}$ (J) $\lambda = \frac{6.63 \times 10^{-34}\,\text{J s} \times 3 \times 10^8\,\text{m s}^{-1}}{8.4 \times 10^{-19}\,\text{J}}$ $\lambda = 2.4 \times 10^{-7}$(m)	4

Q16.

Question Number	Answer	Additional Guidance	Mark
	electron falls back down energy levels emitting a photon (1) wavelength (of photon) is inversely proportional to the energy change (1) refers to energy transition n=3 to n=2 **or** n=2 to n=1 (1)		3