22. Quantum Physics

22.4 Energy levels in atoms and line spectra

Paper 4

Marking Scheme

Q1.

(b)(ii)	photon energy = $(4.08 \times 10^{-19}) / (1.60 \times 10^{-19})$ = 2.55 eV	**C1**
	energy level = –3.40 + 2.55 = –0.85 eV	**A1**

Q2.

(a)	transition (emits) (one) photon with energy equal to the difference in energy between the two levels	**B1**
	frequency of radiation corresponds to energy of photon	**B1**
(b)(i)	line to the left of the pair in Fig. 8.2, labelled A	**B1**
	larger gap between line A and the nearest of the pair in Fig. 8.2 than between the lines in the pair	**B1**
(b)(ii)	line to the left of both the pair in Fig. 8.2 and line A, labelled B	**B1**
	larger gap between line B and line A than between line A and the nearest one of the pair in Fig. 8.2	**B1**
(c)	$E = hf$	**C1**
	$E_3 = E_1 + h(f_A + f_B)$	**A1**

Q3.

(a)(i)	• energy of photon has a corresponding frequency • change in electron energy level emits a single photon • photon energy = difference in energy levels • discrete frequencies must have come from discrete energy gaps • discrete energy changes imply discrete energy levels *Any three points, 1 mark each*	**B3**
(a)(ii)	transition (to – 3.400 eV) from X corresponds to 658 nm line	**C1**
	$E_1 - E_2 = hc / \lambda$	**C1**
	$E_1 - (-3.400) = (6.63 \times 10^{-34} \times 3.00 \times 10^{8}) / (658 \times 10^{-9} \times 1.60 \times 10^{-19})$ and so $E_1 = -1.51$ eV (*full substitution and answer needed*)	**A1**

Q4.

(a)	• photon gives energy to electron (in an inner shell) **or** electron (in an inner shell) absorbs a photon • electron moves (from lower) to higher energy level • energy (of photon) is equal to difference in energy levels • electron de-excites giving off photon (of same energy) • photons emitted in all directions *Any four points, 1 mark each*	**B4**

Q5.

(b)	mostly dark/dark background	**B1**
	coloured lines	**B1**
(c)(i)	6	**A1**
(c)(ii)	**1.** maximum photon energy = 13.6 – 0.85 (= 12.75 eV)	**C1**
	maximum kinetic energy = (13.6 – 0.85) – 5.6 = 7.2 eV	**A1**
	2. energy = hc / λ	**C1**
	$\lambda = (6.63 \times 10^{-34} \times 3.00 \times 10^{8}) / [(13.6 - 0.85) \times 1.60 \times 10^{-19}]$	**C1**
	$= 9.8 \times 10^{-8}$ m	**A1**