8(a)	*Any three points from*: • electrons moving between levels emit a single photon • energy of photon = difference between energy levels • energy of photon depends on frequency • discrete frequencies (in spectrum) so differences between electron energies must be discrete • discrete differences between electron energies means energy levels must be discrete
8(b)(i)	energy $= -(13.6 \times 1.60 \times 10^{-19})$ $= -2.18 \times 10^{-18}$ J
8(b)(ii)	$\Delta E = hf$
	$= (6.63 \times 10^{-34} \times 2.47 \times 10^{15}) / (1.60 \times 10^{-19}) = 10.2$ eV
8(b)(iii)	$n = 2$ energy level = – 3.4 eV
	$n = 3$ energy difference = 12.1 eV
	$n = 4$ energy difference = 12.8 eV
	$n = 3$ energy level = – 1.5 eV **and** $n = 4$ energy level = – 0.8 eV

8(a)(i)	movement of star causes change in (observed) frequency **or** movement of star causes redshift
	observed frequency is lower (than emitted frequency)
8(a)(ii)	all three lines shown to left of corresponding printed lines
	distance between drawn line and corresponding printed line approximately the same for all three lines
8(b)(i)	$E = hf$ **and** $\lambda = c / f$
	$E = (6.63 \times 10^{-34} \times 3.00 \times 10^{8}) / (488 \times 10^{-9})$ $= 4.08 \times 10^{-19}$ J
8(b)(ii)	photon energy $= (4.08 \times 10^{-19}) / (1.60 \times 10^{-19})$ $= 2.55$ eV
	energy level = –3.40 + 2.55 = –0.85 eV
8(b)(iii)	$\Delta\lambda = \lambda \times (v / c)$ $= (488 \times 6.2 \times 10^{6}) / (3.00 \times 10^{8})$ (= 10 nm)
	observed wavelength = $488 + \Delta\lambda = 488 + 10$ = 498 nm
8(c)	$v = H_0 d$
	$d = (6.2 \times 10^{6}) / (2.3 \times 10^{-18})$ $= 2.7 \times 10^{24}$ m