8 Fig. 8.1 shows the three lowest-frequency lines in the part of the emission spectrum for hydrogen that relates to electron transitions to the ground state (level n = 1).

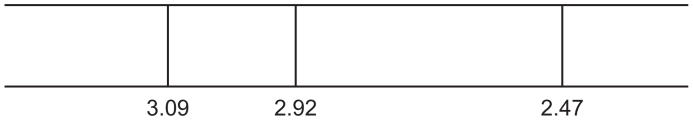

Fig. 8.1 (not to scale)

The numbers represent the frequencies, in 10^{15} Hz, associated with the spectral lines.

(a) Use the photon model of electromagnetic radiation to explain how the existence of spectral lines in the emission spectrum provides evidence for discrete electron energy levels in the hydrogen atom.

....

....

....

....

.... [3]

(b) The energy of the ground state (level n = 1) in a hydrogen atom is –13.6 eV.

(i) Calculate the energy, in J, of the ground state.

energy = ... J [1]

(ii) Show that the energy difference between levels n = 1 and n = 2 is 10.2 eV.

[2]

(iii) Complete Table 8.1 to show the energy differences from the ground state, and the energies of the levels up to n = 4, in the hydrogen atom. Use the space for any working.

Table 8.1

level	(energy difference from n = 1) / eV	energy / eV
n = 4		
n = 3		
n = 2	10.2	
n = 1	0.0	–13.6

[4]

[Total: 10]

8 Fig. 8.1 shows part of the emission spectrum of visible radiation emitted by hydrogen gas in a star in a distant galaxy.

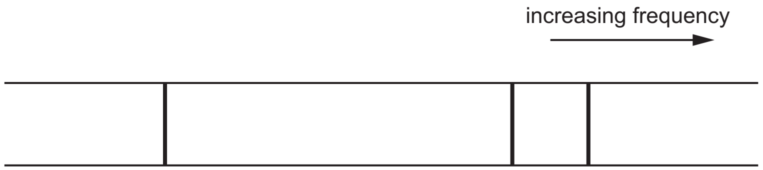

Fig. 8.1

The galaxy is moving away from the Earth at a speed of $6.2 \times 10^6\,\mathrm{m\,s^{-1}}$.

(a) **(i)** Explain how the positions of the lines in the emission spectrum seen by an observer on the Earth differ from the positions shown in Fig. 8.1.

....

....

.... [2]

(ii) On Fig. 8.1, draw the three lines in possible positions in the spectrum seen by the observer. [2]

(b) The lines in Fig. 8.1 correspond to electron transitions down to the energy level –3.40 eV. One of the lines represents emitted radiation of wavelength 488 nm.

(i) Calculate the energy of a photon of this radiation.

photon energy = ... J [2]

(ii) Determine the energy, in eV, of the energy level from which the electron transition originates to cause the emission of this radiation.

energy level = ... eV [2]

(iii) Determine the wavelength, in nm, of this radiation as detected by the observer on the Earth.

wavelength = ... nm [2]

(c) A value for the Hubble constant is $2.3 \times 10^{-18}\,\mathrm{s^{-1}}$.

Determine the distance of the galaxy from the Earth.

distance = ... m [2]

[Total: 12]