8 **(a)** State **one** piece of experimental evidence for:

(i) the particulate nature of electromagnetic radiation

..... [1]

(ii) the wave nature of matter.

..... [1]

(b) **(i)** Calculate the de Broglie wavelength λ of an alpha-particle moving at a speed of $6.2 \times 10^7\,\text{m s}^{-1}$.

λ = ... m [3]

(ii) The speed v of the alpha-particle in **(b)(i)** is gradually reduced to zero.

On Fig. 8.1, sketch the variation with v of λ.

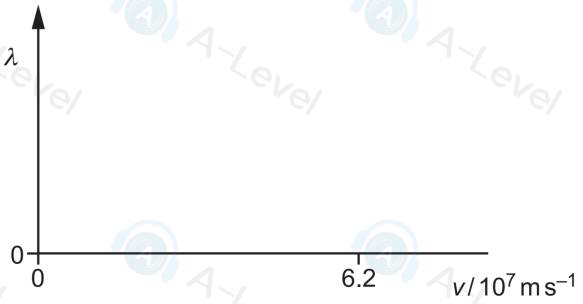

Fig. 8.1

[2]

(c) Suggest an explanation for why people are not observed to diffract when they walk through a doorway.

.....

.....

..... [1]

[Total: 8]

9 **(a)** Fig. 9.1 shows the visible part of the emission spectrum from hydrogen gas in a laboratory on the Earth. The numbers indicate the wavelength, in nm, represented by each line.

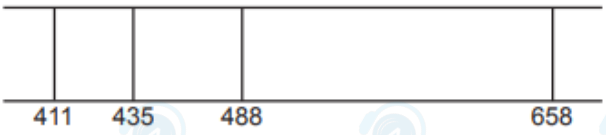

Fig. 9.1

(i) Explain how the emission spectrum provides evidence for the existence of discrete energy levels for the electron in a hydrogen atom.

.....

.....

.....

..... [3]

(ii) Fig. 9.2 shows five of the energy levels in the hydrogen atom. The wavelengths of radiation shown in Fig. 9.1 relate to transitions to the –3.400 eV level in Fig. 9.2.

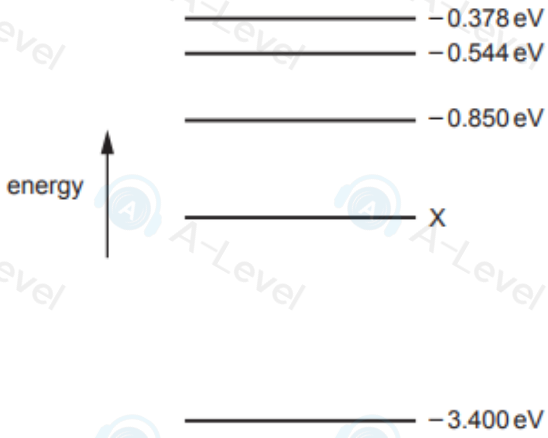

Fig. 9.2 (not to scale)

Show that the energy level X is –1.51 eV.

[3]

(b) The same part of the emission spectrum from hydrogen as in **(a)**, observed in light from stars in a distant galaxy, is shown in Fig. 9.3. The numbers indicate the wavelengths in nm.

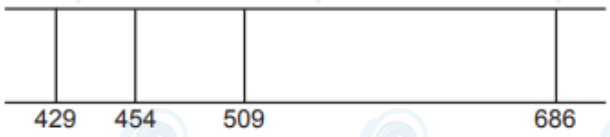

Fig. 9.3

The spectrum shows the same pattern as Fig. 9.1 but with different wavelengths.

(i) State the name of the phenomenon that gives rise to the change in the wavelengths.

..... [1]

(ii) State what this phenomenon shows about the motion of the galaxy.

..... [1]

(iii) Use one of the lines in Fig. 9.1, and the corresponding line in Fig. 9.3, to determine the speed of the distant galaxy relative to the observer.

speed = ... $m\,s^{-1}$ [3]

(c) The galaxy in **(b)** is known to be a distance of 5.7×10^{24} m from the Earth.

Use your answer in **(b)(iii)** to determine a value for the Hubble constant H_0.

H_0 = ... s^{-1} [2]

[Total: 13]