8 **(a)** Explain what is meant by a *photon*.

.....

.....

..... [2]

(b) **(i)** Describe the appearance of a visible line emission spectrum.

.....

.....

..... [2]

(ii) State how line spectra, together with the concept of a photon, provide evidence for discrete energy levels in isolated atoms.

.....

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.....

.....

..... [2]

(c) Some electron energy levels of the hydrogen atom are illustrated in Fig. 8.1.

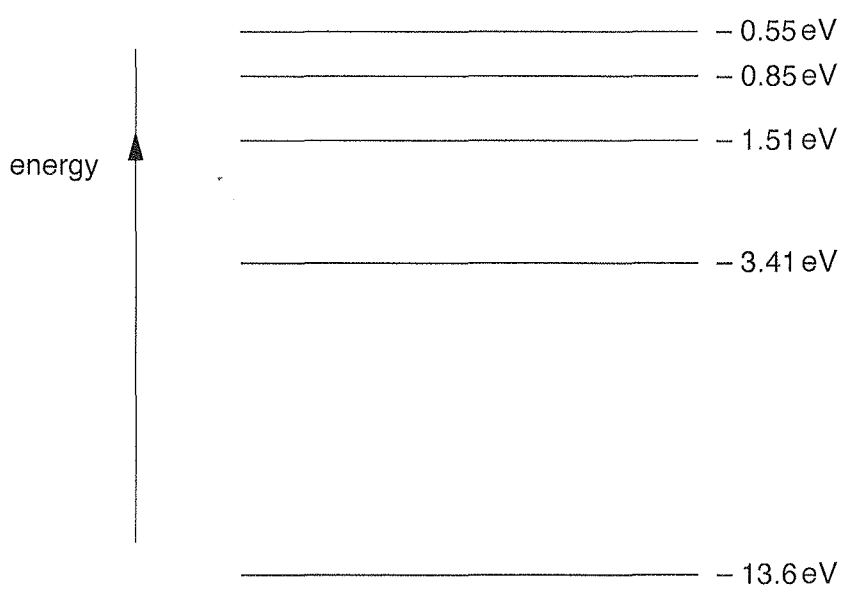

Fig. 8.1 (not to scale)

(i) The wavelength of violet light is approximately 400 nm.

By calculating the energy, in eV, of a photon of violet light, explain why electron transitions to the energy level –13.6 eV do not result in emissions in the visible spectrum.

[4]

(ii) The minimum energy of a photon of visible light is 1.6 eV.

Use Fig. 8.1 to determine, for the electron energy levels shown,

1. the number of lines that lie in the visible spectrum,

number = ... [1]

2. the shortest wavelength of photons in this visible spectrum.

wavelength = ... m [2]

(d) The radiation emitted from transitions between levels shown in Fig. 8.1 is incident on the surface of a sheet of platinum.
Platinum has a work function energy of 5.6 eV.

(i) On Fig. 8.1, mark with the letter P the transition that will give rise to radiation with the longest wavelength that will cause emission of electrons from the platinum. [1]

(ii) Calculate the maximum energy of an electron emitted from the platinum by the radiation in **(i)**.

energy = ... eV [2]

(e) A photon in free space has an energy of 4.8×10^{-19} J.
The photon crosses a gold atom of diameter 2.6×10^{-10} m.

(i) Calculate the time for the photon to travel the distance of 2.6×10^{-10} m in free space.

time = ... s [1]

(ii) Suggest, by reference to your answer in **(i)**, the maximum uncertainty in the time to cross the gold atom.

..... [1]

(iii) Use your answer to **(ii)** and the uncertainty principle to suggest why, during the time that the photon crosses the atom, its energy may not be equal to that of the photon in free space.

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.....

..... [2]