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

.....

[1]

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

.....

.....

[2]

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

.....

.....

.....

.....

.....

[3]

(c) Some electron energy levels of the hydrogen atom are illustrated in Fig. 9.1.

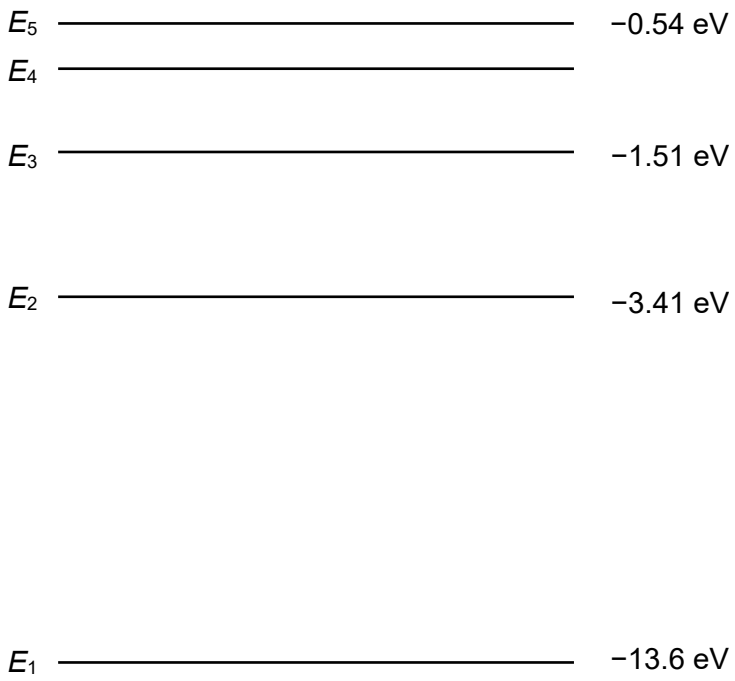
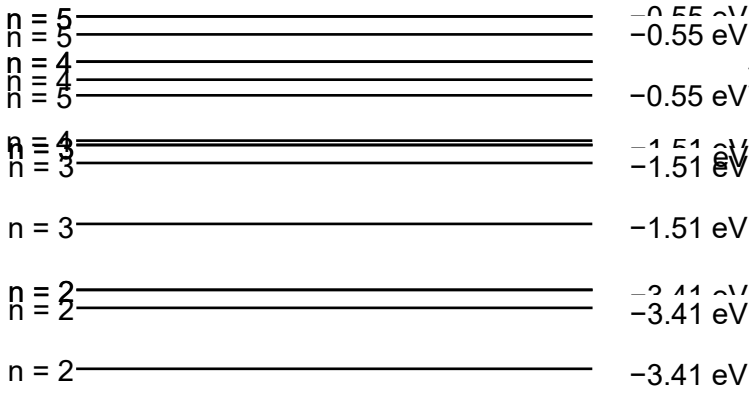


Fig. 9.1 (not to scale)

(i) By considering the transitions between these energy levels, state how many spectral emission lines might be produced by transitions among these levels.



number of lines = ... [1]

The wavelength of a photon produced by the transition from energy level E_4 to E_1 is 97.5 nm.

(ii) State the type of electromagnetic radiation of the photon.

..... [1]

(iii) Determine the energy level E_4 in electronvolts.

energy = ... eV [2]

(iv) Show that the shortest possible wavelength of the photons that can be emitted from a hydrogen atom is 91.4 nm.

……[2]

(d) The radiation emitted from hydrogen atoms is incident on the surface of a sheet of gold.

The stopping potential for photoelectrons emitted from the gold surface is 8.13 V.

(i) Calculate the work function of the metal surface in electronvolts.

work function = ... eV [2]

(ii) Calculate the momentum of the most energetic electrons emitted from the gold surface.

momentum = ... N s [2]

(iii) Hence, determine the de Broglie's wavelength of the electrons in **(ii)**.

wavelength = ... m [2]

(iv) The speed of one of the photoelectrons emitted is measured to be 1.2×10^6 m s^{-1} to an accuracy of 0.0025 %.

Calculate the minimum uncertainty in the position of this photoelectron.

minimum uncertainty in position = ... m [2]

[Total: 20]