Oxford Cambridge and RSA

A Level Physics A

H556/01 Modelling physics

Question Set 9

1 **(a)** Fig. 21.1 shows some of the energy levels of electrons in hydrogen gas atoms. The energy levels are labelled **A**, **B**, **C** and **D**.

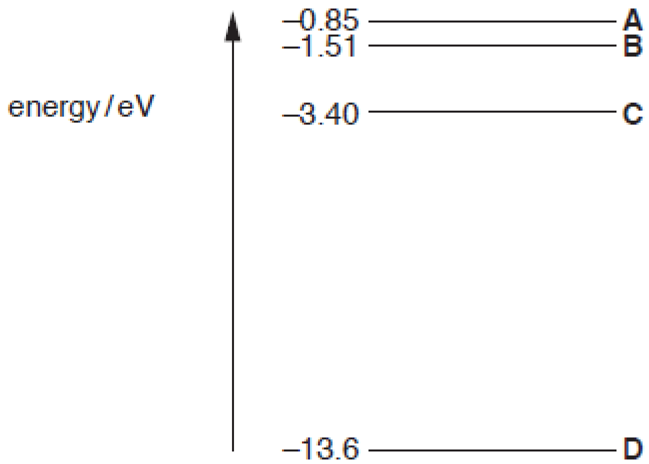

Fig. 21.1 (not to scale)

(i) Explain why the energy levels are negative. **[1]**

Electrons are bound to the nucleus, so require energy to leave the nucleus.

(ii) An electron makes a transition (jump) from level **C** to level **A**.

1 Calculate the energy gained by this electron.

$3.4 - 0.85 = 2.55$ eV

energy = ...2.55.......... eV **[1]**

2 Calculate the wavelength in nm of the photon absorbed by this electron.

$E = 2.55 \times 1.6 \times 10^{-19}$ J $= 4.08 \times 10^{-19}$ J

$E = \frac{hc}{\lambda} \rightarrow \lambda = \frac{hc}{E}$

wavelength = ...490.......... nm **[3]**

$\lambda = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{4.08 \times 10^{-19}} = 4.875 \times 10^{-7}$ m

$= 487.5$ nm

(b) Light from a distant galaxy is passed through a diffraction grating. Fig. 21.2 shows the part of the spectrum of light that shows a strong hydrogen-alpha emission line.

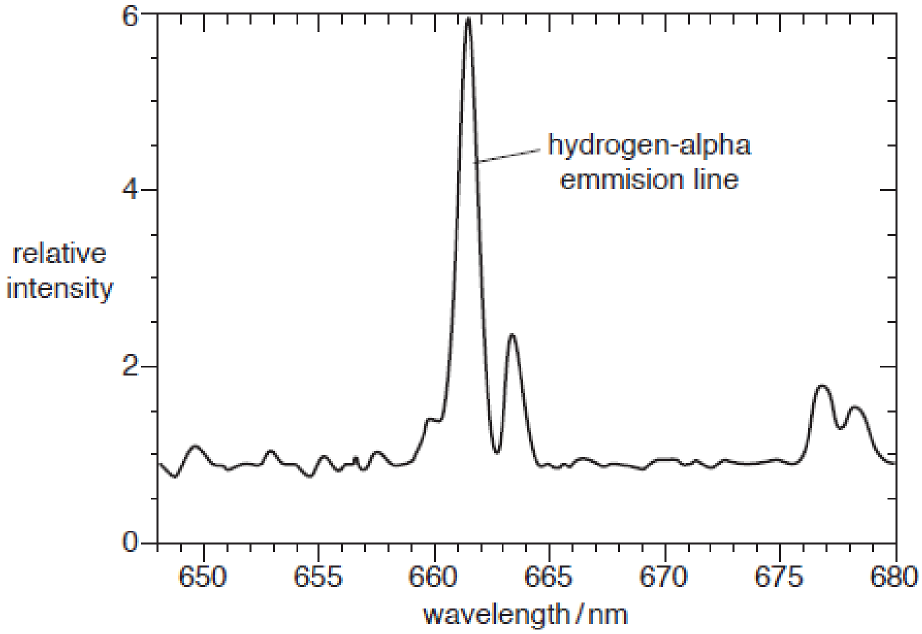

Fig. 21.2

(i) State how an emission line is produced. **[1]**

Electrons drop to a lower energy level and emit EM radiation.

(ii) State an adjustment that could be made to the experimental arrangement that would space the emission lines more widely. **[1]**

Reduce grating seperation

(iii) In the laboratory, the wavelength of the hydrogen-alpha emission line is 656.3 nm. Use Fig. 21.2 to determine the recession velocity of the galaxy.

$\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$ $v = \frac{\Delta\lambda}{\lambda} c = \frac{5.2}{656.3} \times 3\times10^8 = 2376962 \text{ ms}^{-1}$

λ of peak = 661.5nm

$\Delta\lambda$ = 656.3 − 661.5

= 5.2nm

recession velocity = ...2.4×10^6.......... m s^{-1} **[3]**

(iv) Suggest why hydrogen spectral lines play an important role in determining red shift of galaxies. **[1]**

Hydrogen is very abundant in stars.

(c) Light from a similar star is viewed in a galaxy **further** away. The star is part of a pair of stars which orbit a common centre of mass.
Describe and explain how the equivalent spectrum might appear. **[3]**

- Less intense as the light has travelled further
- As it is further away, we would expect it to have a larger recessional velocity. There will therefore be more redshift and the wavelengths will be longer
- There could be a periodic shift in λ due to the orbit.

Total Marks for Question Set 9: 14