

**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.

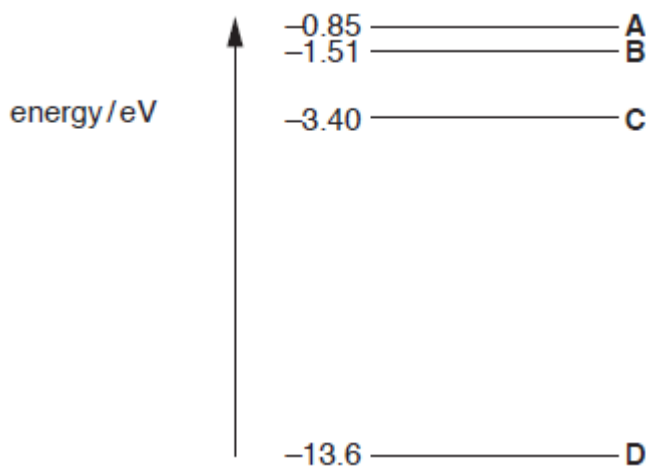


Fig. 21.1 (not to scale)

(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.

$$3.4 - 0.85 = 2.55 \text{ eV}$$

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

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

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

$$E = \frac{hc}{\lambda} \rightarrow \lambda = \frac{hc}{E} \quad \text{wavelength} = \dots\dots\dots 490 \dots\dots\dots \text{ nm} \quad [3]$$

$$\lambda \approx \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{4.08 \times 10^{-19}} = 4.875 \times 10^{-7} \text{ m} = 487.5 \text{ nm}$$

- (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.

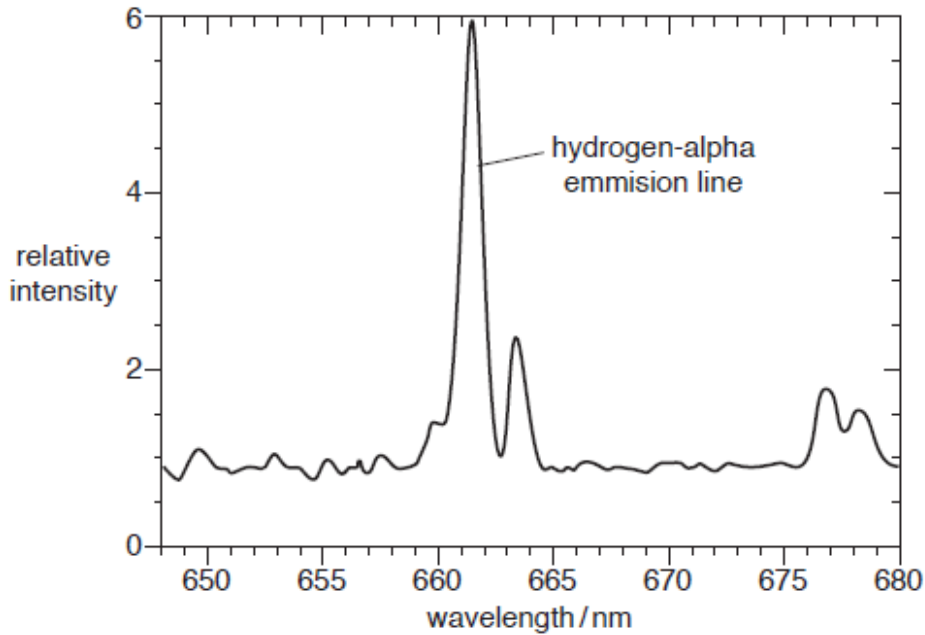


Fig. 21.2

- (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 separation*
- (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. [3]  

$$\frac{\Delta\lambda}{\lambda} = \frac{v}{c} \quad v = \frac{\Delta\lambda}{\lambda} c = \frac{5.2}{656.3} \times 3 \times 10^8 = 23\,769\,62 \text{ m s}^{-1}$$

$$\lambda_{\text{of peak}} = 661.5 \text{ nm} \quad \text{recession velocity} = \dots\dots\dots 2.4 \times 10^6 \dots\dots\dots \text{ m s}^{-1}$$

$$\Delta\lambda = 656.3 - 661.5 = 5.2 \text{ nm}$$
- (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 recession velocity. There will therefore be more redshift and the wavelengths will be larger*
  - *There could be a periodic shift in  $\lambda$  due to the orbit.*

**Total Marks for Question Set 9: 14**

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