(a) Explain how the line spectrum of hydrogen provides evidence for the existence of discrete electron energy levels in atoms.

Each line in the spectrum is representing photon of a specific energy, photon is emmited as a result of energy change of electron and this specific energy changes tells about discrete energy levels in atoms. [3]

(b) Some electron energy levels in atomic hydrogen are illustrated in Fig. 7.1.

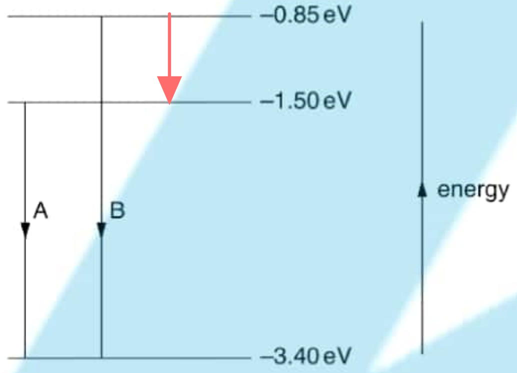


Fig. 7.1

Two possible electron transitions A and B giving rise to an emission spectrum are shown.
These electron transitions cause light of wavelengths 654 nm and 488 nm to be emitted.

(i) On Fig. 7.1, draw an arrow to show a third possible transition. [1]

(ii) Calculate the wavelength of the emitted light for the transition in **(i)**.

$$(1.5 - 0.85) \times 1.6 \times 10^{-19} = \frac{hc}{\lambda}$$

$$\lambda = 1.91 \times 10^{-6}\ m$$

0.0019×10^{-6} nm

wavelength = 1.91×10^{-6} = 1900 NM m [3]

(c) The light in a beam has a continuous spectrum of wavelengths from 400 nm to 700 nm.
The light is incident on some cool hydrogen gas, as illustrated in Fig. 7.2.

Fig. 7.2

Using the values of wavelength in **(b)**, state and explain the appearance of the spectrum of the emergent light.

The spectrum appears as continouse spectrum crossed by dark lines according to the data in (b), there will be 2 dark lines observed electrons in gas absorb photons with energies equal to the excitation energies and light photons will be re emitted in all directions while dexcitation. [4]

(a) State what is meant by the *de Broglie wavelength*.

$\lambda = \frac{h}{p}$ where λ is , h is the plancks constant and p is the momentum of the particle

[2]

(b) An electron is accelerated in a vacuum from rest through a potential difference of 850V.

(i) Show that the final momentum of the electron is 1.6×10^{-23} N s.

$qV = \frac{p^2}{2m}$

$p = \sqrt{2qVm}$

$= \sqrt{2(1.6 \times 10^{-19})(850)(9.11 \times 10^{-31})}$

$= 1.57 \times 10^{-23}$

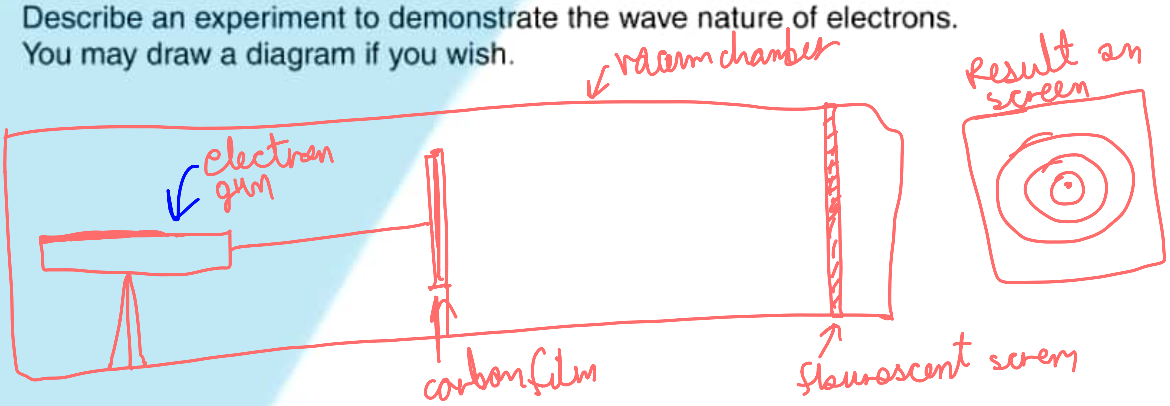
[2]

(ii) Calculate the de Broglie wavelength of this electron.

$\lambda = \frac{h}{p} = 4.22 \times 10^{-11}$

wavelength = 4.22×10^{-11} m [2]

(c) Describe an experiment to demonstrate the wave nature of electrons.
You may draw a diagram if you wish.



The pattern of concentric rings are observed on the flourescent screen and this pattern is similar to diffraction pattern observed with a visible light

[5]

For Examiner's Use

Electrons, travelling at speed v in a vacuum, are incident on a very thin carbon film, as illustrated in Fig. 7.1.

Fo Exami Us

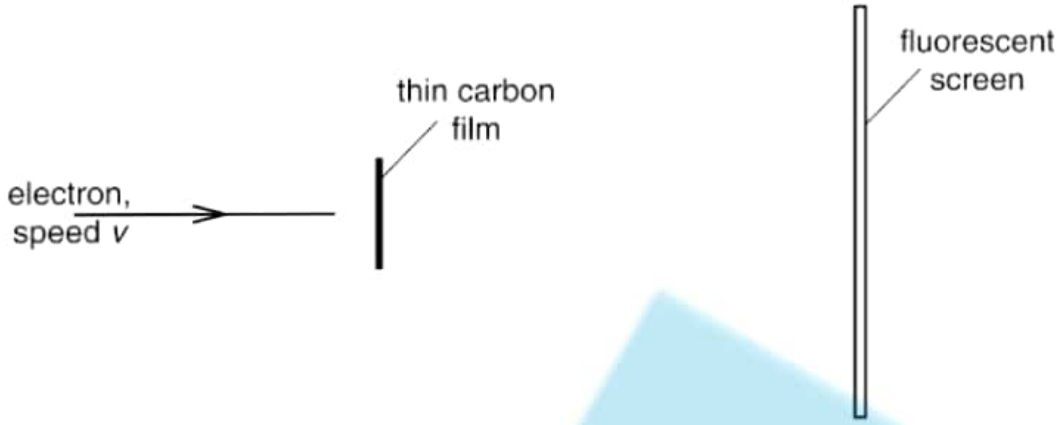


Fig. 7.1

The emergent electrons are incident on a fluorescent screen.
A series of concentric rings is observed on the screen.

(a) Suggest why the observed rings provide evidence for the wave nature of particles.

concentric circle are evidence of diffraction, and diffraction is a wave property

.... [2]

(b) The initial speed of the electrons is increased. State and explain the effect, if any, on the radii of the rings observed on the screen.

....

....

....

.... [3]

(c) A proton and an electron are each accelerated from rest through the same potential difference.
Determine the ratio

Fo Exami Us

$$\frac{\text{de Broglie wavelength of the proton}}{\text{de Broglie wavelength of the electron}}.$$

$P = \frac{h}{\lambda}$ $P = \sqrt{2Em}$

$\frac{h}{\lambda} = \sqrt{2Em}$

$\lambda = \frac{h}{\sqrt{2Em}}$

$$\frac{\cancel{\frac{h}{\sqrt{2(q_1 V)(m_1)}}}}{\cancel{\frac{h}{\sqrt{2(q_2 V)(m_2)}}}}$$

$$\frac{\frac{1}{\sqrt{q_p m_p}}}{\frac{1}{\sqrt{q_e m_e}}} =$$

ratio = 2.342×10^{-2} [4]

(a) State what is meant by a *photon*.

Its a packet of energy of electromagnetic radiation $E = hf$ where E is the energy of the photon and h is plancks constant, f is the frequency of the photon. [2]

(b) A beam of light is incident normally on a metal surface, as illustrated in Fig. 8.1.

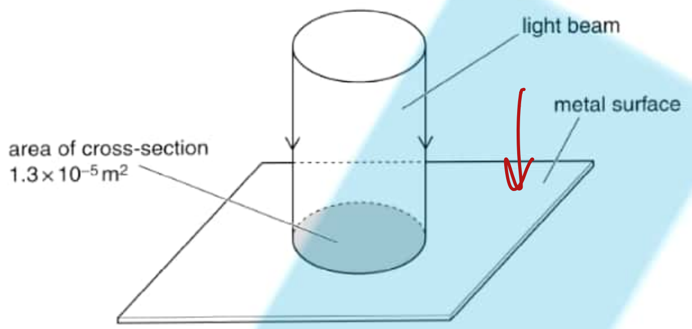


Fig. 8.1

The beam of light has cross-sectional area $1.3 \times 10^{-5}\,m^2$ and power $2.7 \times 10^{-3}\,W$.
The light has wavelength 570 nm.

The light energy is absorbed by the metal and no light is reflected.

(i) Show that a photon of this light has an energy of $3.5 \times 10^{-19}\,J$.

$E = \frac{hc}{\lambda} = \frac{h \times c}{570 \times 10^{-9}} = 3.48 \times 10^{-19} \approx 3.5 \times 10^{-19}\,J$

[1]

(ii) Calculate, for a time of 1.0 s,

1. the number of photons incident on the surface,

$$\frac{2.7 \times 10^{-3}}{3.48 \times 10^{-19}}$$

number = 7.76×10^{15} [2]

2. the change in momentum of the photons.

$P = \frac{h}{\lambda}$ $\frac{h}{570 \times 10^{-9}} = 1.16 \times 10^{-27}$

$1.16 \times 10^{-27} \times 7.76 \times 10^{15}$

9×10^{-12}

change in momentum = 9×10^{-12} $kg\,m\,s^{-1}$ [3]

(c) Use your answer in **(b)(ii)** to calculate the pressure that the light exerts on the metal surface.

change in momentum = Pressure

force = Pressure × Area

$= 9 \times 10^{-12} \times 1.3 \times 10^{-5}$

pressure = 1.17×10^{-16} Pa [2]

Light of wavelength 590 nm is incident normally on a surface, as illustrated in Fig. 8.1.

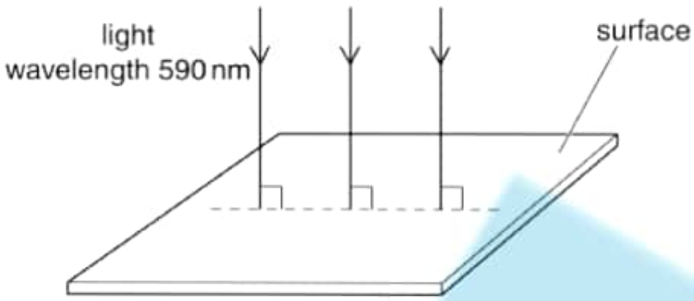


Fig. 8.1

The power of the light is 3.2 mW. The light is completely absorbed by the surface.

(a) Calculate the number of photons incident on the surface in 1.0 s.

$E = \frac{hc}{\lambda} = \frac{hc}{590 \times 10^{-9}} = 3.663 \times 10^{-19}$

$\therefore \frac{3.2 \times 10^{-3}}{3.668 \times 10^{-19}} = 9.5 \times 10^{15}$

number = 9.5×10^{15} .... [3]

(b) Use your answer in **(a)** to determine

(i) the total momentum of the photons arriving at the surface in 1.0 s,

$p = \frac{h}{\lambda} = \frac{h}{590 \times 10^{-9}} = 1.12 \times 10^{-27}$

$1.12 \times 10^{-27} \times 9.5 \times 10^{15}$

$= 1.0669 \times 10^{-11}$

momentum = 1.1×10^{-11} .... kg m s^{-1} [3]

(ii) the force exerted on the surface by the light.

$f = PA$??

$= 1.1 \times 10^{-11} \times$

force = ... N [1]

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