(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, represents photon of a specific energy, a photon is released as a result of this energy change of electron, this specific energy of which photon is released is the change in the discrete level of energy. [3]

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

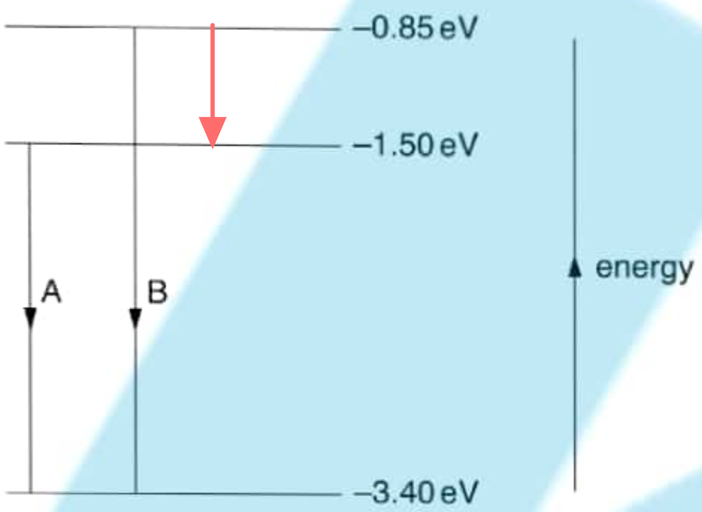

Fig. 7.1

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)**.

$-1.5-(-0.85) = -0.65$

$0.65 \times 1.6 \times 10^{-19} = 1.04 \times 10^{-19}$

$E = \frac{hc}{\lambda}$ $\qquad \frac{h \times 3 \times 10^{8}}{1.04 \times 10^{-19}} = 191\ nm$

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

wavelength = 191×10^{-9} m [3]

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(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.

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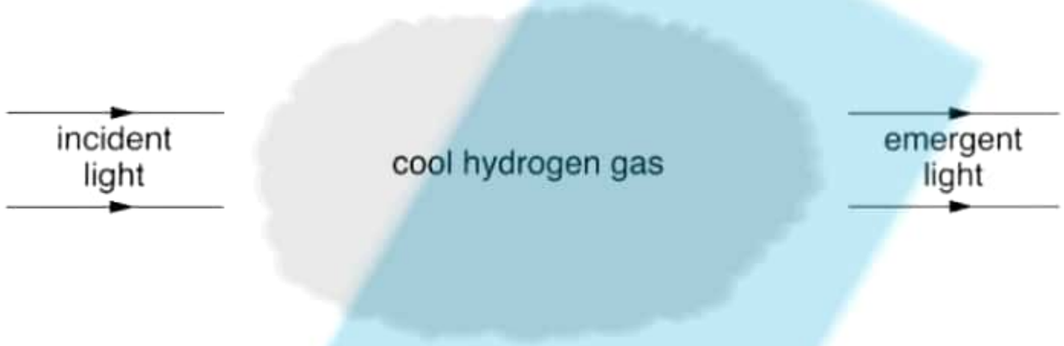

Fig. 7.2

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

Two dark lines will be observed in the continouse spectrum, electrons in the gas, absrob photons with energy equal to that of the excitation energy and while deexcitation, the light photons are re emmited in all the directions

.... [4]

as the light passes through the cool hydrogen gas, the e- absorbs a descrete energy and get excited and therefore jumps to a higher shell, and this absrbtion energy is represented by a dark spot in the continious spectrum soon deexcitation takes place and in that process, it releases energy while going back to the lower shell, and

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(a) By reference to the photoelectric effect, explain

(i) what is meant by *work function energy*,

It is the minimum energy required by photons for electrons to be emmited because of the incident photons on a metal [2]

(ii) why, even when the incident light is monochromatic, the emitted electrons have a range of kinetic energy up to a maximum value.

As some electrons are emmited from the surface and some from below the surface of the metal, so energy is used to bring those to surface and hence they have less energy. [2]

(b) Electromagnetic radiation of frequency f is incident on a metal surface. The variation with frequency f of the maximum kinetic energy E_{MAX} of electrons emitted from the surface is shown in Fig. 7.1.

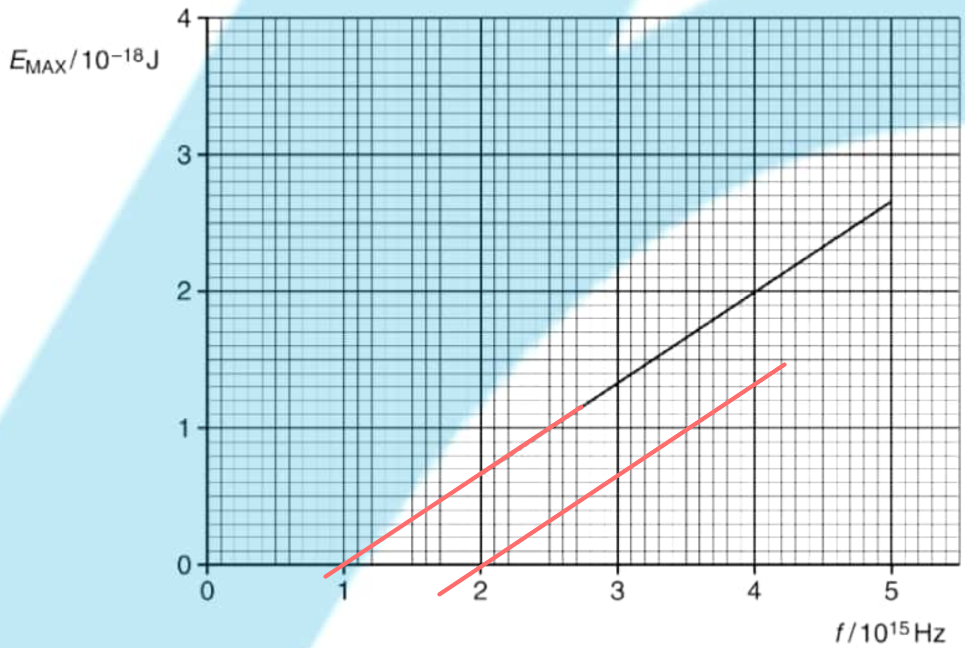

Fig. 7.1

(i) Use Fig. 7.1 to determine the work function energy of the metal surface.

$E = hf - hf_0$

$0 = h(1\times10^{5}) - hf_0$

$hf_0 = h(1\times10^{5})$

$= 6.626\times10^{-29}$

work function energy = 6.63×10^{-29} J [3]

(ii) A second metal has a greater work function energy than that in **(i)**. On Fig. 7.1, draw a line to show the variation with f of E_{MAX} for this metal. [2]

(iii) Explain why the graphs in **(i)** and **(ii)** do not depend on the intensity of the incident radiation.

Intensity determines number of photons arriving per unit time on the metals surface, not the energy. [2]

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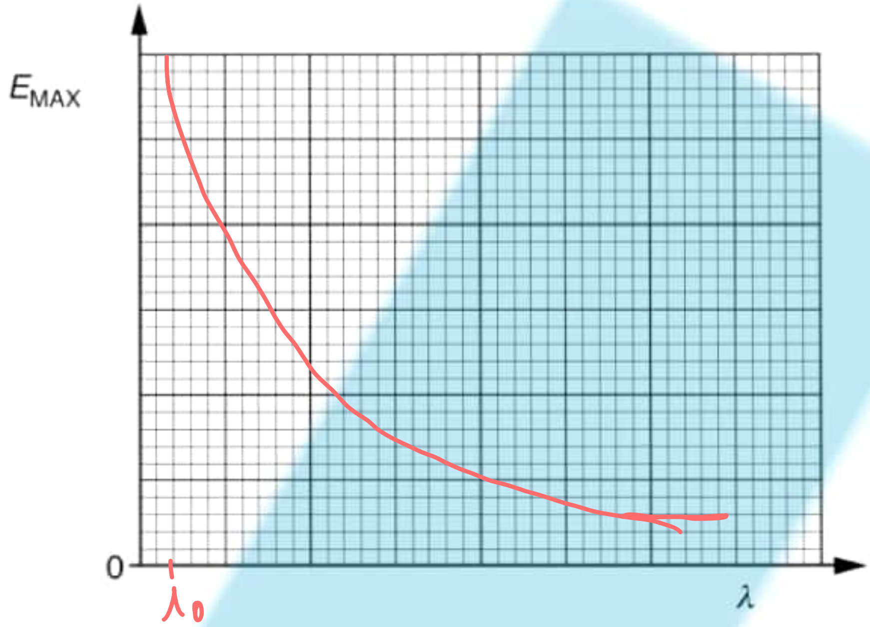
(a) A metal surface is illuminated with light of a single wavelength λ.
On Fig. 10.1, sketch the variation with λ of the maximum kinetic energy E_{MAX} of the electrons emitted from the surface.
On your graph mark, with the symbol λ_0, the threshold wavelength.

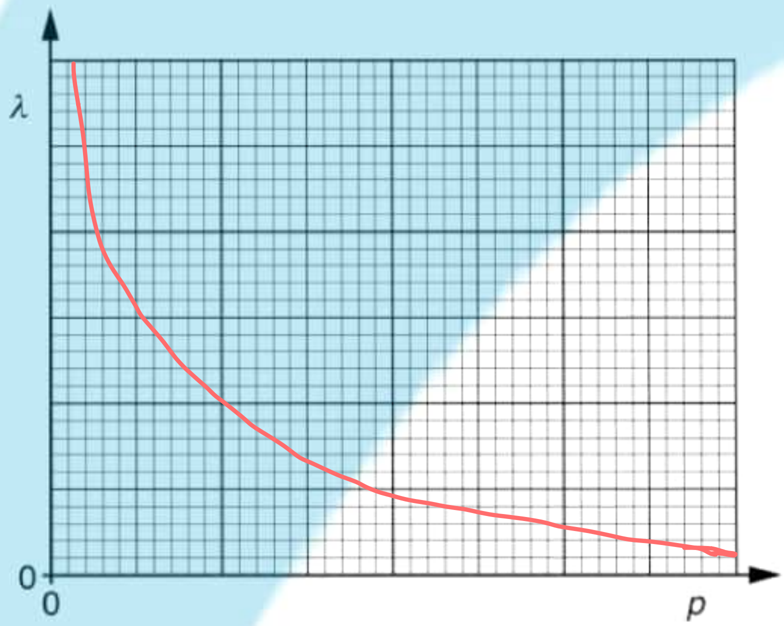


$\frac{hc}{\lambda} = hf$

$f \propto \frac{1}{\lambda}$

Fig. 10.1 [3]

(b) A neutron is moving in a straight line with momentum p.
The de Broglie wavelength associated with this neutron is λ.
On Fig. 10.2, sketch the variation with momentum p of the de Broglie wavelength λ.



$\lambda = \frac{h}{p}$

Fig. 10.2 [2]

[Total: 5]

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

A discrete packet of energy of electromagnetic radiation

.... [2]

(b) Describe the appearance of a visible line emission spectrum, as seen using a diffraction grating.

....

....

....

.... [2]

(c) The lowest electron energy levels in an isolated hydrogen atom are shown in Fig. 11.1.

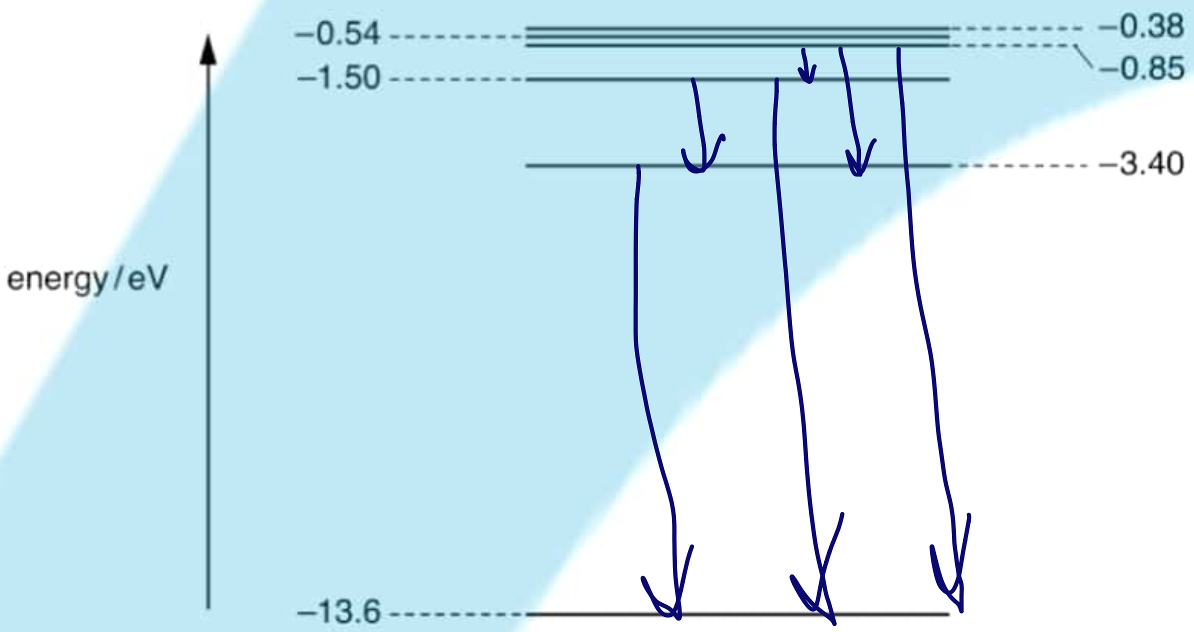

Fig. 11.1 (not to scale)

(i) An electron is initially at the energy level −0.85 eV. State the total number of different wavelengths that may be emitted as the electron de-excites (loses energy).

2

number = ...6...................................... [1]

(ii) Photons resulting from electron de-excitation from the −0.85 eV energy level are incident on the surface of a sample of platinum.

Platinum has a work function energy of 5.6 eV.

Determine

1. the maximum kinetic energy, in eV, of a photoelectron emitted from the surface of the platinum,

? $13.6 - 0.85 = 12.75$

$12.75 - 5.6 =$

maximum energy = 7.2 eV [2]

2. the wavelength of the photon producing the photoelectron in **(ii) part 1**.

$12.75 = \frac{hc}{\lambda}$

$\lambda = \frac{hc}{12.75 \times 1.6 \times 10^{-19}}$

wavelength = ... m [3]

[Total: 10]

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