5 **(a)** Electrons are accelerated through a potential difference of 15 kV. The electrons collide with a metal target and a spectrum of X-rays is produced. The variation with wavelength λ of the intensity I of the emitted X-ray radiation is shown in Fig. 5.1.

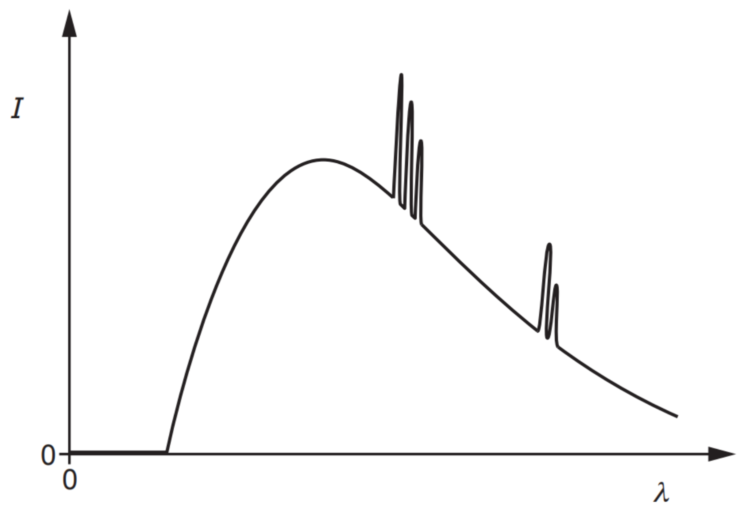

Fig. 5.1

(i) Explain why there is a continuous distribution of wavelengths.

....

....

....

....

.... [2]

(ii) Explain why at certain wavelengths, there are narrow peaks of increased intensity.

....

....

....

....

.... [2]

(iii) Calculate the wavelength of the highest energy X-ray photon produced.

wavelength = ………………………… m [2]

(iv) Draw, on Fig. 5.1, the spectrum of X-ray produced if the potential difference is increased. [2]

(b) An electron of mass 9.11×10^{-31} kg travelling at 3.00×10^{7} m s^{-1} passes through a narrow slit of width 1.00×10^{-10} m (comparable to the spacing of atoms in a crystal).

(i) Calculate the uncertainty in momentum of the electron along the slit as it passes through the slit.

uncertainty in momentum = ………………………… kg m s^{-1} [2]

(ii) Suggest the significance of this uncertainty.

……………………………………………………………………………………………..

…………………………………………………………………………………………… [1]

(c) Explain how Einstein's photon model of light differs from the classical description of light as an electromagnetic wave in the way it explains

(i) light intensity,

classical explanation: …………………………………………………………………

……………………………………………………………………………………………

quantum explanation: …………………………………………………………………

…………………………………………………………………………………………. [2]

(ii) the absorption of light energy by a metal surface.

classical explanation: …………………………………………………………………

……………………………………………………………………………………………

quantum explanation: …………………………………………………………………

……………………...……………………...……………………...…………………….. [2]

(d) The maximum kinetic energy E_{MAX} of electrons emitted from a metal surface is determined for different wavelengths λ of the electromagnetic radiation incident on the surface.

The variation with $\frac{1}{\lambda}$ of E_{MAX} is shown in Fig. 5.2.

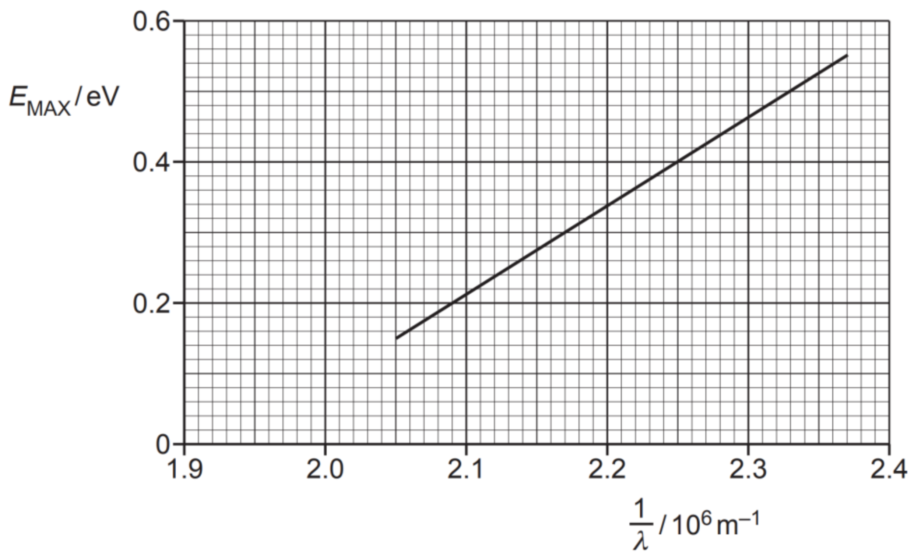

Fig. 5.2

(i) Use Fig. 5.2 to determine the threshold frequency f_0.

f_0 = ... Hz [2]

(ii) The electromagnetic radiation is now incident on a metal with a larger work function energy than the metal in (d)(i).

On Fig. 5.2, sketch the variation with $\frac{1}{\lambda}$ of E_{MAX}. [1]

Section B

Answer **all** question from this Section in the spaces provided.