9 **(a)** An electron is travelling in a vacuum towards an electrode with kinetic energy of 8.55×10^{-19} J.

Calculate the stopping potential V_s required to stop the electron.

V_s = ... V [2]

(b) **(i)** The electron in **(a)** is emitted from a material whose work function is 2.80 eV. Calculate the wavelength of the radiation responsible for causing the emission of the electron.

wavelength = ... m [2]

(ii) Suggest the type of radiation which has the wavelength in **(b)(i)**.

type of radiation = ... [1]

(c) **(i)** Calculate the de Broglie wavelength of an electron travelling with speed 1.85×10^{7} m s^{-1}.

wavelength = ... m [2]

(ii) Graphite, with its layered structure as shown in Fig. 9.1, acts as a natural diffraction grating when used in electron diffraction experiments. The distance between each layer of graphite is 0.335 nm.

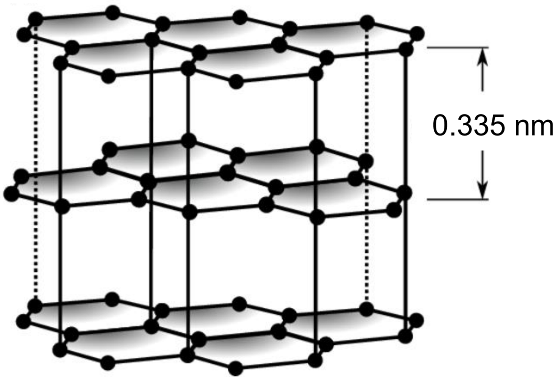

Fig. 9.1

Explain whether electrons having the speed of 1.85×10^{7} m s^{-1} can be used to demonstrate electron diffraction.

....

....

....[2]

(d) Tungsten, a transition metal, is commonly used as a target metal to produce X-rays. The energy levels of the K- to M-shells for tungsten are shown in Fig. 9.2 below.

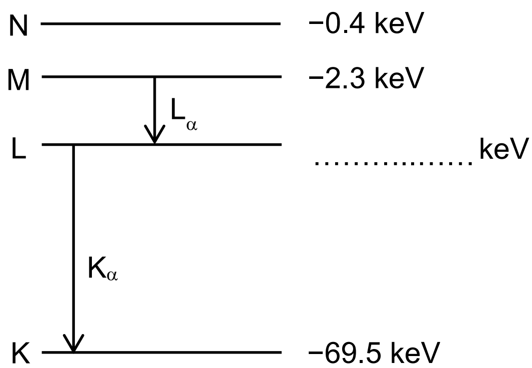

Fig. 9.2 (not to scale)

The wavelength of the photon produced by the K_α transition is 21.2 pm.

(i) Complete Fig. 9.2 by filling in the energy level of the L-shell for tungsten. Show your working clearly.

[3]

(ii) The intensity of various photon wavelengths from electron bombardment of a tungsten target metal is shown in Fig. 9.3. The peak representing K_α transition is labelled.

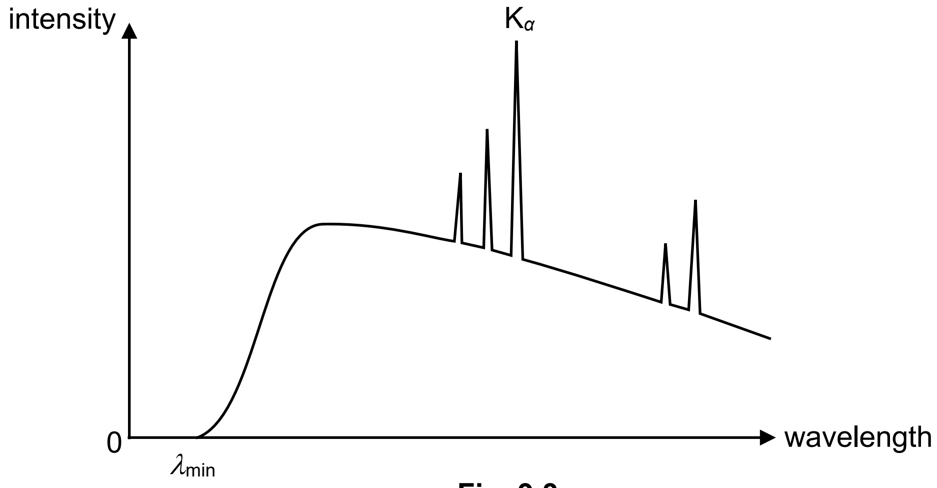

Fig. 9.3

1. On Fig. 9.3, label the peak for L_α transitions. [1]

2. Explain the existence of a minimum wavelength λ_{min}.

....

....

....

....[2]

(iii) With reference to Fig. 9.2, state the minimum energy of the bombarding electrons to produce the characteristic X-rays lines shown in Fig. 9.3.

minimum energy = ... keV [1]

(iv) Explain your answer in **(d)(iii)**.

....

....

....[1]

(e) Fig. 9.4 below shows a typical setup for producing such X-ray beams.

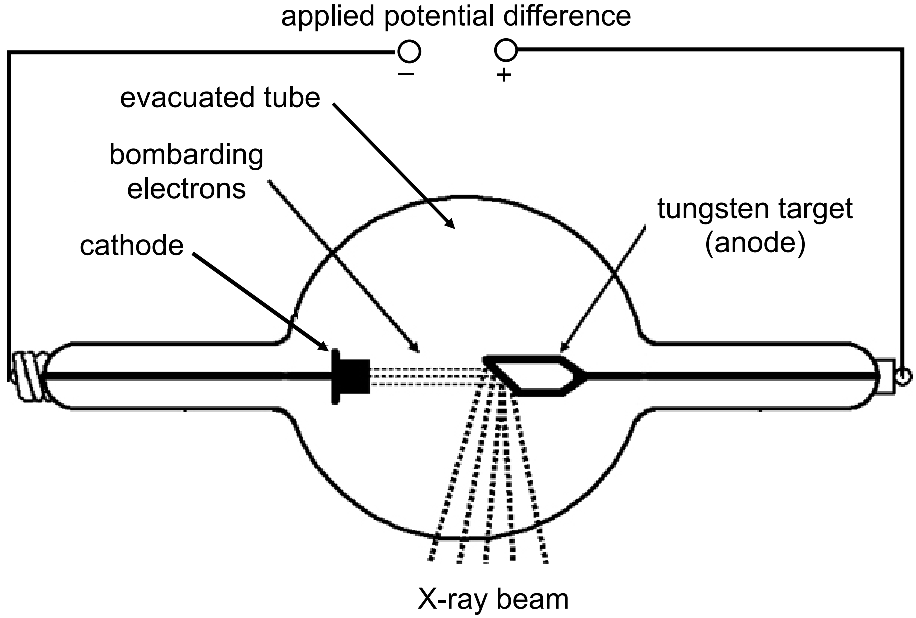

Fig. 9.4

(i) For safety reasons, the wavelength of radiation used for medical X-rays should not be shorter than 50 pm.

Suggest why the wavelength of X-rays radiation should not be shorter than 50 pm.

....

....

....[1]

(ii) Determine the minimum applied potential difference for medical X-rays.

minimum potential difference = ... V [2]

[Total: 20]