9 (a) X-rays are produced when electrons are accelerated through a potential difference towards a metal target such as tungsten. Fig. 9.1 shows a typical X-ray intensity spectrum that can be produced from an X-ray tube.

Fig. 9.1

(i) Explain the origins of the following features of Fig. 9.1:

1. characteristic lines,

._____.

._____.

.._____.

._____.

._____.[2]

2. cutoff wavelength.

._____.

._____.

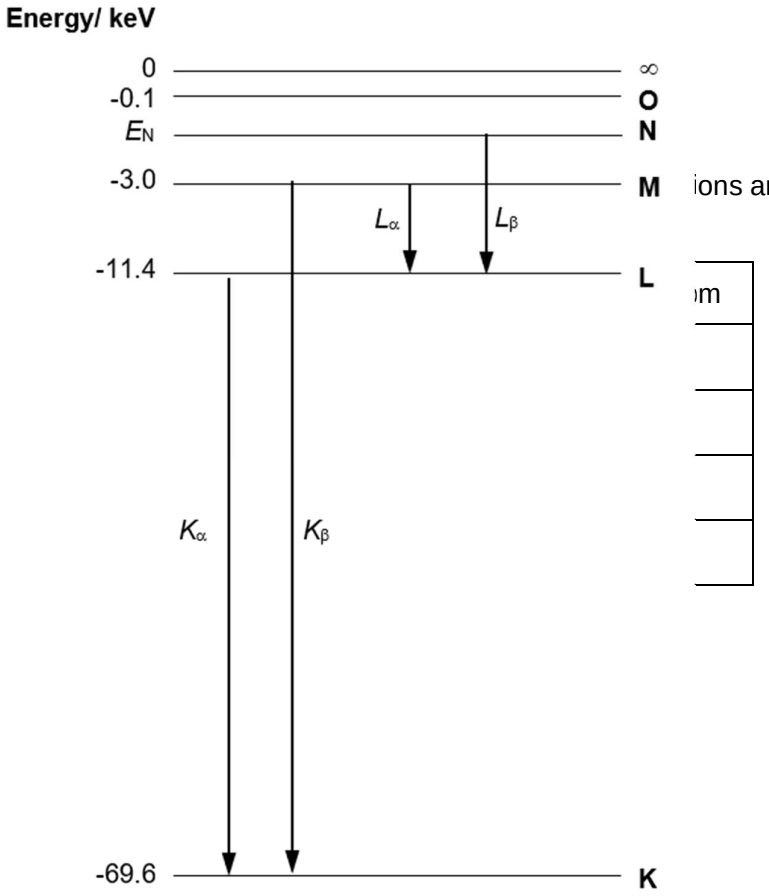
._____.[1]

(ii) If the electrons are accelerated through a potential difference of 75.0 kV, determine the cutoff wavelength λ_{cutoff} of X-rays that can be produced by the tube.

cutoff wavelength = _____ m [2]

(iii) If the potential difference used to accelerate the electrons is decreased, sketch on Fig. 9.1 to show the new spectrum obtained. [2]

(b) Fig. 9.2 shows some of the energy levels within an atom of tungsten and four possible transitions (K_α, K_β, L_α and L_β) that can be detected for the experiment depicted in **(a).**



Tl ions are given in Fig. 9.3.

m

(i) Use Fig. 9.2 to deduce the energy level E_N, in keV, for the N-shell electrons.

E_N = _____ keV [2]

(ii) In reality, transitions from O *to* L or N to K shells are also possible, but in practice the observed intensities associated with these transitions are low.

Suggest a possible reason why this is so.

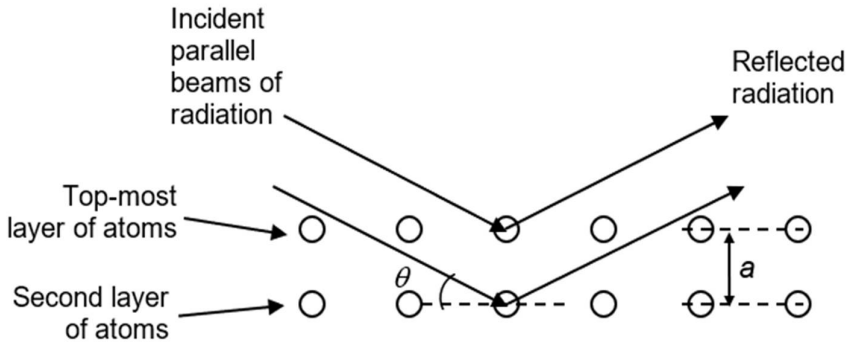
._____.

._____.

._____.[1]

(c) A researcher is investigating a cubic crystal with X-rays. The X-rays are incident at an angle θ to the crystal surface and the crystal has a lattice spacing a. He is looking at the reflection from parallel layers of atoms in a thin film deposit of the material, as shown in Fig. 9.4.

Constructive interference occurs when the path difference between radiation reflected off adjacent layers is an integer product of the wavelength of the radiation.



(i) layers of atoms can

maximum occurs as

a = _____ m [2]

(ii) The beams indicated in Fig. 9.4 depict the conditions for first order maxima.

Sketch, in the same figure, the beams of incident and reflected radiations corresponding to the second order maxima. [1]

(iii) Calculate the angle θ_2 at which the second order maxima occurs.

angle θ_2 = _____ ^{o} [2]

(d) It is suggested that electron beam can be used in place of X-rays to carry out this diffraction experiment.

(i) Calculate the maximum wavelength of the electrons which can be used to probe the crystal lattice.

maximum wavelength = _____ m [2]

(ii) Hence, find the minimum speed which the electrons must possess to be used for electron diffraction.

minimum speed = _____ m s^{-1} [3]

[Total: 20]

End of Paper