6 Fig 6.1 shows the set-up of the Davisson and Germer experiment which was originally designed to measure the energy of electrons scattered from a nickel metal target.

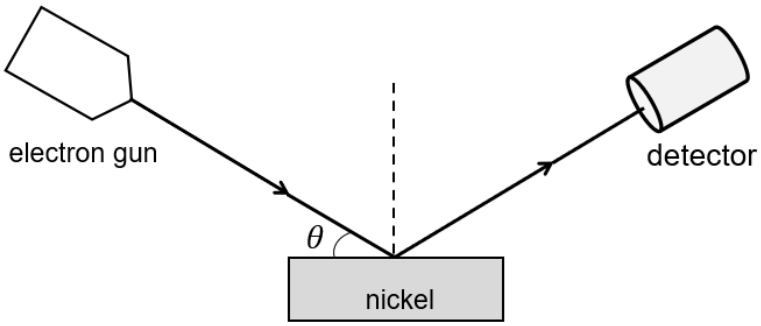

Fig. 6.1

Electrons are accelerated from rest through a potential difference of 100 V in the electron gun.

The accelerated beam of electrons, which emerge from the electron gun, is then directed at an angle θ with respect to the surface of the nickel target.

Electrons that are scattered from the nickel are collected by a detector which measures the rate I at which the charges are collected.

(a) Consider a single electron that is being accelerated inside the electron gun.

(i) Calculate the final speed attained by the electron before emerging from the gun.

speed = ... m s^{-1} [2]

(ii) Deduce the corresponding de Broglie wavelength of the electron.

de Broglie wavelength = ... m [2]

(b) The nickel metal has a regular crystalline geometry. Two horizontal atomic planes in the nickel metal, separated by distance *d*, are shown in Fig 6.2.

The electrons in the electron beam from the electron gun can take different paths to the nickel and then to the detector. Two possible paths, path 1 and path 2, are illustrated. Both paths make the same angle θ with respect to the planes.

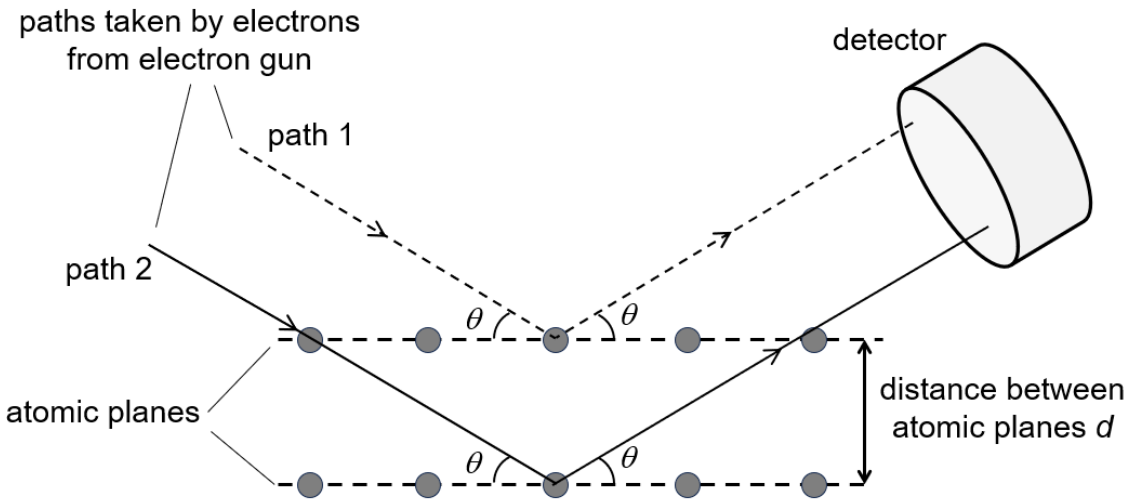

Fig. 6.2 (not to scale)

(i) Determine an expression, in terms of *d* and θ, for the path difference between the electrons of path 1 and path 2.

path difference = ... [1]

(ii) In a particular experiment, the angle θ that the electron beam makes with the atomic planes is kept constant while the accelerating voltage *V* of the electron gun is slowly increased.

Fig 6.3 shows the graph of the rate I at which the charges are detected against the square root of the accelerating voltage $\sqrt{V}$ for the experiment. The rate of charges detected fluctuates between a series of maximum and minimum values of I as *V* is increased.

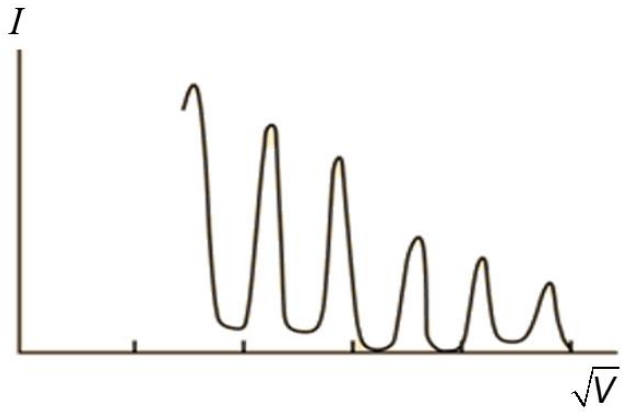

Fig 6.3

1. Describe and explain how the de Broglie wavelength of the electrons emerging from the electron gun changes as the accelerating voltage is increased.

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.....[2]

2. Hence, explain why the graph in Fig. 6.3 shows maximum values of I being detected at only certain accelerating voltages.

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.....[3]

[Total: 10]

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