التجربة الثالثة

اسم التجربة:- حيود الالكترونات

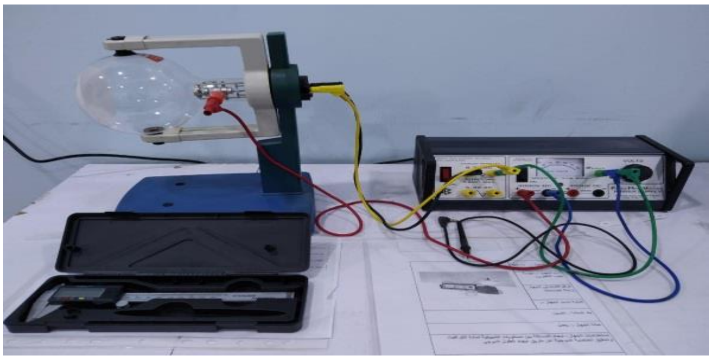
Electron Diffraction Experiment

The purpose of the experiment:-

1- Achieving the wave property of the electron by finding its wavelength.
2- Calculating the distance between the levels in the graphite crystal

Used equipment's :-

Electron diffraction tube, power supply.



Theory :-

The particle-wave property of the electron is one of the most important pillars of quantum physics. The particle property of the electron was verified through a series of experiments, the most important of which was the one carried out by the scientist Thomson in tracking the path of electrons as they pass between two fields: electric and magnetic. As for the wave property of the electron, the scientist De Broglie had the lead in crystallizing the idea that moving electrons might possess the particle property and the wave property at the same time. Based on this assumption, the wavelength of the particle will be inversely proportional to its linear momentum, that is,

$$\lambda = \frac{h}{p} = \frac{h}{mv} \dots\dots(1)$$

where

h = Planck's constant.

(p=mv) ≡ Linear momentum of the particle.

In this experiment, we will apply equation (1) to prove the particle property of the electron by studying the diffraction of accelerated electrons that fall on a sample of polycrystalline graphite (hexagonal crystal structure), and from there to the screen display (Figure (1)).

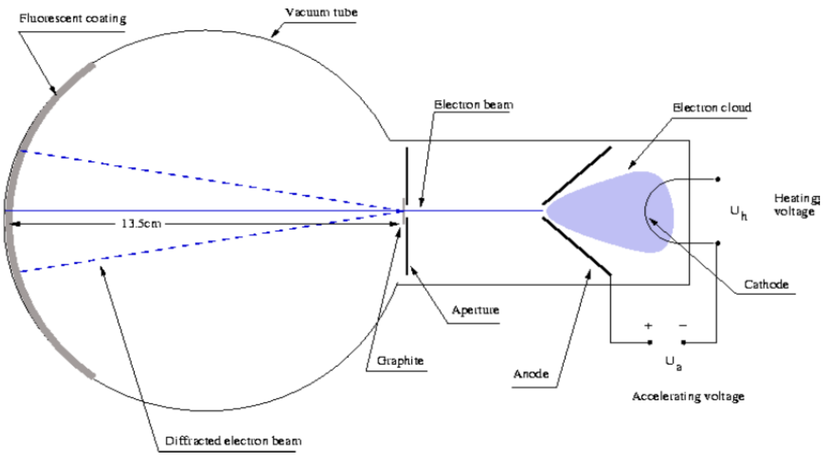


Figure 1 shows the emission of electrons

During the acceleration process resulting from the application of a voltage (V), the electron will gain kinetic energy given by:

$$\frac{P^2}{2M} = eV \ \ldots\ldots \quad (2)$$

whereas :

$(e = 1.6 * 10^{-19}\ C) \ldots\ldots\ldots\ldots (M = 9.1 * 10^{-34}\ Kg)$

Then, using the relationships (1) and (2), the wavelength of the electron can be calculated, that is,

$$\lambda_{th} = \frac{h}{\sqrt{2MeV}} \ \ldots\ldots \quad (3)$$

By substituting for the values of (e), (M) and (h) We get:

$$\lambda_{th} = \frac{6.63 * 10^{-34}}{\sqrt{2 * 9.1 * 10^{-34} * 1.6 * 10^{-19} * V}} = \sqrt{\frac{150}{V}}$$

If the accelerated electrons possess the wave characteristics, the two phenomena of diffraction and interference, which are among the most important characteristics of the wave, will appear on the screen.

Accordingly, the electron beam will collide with the graphite crystals, which form a high-resolution diffraction grating and then be reflected (Fig. 2).

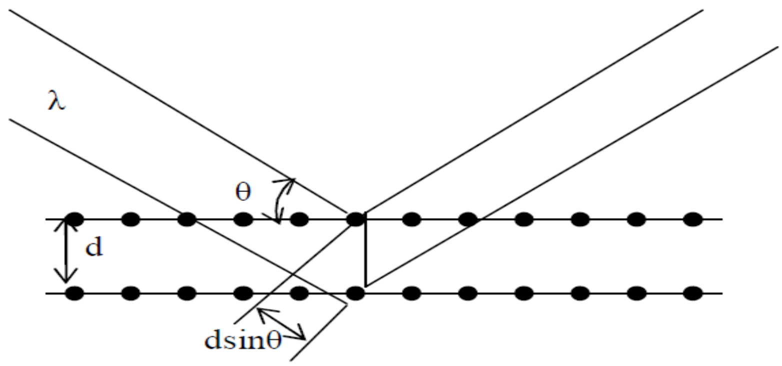


Figure (2) shows the levels of graphite crystal

There are two conditions for constructive interference of waves

1- The angles of incidence and reflection are equal.
2- That the path difference is equal to an integer number of wavelengths.

From Figure (2) and according to Barak's law,

$$2d\ sin\theta = n\lambda \dots\dots \quad (4)$$

whereas-:

(d) ≡ the distance between the graphite grid planes.

(θ) ≡ is the angle between the incident electron beam and the layer of atoms.

(n) ≡ diffraction order.

If the electrons have wave properties, then in this case we can use Equation (4) to describe the diffraction of electrons. When it falls on a graphite crystal, it will be reflected and received on a phosphorescent screen and ionize as a result of electrons falling on it, giving us the opportunity to see them as rings whose center is a bright spot, Figure(3).

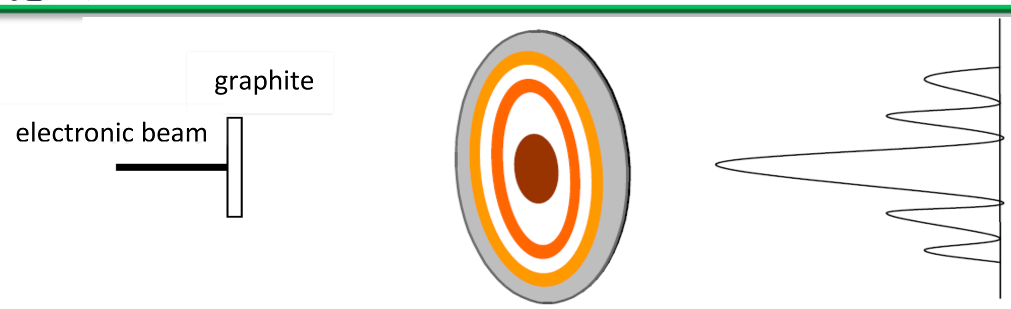


Figure (3) shows a picture of the diffraction of electrons as a ring whose center is a bright spot

As for graphite crystals, the reflected electrons are scattered in the form of a cone with its base on the screen. Figure (4)

$$\tan 2\alpha = \frac{D}{2L} \ldots\ldots\ldots (5)$$

whereas-:
(α) diffraction angle equal to twice the angle of incidence (θ).
(L) The length of the glass tube is a fixed amount (13.5 cm).
(D) Radius of the diffraction ring.

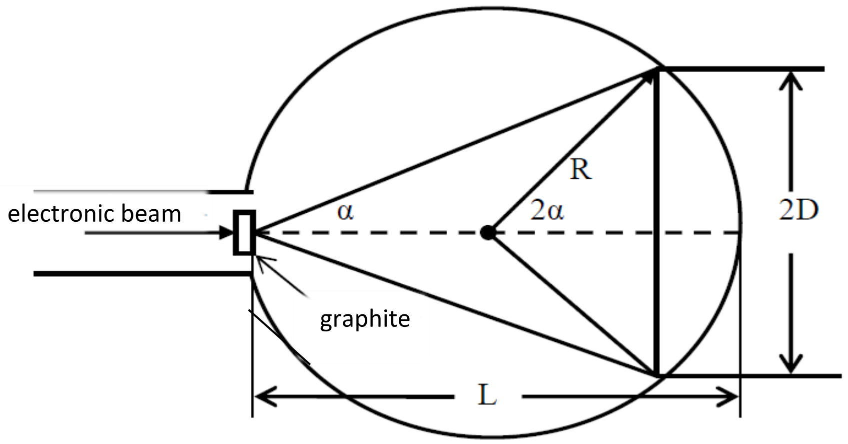


Figure (4) shows the diffraction angle and radius of the glass tube.

And since the

$$\sin 2\alpha = 2\sin\theta \ldots\ldots\ldots$$

$$2\sin\theta = \frac{D}{2L} \ldots\ldots (6)$$

Using equation (4), we get

$$d = \frac{2L\,n\,\lambda}{D} \ldots\ldots\ldots\ldots (7)$$

Work steps :-

1- Apply an acceleration voltage of (5 KV).

2- Change the acceleration potential by (0.5 KV) and each time measure both D1 and D2 on the diffraction tube screen, as in Figure (6) and then record the results in a table.

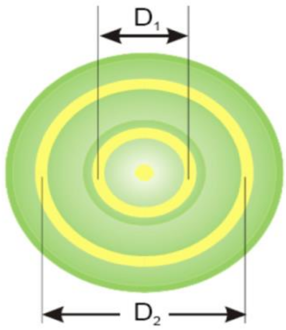


Figure (6) shows the diagonals of the two diffraction rings

3- Draw the relationship between D2, D1 on the y-axis and ג on the x-axis, as shown in Figure (7).

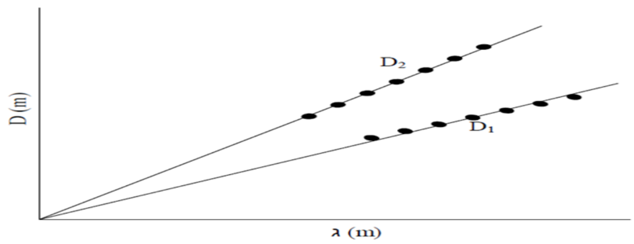


Figure (7) shows the relationship between D and the wavelength

4- Practically find the wavelength from the following equations:

$$\lambda_1 = \frac{r_1 \ * d}{L} \ldots \quad \lambda_2 = \frac{r_2 \ * d}{L} \quad \ldots \ldots \ldots \quad \lambda_{av} = \frac{\lambda_1 + \lambda_2}{2}$$

5- Record the values in a table

V (KV)	D_1 (cm)	D_2 (cm)	λ_{av} (nm)