4-Electron Diffraction

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- The motion of electron might have a wave aspect that an electron of mass (m) and speed (v) would have wave length associated with it .
- De Broglie arrived at equation (1)
- ג= h/mv = h/p …….(1)
- where (p) is the linear momentum .
- The energy of any particle including a photon can be expressed according to Einstein special theory of relativity , as [E= mC2] , where (C) is speed of light and (m) is the particle s relativistic mass using :

- $E_{photon} = h\,v$……(2)
- $mC^2 = h\,v$…(3)
- $mC^2 = h\,C/\lambda$ …(4)
- $\lambda = h/mC = h/p$ …..(5)
- For a photon traveling at speed (C) .

- Davisson Confirmed De Broglie's hypothesis by reflecting electron from metals and observing diffraction effects .
- Electrons behave in some respects like particles and in other respects like wave .
- We are faced with the apparently contradictory (wave – particle duality) of matter and of light .
- An accurate pictorial description using the wave or particle concept of classical physics.

- Ex1/ what is the wave length for the expelled electron from Ni metal which has a work function of (3.1 eV) (1eV= $1.6X10^{-19}$ J) if the metal irradiated with height of wave length (190 nm).
- Sol/
- Ek= hv – Q

- $1/2\ mv^2 = h\ c/\ \lambda - Q$

- $1/2 \times 9.1 \times 10^{-31} \times V^2 = 6.62 \times 10^{-34} \times 3 \times 10^{8} / 190 \times 10^{-9} - 3.1 \times 1.6 \times 10^{-19}$ J

- $v = 2.39 \times 10^{6}$ m.s^{-1}

- $\lambda = h / mv$

- $= 6.6 \times 10^{-34}$ J.s$/ 9.1 \times 10^{-31}$kg $\times 2.39 \times$

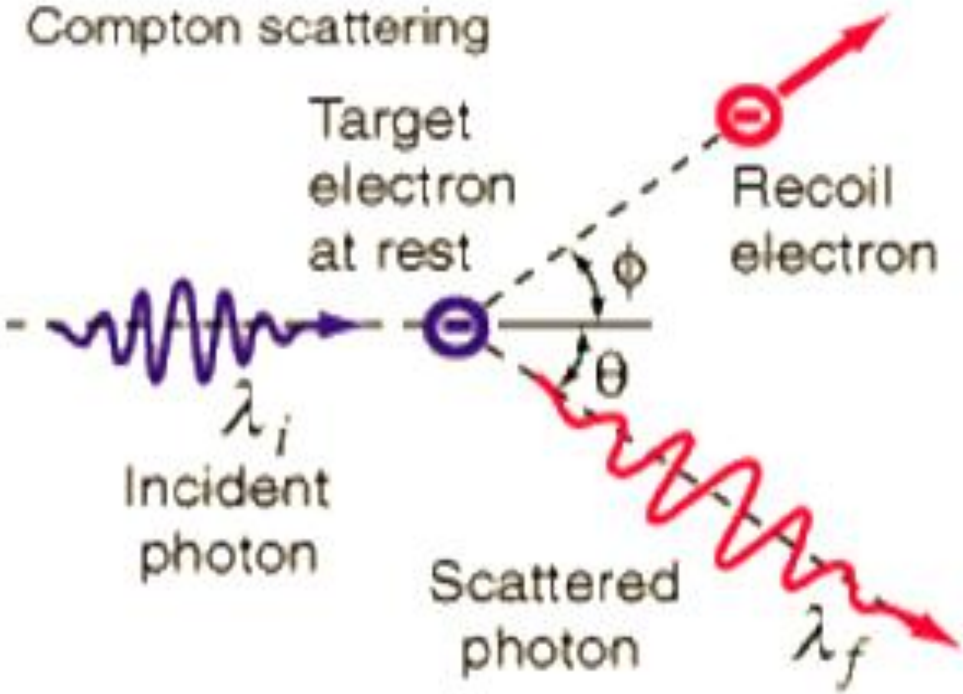
- 10^{6}m.s$^{-1} = 0.304 \times 10^{-9}$m

- **5-Compton Effect**
- Compton effect change is momentum of an electron resulting from collision with a photon
.
- According to compton s experimental observations , a photon , on colliding with any
- material particle , acts as *though* it has a linear

momentum of (h / λ) Where (λ) Is the wave length of the light.

Researchers found that when X-rays of a known wave length interact with electrons , the X-rays are scattered through an angle Θ and emerge at a different wave length related to Θ.

- Although classical electromagnetism predicted that the wave length of scattered rays should be equal to the initial wave length , multiple experiments found that the wave length of the scattered rays was longer than the initial wave length.


Compton scattering
Target
electron
at rest
Recoil
electron
φ
θ
λ i
Incident
photon
Scattered
photon
λ f

- The velocity of the particle is much smaller than the speed of light in vacuum the magnetic component of the electromagnetic wave does not affect the motion of the particle .
- The resulting ,scattered wave therefore will have the same frequency as the original .

- Inelastic scattering in which both the energy and momentum of the electron and the frequency of the light changes the frequency of the light always decreases , is called Compton scattering , and the frequency shift of the light is the Compton effect .
- Assuming light consists of photons which can collide with electrons we can easily explain the observed behavior , by applying the energy and momentum conservation laws .the result is

$$\lambda_f - \lambda_i = \Delta\lambda = \frac{h}{m_e c}(1 - \cos\theta)$$

Where (λ_i)is the initial wavelength,

(λ_f)is the wavelength after scattering,

(h)is the Planck constant,

(me)is the electron rest mass,

(c)is the speed of light, and

(θ)is the scattering angle.

EX1/X- ray band has $1x10^{-5}$ nm incident wave length collision with an electron band what is the wave length after scattering by 60 angle ?

Sol/ $\lambda_2 - \lambda_1 = h/ m_e c (1 - \cos \Theta)$

$\lambda_2 - 1x\, 10^{-5} x\, 10^{-9} = 6.62x\, 10^{-34} / 9.1x10^{-31} x\, 3x\, 10^{8} (1 - \cos 60)$

$\lambda_2 = 0.999x\, 10^{-12} + 1x\, 10^{-14} = 1.009x\, 10^{-12}$ m

Ex2/ what will be the momentum of the Compton electron if for (λ_1= 0.005nm) the photon scattering angle is 90 °?

Sol/ $\lambda_2 - \lambda_1 = h/m_e c\,(1-\cos\Theta)$

$\lambda_2 = 6.62\times 10^{-34}/9.1\times10^{-31}\times 3\times 10^{8}\,(1-\cos 90)+\lambda_1$

$\lambda_2 = 6.62\times 10^{-34}/9.1\times10^{-31}\times 3\times 10^{8}\,(1-0.156)+0.005\times10^{-9}m$

$\lambda_2 = 7.04\times 10^{-12}m$

$P = hv/c = h/\lambda$

$\Delta p = h/\lambda_1 - h/\lambda_2$

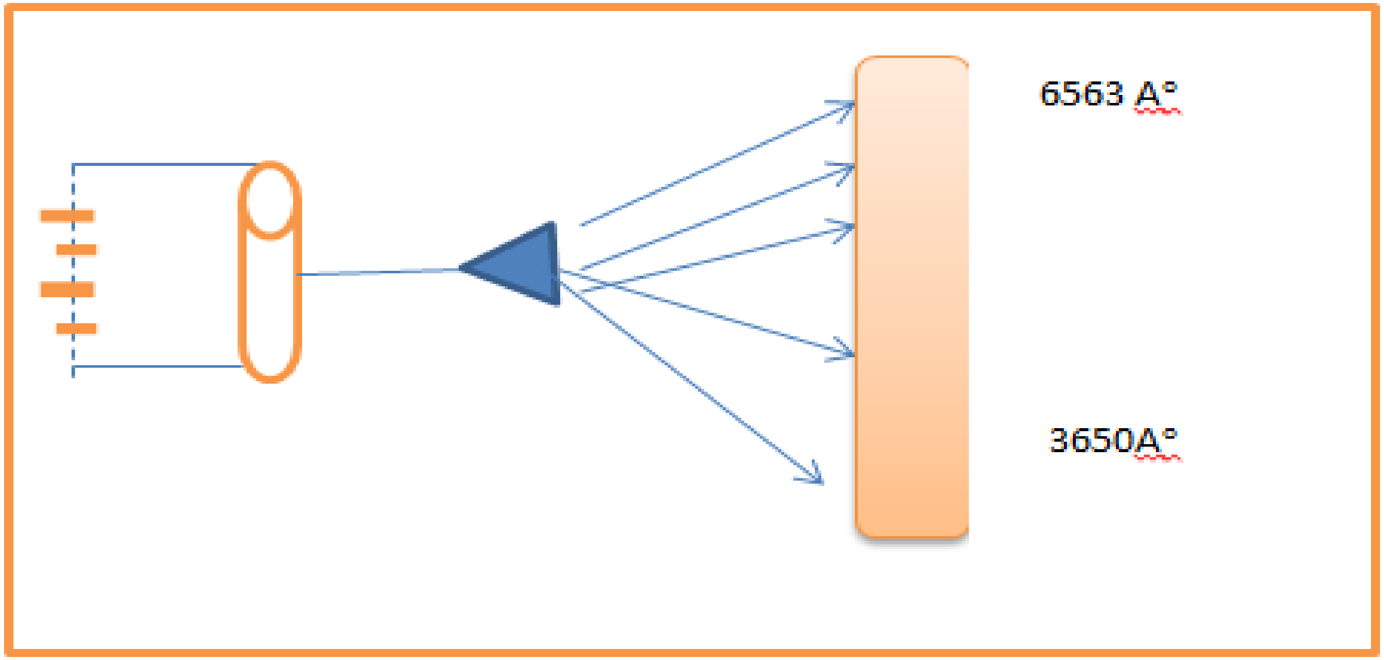
$=6.62\times10^{-34}/0.005\times 10^{-9} - 6.62\times10^{-34}/7.04\times10^{-12} = 3.79\times10^{-23}\ kg.m.s^{-1}$

- Because of the momentum conservation the total momentum of the electron after the collision equals to the total momentum difference between the incoming and outgoing photons.

- **6- Spectral Lines of atoms**
- When an electron discharge is passed through gaseous hydrogen , the hydrogen molecules are dissociated and the energetically excited H atoms that are produced emit light of discrete frequencies.
- The first important contribution to the interpretation of this spectrum was made by the Swiss school teacher , Johann Ballmer .who pointed out in that the wave numbers of the lines in the visible region .
- The transitions describes are now called Ballmer series.

- When further lines were discovered in the Ultraviolet, giving the Lyman series ,and the Infra red , the Paschen series , the Swedish spectroscopist Johannes Rydberg noted that all of them could be fitted to the expression
- $V^{-} = R(1/ n_1^2 – 1/ n_2^2)$
- Where V^{-} = wave number
- R= Rydberg constant for hydrogen atom (109677 cm^{-1})

The series	n1	n2
Lyman	1	2,3
Ballmer	2	3,4
Pascha	3	4,5
Brackett	4	5,6



Ex1/ what is the wave number and wave length (nm) in the Lyman series for H atom ?

$V\bar{} = R (1/n_1^2 - 1/ n_2^2)$

$= 109677(1/1 +1/ 4) = 82258 cm^{-1}$

$\lambda = 1/ V\bar{} = 1.2157 x 10^{-7} m = 121.57 nm$

Ex2/ what is the wave number and wave length (nm) in the Pascha series for Li^{+2} ion?