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)
- ƛ= 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

$1/2\ mv^2 = h\ c/ ג - Q$

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

$v = 2.39 \times 10^{6}$ m.s^{-1} •

ƛ= h/ mv •

$= 6.6 \times 10^{-34}$ J.s/ 9.1×10^{-31}kg x2.39x •

10^{6}m.s^{-1} = 0.304×10^{-9}m •

5-Compton Effect

Compton effect change is momentum of an electron resulting from collision with a photon

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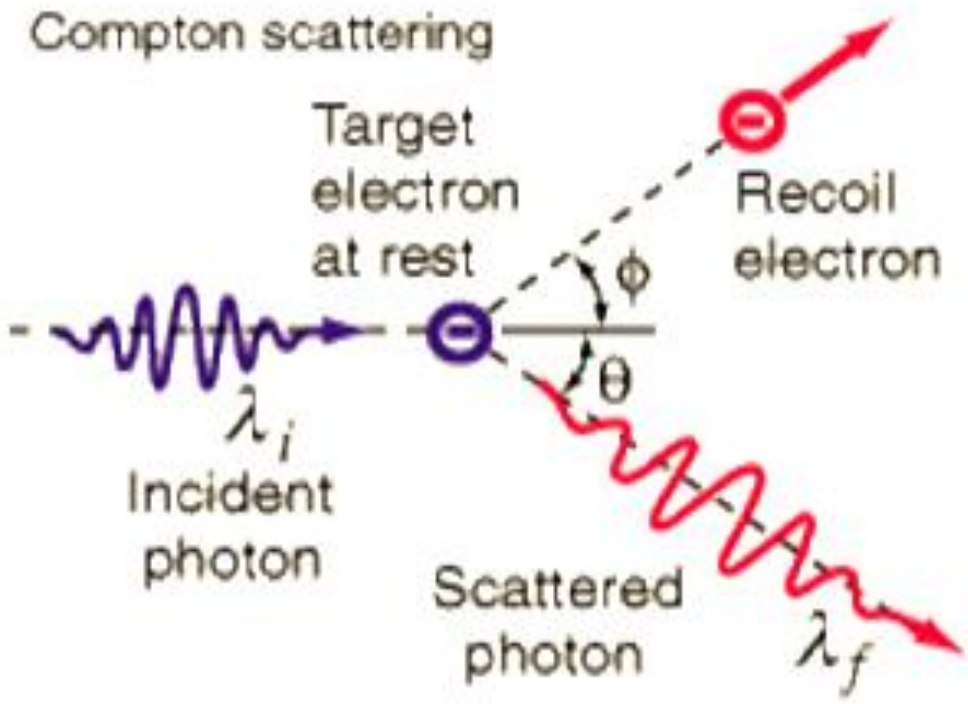
According to compton s experimental observations , a photon , on colliding with any material particle , acts as *though* it has a linear

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 1×10^{-5} nm incident wave length collision with an electron band what is the wave length after scattering by 60 angle ?

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

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

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

Ex2/ what will be the momentum of the Compton electron if for ($\lambda_1 = 0.005$nm) the photon scattering angle is 90 °?

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

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

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

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

$P = \quad = h/\lambda$

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

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

- 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.

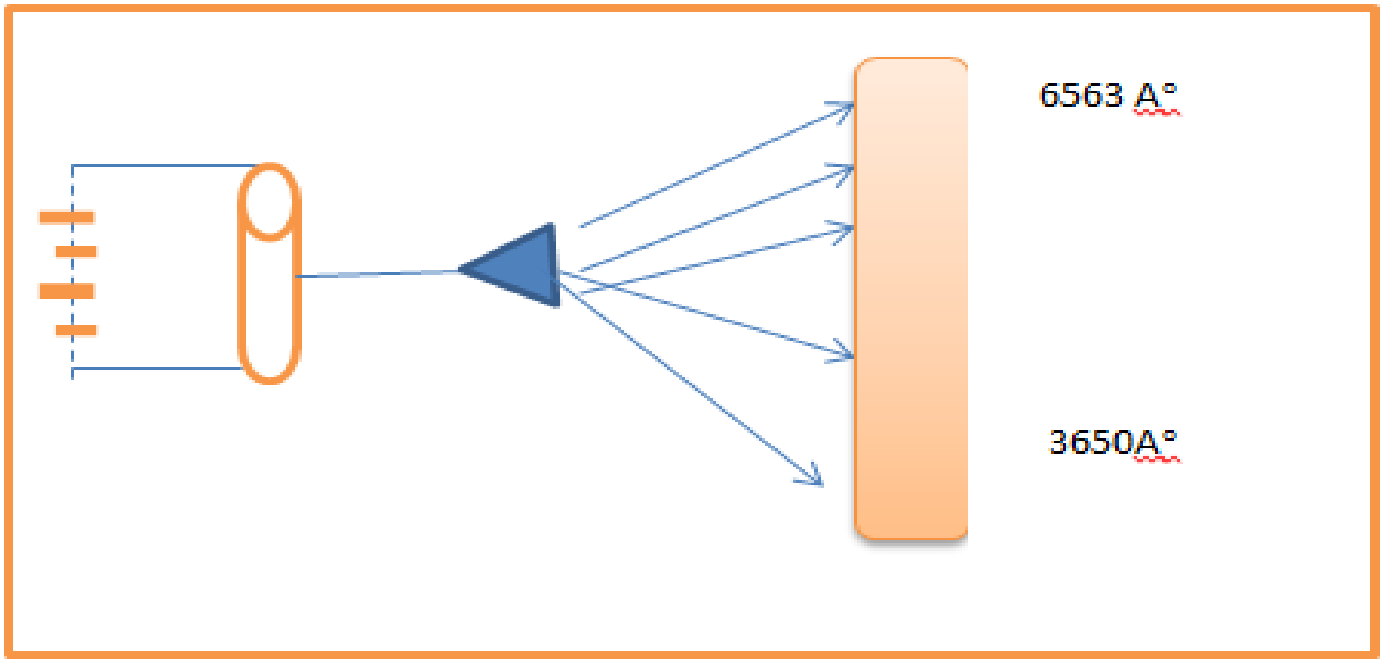
6- Spectral Lines of atoms

- 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

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

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

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

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

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