2-1-2019

Modern physics Including special theory of Relativity

DRAW BACK

- electrons
- H = 13.6V value.
- Doesn't deal with atom

– Total E of sysm (system which contain charged particles)

→ microscopic object can't sol
→ photo electric effect can't
→ Radiation from an objects
→ spectral lines in atoms.

d [t_{2g}, e_g] Crystal field splitting

transmission elements
↓
partially filled 'd'

- which proved the existence of spin. Stern & Gerlach exp.
- magnetic moment is not only the prop of d orbital it has s & p but magnitude is small.

↓

They took silver as source fry to hit radiation & send radiation in non uniform magnetic field. some particles go up and others go down probability only 2 [go up, go down.

- density rules
- selection rules
possible transition.

Black body radiation

I = intensity
λ = wave length

Conclusion

energy levels in atoms are discrete
They are quantised

Why this ↑ & then ↓

bcz when ~~ate~~ the T ↑sing the valence electrons are come out and emitting radiation but after ~~val~~ valence ē gone then the atom stable so we need to give more Energy ~~for~~ get that intensity.

3-1-2019

Thermal radiation
↓
Radiation due to heat energy
- Thermal

Electromagnetic radiation occurs when giving heat to a system contains particles. In vaccum.

Na - Lamb
Valance e⁻ goes to low energy to higher energy level.

Black body radiation
absorb all radiation then emit radiation.
- perfect black body.

Thermal equilibrium
const temp

Newton - particle.
Einstein - "
(photoelectric effect)

Compton - particle

Hygens - waves.
since interference
it like a wave

Maxwell - EM theory
hence waves.

Lewis de Broglie - Matter waves.

→ temp ↑ intensity ↑.

Ideal black body prop

1) Ideal emitter; at every frequency it emits as much or more thermal energy as any other body at the same temp.

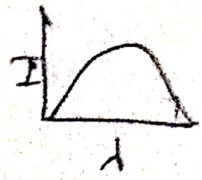
2) It is diffuse emitter, the energy is radiated isotropically independent of direction.

Eg. - metal can trap radiatⁿ

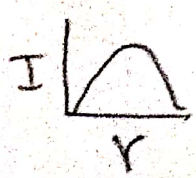
In black body radiation as a fⁿ of distance you can feel radiatⁿ.

Plank's law

In vacuum
I Vs λ



In medium.
I Vs ν



plank's law - explain black body radiation.

plank's law

describes the spectral density of electromagnetic radiation emitted by a black body at a given temp 'T'

B_ν → describes amount of energy it emits at diff radiatn frequency

(intensity) - spectral density.

It is the power emitted per unit area of the body per unit solid angle of emission per unit frequency.

ν at temp T is given by

$$B_\nu(\nu, T) \xrightarrow{\text{power emitted unit frequency}} = \frac{2h\nu^3}{c^2} * \frac{1}{e^{h\nu/k_BT} - 1}$$

k_B - Boltzman const = 1.38×10^{-23} J/K

h - plank's const

c - speed of light.

→ isolate black body in a vaccum giving temp to system then also radiation will there but in vaccum.

$E = h\nu$

Temp - driving force.

photoelectric effect

9-1-2019

1. Rayligh - Jeans law
2. Wein's displacement law.

emits electromagnetic radiation.

$$B_\lambda(\lambda, T) = \frac{2hc^2}{\lambda^5} \times \frac{1}{e^{\frac{hc}{\lambda k_BT}} - 1}$$

- lower frequency } Rayligh
  longer wavelengths } Jeans
- higher ν smaller λ

↓

weins approximation

Rayligh - Jeans is in classical approach.

Rayligh-Jeans law

$$\boxed{B_\lambda(T) = \frac{2ck_BT}{\lambda^4}}$$

B_λ = spectoral radiance

c = speed of light

k_B = boltzman const

T = temp

$$\boxed{B_\nu(T) = \frac{2\nu^2 k_B T}{c^2}}$$

larger ν small λ

Ultra violet catastrops
or Rayligh-Jeans ~~law~~ catastrops.

higher ν can't do with Rayligh Jeans $\therefore$ called UV catastrops.
purely based on classical physics.

Assume black body in thermal equilibrium radiate all range frequency

It is contradicting to conservation of energy.

for black body radiation

$$\lambda = c/\nu$$

$$B_\lambda(T) = \frac{2hc^2}{\lambda^5} \cdot \frac{1}{e^{\frac{hc}{\lambda k_BT}}-1}$$

h = plank's const.

k_B = boltzman const.

$$e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!}$$

$$e^{\frac{hc}{\lambda k_BT}} = 1 + \frac{hc}{\lambda k_BT}$$

then

$$\frac{1}{e^{\frac{hc}{\lambda k_BT}}-1} = \frac{1}{\frac{hc}{\lambda k_BT}} = \frac{\lambda k_BT}{hc}$$

then

$$B_\lambda(T) = \frac{2ck_BT}{\lambda^4}$$

It is ~~form of~~ classical physics.

$$B_\nu(T) = \frac{2h\nu^3}{c^2}\frac{1}{e^{\frac{h\nu}{k_BT}}-1}$$

$$= \frac{2h\nu^3}{c^2}\frac{k_BT}{h\nu}$$

$$= \frac{2h\nu^2 k_BT}{c^2}$$

Wein's displacement law

$\lambda_{max} = \frac{b}{T}$

b = proportionality const

Black body radiation curve peak wave length inversely proportional to Temp.

T = temp

$b = 2.8977 \times 10^{-3}$ m-K.

frequency $\propto$ Temp.

→ The displacement is change in wave length with (as a fn of temp) change in temp

→ λ & ν only depending on temp.

~~photoelectric effect~~

10-1-2019

Radiation Thermometer

Rayleigh-Jeans & Weins apply's in Radiation thermometer.

1 - Temperature sensor

2 - converting the sense in numbers.

we are putting body then then the heat transfer to the thermometer than the mercury level increase.

NIBGYOR

Heating a Iron cone.

Red hot → very longest visible λ

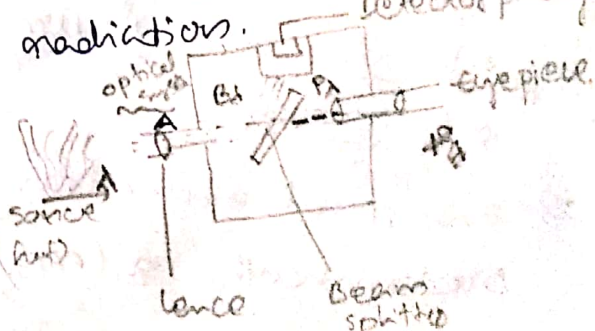
Red orange → ''

white → shortest length

Radiatn thermometer
↓
measure the thermal energy emitted by a source
↓
It related to temp (Plank's law)

· Direct applicatn of plank's law.

Temp measurement using radiation.



P_λ = spectral transmission of the medium b/w instrument & target

effect radiatn in from source

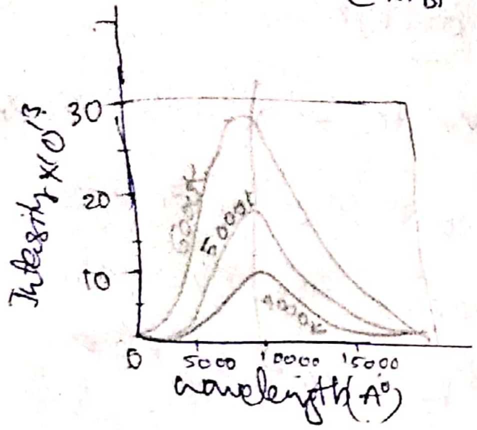
R_λ = response depends only on λ

A radiating black body produce in all directn radiation. That or Intensity we can see in the shape and spherical.

$I_b = f(r, \theta, \phi)$

to understand Intensity we can use spherical thing.

$$B_\lambda(T) = \frac{2hc^2}{\lambda^5} \frac{1}{e^{\frac{hc}{\lambda k_B T}} - 1}$$



Black body spectra.

area under the curve shows rapidly with temp.

~~[illegible]~~

Basic Ideas for radiation thermometer

1) λ varies b/w 10.6 μm at $0^\circ C$ and 1.3 μm at $2000^\circ C$.

2) most of radiation predominantly is (99%) visible region some times near or middle IR region.

3) produces output signal usely electrical.

~~R_λ - spectral radiation~~

$$R_\lambda = \frac{dV}{dE_\lambda}$$

dV = output in response to the radiation flux dE_λ

$$dV = R_\lambda dE_\lambda$$

$$dV = R_\lambda I_\lambda A B_\lambda d_\lambda P_\lambda$$

$$V = \int_0^\infty R_\lambda I_\lambda A B_\lambda P_\lambda$$

Radiometer measurement equation

This used to find what is the temp.

→ Main factor is the wavelength of the source

modifying the P_λ

$$I_{b,\lambda}(\lambda, T) = \frac{2hc^2}{\lambda^5} \times \frac{1}{e^{\frac{hc}{\lambda k_B T}} - 1}$$

I = ~~[illegible]~~ quantity it gave the temp.

Differentiating $I_{b,\lambda}(\lambda, T)$ w.r.t Temp (T)

$$I_{b,\lambda}(\lambda, T) = \frac{2hc^2}{\lambda^5} \times \frac{1}{e^{\frac{hc}{\lambda k_B T}} - 1}$$

$$\frac{d I_{b,\lambda}}{dt} = \frac{2hc^2}{\lambda^5} \frac{d}{dT} \frac{1}{e^{\frac{hc}{\lambda k_B T}} - 1}$$

$(e^{\frac{hc}{\lambda k_B T}} - 1)^{-1}$

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$$= \cancel{\frac{2hc^2}{\lambda^5} \frac{\lambda k_B T}{hc}}$$

$$= \cancel{\frac{2ck_BT}{\lambda^4}}$$

$$= \frac{2ck_B}{\lambda^4}$$

$$dI_{b,\lambda}(\lambda,T) = \frac{2hc^2}{\lambda^6 T^2} \frac{1}{e^{\frac{hc}{\lambda k_B T}}-1} dT$$

$$\frac{dI_{b,\lambda}(\lambda,T)}{I_{b,\lambda}(\lambda,T)} = \frac{hc}{k_B} \frac{dT}{\lambda T^2}$$

Error measured in the temperature dT — dI_b
↓
which coming from dI_b

$$\frac{dT}{T} = \frac{dI_{b,\lambda}(\lambda,T)}{I_{b,\lambda}(\lambda,T)} \times \frac{\lambda T}{\frac{hc}{k_B}}$$

↑

find errors in the measuring temp.

precision measured temp always depend on λ

1) Wavelength
2) always advisable work with shorter wave length,
3) Wavelength Vs temp ... given by plank's

4) main source is should be absorption free then whatever coming out it'd enter to the chamber

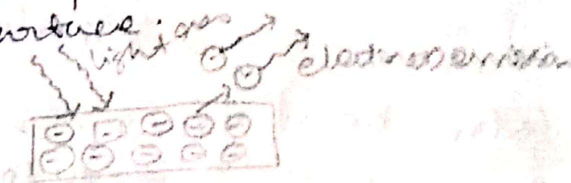
16-1-2019

photoelectronic effect

Frank, & Hertz experiment.

~~16/01/2019~~

photoelectronic came after this experiment. try to get spark in the metal surface



These ejected e^- - photoelectrons.

Is it mandatory ~~for~~ only for metals? If take semi-conductor.

metals has free electrons.

It is like optical exp. you are shining a photon ($h\nu$)

$H = H_0 + H'$
↓
original hamiltonian

inter band transmission

~~when~~ occure when we apply photon to ~~...~~ semiconductor they act on the valency ~~...~~ electron than they cross the barrier.

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The $\bar{e}$ has to get adiquate energy and it has to travel than the Inter band transmission occur.

In ~~semiconductor and~~ metal the thing. Intra band transmission will occur.

Inter band transmission - semicondt & Insulator

Intra band transmission - metals

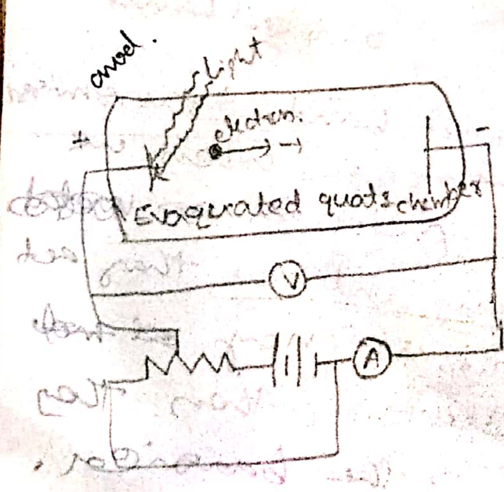
CSIR
Optical conduction - metal ans

Optical absorption - semi conductor, Insulator.

→ anod shine it emit $\bar{e}$ In vaccum exp.

Experimental set up

→ voltage is corresponds the K.E max of photoelectron



Light falls in to the anod.

Evaquated tube contain two electrods (anod (+) & cathod (-))

- It is not mandatory to all the electron not move from + to -ve bcs of the collition (Not all $\bar{e}$ reach the cathod)

$\phi = h\nu_0$

→ work function $h\nu_0$ minimum energy to eject an electron.

→ There is a potential difference b/w the anod & cathod ∴ the $\bar{e}$ move from anod to cathod.

→ Not maintaining the sme Potential difference b/w anod & cathod

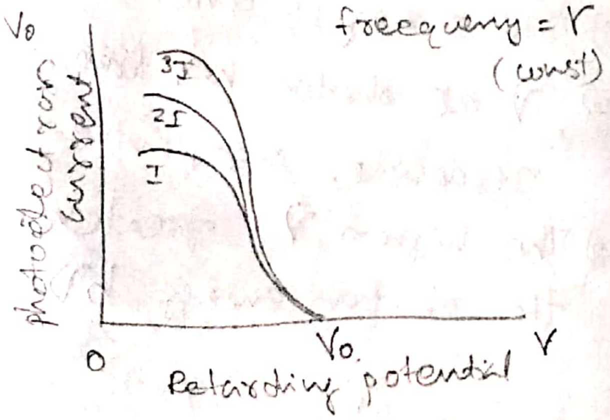
→ freequency of electron is high enogh than the electron will go & hit the cathod.

→ Stopping potential -

potential diff b/w the anod & cathod. that stop the movement of $\bar{e}$

Electronic dipole approximation.

- The giving energy it can only eject the $\bar{e}$ not the nucleous.
- The petondation will low
- Very Intens light able to cross threshold frequency then $\bar{e}$ move to cathod.



current produced by photoelectrons ∝ Intensity

- because light is EM wave.
- Current I
- The minimal energy called work fn (φ)

→ K.E of $\bar{e}$ ∝ Intensity of the radiation

→ Intensity ↑ probabilities $\bar{e}$ hit cathod more.

17-1-2019

EM energy is concentrated on a single thing called - photone.

Energy transfered to the metal surface and eject the $\bar{e}$ from surface.

K.E of $\bar{e}$ is large enough that only reach the cathod. There will be coloumbic repulsion but it will maintain by the K.E. bcz K.E is relatively large. then current on the circuit we can see.

1) More K.E than travel to other side. (cathod)
2) voltage ↑sed to a certain range beyond that

For all the metals. the threshold frequency is different i.e work fn of elements is different.

→ They could see time diff in the ejection of the $\bar{e}$

→ No time interval observed in this experiment. $10^{-6} w/m^2$

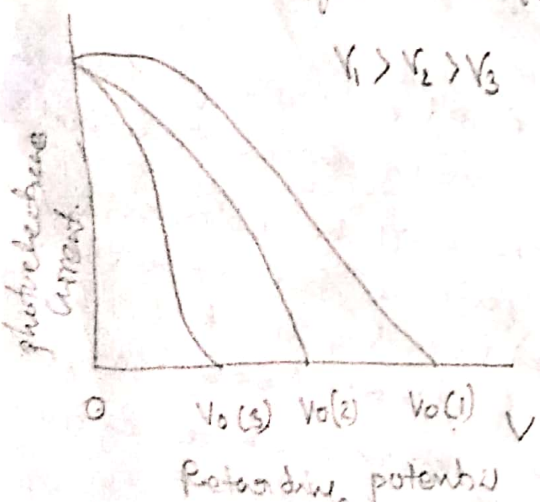
– In principle light hit on a surface there is a time required to get the $\bar{e}$ coming out of it.

eg:- A layer of Na. one atom thick. $1m^2$ each atom took $10^{-25} w$. power.

more intense light → greater the energy of electron

light intensity = const

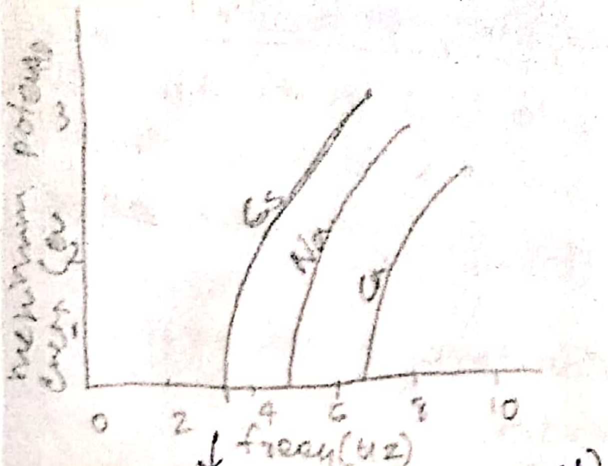
$\nu_1 > \nu_2 > \nu_3$



Higher the frequency of light → more the energy of photoelectron.

Blue light → fast electrons than red

ν_0 → characteristic frequency of a metal below which no electron will be omitted.



slope = h (Einstein's right)

light is not spread as wavefront → small packets called photons

each photon frequency ν

energy = $h\nu$

1) Total energy is conc: on photon
2) ν as photon has frequency. It decide. everything
3) The higher ν greater the photon energy $h\nu$

<u>Work f^n</u>

Cs = 1.9 eV

K = 2.2 eV

Na → 2.3 eV

Li → 2.5 eV

according to Einstein

$h\nu = K_{max} + \phi$

$h\nu$ → photon energy

$K.E_{max}$ → maximum photoelectron energy which is proportional to stopping potential

ϕ → minimum energy required for an electron to leave the metal

$$\boxed{h\nu = K.E_{max} + h\nu_0}$$

$$K.E_{max} = h\nu - h\nu_0$$

$$\boxed{K.E_{max} = h(\nu - \nu_0)}$$

↑sing potential we can stop the e^- movement but still K.E ↑ than can't possible.

23-01-2019

1 - What are the energy & momentum of a photon of a red light at wavelength 650nm?

2 - What are is the wavelength of photon of energy 240eV?

1 - $\lambda = 650nm$

$E = h\nu$

$f = \frac{c}{\lambda}$

$\lambda = \frac{c}{f}$

$$= \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{650 \times 10^{-9}}$$

$$\frac{19.8}{}$$

$$= 0.030 \times 10^{-17}$$

$$= 3.00 \times 10^{-19} J.$$

$\cancel{3.4 \times 8 \times}$ $18 \times 10^{-1} = 1.8$ eV

2 - $E = 240eV$

$\lambda = ?$

$$E = \frac{h.c}{\lambda}$$

$$\lambda = \frac{hc}{E}$$

$$= \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{\cancel{6550} \; 6 \times 240 \times 10^{-18}}$$

$0.014 \times$ $= \cancel{0.082 \times 10^{-26}}$

$= \cancel{8.2 \times 10^{-28}}$ m

$= \cancel{8.2 \times 10^{-19}}$ nm

$$\boxed{1J = 6.6 \times 10^{18}}$$

1 - $P = \frac{E}{c}$

$$= \frac{1.8}{3 \times 10^{8}} = 0.6 \times 10^{8}$$

$$\frac{6.63\times10^{-34}\times3\times10^{8}}{240\times\cancel{6\times10^{-18}}\,1.6\times10^{-19}}$$

$\neq \cancel{0.0138\times10^{-44}}$ (517nm)

$= \cancel{1.38\times10^{-44}}\,m$

$= 5.15\times10^{-7}$

$= 515\,nm$

$$\frac{E}{6.6\times10^{8}} = \frac{hc}{\lambda}$$

2) The workfunction of tungsten metal is $4.52\,eV$

a) what is the cut of wavelength. λ_c for ~~tuncti~~ W.

b) What is the max. kinetic energy of $\bar{e}$ when radiation of wavelength 198.nm is used?

c) What is the stopping potential. in this case

2) $\phi = 4.52\,eV$

a) $\boxed{\lambda_c = \frac{hc}{\phi}}$

$$= \frac{6.6\times10^{-34}\times3\times10^{8}}{4.52\times1.6\times10^{-19}}$$

$= 2.7\times10^{-7}$

$= 270\,nm$

b) $\lambda = 198\,nm$

$K.E_{max} = ?$

$h\nu = KE_{max} + \phi$

$KE_{max} = h\nu - \phi$

$$= \frac{6.6\times10^{-34}\times3\times10^{8}}{198\times10^{-9}} - 4.52 \times 1.6\times10^{-19}$$

$= 0.1\times10^{-17} - 7.2\times10^{-19}$

$= 10\times10^{-19} - 7.2\times10^{-19}$

2.8×10^{-19}

c) $V_s = \frac{K_{max}}{e}$

$= \frac{1.74\, eV}{1.6 \times 10^{-19}}$

$= 1.74\, eV.$

3) The wave length of the threshold of silver is $3.25 \times 10^{-10} m$. Determine the velocity of the electron ejected from silver surface by ultraviolet lights of wave length $2.536 \times 10^{-10} m$.

Ans $\lambda = 3.25 \times 10^{-10} m$

$T = h\nu - h\nu_0$

ν - freequency of the photon.

~~253.6 nm~~

$E = h\nu$

$= \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{2536}$

$= 0.078 \times 10^{-25}$

$= 0.78 \times 10^{-25}$

$= \cancel{0.25.400}$

2815

$V = 1074\, eV.$

$K.E = \frac{1}{2} m v^2$

$E_0 = \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{3}$

~~$T = 6.63 \times 10^{-4}($~~

$\frac{1}{2} m v^2 = 6.63 \times 10^{-34} \times 3 \times 10^{8} \left(\frac{1}{2536} - \frac{1}{3.250} \right)$

$= 19.89 \times 10^{-26} (8.66 \times 10^{3})$

$= 0.172 \times 10^{-29}$

$m v^2 = .344 \times 10^{-29}$

$v^2 = \frac{0.344 \times 10^{-29}}{m}$

$v = \sqrt{\frac{0.344 \times 10^{-29}}{m}}$

$\phi = \frac{hc}{\lambda c}$

$\frac{1}{2} m v^2 = hc \left[\frac{1}{\lambda} - \frac{1}{\lambda c} \right]$

$= hc \left[\frac{1}{3.25 \times 10^{-10}} - \frac{1}{2.56 \times 10^{-10}} \right]$

$= 1.659 \times 10^{-16}$ $= 1.9 \times 10^{6} m/s$

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b) $\cancel{V}_0 = \frac{c}{\lambda}$

$= \frac{3 \times 10^8}{198 \times 10^{-9}}$

$= 0.015 \times 10^{7}$

$h\left(\frac{c}{\lambda} - \frac{c}{\lambda c}\right]$

$= 6.6 \times 10^{-34} \times 3 \times 10^8 \left[\frac{1}{276} - \frac{1}{198}\right]$

$= 0.028 \times 10^{-26} J$

$= 1.74\ eV$

c) stopping potential

$\boxed{V_s = \frac{k_{max}}{e}}$

$= -1.74 V$

24-01-2018

4) An ultraviolet light of wavelength 350nm and intensity $1.00 w/m^2$ is directed at a pottassium surface

a) Find the max k.E of the photoelectrons

b) If 0.5% of incident photon produce photoelectrons, how many are emitted per second if the potassium surface has an area $1.00 cm^2$?

Ans:-

a) $E = \frac{hc}{\lambda}$

$\lambda = 350nm$

$I = 1.00 w/m^2$

$E = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{350nm \times 10^{-9}}$

$= 0.056 \times 10^{-17} J$

$1ev = 1.6 \times 10^{-19} J$ $= \cancel{5.6 \times 10^{-19} J}$

$\cancel{0.8.96 \times}$

$= 0.035 \times 10^2$

$= 3.5\ eV$

$k_{max} = \cancel{hf}\ hV - hV_0$

$= 3.5 - 2.2$

$= 1.3 eV$

b) ~~Power~~

$A = 1\cdot cm^2$

$= 1\times10^{-4} m^2$

$$\boxed{I = \frac{nh\nu}{A} = \frac{nE}{A}}$$

injouls

Area

$$1 = \frac{n\times0.056\times10^{-17}}{10^{-4}}$$

$$\frac{10^{-4}}{0.056\times10^{-17}} = n$$

photons/sec $10^{13}\times17.86 = n$

The rate at which photoelectrons are emitted is (ne)

$$\frac{n\times0.5}{100} = \frac{10^{13}\times17.86\times.5}{100}$$

$$ne = \left(\frac{0.50}{100}\right)\times n = 8.93\times10^{11}$$

photoelectrons/sec

5) Show that photoelectric effect cannot take place with a free electron.

$E = h\nu$

momentum. $p = h\nu/c$

Assume that photoelectric effect take place with free electron.

$E = h\nu$

$$p = \frac{E}{C} = \frac{h\nu}{C}$$

$P = \sqrt{2mE}$

$P^2 = 2mT$

$T^2 = p^2c^2 = \cancel{T^2}\ 2Tmc^2$

$\cancel{T^2 = \frac{h^2\nu^2}{C^2}C^2}$

$\cancel{2h\nu mc^2 = 0}$

$T^2 = p^2c^2$

$= c^2\, 2mT$

$= 2Tmc^2$

$\cancel{2mc^2 h\nu = 0}$

$\cancel{2mc^2 h\nu = 0}$

$\cancel{T^2 = 0}$

$T^2 = 2mTc^2$

$T = 2mc^2$

$T - 2mc^2 = 0$

$h\nu - 2mc^2 = 0$

6 – A photon is incident upon a hydrogen atom ejects an electron of kinetic energy 10.7eV. If the ejected electron is in first excited state, calculate the energy of the photon. How much K.E should be imparted to an electron in ground state.

Ans:- K.E = 10.7eV

E = ?

6-2-2019

Compton effect

(Light matter interaction)

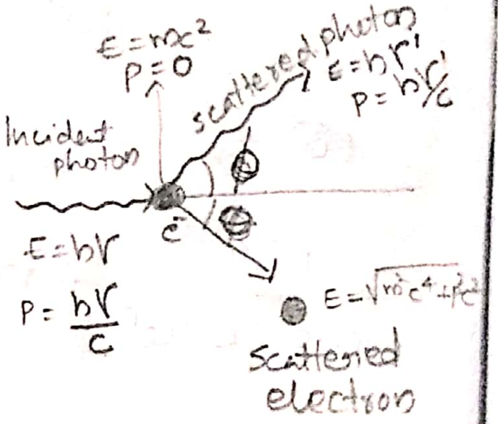
opposite to photoelectronic effect

scattering of light.

Inelastic scattering

- K.E not conserved.

Momentum is not conserved



Scattering of electrons.

first discovered

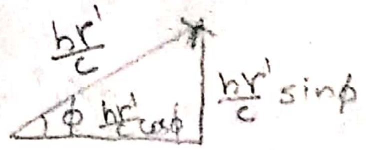
Arthur Holly compton

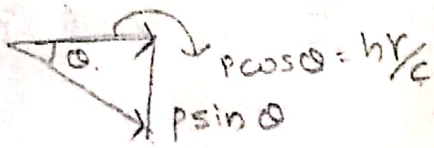
Coming photon has some K.E hitting a $\bar{e}$ then K.E of photon loses and then the wavelength will rises.

photon imparted to knock out the $\bar{e}$ then the K.E will loses than also the K.E is high then start hit another electron.

Energy & Momentum conservedⁿ

Energy is conserved
Momentum is not conserved





vector diagram of the Momenta & their components of incident & scattered photon

$\nu \rightarrow$ Initial photon

$\nu' \rightarrow$ lower than the initial. (scattered frequency)

Loss in photon energy = Gain in electron energy.

$$h\nu - h\nu' = K.E \quad \text{—(1)}$$

$$E = PC \quad \text{—(2)}$$

$$p = E/c = h\nu/c \quad \text{—(3)}$$

Momentum vector quantity incorporate with ~~velocity~~.

~~Why~~

(Initial photon momentum) $\frac{h\nu}{c}$

$p = \frac{h\nu'}{c}$ scattered photon momentum.

collition momentum conserved in each of two mutually ⊥ directions.

Initial momentum = final momentum

Initial ē momentum

$$\frac{h\nu}{c} + 0 = \frac{h\nu'}{c}\cos\phi + P\cos\theta \quad \text{—(4)}$$

Initial photon momentum

find photon p

find ē p

Initial momentum = Final momentum

($\perp^r$ direction)

$$0 = \frac{h\nu'}{c}\sin\phi - p\sin\theta \quad \text{—(5)}$$

ϕ. is the angle b/w. direction of the initial and scattered photons

θ = angle b/w direction of initial photon and the recoil electron.

Multiply (4) × c
(5) × c

$$h\nu = h\nu'\cos\phi + cp\cos\theta$$

$$0 = h\nu'\sin\phi - cp\sin\theta$$

$- n\cos^2\phi + n$

$-n($

$$h\nu = h\nu'\cos\phi + E\cos\theta$$

$$E = K.E + Mc^2 \quad — (7)$$

$$0 = h\nu'\sin\phi - E\sin\theta$$

$$E = \sqrt{M^2c^4 + p^2c^2} \quad — 8$$

$$E^2\cos^2\theta = (h\nu - h\nu'\cos\phi)^2$$

$$E^2\sin^2\theta = h^2\nu'^2\sin^2\phi$$

$$\cancel{E^2(\cos^2\theta\ \sin^2\theta)}$$

$$\cancel{= h^2\nu^2 - h^2\nu'^2 \cos\phi}$$

$$\cancel{E^2 = h^2\nu^2 - h^2\nu'^2}$$

$$E^2 = h^2\nu^2 + h^2\nu'^2\cos^2\phi - 2h^2\nu\nu'\cos\phi + h^2\nu'^2\sin^2\phi$$

$$E^2 = h^2\nu^2 + h^2\nu'^2 - 2h^2\nu\nu'\cos\phi \quad — (6)$$

$E = K.E + mc^2$

We know that

$$(K E + mc^2)^2 = m^2c^4 + p^2c^2$$

$E = K.E + mc^2$

$(n + y)^2$ $\quad n^2 \quad y^2 + 2ny$

total energy of particle

$$p^2c^2 = K.E^2 + 2mc^2 K E.$$

$$K.E = h\nu - h\nu'$$

p^2c^2 — K.E^2 + $2mc^2$ K.E

$$p^2c^2 = (h\nu)^2 - 2(h\nu)(h\nu') + (h\nu_1)^2 + 2m_c^2(h\nu - h\nu')$$

sub p^2c^2 in (6)

$$2M_c^2(h\nu - h\nu') = 2(h\nu)(h\nu')(1-\cos\phi) \longrightarrow (9)$$

eq. (9) divid by $2h^2c^2$

$$\frac{mc}{h}\left(\nu/c - \frac{\nu'}{c}\right) = \nu/c \; \frac{\nu'}{c}(1-\cos\phi)$$

$$\nu/c = 1/\lambda \; \&$$

$$\frac{\nu'}{c'} = \frac{1}{\lambda'}$$

$$\frac{mc}{h}\left(\frac{1}{\lambda} - \frac{1}{\lambda'}\right) = \frac{1-\cos\phi}{\lambda\lambda'}$$

$$\boxed{\lambda - \lambda' = \frac{h}{mc}(1-\cos\phi)}$$

Compton effect.

λ = initial wavelength

λ' = scattering

m = mass of e^-

ϕ = scattering angle

It is strong evidence to support quantum theory of radiation.

7-2-2019

compton scattering.

$$E = \sqrt{m^2c^4 + p^2c^2}$$

Mass & energy.

workdone = W on an object by a const force distance 's'

$$W = Fs$$

This is for electron which is arest.

no additional force.

Force make object to move

$$K.E = Fs$$

force need not to be const force ↑ or ↓ then change K.E

F is not const

$$K.E = \int_0^s F\,ds \quad \text{(classical)}$$

Generaly

$$K.E = \tfrac{1}{2}mv^2$$

to get relativistic formula.

$$P = \gamma m v \quad \text{(Relativistic momentum)}$$

$$\gamma = \frac{1}{\sqrt{1 - v^2/c^2}}$$

$$F = \frac{dP}{dt}$$

$$F = \frac{d}{dt}(\gamma m v)$$

$$K.E = \int_0^s \frac{d}{dt}(\gamma m v)\, ds$$

$$\frac{ds}{dt}\, d(\gamma m v)$$

$$= \int_0^v v\, d(\gamma m v)$$

$$= \int_0^v v\, d\left(\frac{mv}{\sqrt{1-v^2/c^2}}\right)$$

Integrating by parts

$$K.E = \frac{mv^2}{\sqrt{1-v^2/c^2}} - m\int_0^v \frac{v\,dv}{\sqrt{1-v^2/c^2}}$$

$$= \frac{mv^2}{\sqrt{1-v^2/c^2}} + \left[mc^2\sqrt{1-v^2/c^2}\right]_0^v$$

$$= \frac{mc^2}{\sqrt{1-v^2/c^2}} - mc^2$$

$$KE = \gamma mc^2 - mc^2$$

$$= (\gamma - 1)mc^2$$

Total Energy

$$E = mc^2 + K.E$$

$$E = E_0 + K.E$$

mc^2 - rest energy

when object is moving

$$E = \gamma mc^2$$

$$= \frac{mc^2}{\sqrt{1-v^2/c^2}}$$

Energy & Momentum

$$E = Pc$$

E & P conserved in isolated system rest energy to will not change until hit the molecule in the system

E_0 = rest energy

T.E, E_0 & P of a particle Relation

$$E = \frac{mc^2}{\sqrt{1-v^2/c^2}}$$

squaring.

$$E^2 = \frac{m^2c^4}{1-v^2/c^2}$$

$$P = \frac{mv}{\sqrt{1-v^2/c^2}}$$

Square & multiple by c^2

$$p^2c^2 = \frac{m^2c^2v^2}{1-\frac{v^2}{c^2}}$$

Substract

$$E^2 - p^2c^2 = \frac{m^2c^4 - m^2c^2v^2}{1-\frac{v^2}{c^2}}$$

$$E^2 - p^2c^2 = \frac{m^2c^2(c^2-v^2)}{\frac{c^2-v^2}{c^2}}$$

$$E^2 - p^2c^2 = m^2c^4$$

$$E^2 - p^2c^2 = (mc^2)^2$$

hence energy & momentum

$$E^2 = (mc^2)^2 + p^2c^2$$

compton effect

e initially at rest

$$\frac{h\nu}{c} + 0 = \frac{h\nu'}{c}\cos\phi + p\cos\theta$$

+ compton effect give

· incident & scatter light

diff in wavelength

through a electron

$$\lambda_c = \frac{h}{m_e}$$

$\downarrow$

compton wavelength

$$\lambda' - \lambda = \lambda_c(1-\cos\phi)$$

Difference

compton	Photoelectric
$\bar{e}$ with rest	eject innershell
scattering	no scattering; just ejection
continuous	not continuous
depend on K.E photon; energy con.	K.E depend energy is thing

Minor - 2.

13-2-2019

1) X ray 300 keV. = Energy

Scatered angle. 30^0

$h = 6.626\times10^{-34}$ J/s

$c = 3\times10^8\ ms^{-1}$

$eV = 1.6\times10^{-19}$ J

$= 1.6022\times10^{-19}$ J.

$$\lambda_e = \frac{h}{m_e}$$

$$= \frac{6.626\times10^{-34}}{9.1\times10^{-31}}$$

$\boxed{m_e = 511\ keV/c^2}$

$E = mc^2$

$m = E/c^2$

$$\lambda_e = \frac{6.6 \times 10^{-34}}{9.1 \times 10^{-31} \times 3 \times 10^{8}}$$

$$= 0.24 \times 10^{-34} \times 10^{31} \times 10^{-8}$$

$$= 0.24 \times 10^{-11}\ m$$

$$\lambda_e = 4.3 \times 10^{-3} \times 10^{-34} \times 10^{-8}$$

$$= 4.3 \times 10^{-45} \times 10^{-3}$$

$$= 4.3 \times 10^{-48}$$

$$\lambda_e = \frac{h}{\frac{m_e \times c}{c^2}}$$

$$= \frac{hc}{m_e}$$

$$= \frac{hc}{511\ keV}$$

$$= 0.038 \times 10^{-34} \times 10^{8} \times 10^{-3}$$

$$= 0.038 \times 10^{-29}$$

$$\cancel{3.9 \times 10}$$

$$= \frac{0.038 \times 10^{-29}}{1.6 \times 10^{-19}}$$

$$= 0.024 \times 10^{-29} \times 10^{19}$$

$$= 0.024 \times 10^{-10}$$

$$= 2.4 \times 10^{-12}\ m$$

$$= 2.4\ pm$$

$\theta = 30°$

$$\Delta\lambda = 2.4(1 - \cos\theta)$$

$$= 2.4(1 - \cos 30°)$$

$$= 2.4(0.13)$$

$$= 0.319$$

$\theta = 0°$

$$\Delta\lambda = 2.4(1-1)$$

$$= 0$$

$\theta = 180°$

$$\Delta\lambda = 2.4(1 - -1)$$

$$= 4.8$$

$\theta = 60°$

$$\Delta\lambda = 2.4(1 - 0.5)$$

$$= 1.2$$

Scanned by CamScanner

$E' = h\nu'$

λ'

$h\nu' = ?$

λ

$h\nu = 300\,keV$

$eV = \ldots J$

$h\nu = 300\,keV$

$\frac{c}{\lambda} = \frac{300}{\frac{6.6 \times 10^{-34}}{1.6 \times 10^{-19}}}$

$10^{-19} \times 10^{34}$

$\frac{c}{\lambda} = \cancel{45.276 \times 10^{34}}$ 72.44×10^{15}

$\frac{3 \times 10^{8}}{45.276 \times 10^{34}} = \lambda$

$\cancel{0.066 \times 10^{-26} = \lambda}$

$= 0.0414 \times 10^{8} \times 10^{-15}$

$= 0.0414 \times 10^{-7}$

$= 4.14 \times 10^{-12}$

$\cancel{\lambda'}$

$\lambda' - 4.14 \times 10^{-12} = 0.325 \times 10^{-12}$

$\lambda' = 4.465 \times 10^{-12}$

$E' = \frac{hc}{\lambda' \times 1.6 \times 10^{-19}}$

$= \cancel{6.6066}$

$= \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{4.465 \times 10^{-12} \times 1.6 \times 10^{-19}}$

$= \frac{19.8 \times 10^{-34+8+12+19}}{7.144}$

$= 2.77 \times 10^{5}$

$= 277\,keV$

$\Delta E = 300 - 277$

$= 23\,keV$

ē gained energy.

14-2-2019

$$F = \frac{dP}{dt}$$

$$F = \frac{d}{dt}(\gamma m v)$$

$$K.E = \int_0^s \frac{d}{dt}(\gamma m v)\, ds$$

$$\frac{ds}{dt}\, d(\gamma m v)$$

$$= \int_0^v v\, d(\gamma m v)$$

$$= \int_0^v v\, d\left(\frac{mv}{\sqrt{1-v^2/c^2}}\right)$$

Integrating by parts

$$K.E = \frac{mv^2}{\sqrt{1-v^2/c^2}} - m\int_0^v \frac{v\,dv}{\sqrt{1-v^2/c^2}}$$

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$$KE = \gamma mc^2 - mc^2$$

$$= \boxed{(\gamma - 1)mc^2}$$

Total ~~KE~~ Energy

$$E = mc^2 + K.E$$

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mc^2 - rest energy

when object is moving

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E & P conserved in isolated system rest energy E_0 will not change until hit the molecule in the system

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$$E^2 - p^2c^2 = m^2c^4$$

$$E^2 - p^2c^2 = (mc^2)^2$$

hence energy & momentum

$$E^2 = (mc^2)^2 + p^2c^2$$

compton effect

E initially @ rest

$$\frac{h\nu}{c} + 0 = \frac{h\nu'}{c}\cos\phi + p\cos\theta$$

+ compton effect give incident & scatter light diff in wavelength through a electron

$$\lambda_c = \frac{h}{m_e}$$

$\downarrow$

compton wavelength

$$\lambda' - \lambda = \lambda_c(1-\cos\phi)$$

Difference

compton	Photoelectric
$\bar{e}$ with rest scattering	eject innershell. no scattering just ejection
continuous.	not continuous
depend on k.E photon energy con.	k.E depend energy is thing

Minor - 2.

13-2-2019.

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$\boxed{m_e = 511 \text{ keV}/c^2}$

$E = mc^2$

$m = E/c^2$

$$\lambda_e = \frac{6.6 \times 10^{-34}}{9.1 \times 10^{-31} \times 3 \times 10^{8}}$$

$$= 0.24 \times 10^{-34} \times 10^{31} \times 10^{-8}$$

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$$= 0.038 \times 10^{-34} \times 10^{8} \times 10^{-3}$$

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~~3.9 × 10~~

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$$\Delta\lambda = 2.4(1-1)$$

$$= 0$$

$\theta = 180°$

$$\Delta\lambda = 2.4(1--1)$$

$$= 4.8$$

$\theta = 60°$

$$\Delta\lambda = 2.4(1-0.5)$$

$$= 1.2$$

Scanned by CamScanner

$E' = h\nu'$

$h\nu' = ?$

$h\nu = 300 keV$

$eV = 6 \cdot J$

$\frac{c}{\lambda} = \frac{300}{6.6 \times 10^{-34}} \times 1.6 \times 10^{-19}$

$\frac{c}{\lambda} = \cancel{45.276 \times 10^{34}}$ 72.44×10^{15}

$\frac{3 \times 10^8}{45.276 \times 10^{34}} = \lambda$

$\cancel{0.066 \times 10^{-26} = \lambda}$

$= 0.0414 \times 10^8 \times 10^{-15}$

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$\lambda' = 4.14 \times 10^{-12} = 0.325 \times 10^{-12}$

$\lambda' = 4.465 \times 10^{-12}$

$E' = \frac{hc}{\lambda' \times 1.6 \times 10^{-19}}$

$= \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{4.465 \times 10^{-12} \times 1.6 \times 10^{-19}}$

$= \frac{19.8 \times 10^{-34+8+12+19}}{7.144}$

$= 2.77 \times 10^5$

$= 277 keV$

$\Delta E = 300 - 277$

$= 23 keV$

$\bar{e}$ gained energy.

14-2-2019

14-2-2019

2- x-ray violet light $\lambda = 400nm$

$\theta = 180°$ (coming back)

what is the energy for scattered light $E' = ?$

$\lambda = 400nm$

$\theta = 180°$

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

$$= \frac{h}{\frac{511}{c^2} \times c}$$

$$= \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{511 \times 10^3}$$

$$= \frac{0.0389 \times 10^{-29}}{1.6 \times 10^{-19}}$$

$$= \underline{0.0243 \times 10^{-10}}$$

$$= \underline{2.4 \times 10^{-12}}$$

$$\lambda' - \lambda = 2.4 \times 10^{-12}(1 - -1)$$

$$\lambda' - \lambda = 4.8 \times 10^{-12}$$

$$\lambda' - 400 \times 10^{-9} = 4.8 \times 10^{-12}$$

$$\lambda' = 4.8 \times 10^{-12} + 400 \times 10^{-9} \times 10^3 \times 10^{-3}$$

$$= 400004.8 \times 10^{-12}$$

$$= \underline{4 \times 10^{-7}}$$

$$E' = \frac{hc}{\lambda'}$$

$$= \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{4 \times 10^{-7}}$$

$$= \frac{4.969 \times 10^{-19}}{1.6 \times 10^{-19}}$$

$$= \underline{3.1056 \text{ ev.}}$$

$$\Delta E = \frac{hc}{\lambda} - \frac{hc}{\lambda'}$$

$$= hc\left(\frac{\lambda' - \lambda}{\lambda\lambda'}\right)$$

$$E = \frac{hc}{\lambda}$$

$$\frac{6.626 \times 10^{-34} \times 3 \times 10^8}{400 \times 10^{-9}}$$

$$= \frac{0.0497 \times 10^{-17}}{1.6 \times 10^{-19}}$$

Scanned by CamScanner

$E' - E =$

$= 0.03106 \times 10^{2}$

$= \cancel{3.106 \times 10^{2}\ eV}$

$= 3.106\ eV$

$hc = 1240\ keV$

$$\Delta E = \frac{\overset{hc}{1240} \times \overset{\Delta\lambda}{4.86}}{400 \times 400 \times 10^{8}\ \lambda(pm)}$$

$$= \frac{\cancel{6.032}\ 6026.4 \times 10^{-6}}{16 \times 10^{4}}$$

$= 376.65 \times 10^{-10}$

$= 3.76 \times 10^{-8}\ keV$

$= 3.76 \times 10^{-8} \times 10^{3}$

$= 3.76 \times 10^{-5}$

$= 37.6\ \mu eV$

$$E = \frac{\overset{hc}{1240\ keV}}{400 \times 10^{3}\ \lambda(pm)}$$

$= 3.1\ eV$

Qe:- $\lambda = 0.24\ nm$

Longest λ ?

Ans $\theta = 180°$

$$\lambda' - \lambda = \frac{h}{m.c}(1 - \cos\theta)$$

$$E' = \frac{hc}{\lambda'}$$

$\lambda' - \lambda = 4.8 \times 10^{-12}$

$\lambda' = 4.8 \times 10^{-12} + 0.24 \times 10^{-9} \times 10^{3} \times 10^{-3}$

$= 244.8\ pm$

$E_e = \Delta E$ energy of e

$\cancel{\Delta E =}$

$$E = \frac{1240\ keV}{0.24 \times 10^{3}}$$

$= 5166.6\ eV$

$$\Delta E = \frac{1240 \times 4.86 \times 10^{}}{0.24 \times 0.24 \times 10^{6}}$$

$= 104.625 \times 10^{-3}$

$= 104.625\ eV$

$\Rightarrow$

$\lambda = 0.24\ nm$

$\lambda' = 0.2412\ nm$

$\theta = ?$

$$\lambda' - \lambda = \frac{h}{\frac{m_o c}{c^2}}\left[1 - \cos\theta\right]$$

$$0.2412 \times 10^3 - 0.24 \times 10^3$$

$$= \frac{1240 \times 10^3}{511 \times 10^3}\left[1 - \cos\theta\right]$$

$$1.2 \times 10^{-3} = 2.43\left[1 - \cos\theta\right]$$

$$0.494 = 1 - \cos\theta$$

$$1 - 0.494 = \cos\theta$$

$$0.506 = \cos\theta$$

$$\theta = 60^\circ$$

$\phi = ?$

$$\frac{h\nu}{c} = \frac{h\nu'}{c}\cos\theta + p\cos\phi$$

$$\frac{h\nu}{c} - \frac{h\nu'}{c}\cos\theta = p\cos\phi$$

$$\frac{h}{\cancel{c}}\left(\frac{\nu}{c} - \frac{\nu'}{c}\cos\theta\right) = p\cos\phi$$

$$h\left[\lambda - \lambda'\cos\theta\right] = p\cos\phi$$

$$6.62 \times 10^{-34}\left[0.24 \times 10^3 - 0.2412 \times 10^3 \times 0.5\right]$$

$$= \frac{h\nu}{c}\cos\phi$$

$$6.62 \times 10^{-34}\left[0.1194 \times 10^3\right] =$$

$$10^{-34} \times 10^3 \times 1.59 \cos\phi$$

$$\frac{0.7911 \times 10^{-31}}{10^{-31} \times 1.59} = \cos\phi$$

$$\frac{0.497 \times 10^{-31}}{10^{-31}} = \cos\phi$$

$$0.497 = \cos\phi$$