
The best
preparation
for tomorrow
is doing your
best today.

Murugesan → Modern physics
Sathya prakash
Aruldass

Unit – 6

Quantum Mechanics and Relativity

DQ

PPOV

PPOV (Wave nature of particles – deBroglie waves – Davison and Germer experiment – waves and particle duality – photoelectric effect – photo electric multiplier – Einstein's equation – Compton Effect – experimental verification of Compton effect – wave nature of electron – Heisenberg's uncertainty principle – position and momentum, energy and time uncertainty – Schrodinger's wave equation – probability amplitude – properties of wave function–normalization – potential barriers – tunnelling across barriers – particle in a box (one dimension only))

O.J

G.T

(Relativity — postulate of Special theory of Relativity – Lorentz transformation of equations and its application – length contraction, time dilation – variation of mass with velocity – Mass energy equivalence - Physical Significance.) PPOV

Quantum mechanics class - I

Topics to be covered:

- ✓ Introduction to QM
- ✓ Dual nature of Matter
- ✓ Wave nature of matter - de Broglie waves
- ✓ Practice problems

1. Note → each unit → min 10 times
→ 2 note → Descriptive
→ MCQ Note

2. Muddi paper → 1 Bunch

3. pen → 1 cover

4. Table clock

5. small note | diary ⭑

sticky note

→ Book note

6. Before call → complete syllabus

after :- Revise | practice

Time Table

7. No zero day ⭑ short break Test daily Test

Each (X)

Errorlog →

Quantum Mechanics

↳ Branch of Physics which deals with the dynamics of bodies at microscopic level.

↓

ex (Subatomic particles)

$\bar{e}$, p^+, n^0, photons

phonons

↳ Non relativistic Q.M

↳ Particle velocity

$V <<< C$ [3×10^8 m/s]

↳ Relativistic Q M

↳ $V \simeq C$

0.77c

·25c

0.99c

Quantum Mechanics

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0.77c

.25c

0.99c

Non Relativistic Q.M

→ Wave mechanics

[Erwin Schrodinger]

→ Matrix mechanics

[Heissenberg
Dirac]

Classical Mechanics

[Newtonian "] C.M

↳ Based Newton's Laws of Motion]

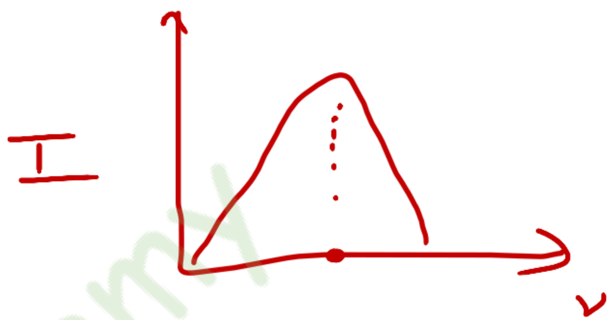
↳ Inadequency of C.M

↓

lead Q.M

Inadequencies of C.M

→ BBR - Spectrum

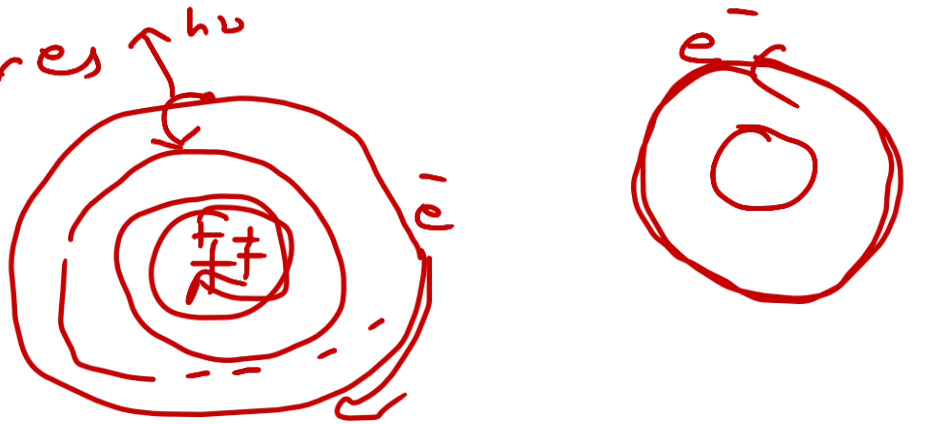


→ Stability atoms

↳ charged particle → move

→ radiate energy → particle Energy ↓

→ orbit size des



→ S.H.C [C] metallic gases

→ Photo electric effect

Compton effect

→ Light → Dual nature → particle

↳ PEE, Compton Effect

↳ BBR (Planck)

$$\frac{8\pi h\nu^3}{c^3}\left(\frac{1}{e^{h\nu/kT}-1}\right)$$

→ wave

↳ Reflection

↳ Interference

↳ Diffraction

↳ polarization.

Dual nature ↓ Complementary mode

→ Matter (collection of particles)

↓

Dual nature

↓ wave

↓ particle

* The Universe is madeup of matter (particles) & radiation (waves)

* As light exhibits dual nature, Sometimes it behaves as particles & sometimes as waves (Radiation)

* Both the behaviours are complement to each other.

* The spectral distribution of BBR is explained by Max Planck.

According to him, the energy of one quantum of light (Photon) is

$$\boxed{E = h\nu}$$

$h \rightarrow$ Planck constant

$\nu \rightarrow$ frequency

$E = h\nu$

Velocity = frequency x wave length

$$v = \nu\lambda$$

$$c = \nu\lambda$$

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

$$\boxed{E = h\nu = \frac{hc}{\lambda}}$$ * PPOV

$h = 6.626 \times 10^{-34}\ Js$

$$\hbar = \frac{h}{2\pi} = 1.05 \times 10^{-34}\ Js$$

$$\nu = \frac{\omega}{2\pi}$$

$$\omega = 2\pi\nu$$

$$E = \frac{h}{2\pi} \cdot 2\pi\nu$$

* $$\boxed{E = \hbar\omega}$$ PPOV

$$\boxed{E = Pc}$$

$$P = E/c$$

↓

Momentum of light quantum

↓

photon

↳ Rest mass = 0

← PPOV

Matter Waves

In 1924, Louis de Broglie proposed the concept

" A matter (or) light never exhibits both particle and wave nature at same instant.

↳ Both the natures are complementary to each other

particle property	wave property
Momentum Energy	Frequency wavelength

DQ

* Moving particle associated with wave nature, known as matter waves.

* The waves associated with material particles are known as de-Broglie waves.

* The wavelength associated with particle having momentum p is,

$$\boxed{\lambda_D = \frac{h}{p}} \longrightarrow ①$$

Here $p = mv$

$m \rightarrow$ mass of particle

$v \rightarrow$ velocity

∴

$$\boxed{\lambda_D = \frac{h}{mv}} \longrightarrow ②$$

Other forms of λ_D:

★ $$\boxed{\lambda_D = \frac{h}{\sqrt{2mE_k}}} \longrightarrow (3)$$

$$\lambda_D = \frac{h}{p}$$

$E_k \rightarrow$ KE of particle

$$E_k = \frac{1}{2}mv^2 = \frac{m^2v^2}{2m}$$

$$= \frac{(mv)^2}{2m} = \frac{p^2}{2m}$$

$$E_k = \frac{p^2}{2m} \Rightarrow p = \sqrt{2mE_k}$$

★ For a charged particle of charge q moving with P.D (potential difference) V,

K.E, $\boxed{E_k = qV}$

$(3) \Rightarrow$ $$\boxed{\lambda_D = \frac{h}{\sqrt{2mqV}}} \longrightarrow (4)$$

$$\lambda_D = \frac{h}{\sqrt{2mqV}}$$

For electron $[e^-]$,

$$q = e = 1.6\times10^{-19}\ C$$

$$m = 9.1\times10^{-31}\ kg$$

$$\lambda_D = \frac{6.6\times10^{-34}}{\sqrt{2\times9.1\times10^{-31}\times1.6\times10^{-19}\times V}}$$

$$\boxed{\lambda_D = \frac{12.27}{\sqrt{V}}} \rightarrow 5$$

$\mathring{A}$

$\times10^{-10}\ m$

for e^- of P.D 'V'

* When the particle is in thermal equilibrium at temperature T

is According to C.M

$$\boxed{E_k = k_B T}$$

$K_B = K$ = Boltzmann Const

$= 1.38 \times 10^{-23}\ JK^{-1}$

$$\boxed{\lambda = \frac{h}{\sqrt{2mK_BT}}} \rightarrow b$$

ii) Acc. to Q.M,

↳ Equipartition theorem

[each DOF → $\frac{1}{2}kT$]

$E_k = \frac{f}{2}kT$

particle → free particle

↳ DOF 3

$$\boxed{E_k = \frac{3}{2}K_BT}$$

$$\lambda_D = \frac{h}{\sqrt{\cancel{2}m \cdot \frac{3}{\cancel{2}}k_BT}} = \frac{h}{\sqrt{3mk_BT}}$$

$$\lambda_D = \frac{h}{\sqrt{3mk_BT}} \rightarrow (7)$$

#1. Find the λ_D of a proton moving with velocity $v = \frac{c}{20}$. m, v

$$\lambda_D = \frac{h}{mv}$$

$h = 6.6 \times 10^{-34}$ JS

$m_p = 1.67 \times 10^{-27}$ kg

$$v = \frac{3 \times 10^8}{20}$$

$$\lambda_D = \frac{6.6 \times 10^{-34}}{1.67 \times \frac{3 \times 10^8}{20} \times 10^{-27}}$$

$$= \frac{\overset{2.2}{\cancel{6.6}} \times 10^{-34} \times 20}{1.67 \times \cancel{3} \times 10^8 \times 10^{-27}}$$

$$\boxed{\lambda_D = \frac{h}{\sqrt{3mk_BT}}} \rightarrow 7$$

#1. Find the λ_D of a proton moving with velocity $v = \frac{c}{20}$. (M,10)

$$\lambda_D = \frac{h}{mv}$$

$h = 6.6 \times 10^{-34}$ JS

$m_p = 1.67 \times 10^{-27}$ kg

$$v = \frac{3 \times 10^8}{20}$$

$$\lambda_D = \frac{6.6 \times 10^{-34}}{1.67 \times \frac{3 \times 10^8}{20} \times 10^{-27}}$$

$$= \frac{\overset{2.2}{\cancel{6.6}} \times 10^{-34} \times 20}{1.67 \times \cancel{3} \times 10^8 \times 10^{-27}}$$

$$\lambda_D = \frac{44 \times 10^{-34}}{1.67 \times 10^{-19}}$$

$$\begin{array}{r} 34 \\ 19 \\ \hline 15 \end{array}$$

$$= \frac{44}{1.67} \times 10^{-34+19}$$

$$= \frac{44}{1.67} \times 10^{-15}$$

$$= \frac{44}{1.7} \times 10^{-15}$$

$$\begin{array}{r} 25. \\ 17\overline{)440} \\ 34 \\ \hline 100 \\ 85 \\ \hline 150 \end{array}$$

3

$$\begin{array}{r} 17 \times 6 \\ \hline 12 \end{array}$$

4

$$= 26 \times 10^{-15} \text{ m}$$

$$= 2.6 \times 10^{-14} \text{ m}$$

H.w

1) Find λ_D of e^- subjected to PD of 1.25 kV

2) Find λ_D of e^- having k.E 500 eV

Doubt

CM $\rightarrow$ Mass $\rightarrow$ constant

QM $\rightarrow$ $m \rightarrow$ vary with $\underline{v \approx c}$

$m \neq m_0$

$\downarrow$

rest mass $(v = 0)$

$\hookrightarrow$ at rest