Quantum mechanics.

(1) E_λ = radiant energy density.

MCQ

$\boxed{\text{(1) Compton effect}}$

(a) Black body is a perfect absorber and radiator

(b) At diff. temperatures, when a perfect black body is allowed to emit radiations, then the distribution of energy for diff λ is uniform

(c) Rayleigh - Jean's law = longer wavelength

(d) Wein displacement law = shorter wavelength

→ Rayleigh Jean's law :-

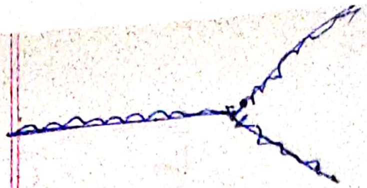
- Energy distribution $\propto$ absolute temp.

  " $\propto \frac{1}{\lambda^4}$

  {longer the λ greater is the E_λ}

→ product of λ corresponding to max. energy and the abs. temp. is constant.

If λ is less, then $\frac{1}{\lambda}$ will be great.



(e) magnetic or elec. field do not affect photons.
↳ have no charge

(f) compton shift = shift in WAVELENTH
⇒ When photon collides with an electron it gives its energy to the electron.
∴ the scattered photon will have higher wavelength compared to λ of incident wavelength.
The shift is compton shift.

$$\Delta\lambda = \frac{h}{mc}(1-\cos\theta)$$
↳ angle of scattering.

• matter waves associated with an electron microscope.

de-broglie wavelength —

$$\lambda = \frac{h}{\sqrt{2meV}}$$

$\boxed{\text{BLACK BODY RADIATION}}$:— By max planck

• as λ of radiation decreases intensity of bbr first increases than decrease.
→ HOT BODY emit RADIATIONS OVER WIDE RANGE OF WAVELENTH.
emits / absorb.

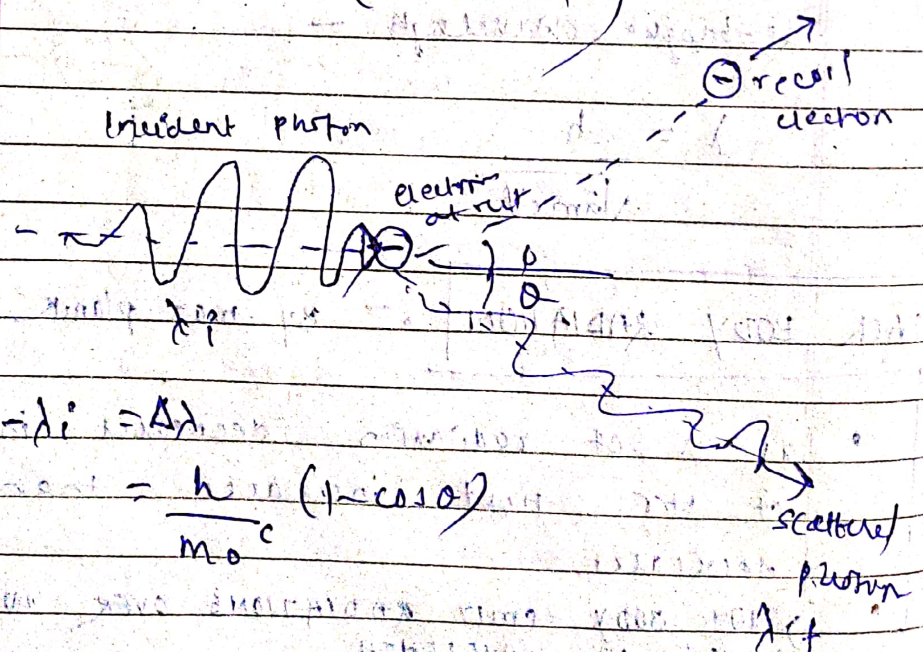
band :-

- As the body gets hotter, the freq. of the emitted radiations keeps on increasing. Blue color has the highest frequency out of Red, Orange and white,

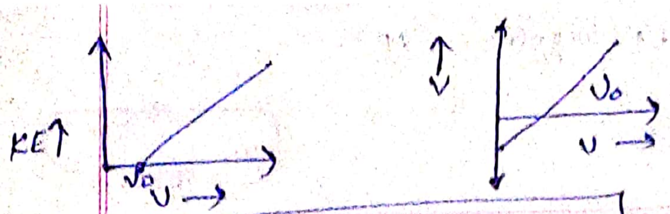
Red → orange → white → blue
(least hot) (most hot)

Black Body → perfect absorber + perfect emitter.

- Temp higher = intensity higher
- Absorptive power has no unit
  = 1 (for BB)
- Emissitivity for BB = 1 $\{e = a\}$
  $(0 < e < 1)$



$$\lambda_f - \lambda_i = \Delta\lambda$$
$$= \frac{h}{m_0 c}(1 - \cos\theta)$$



PHOTOELECTRIC EFFECT

- frequency $\propto$ stopping potential
  As freq. increases KE increases
- intensity increase PE current increase
- PE emission = particle nature of light

$$W = h\nu = \frac{hc}{\lambda}$$

- Intensity no effect on stopping pot.

$$h\nu = h\nu_0 + \frac{1}{2}mv^2$$

PAIR PROD.

Photon < electron, positron (energy into matter)

- If $b < R$ (interaction parameter < at. radius) the photon is directly converted into an electron - positron pair.

If $b > R$ (PE effect)
If $b \approx R$ (compton effect)

Two cond. i) $b < R$ ii) > 1.02

- photon must have energy > 1.02 MeV for pair prod. to occur.
  → γ-ray photon

When a γ-ray photon passes close to an atomic nucleus ($b<R$) and it possesses energy > 1.02 MeV, the photon is converted into electron - positron pair. photon is pair production.

nature → de-broglie hyp.

Date: / /

- Rest mass energy for electron and positron = 0.51 MeV each.
- can't occur in free space (nucleus luds)
- charge and momentum are conserved in pair production

opp

pair annihilation

DUAL NATURE – DE-BROGLIE

- $\lambda = \frac{h}{p} = \frac{h}{mv}$ (matter waves or de-broglie waves)

- for free particle :– (only KE)

  KE ; PE = 0

  $E = \frac{1}{2}mv^2$; $\lambda = \frac{h}{\sqrt{2mE}}$

- for any particle (KE + PE)

  $T = E + V$

  $E = T - V$; $\lambda = \frac{h}{\sqrt{2m(T-V)}}$

- for a charge particle

  $KE = qV$; $\lambda = \frac{h}{\sqrt{2mqV}}$

- for electron :–

  $\lambda = \frac{h}{\sqrt{2meV}} = \frac{12.27}{\sqrt{V}}$ Å {V = pd}

Photon has 0 rest mass

mass of $\alpha = 4m_p$

$q_\alpha = 2q_p$

HEISENBERG- UNCERT. PRINC.

$$\Delta x \cdot \Delta p \geq \frac{h}{4\pi} \qquad \hbar = \frac{h}{2\pi}$$

Δx → position

Δp → momentum

$$\Delta t \cdot \Delta E \geq h/4\pi$$

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

$4.5 eV =$

LASER

- LASER = Light Amplification by stimulated Emission of radiations.

- Amplifies E.M radiations and generates extreme, intense, coherent, monochromatic & directional radiation.

- An electron in an atom can be excited from an energy level E_1 to a higher energy level E_2 by absorption.

photon absorption $= h\nu = E_2 - E_1$

$$\nu = \frac{E_2 - E_1}{h}$$

- Spontaneous emission :- It is a completely random process. The atom decays from level 2 to level 1 through emission of photon with the energy $h\nu$.
No coherent sources can be produced.

- **Stimulated Emission** :- Atoms in upper energy level can be triggered or stimulated in phase by an incoming photon of a specific energy.
coherent source can be produced.

Stimulated photons
- in-phase
- same λ
- same direction

} with incident photons.

- **POPULATION INVERSION**

In normal cond. or thermal equil, the density or population of atoms decreases as we go from lower state to higher ~~state~~ energy level.
But
when the population of higher energy level is ~~less~~ more than the lower level → population inversion.

Pumping :- process of producing a population inversion.

$$N_1 = N_0 e^{-E_1/KT}$$

$$N_2 = N_0 e^{-E_2/KT}$$

If $E_1 < E_2$ and $N_1 < N_2$

→ raising a particle from lower to higher energy state

- **META-STABLE STATES** (req. for laser prod.)

Energy state with long life times are called meta-stable states
no. of atom in this state

- Total Emission Probability
  $= A_{21} + B_{21} E(\nu)$
  Spontan. + Stimulated

- No. of atoms that can jump E_2 to E_1
  $[A_{21} + B_{21} E(\nu)] N_2$

- $[B_{12} E(\nu)] N_1$ = Total Absorption Prob.
- $\frac{dN}{dt} = 0$ { equilibrium }
  no. of atoms in 2 states.

- Maxwell Boltzmann Distribution :-

  $N_1 = N_0 e^{-E_1/kT}$

  $N_2 = N_0 e^{-E_2/kT}$

  $\frac{N_1}{N_2} = e^{h\nu/kT}$

- CHARACTERSTICS

→ High directionality
→ High intensity $I = P/4\pi r^2$
→ Monochromatic
→ Coherence

- Need for laser
  - Population inversion
  - Stimulated emission
  - Pumping source.

10:1

- He-Ne Laser [Gas laser : 4 level laser system]

→ He acts as coolant

→ Laser action takes place in the energy level of Ne atoms.

→ He atom helps to achieve population inversion in the Ne atoms.

λ of laser = 632.8nm

→ Use:- to read bar codes.

→ Merits :- • continous
• stable
• No seperate cooling

→ Demerits :- • low efficiency
• low power output

- Ruby Laser [solid state : 3 level laser system]

→ produce visible light

→ $\lambda = 694.3$ nm

→ crystal of ruby [$Al_2O_3 : Cr^{3+}$]

→ optical pumping supply energy.

→ Merits :- • economical
• Beam diameter is less
• output power is more than He-Ne laser
• solid form, no waste.

→ Demerits :- • No stimulated emission.
• efficiency is low.
• optical cavity is short.

→ Use:-
• artistic display
• toys.

• Applications:
→ cutting, drilling, welding
→ medical
→ communication
→ hologram, 3D

OPTICAL FIBRES

• transmission of data through optical fibre is called PHOTONIC devices.

• parts = (glass) core, cladding, primary coating (plastic), secondary coating (nylon)

• Types of Optical fibres :-
  → step Index optical fibres
  → Graded Index optical fibre

Step	Graded
• zig-zag path	• helical path
• short distance comm.	• long dist. comm
• more dispersion	• less dispersion

• Applications :- (1) communication
• FOCL → fibre optics comm. link
• NUMERICAL APERTURE
  ↳
  core of RI = n_1
  cladding of RI = n_2 $\therefore n_1 > n_2$

θ must be greater than θ_c :-

$$\therefore \theta_c = \sin^{-1}\left(\frac{n_2}{n_1}\right)$$

Imp. formulae.

(1) $\lambda = \frac{c}{f}$

(2) $W_0 = h\nu_0$

(3) $V_0 = eW_0$

(4) $E = h\nu = \frac{hc}{\lambda}$ (plank - einstein)

(5) $p = \frac{h\nu}{c} = \frac{h}{\lambda}$

(6) $\lambda = \frac{h}{p} = \frac{h}{mv}$ (de-broglie)

(7) $\Delta x \, \Delta p \geq \frac{\hbar}{2}$ or $\frac{h}{4\pi}$ (Heisenberg).

$\Delta E \, \Delta t \geq \frac{h}{4\pi}$

(8) pe effect

$$h\nu = h\nu_0 + \frac{1}{2}mv^2$$

(9) compton effect

$$\Delta\lambda = \frac{h}{2m}(1-\cos\theta)$$

(10)

(9) ~~repeat~~ $n = 1$

$n_1 = 1.46$

$n_2 = 1.45$

(a) critical angle

$$\theta_c = \sin^{-1}\left(\frac{n_2}{n_1}\right) = \sin^{-1}\left(\frac{1.45}{1.46}\right) = 83.27^{\circ}$$

(b) num. aperture

$$N.A = \sqrt{n_1^2 - n_2^2}$$

$$= \sqrt{(1.46)^2 - (1.45)^2}$$

$$= 0.17$$

$$\sqrt{(1.5)^2 - (1.4)^2}$$

$$\sqrt{2.25 - 1.96}$$

$$\sqrt{.29}$$

(c) angle of acceptance :-

$$\alpha_{max} = \sin^{-1}\sqrt{1.46^2 - 1.45^2}$$

$$= 9.72^{\circ}$$

$$\alpha_{max} = \sin^{-1}\left(\frac{1}{n}\sqrt{n_1^2 - n_2^2}\right)$$

$\lambda = 550\,nm$

$h =$

$$E = \frac{hc}{\lambda} = \frac{19.878 \times 10^{-26}}{550 \times 10^{-9}}$$

$$= 0.036 \times 10^{-17}$$