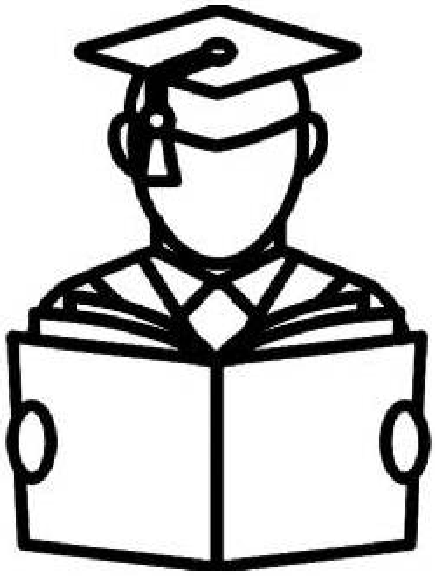


Physics

Dias IAS

Vajpaye Sir

- $\hat{H}$ means 'Operator H' i.e. Hamiltonian.

  eg. $\hat{p} = -i\hbar \frac{\partial}{\partial x}$

- BOSON : Integral spin $s = 0, 1, 2, 3, \ldots$

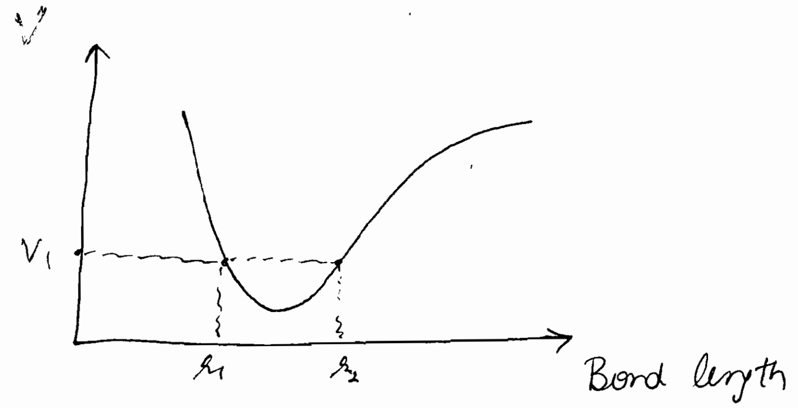
  eg. Photon, Ground state He atom

  FERMION : Half Integral Spin

  eg. Electron
  Proton
  Neutron

- $\bar{\omega} : \frac{1}{\lambda} \Rightarrow E = hc\bar{\omega}$ and $\nu = c\bar{\omega}$

- $\nu_\gamma \simeq 10^{20}$ Hz → $\nu_{Xray} = 10^{18}$ Hz → $\nu_{UV} = 10^{16}$ Hz → Visible 10^{15} Hz → $\nu_{IR} = 10^{12}$ Hz → $\nu_{MW} = 10^{10}$ Hz → $\nu_{radio} = 10^{6}$ Hz

- 

- In deuteron problem, m = reduced mass $= \left(\frac{m_p m_n}{m_p + m_n}\right)$

- Value of R_0

  m_π : 1.4 fm

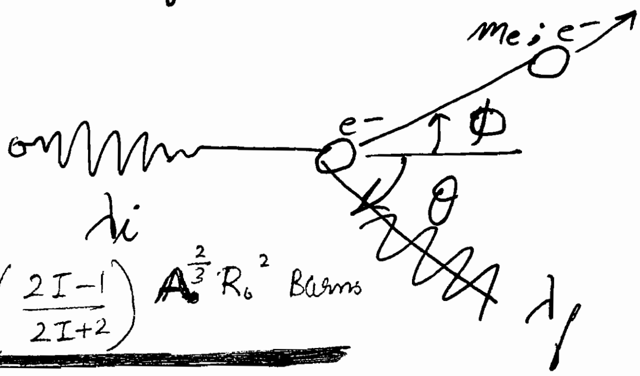
  Fission parameter : 1.5 fm

Note that x component of points on this curve give Bond length. Note that molecule with bond length r_1 and r_2 have same value of Potential Energy V_1.

- Visible lights range = 4000 Å – 7000 Å

⊙ Compton Scattering : $\lambda_f - \lambda_i = \frac{h}{m_e c}[1-\cos\theta]$

θ: scattering angle of photon



⊙ $Q = \frac{3}{5}\left(\frac{2I-1}{2I+2}\right) A^{\frac{2}{3}} R_0^2$ Barns $= \frac{1}{e}\int(3z^2 - r^2)\rho(r)\, d\tau$

NUCLEAR PHYSICS

Lectures	Ch: BT	Ch: Beiser
1, 2, 3 →	1, 2 →	11, 12
4 →	7, 5(b)	
5, 6A →	3A, 6 of Particle Physics	
6B, 7A →	3B,	
7B →	4, 5(a), 6	

PARTICLE PHYSICS

Lectures	Ch: BT	Ch: Beiser
1, 2, 3	1, 2, 3, 4, 5, 7 ←	13

Atomic Physics

Lectures	Chapters (Raj kumar)
1	1, 2, 3, 4
2, [half of 3]$_A$	5, 6, 7, 8
[half of 3]$_B$, [first page of 4]	9
[rest of 4]	12, 15 ↓ Chapter 5 of Banwell

Molecular Physics

Lectures	Chapters
1, 2	17, 18 → Chapter 2 of Banwell → 19
3	Chapter 3 of Banwell → 21, 22
4	Chapter-6 → 20, 23
5	Chapter-4

5 ↳ Ch-7, 8, 9 of Banwell

Atomic Physics

- ✓ Concept of Spin : Stern - Gerlach Experiment (1)
- ✓ Fine Structure of Hydrogen atom : Lamb Shift & its significance (1)
- ✓ Spectroscopic Notations ; LS & JJ coupling (1)
- ✓ Zeeman Effect (1)

> If asked magnetic moment of an atom, take only contribution of electrons
> $\because \mu \propto \frac{1}{m}$

Molecular Physics

- ✓ Elementary idea about rotational, vibrational and electronic spectra of diatomic molecules : (3)
  Frank Condon Principles
- ✓ Raman Effect & Laser Raman Spectroscopy (1)
- ✓ Fluorescence & Phosphorescence : 21 cm line of H_2 (1)
- ✓ NMR / EPR (1)

$$\vec{\mu_J} = -g_J \frac{e}{2m} \cdot \vec{J}$$

$$\Delta E = \mu_B B \, g_J m_j$$

A & M Physics

- Quantum Analysis is the best study of A & M Physics
- No e^- occurs in isolation. We need to study via a sample.

Similar atoms & Molecules require samples.

✓ Best way to reveal internal structure of nucleus, atom & molecules is spectrum.

Spectral line can be characterized by ν or $\bar{\omega}$ or λ.

$$\frac{\nu}{c} = \bar{\omega} = \frac{1}{\lambda_{vacuum}}$$

○ Every field of science has its own notations !!

○ $\bar{\omega}$ is a replacement of frequency which is usually a large number.

✱ Called wave number, $\bar{\omega}$ = no. of waves per metre or centimeter

○ It remains const. irrespective of medium.

(✱) As long as particle (e^- or atom or molecule or nucleus) is in fixed state, no energy released. Bohr's Argument

When it goes to higher energy and it comes down and releases energy

$$\Delta E = h\nu = hc\bar{\omega} = \left(\frac{hc}{\lambda}\right)$$

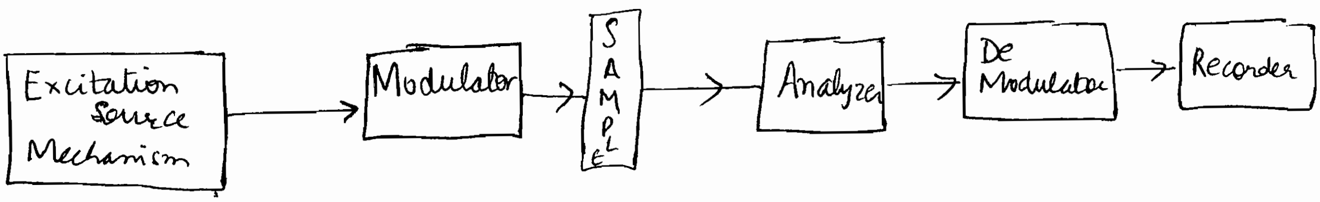
- Same specimen can give spectra of e^-, atoms, molecules & nucleus.

- [redacted] Excitation Mechanism : that causes particle to go to higher energy.

It has to be chosen in such a way that it is able to change : Molecular Energy levels
& Atomic Energy levels
& Nucleus Energy levels

It could be suitable radiation or current or atomic collisions.

Typical Spectrometer



⊙ If white light source, I require modulator to choose wavelength of our choice (filter)

Maximum ΔE : atoms <u>several eV</u> eg. $(-13\cdot 6\,eV) - \left(\frac{-13.6}{4}\right) eV$

Then ΔE : molecular

Then ΔE_{min} : nuclear $\approx 10^{-8}\,eV$

[illegible] [illegible]

$\Delta E_{nucleus} \simeq 10^{-8}\,eV$

$\lambda = \frac{hc}{\Delta E}$: <u>Radio Frequency Regions</u>

⊛ Note that there are two ~~types~~ of nuclear energy levels. 1 due to excitation of shell model states ... they correspond to γ ray. While those states that are created due to external magnetic field are that of radio frequency rays.

Hence, Radio Frequency Spectra of nuclear energy levels

Therefore suitable source is Radio Frequency Oscillator.

example NMR.

$\Delta E_{molecular} \simeq 10^{-3}\,eV$

3 types of energy: (1) <u>Rotational</u> ~ <u>MICROWAVE SPECTRA</u>

eg. Klystron Oscillator : Microwave Source

(2) <u>Vibration $10^{-1}\,eV$</u> ~ <u>Infrared Region</u>

(3) <u>Electronic Energy levels</u> ~ several eV

i.e. $10^{1}\,eV$

i.e. <u>Visible or UV range</u>.

$\Delta E_{atomic} \simeq$ many eV — Balmer, Paschen, Brackett, Pfund ....

Lyman ← UV, visible and Infrared Spectrum

due to jumping of e^-

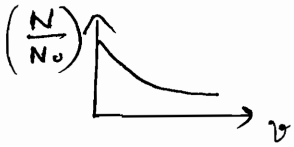
eg. $\left(13\cdot6 - \frac{13\cdot6}{4}\right)$ eV in H atom

If $T = 300\,k = 27°C$

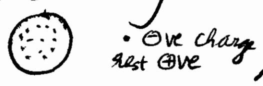
$E_{equivalent} = kT = 0\cdot026$ eV

It is sufficient to cause rotation of molecules but not vibration.

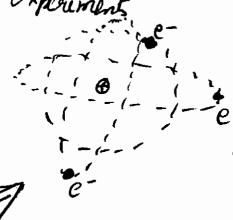
⇒ 



Atomic Models

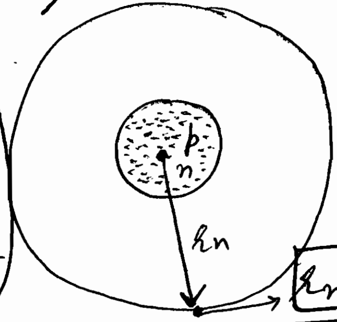
Thomson Model (Plum Pudding Model )

↓

Rutherford Model (Based on scattering experiment )

↓

Bohr's Model (1913) (Angular Momentum Quantization Model)



$r_n = a n^2$

$a = 0\cdot53$ Å

$E_n = -\left(\frac{13\cdot6}{n^2}\right)$ eV

↓

Somerfield's Model

↓

Dirac's Quantum Mechanical Model

or

Vector Model of Atom

Bohr's Model

- Bohr removed discrepancies in Rutherford Model by introducing quantization of Angular Momentum, thereby quantizing energy and saying that Energy will remain const. and energy will not be continuously emitted thereby e^- will not collapse in nucleus.

① Bohr quantized Angular Momentum $\quad |\vec{L}| = |\vec{r} \times \vec{p}| = n\hbar$

$$\Downarrow$$

$$E_n = -\left(\frac{13.6}{n^2}\right)$$

② $\Delta E = \left(\frac{hc}{\lambda}\right) \Rightarrow E_f \sim E_i = \frac{hc}{\lambda}$

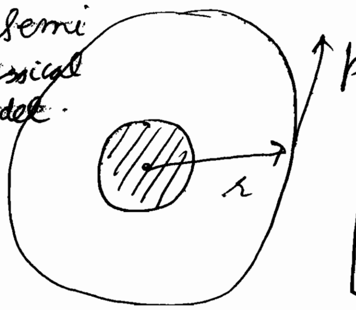
$$= 13.6\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

$\frac{mv^2}{r} = \frac{Zq^2}{4\pi\varepsilon_0 r^2}$ ← Classical

$mvr = n\hbar$ ← Quantization

} Semi Classical Model

$n\hbar v = \frac{Zq^2}{4\pi\varepsilon_0} \Rightarrow v = \frac{Zq^2}{n\hbar 4\pi\varepsilon_0}$ $\qquad r = \frac{n^2\hbar^2 4\pi\varepsilon_0}{Zme^2}$



$$r = \left(a_0 \frac{n^2}{Z}\right)$$

$$v = \frac{Z v_0}{n}$$

$a_0 = 0.53 Å$

$v_0 = 2.18 \times 10^6 m$

$$E = \frac{p^2}{2m} + V(r)$$

$$= \frac{p^2}{2m} - \frac{Ze^2}{4\pi\varepsilon_0 r}$$

$$= \frac{1}{2}mv^2 - \frac{Ze^2}{4\pi\varepsilon_0 r}$$

$$= \frac{1}{2} m_e \frac{Z^2 e^4}{n^2\hbar^2(4\pi\varepsilon_0)^2} - \frac{e^4 Z^2 m_e}{(4\pi\varepsilon_0)^2 n^2\hbar^2} = -\frac{1}{2}\frac{Z^2 m_e e^4}{n^2\hbar^2(4\pi\varepsilon_0)^2}$$

$\alpha = \frac{e^2}{4\pi\varepsilon_0 \hbar c} \simeq \frac{1}{137}$ dimensionless number : FINENESS CONSTANT.

$$E_n = -\frac{me^4}{2(4\pi\varepsilon_0)^2\hbar^2}\left(\frac{Z^2}{n^2}\right) = -Rhc\left(\frac{Z^2}{n^2}\right)$$

R = Rydberg Const. $= (me^4/8\varepsilon_0^2 c h^3)$

10/6

Chemical reaction Engineering ①

- to design a reaction vessel (reactor)
- Type of reactor (mode of operation)
- Volume / size of reactor

Chemical reaction

formation & / breaking of new & old bonds resp.

Homogeneous

Single phase reaction
all Gas phase
or all liquid phase

Heterogeneous

more than one phase
S-G rkn
L-G rkn
Catalytic reaction

* fast - explosion
* slow - radioactive decay.

- $1N_2 + 3H_2 \rightleftharpoons 2NH_3$ (reversible & exothermic) (Haber's process)

Contact reaction exothermic

1, 3, 2 → stoichiometric co-efficients : co-efficients of reactants or products

* stoichiometric cofficients of a chemical rekn represents moles, molecules, or volume (for gases rkn)
* the stoichiometric cofficient tells us about how the chemical reaction will proceed. (puts no restrictions on how much it should be taken)

Conservation of mass is valid in chemical rk^n

$1N_2 + 3H_2 \rightleftharpoons 2NH_3$

	N_2	H_2	NH_3
$t=0$	10 moles	20 moles	0
$t=t_1$ (1 mole reacted)	9 moles	17 moles	2 moles
mass	28 gm	6 gm	34 gm
$t=t_2$	8 mols	14 mols	4 moles
$t=t_x$	4 mols	2 mols	12 moles
$t=t_y$	$4-\frac{2}{3}$	0 mols	$12+\frac{4}{3}$

rates is $\propto C_A$.

time increases as next rk^n happens

In reality no reaction goes to completion, it stops before which is decided by thermodynamics.

$t=t_y$: completion.

The reactant which get consumed first is called the limiting reactant, while the other one is called excess reactant.

to find the limiting reactant, we have to assume that the reaction goes to completion.

to find the limiting reactant, we will divide the ~~initial~~ initial number of moles of reactants by their respective stoichiometric co-efficients

The reactant which gives lesser value is limiting ~~rea~~ reactant (2)

All this stoichiometric calculation in a reaction is done on the basis of the limiting reactant.

Stoichiometric proportion – Reactants are said to be in " if the ratio of the initial moles of the reactants is same as the ratio of the corresponding stoichiometric cofficients.

	N_2	+	$3H_2$	$\longrightarrow 2NH_3$
t=0	10 mole		10 mole	✗
t=0	10 mole		30 mole	✓
t=0	10 Kg		30 Kg	✗ (no because always it is done on basis of ~~mass~~ mole)

we can convert it into mol.

$$\frac{10}{28\ Kg/Kmol} \qquad \frac{30}{2\ Kg/Kmol}$$ ✓

If these are in stoichiometric proportion than both we get over at same time & either both can be limiting or none.

reversible $aA + bB \rightleftharpoons cC + dD$

$$K_C = \frac{[C]_e^c\,[D]_e^d}{[A]_e^a\,[B]_e^b}$$ (are taken at equilibrium)

Gate 2017

Q) The reversible reaction of tertiary butyl alchohol & ethanol to give ethyl teriatu butyl ether is given by.

$$TBA + EtOH \longrightarrow ETBE + H_2O$$

the equilibrium constant for this reaction is equal to 1

Initially 74 gm of TBA is mixed with 100 gm of aq solⁿ

Containing 46% ethanol by wt

Given → $MW_{TBA} = 74$

$M.W_{EtOH} = 46$

$MW_{ETBE} = 102$

the mass of ETBE at eqᵘⁱ.

	TBA	+ EtOH	→ ETBE	+ H_2O
t=0	74 gm	46% ~~100 gm~~	0	
t=0	1 mole	1 mol	0	$\frac{54}{18} = 3$ mol
t=teq.	1-x	1-x	x	3+x

$$1 = \frac{x (3+x)}{(1-x)(1-x)}$$

$$i = \frac{3x + x^2}{1 - 2x + x^2}$$

← In this question volume is constant so in place of conc^n we can take moles.

$1 - 2x + x^2 = 3x + x^2$

$x = 0.2$ mol

<u>at equilibrium</u>

0.2 mols of E.TBE

∴ Mass of ETBE = 0.2 × 102
= 20.4 gm

mass of H_2O = 3.2 × 18
= 57.6 gm

$$aA + bB \rightarrow cC + dD$$

* <u>Conversion</u> - it is only defined ~~only~~ for reactants and never for products.

Conversion of a reactant A is denoted by X_A

$$X_A = \frac{\text{moles of A reacted}}{\text{moles of A fed}}$$

$$= \frac{N_{A_0} - N_A}{N_{A_0}}$$

(N_{A_0} → initial, N_A → final (left))

** $X_A = 1 - \frac{N_A}{N_{A_0}}$ → for batch

$$X_A = 1 - \frac{N_A/t}{N_{A_0}/t}$$

$X_A = 1 - \frac{F_A}{F_{A_0}}$ → for continuous reactor (F_A → molar flow rate)

It can also be expressed as a %.

for solving numerical problems, we should always use the fractional value of conversion

For reporting the final answer, we should read the question and according to that conversion should be reported.

$$aA + bB \longrightarrow cC + dD$$

$t = 0 \qquad N_{A0} \qquad N_{B0} \qquad N_{C0} \qquad N_{D0}$

let us suppose conversion of A is known & it is X_A

(A here is limiting agent)

$$N_A = N_{A0}(1 - X_A)$$

mols of A reacted $= N_{A0} X_A$

$$B \text{ reacted} = \frac{b}{a} (A \text{ reacted})$$

$$= \frac{b}{a} (N_{A0} X_A)$$

$$N_B = N_{B0} - \frac{b}{a} (N_{A0} X_A)$$

$$N_C = N_{C0} + \frac{c}{a} (N_{A0} X_A)$$

$$N_D = N_{D0} + \frac{d}{a} (N_{A0} X_A)$$

relationship b/w X_A & X_B

$$N_B = N_{B0}(1 - X_B)$$

~~$N_{B0} - \frac{b}{a} = N_{B0}(1 - X_B)$~~

$$N_{B0} - \frac{b}{a} (N_{A0} X_A) = N_{B0}(1 - X_B)$$

$$\boxed{X_B = \frac{b}{a} \frac{N_{A0}}{N_{B0}} X_A}$$

(★) $\vec{\nabla}\cdot\left(\frac{\hat{r}}{r^2}\right) = 4\pi\,\delta^3(\vec{r})$

(★) Avogadro's Number में Prime ही Prime है, तभी साला याद नहीं होता : $N_0 = 6.023 \times 10^{23}$

(★) $\zeta(4) = \left(\frac{\pi^4}{90}\right)$
(Stefan Boltzmann)

$\zeta\left(\frac{3}{2}\right) = 2.6$
(Bose Einstein Condensate)

$$\zeta(x+1)\,\Gamma(x+1) = \int_0^\infty \frac{x^n}{e^x - 1}\,dx$$

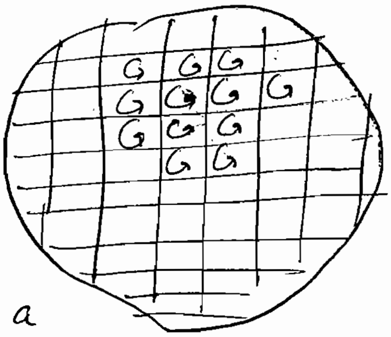
By defn

$$\zeta(x) = \sum_{n=1}^{\infty} \frac{1}{n^x}$$

eg. $\zeta(4) = \frac{1}{1^4} + \frac{1}{2^4} + \frac{1}{3^4} + \frac{1}{4^4} + \dots$

Magnetic Shell

✓ Magnetic shell is a theoretical concept which can be regarded as the cause of magnetic field

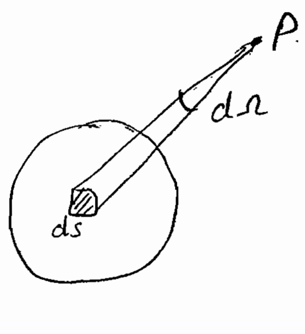


Magnetic shell is a thin sheet of magnetic material magnetized in such a way that magnetization is perpendicular to the surface of sheet everywhere.

It may be regarded as a large number of very short magnetic dipoles placed edge to edge with similar dipoles pointing in same direction.

Magnetic potential due to magnetic shell at any point P subtending solid angle $d\Omega$ is

$$\phi = \frac{I}{4\pi} d\Omega = \frac{I}{4\pi}\left(\frac{\vec{ds}\cdot\vec{r}}{r^3}\right)$$



If the shell is divided into small elements of small area $\vec{ds}$, we say that each element corresponds to magnetic moment

$$\vec{m} = I\,\vec{ds} \Rightarrow I = \frac{|\vec{m}|}{|\vec{ds}|}$$

This is also called strength of the cell i.e. magnetic moment per unit area.

ELECTRICITY & MAGNETISM (1)

* 4Q : 60×4 = 240

If all correct : 0.7×240 = 168

Total : 336

16 lectures

8 + 6 + 2

statics dynamics current

* 15 classes course

* 3 units :

Q6 { ① Electrostatics & Magnetostatics ⑥

② Current Electricity ③ }

{ ③ EM Theory & Blackbody Radiation ⑥ - ⑦ }

Q7 ← Most scoring question

(a) Electrostatics & Magnetostatics Electrodynamics (6)

(i) Field & Potential due to Dipole, Dipole-Dipole interactions, Multipole expansion of Potential,

(ii) Laplace & Poisson Equation & simple applications

(iii) Method of electrical images

(iv) Dielectric & Polarization

(v) Boundary Value Problem of Conducting & Dielectric Sphere in Uniform Field

(vi) Magnetostatics : Magnetized Sphere in Uniform Field
Ferromagnetic Material & Hysteresis

Prerequisites

Field
Potential
Energy

Electrostatics : stationary charges

Electro Magnetism : moving charge

Field & Potential

$\vec{F} = -\vec{\nabla} U$
↑ Potential Energy

★ $\vec{\nabla} U \cdot d\vec{r} = dU$

$$\boxed{\Delta U = -\int \vec{F}\cdot d\vec{r}}$$
↑ Change in Potential Energy

dividing by unit mass (or charge)

$\vec{E} = -\vec{\nabla} V$ ← Potential

where $\vec{E} = \frac{\vec{F}}{m}$ & $V = \frac{U}{m}$

or

$\vec{E} = \frac{\vec{F}}{q}$ & $V = \frac{U}{q}$

$$\Rightarrow \boxed{\Delta V = -\int E \cdot dr}$$
↑ change in Potential

if $\vec{F}_{known} \Rightarrow \vec{E}_{known} \Rightarrow dV_{known} \Rightarrow dU_{known}$

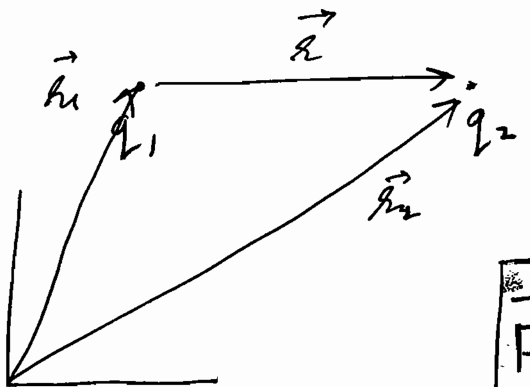
ϵ : Permittivity

Coulumb's law

$$\vec{F} = \left(\frac{1}{4\pi\varepsilon}\right)\frac{q_1 q_2}{r^2}\hat{r}$$

$\varepsilon = \varepsilon_0 k$

k : dielectric const. or relative permittivity



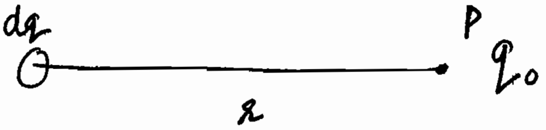
$\vec{r} = \vec{r}_2 - \vec{r}_1$

$$\boxed{\vec{F}_{medium} = \left(\frac{\vec{F}_{air}}{k}\right)}$$

$k \geq 1$

$\Rightarrow E_{medium}$ reduced $\Rightarrow \Delta V_{medium}$ reduced

Let us consider a system :-



$$d\vec{F} = \frac{1}{4\pi\varepsilon_0 k} \frac{dq\, q_0}{r^2} . \hat{r}$$ (from Coulumb's law)

↑ experimental law

empirical observations

$$d\vec{E} = \frac{dF}{q_0} = \text{Field generated by } dq$$

$$d\vec{E} = \frac{1}{4\pi\varepsilon_0 k} \left(\frac{dq}{r^2}\right) \hat{r}$$

$$\boxed{\vec{E} = \int d\vec{E} = \frac{1}{4\pi\varepsilon_0 k} \int \frac{dq}{r^2} \hat{r}}$$

This is how Coulumb law is used to find out $\vec{E}$ at a point $\vec{r}$.

$$V = -\int \vec{E} \cdot d\vec{r}$$

$$U = qV$$

$dq = \lambda\, dl$ (1-dimension)

$\quad\;\; \sigma\, da$ (2-dimension)

$\quad\;\; \rho\, dv$ (3- dimension)

Also note $\boxed{\frac{\hat{r}}{r^2} = \frac{\vec{r}}{r^3} = -\vec{\nabla}\left(\frac{1}{r}\right)}$

$$d\vec{E} = \frac{1}{4\pi\varepsilon_0 k} \frac{dq}{r^2} \hat{r} = -\vec{\nabla}\left(\frac{1}{4\pi\varepsilon_0 k} \frac{dq}{r}\right)$$

Now $d\vec{E} = -\vec{\nabla} V$

$$\Rightarrow \phi = \frac{1}{4\pi\varepsilon_0}\left(\frac{dq}{r}\right)$$

→ ϕ is Potential provided it is Work Done per unit charge.

$$dW = \vec{F}\cdot d\vec{r} = q_0\vec{E}\cdot dr$$

$$\vec{E}\cdot d\vec{r} = \frac{dW}{q} = -\vec{\nabla}\phi\cdot d\vec{r}$$

$$= -\left(\frac{\partial \phi}{\partial x}\hat{i} + \frac{\partial \phi}{\partial y}\hat{j} + \frac{\partial \phi}{\partial z}\hat{k}\right)\cdot(dx\,i + dy\,j + dz\,k)$$

$$= -\,d\phi$$

$$\Rightarrow d\phi = -\vec{E}\cdot d\vec{r} = \left(\frac{dW}{q_0}\right) = dV$$

Hence ϕ is Potential

$$\Rightarrow \quad dV = \frac{1}{4\pi\varepsilon_0}\left(\frac{dq}{r}\right)$$

V_{ref} at $V_\infty = 0$ [Convention]

$$\int_0^V dV = \int \frac{1}{4\pi\varepsilon_0}\frac{dq}{r} = -\int_\infty^r E\cdot dr$$

Gauss law

Flux of Electric Field through a closed surface is $\left(\frac{1}{\varepsilon_0}\right)$ [redacted] times charge enclosed in the surface.

$$\text{Flux} = \oint_S \vec{E}\cdot d\vec{s} = \frac{1}{\varepsilon_0}\left(q_{enc}\right)$$

q_{enc} is q_{total} i.e. $q_{free} + q_{bound}$

From Fundamental law of divergence

$$\oint \vec{E}\cdot d\vec{s} = \int \vec{\nabla}\cdot\vec{E}\, dv = \frac{1}{\varepsilon_0}\int \rho\, dv$$

$$\Rightarrow \int \left(\vec{\nabla}\cdot\vec{E} - \frac{\rho}{\varepsilon_0}\right) dv = 0$$

[redacted]

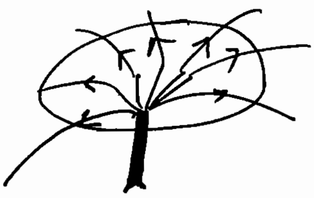
$$\Rightarrow \quad \boxed{\vec{\nabla}\cdot\vec{E} = \frac{\rho}{\varepsilon_0}}$$

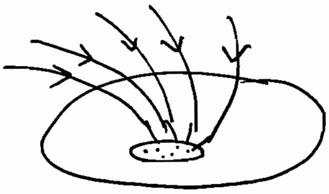
[Note that the Gauss law is independent of medium]

For source : divergence is ⊕ve ⊛ देना देना is a ⊕ve thing !!

For sink : divergence is ⊖ve

Positive divergence





Negative divergence

DIAS Delhi Institute for Administrative Services

26537353 M-9350934622

FOR - IAS-Exam.2011

PHYSICS

PAPER - I

1. (a) Mechanics of Particles:

Laws of motion; conservation of energy and momentum, applications to rotating frames, centripetal and Coriolis accelerations; Motion under a central force; Conservation of angular momentum, Kepler's laws; Fields and potentials; Gravitational field and potential due to spherical bodies, Gauss and Poisson equations, gravitational self-energy; Two-body problem; Reduced mass; Rutherford scattering; Centre of mass and laboratory reference frames.

(b) Mechanics of Rigid Bodies:

System of particles; Centre of mass, angular momentum, equations of motion; Conservation theorems for energy, momentum and angular momentum; Elastic and inelastic collisions; Rigid body; Degrees of freedom, Euler's theorem, angular velocity angular momentum, moments of inertia, theorems of parallel and perpendicular axes, equation of motion for rotation; Molecular rotations (as rigid bodies); Di and tri-atomic molecules; Precessional motion; top, gyroscope.

(c) Mechanics of Continuous Media:

Elasticity, Hooke's law and elastic constants of isotropic solids and their inter-relation; Streamline (Laminar) flow, viscosity, Poiseuille's equation, Bernoulli's equation, Stokes' law and applications.

(d) Special Relativity:

Michelson-Morley experiment and its implications; Lorentz transformations-length contraction, time dilation, addition of relativistic velocities, aberration and Doppler effect, mass-energy relation, simple applications to a decay process; Four dimensional momentum vector; Covariance of equations of physics.

2. Waves and Optics:

(a) Waves:

Simple harmonic motion, damped oscillation, forced oscillation and resonance; Beats; Stationary waves in a string; Pulses and wave packets; Phase and group velocities, Reflection and Refraction from Huygens' principle.

(b) Geometrical Optics:

Laws of reflection and refraction from Fermat's principle; Matrix method in paraxial optics-thin lens formula, nodal planes, system of two thin lenses, chromatic and spherical aberrations.

(c) Interference:

Interference of light-Young's experiment, Newton's rings, interference by thin films, Michelson interferometer; Multiple beam interference and Fabry-Perot interferometer.

(d) Diffraction:

Fraunhofer diffraction-single slit, double slit, diffraction grating, resolving power; Diffraction by a circular aperture and the Airy pattern; Fresnel diffraction: half-period zones and zone plates, circular aperture.

(e) Polarization and Modern Optics:

Production and detection of linearly and circularly polarized light; Double refraction, quarter wave plate; Optical activity; Principles of fibre optics, attenuation; Pulse dispersion in step index and parabolic index fibres; Material dispersion, single mode fibres; Lasers-Einstein A and B coefficients; Ruby and He-Ne lasers; Characteristics of laser light-spatial and temporal coherence; Focusing of laser beams; Three-level scheme for laser operation; Holography and simple applications.

3. Electricity and Magnetism:

(a) Electrostatics and Magnetostatics:

Laplace and Poisson equations in electrostatics and their applications; Energy of a system of charges, multipole expansion of scalar potential; Method of images and its applications; Potential and field due to a dipole, force and torque on a dipole in an external field; Dielectrics, polarization; Solutions to boundary-value problems-conducting and dielectric spheres in a uniform electric field; Magnetic shell, uniformly magnetized sphere; Ferromagnetic materials, hysteresis, energy loss.

(b) Current Electricity:

Kirchhoff's laws and their applications; Biot-Savart law, Ampere's law, Faraday's law, Lenz' law; Self-and mutual-inductances; Mean and r m s values in AC circuits; DC and AC circuits with R, L and C components; Series and parallel resonances; Quality factor; Principle of transformer.

(c) Electromagnetic Waves and Blackbody Radiation:

Displacement current and Maxwell's equations; Wave equations in vacuum, Poynting theorem; Vector and scalar potentials; Electromagnetic field tensor, covariance of Maxwell's equations; Wave equations in isotropic dielectrics, reflection and refraction at the boundary of two dielectrics; Fresnel's relations; Total internal reflection; Normal and anomalous dispersion; Rayleigh scattering; Blackbody radiation and Planck's radiation law, Stefan-Boltzmann law, Wien's displacement law and Rayleigh-Jeans' law.

4. Thermal and Statistical Physics:

(a) Thermodynamics:

Laws of thermodynamics, reversible and irreversible processes, entropy; Isothermal, adiabatic, isobaric, isochoric processes and entropy changes; Otto and Diesel engines, Gibbs' phase rule and chemical potential; van der Waals equation of state of a real gas, critical constants; Maxwell-Boltzman distribution of molecular velocities, transport phenomena, equipartition and virial theorems; Dulong-Petit, Einstein, and Debye's theories of specific heat of solids; Maxwell relations and applications; Clausius- Clapeyron equation; Adiabatic demagnetisation, Joule-Kelvin effect and liquefaction of gases.

(b) Statistical Physics:

Macro and micro states, statistical distributions, Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac distributions, applications to specific heat of gases and blackbody radiation; Concept of negative temperatures.

PAPER - II

1. Quantum Mechanics:

Wave-particle dualitiy; Schroedinger equation and expectation values; Uncertainty principle; Solutions of the one-dimensional Schroedinger equation for a free particle (Gaussian wave-packet), particle in a box, particle in a finite well, linear harmonic oscillator; Reflection and transmission by a step potential and by a rectangular barrier; Particle in a three dimensional box, density of states, free electron theory of metals; Angular momentum; Hydrogen atom; Spin half particles, properties of Pauli spin matrices.

2. Atomic and Molecular Physics:

Stern-Gerlach experiment, electron spin, fine structure of hydrogen atom; L-S coupling, J-J coupling; Spectroscopic notation of atomic states; Zeeman effect; Frank-Condon principle and applications; Elementary theory of rotational, vibrational and electronic spectra of diatomic molecules; Raman effect and molecular structure; Laser Raman spectroscopy; Importance of neutral hydrogen atom, molecular hydrogen and molecular hydrogen ion in astronomy, Fluorescence and Phosphorescence; Elementary theory and applications of NMR and EPR; Elementary ideas about Lamb shift and its significance.

3. Nuclear and Particle Physics:

Basic nuclear properties-size, binding energy, angular momentum, parity, magnetic moment; Semi-empirical mass formula and applications, mass parabolas; Ground state of deuteron, magnetic moment and non-central forces; Meson theory of nuclear forces; Salient features of nuclear forces; Shell model of the nucleus - successes and limitations; Violation of parity in beta decay; Gamma decay and internal conversion; Elementary ideas about Mossbauer spectroscopy; Q-value of nuclear reactions; Nuclear fission and fusion, energy production in stars; Nuclear reactors.

Classification of elementary particles and their interactions, Conservation laws; Quark structure of hadrons, Field quanta of electroweak and strong interactions; Elementary ideas about unification of forces; Physics of neutrinos.

4. Solid State Physics, Devices and Electronics:

Crystalline and amorphous structure of matter; Different crystal systems, space groups; Methods of determination of crystal structure; X-ray diffraction, scanning and transmission electron microscopies; Band theory of solids - conductors, insulators and semiconductors; Thermal properties of solids, specific heat, Debye theory; Magnetism: dia, para and ferromagnetism; Elements of superconductivity, Meissner effect, Josephson junctions and applications; Elementary ideas about high temperature superconductivity.

Intrinsic and extrinsic semiconductors; p-n-p and n-p-n transistors; Amplifiers and oscillators; Op-amps; FET, JFET and MOSFET; Digital electronics-Boolean identities, De Morgan's laws, logic gates and truth tables; Simple logic circuits; Thermistors, solar cells; Fundamentals of microprocessors and digital computers.

MECHANICS

Physics 1

Basics

Lectures —

Chapters [1, 2] of D.S. Mathur

Mechanics of Particles

Lectures [1, 2, 3, 4, 5, 6, 7, 8] Tut [1, 2, 3]

Chapters [5, 6, 11] of D.S. Mathur

Mechanics of Rigid Bodies

Lectures [9, 10] Tut [4]

Chapters [10] of D.S. Mathur

Mechanics of Continuous Media

Lectures [11, 12] Tut [5]

Chapters [12, 14] of D.S. Mathur

Relativity

Lectures [13, 14, 15, 16, 17] Tut [6]

Chapters [3] of D.S. Mathur

14/11/11

Paper 1

> ⊛ kinetic Energy for a rotating system
> $= \frac{1}{2} \vec{\omega} \cdot \vec{J}$
> $= \frac{1}{2} \vec{\omega} \cdot [\overleftrightarrow{I} \vec{\omega}]$

> ⊛ $G = 6.67 \times 10^{-11}$ S.I.

300 Marks : 180 minutes

10 Marks : 6 minutes

1 minute for thinking

5 minutes ⇒ 1 Page

DO NOT WRITE MORE THAN ASKED

⇒ **10 Marks : 1 Page in 5 minutes**

Section A

(1) Mechanics

(2) Optics

Q1: half from (1)
half from (2)

Section B

(3) Electricity & Magnetism

(4) Heat & Thermodynamics

Q5: half from (3)
half from (4)

→ Hence whole course needs to be done for full attempt

But <u>Master</u> 2 courses out of 4.
[to attempt any question on that topic]

- Never interact with unsuccessful candidates

- 2 common mistakes

(i) Lack of proper strategy → lack of proper study

(ii) Lack of proper practice → not to-the-point answers

Correct answer can fetch 50% to 75% depending upon 'Quality of Correct answer'.

Section A : Mechanics Optics

Q1	6 x 10	(3 , 3)
Q2	Mechanics	
Q3	Mechanics & Optics	
Q4	Optics	

① Physics लिखनी होती है !!

② जो पूछा है, उसे define करो !!

- **Prepare 3 books thoroughly for each Paper to attempt minimum 270 marks.**

Mechanics : 120 Marks in Paper ≡ 2 Question

4 units in syllabus :

1. Particle Dynamics / System of Particles
2. Rigid Body Dynamics / System of Particles
3. Mechanics of Continuous Media
4. Special theory of Relativity

every unit is important....

WE CANNOT SKIP ANY SUBTOPIC

MECHANICS

(★) For integration by parts, 2^{nd} function should follow the order

I L A T E

Inverse log Arith trig exp

with exponential being the 1^{st} preference for 2^{nd} function.

(Write the two functions in this order... automatically the function of right becomes the 2^{nd} function)

Particle Dynamics

1. Conservation Laws, Elastic & Inelastic Collisions, Rocket Motion
2. System of Particles
   Centre of Mass
   Transformation of physical quantities from lab frame to Centre of Mass frame.
3. Rutherford Scattering, Differential Scattering Cross-Section
4. Rotating Frame of reference: Coriolis & Centrifugal terms
5. Gravitation
6. Central Force Problems

6 chapters in 'Particle dynamics' unit.

- Classical Mechanics ... J.C. Upadhyay
- Theoretical Mechanics ... M.R. Spigal ~~D. S. Mathur~~

⇒ General Mechanics + Classical Mechanics : hence not everything in 1 book

MECHANICS (1)

15/11/2011

- → $\vec{v}$ & $\vec{a}$ in polar form
- → Conservation of energ
- → Centre of Mass Propert
- → 1-d & 2-d collision
- → Scattering Cross sectio
- → differential scattering cross section
- → Hard Sphere Scattering
- → Rutherford scattering
- → Rocket Motion

Event

✓ Specifying space and time determines event.

✓ These are specified wrt. a frame of reference.

✓ There are 2 types of frames of reference:

1) Inertial Frame : State of observer does not change (non accelarated) eg. laborator
2) Non Inertial Frame : if state of observer change (accelarated frame)

Frame of Reference

Inertial Frame

- $\vec{v}$ = constant
- $\frac{d\vec{v}}{dt} = 0$
- State of observer remains constant

Non Inertial Frame

- $\vec{v} \neq$ constant
- accelarated motion
- $\frac{d\vec{v}}{dt} \neq 0$

(★) **All Basic physical laws hold good in inertial frame of reference**

Laws of Motion

→ Single Particle : dimensions of the particle are insignificant to the distances being talked about

✓ Point particle can have mass as well as charge.

✓ Interaction of 2 particles in 4 ways only :

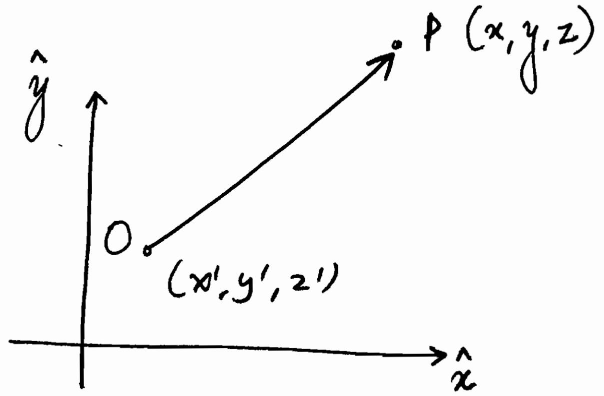
(1) By Virtue of mass : Gravitational interaction (Mechanics)

(2) By virtue of charge : Electromagnetic interaction (Electricity & Magnetism)

(3) Strong Interaction : Nuclear interaction (short time required for huge force)

(4) Weak Interaction : long time interaction

✓ When we study collision, the interaction force for the 2 particles will be of same kind. Not that one interacting due to mass, other interacting due to charge.



$\vec{OP}$ = position vector of Particle P w.r.t. Observer O

$= \vec{r}$

$= (x-x')\hat{i} + (y-y')\hat{j} + (z-z')\hat{k}$

⊙ We have
- Addition
- Subtraction
- Dot Product
- Cross Product
- Multiplication with scalar

of vectors.

No multiplication or division.

$\vec{r} = r\,\hat{r}$

↑ unit vector along $\vec{r}$

$\hat{r} = \left(\frac{\vec{r}}{r}\right)$

NUCLEAR PHYSICS 7 classes

Further study is required in this course. Evolving field. Gets maximum Nobel Prizes.

1) Basic Nuclear Properties

Size
Constituents – their properties
Angular Momentum
Magnetic Moment
Quadrupole Moment
Parity
Binding Energy

2) Models of Nucleus

① Semi Empirical Model (Calculates Binding Energy)
Mass Formula
Mass Parabola

② Shell Model (Calculates rest of properties)

3) Nature of Nuclear Force

Characteristics of strong nuclear force
Yukawa's Meson Theory
Grand state of deuteron & Magnetic Moment

4) β decay

Parity Violation

⑤ <u>γ-decay</u>

Internal Conversion

Mossbauer Effect

⑥ Nuclear Fission & Fusion

Particle Physics

<u>3 classes</u>

① Particle Classification

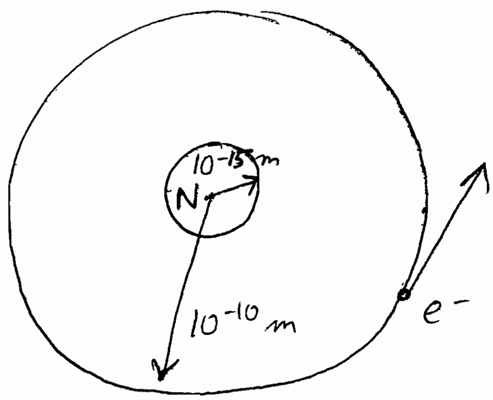
② Conservation laws ③ Quark Structure Hadrons

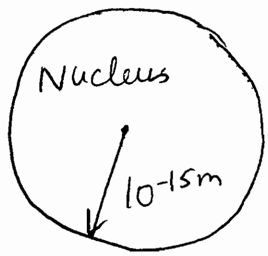
④ Basic idea about unification

Tayal / Pandey

NUCLEAR PHYSICS (1)

→ Remember α- particle experiment by bombarding them on a Gold Foil. It led to discovery of Nucleus by Rutherford. By H.U.P., we now know e^- cannot reside in nucleus. Neutron was discovered much later, to solve <u>mass discrepancy</u>.





1 fm : 10^{-15} m

[femto meter
or
fermi meter]

(For proton, expected $\mu = 1\,\mu_N$)
(⇒ Non uniform charge distribution)

① Constituents of Nucleus

Proton :

$q = +e$

$m_p = 1836\, m_e \simeq 1.66 \times 10^{-27}$ kg

$m_0 c^2 = 938$ MeV

$I = s = \left(\frac{1}{2}\right)$ $\qquad I^2 = \frac{3}{4}\hbar^2$

↑ used for nucleus $\qquad$ ↑ used for e^-

$g \cdot \frac{e}{2m_p} \frac{1}{2}\hbar$

$= \frac{g \mu_n}{2}$

$= \frac{5.586}{2}\mu_n = 2.793\,\mu_n$

$(\mu_p)_z = \pm\, 2.793\,\mu_N \approx +2.8\,\mu_N$

Neutron

$q = 0$

$m_n = 1840\, m_e \simeq 1.67 \times 10^{-27}\, kg$

$m_0 c^2 = 939.5\, MeV \simeq 940\, MeV$

$(\mu_N)_Z = \mp 1.91\, \mu_N \approx -1.9\, \mu_N$

(inspite of the fact that it is uncharged ∴ expected $\mu = 0$)

[Note that it is μ_Z that we are talking about]

$I = \left(\frac{1}{2}\right)$

$I^2 = \frac{3}{4} \hbar^2$

We represent Nucleus as (Z, A)

↑ Z: atomic number

↑ A: mass number

No. of Protons = Z

No. of Neutrons = A − Z

Special Types [redacted] of Nucleus :

[redacted] : Z same , A difference — same element

[redacted] : Z different , A same — different elements

[redacted] : [redacted] Neutrons and Protons are interchanged.

& $N \simeq Z = 1$

$A \simeq 2Z = 1$

$^{15}_{7}N$ unstable nitrogen — $^{15}_{8}O$ unstable Oxygen

$^{3}_{1}H$ (tritium) — $^{3}_{2}He$

Mass of Nucleus = Mass of Z protons $(Z m_p)$

\+ Mass of $(A-Z)$ neutrons $((A-Z) m_N)$

\+ Mass equivalent of Binding Energy $\left(\frac{E_B}{c^2}\right)$

here E_B is taken as positive value i.e. $|E_B|$

→ In any atom, more than 99% mass is contributed by nucleus.

$$\Rightarrow \frac{E_B}{c^2} = [ZM_p + (A-Z)M_N] - M(Z,A$$

[representation of mass of nucleus]

$$E_B = \left(-M(Z,A) + [ZM_p + (A-Z)M_N]\right) c^2$$

difference in a.m.u & m_p/m_n due to B.E

1 a.m.u. = 931 MeV < m_p or m_n

due to "Mass defect", we have

Mass of Constituents – Mass of Nucleus : Mass defect

Binding Energy per nucleon = Average Binding Energy

Nuclei is written in 4 ways:

Pairing [N – Z]	Mass No. A	No. of stable nuclei observed
Even – Even	A even	165
Odd – Odd		4
Even – Odd	A odd	55
Odd – Even		50
N Z		

→ $_1^2H$, $_3^6Li$, $_5^{10}B$, $_7^{14}N$ (deuterium) $N = Z$

≃ 117 elements

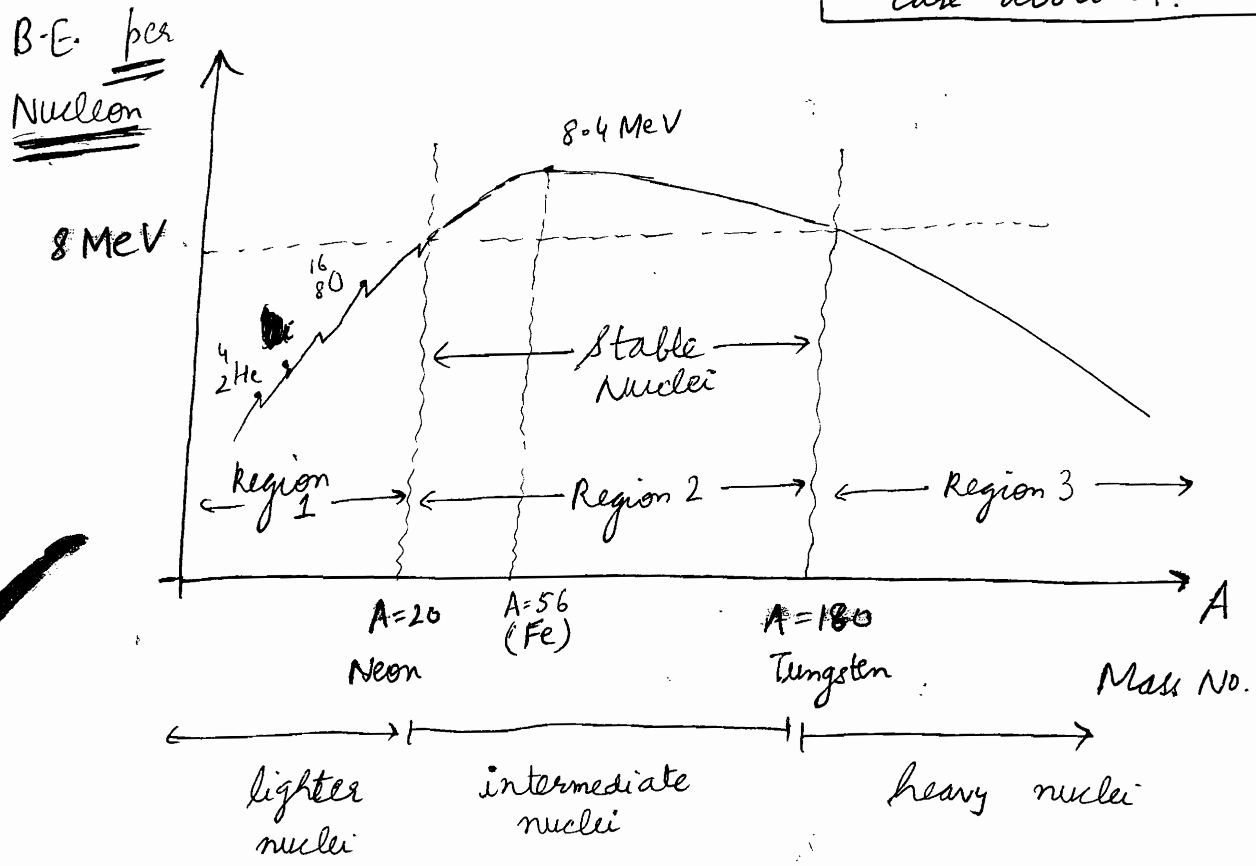
≃ 270 nucleus (stable)

[Many stable isotopes]

- Even - Even are most abundand ⇒ most stable
- Odd - Odd are least abundant ⇒ least stable
- Even-Odd / Odd-Even are normal.

② 'Binding Energy per Nucleon' Curve

> Note that in nuclear physics, we are least interested in Z. We care about A.



It is an empirical (experimental) curve.

→ More the binding energy, more the energy needs to be supplied to break it ⇒ more the stability.

→ Nuclei of [redacted] group1 fuse together to gain higher binding energy to achieve stability: Nuclear Fusion

→ Nuclei of group 2 break to come to region 2, to increase Binding energy in order to achieve stability.

Nuclear Fission & Spallation

(*) More stable the nuclei, more Binding Energy will be released ⇒ reason for energy in fusion & fission

Higher the mass, higher the volume

$\Rightarrow$ High A nucleus will have more Volume

$\Rightarrow$ more radius (if assumed spherical)

$\left(\frac{4}{3}\pi r^3\right) \propto A$

$\Rightarrow$ $r \propto A^{\frac{1}{3}}$

$R = R_0 A^{\frac{1}{3}}$

↑

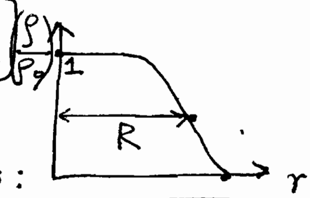
Radius Const. 1.2 - 1.3 fm

Take $r_0 = 1.3$ fm

- The size and shape of neuclei are studied by scattering experiments using high speed electrons and neutrons as Bombarding Particles.

  Electrons interact only with protons and neutrons interact only with special nuclear forces.

  The former provides information on distribution of electric charge and the latter on the distribution of nuclear matter in the nucleus.



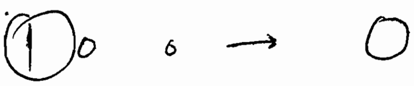
(★) ρ is distribution of charge in the nucleus :

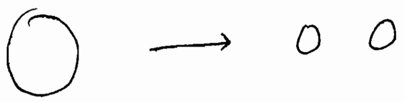
$$\text{Density } \rho = \frac{A \times 1.66 \times 10^{-27} \text{ kg}}{\frac{4\pi}{3} R_0^3 \cdot A} \simeq \frac{10^{-27}}{10^{-45}}$$

$$\simeq 10^{17} \text{ kg/m}^3$$

Now we see density is independent of size or shape as in real world. Similarly is the case with nucleus. Density of Nucleus is independent of mass.

Hence, Nucleus is compared to a liquid drop

eg. (1)  Fusion (Coalescence)

(2)  Fission (breaking down)

(3) ρ independent of shape & size

(4) Both are spherical in shape.

Both neutrons and protons have spin $= (\frac{1}{2})$ and possess

(3) angular momentum.

Hence L-S coupling occurs within nucleus.

$$\vec{I} = \vec{L} + \vec{S} \quad \text{(L-S coupling)}$$

$$\vec{L} = \Sigma(\vec{l_p} + \vec{l_n})$$

$$\vec{S} = \Sigma(\vec{S_p} + \vec{S_n})$$

Nucleon: Neutrons & Protons are together called Nucleons

$$I = I_p + I_s \quad \text{(I-I coupling)}$$

$$|I| = \sqrt{I(I+1)}\,\hbar$$ Magnitude Quantization

I: Nuclear Spin Quantum Number

[Total ang. momentum of Nucleus it may be due to orbital or spin or both. Note that I am not interested in individual momentums I am interested only in total I]

$$I_z = M_I \hbar$$ space Quantization

Here space Quantization will lead to division of energy levels. Order of $\Delta E \simeq 10^{-8}$ eV (NMR)

(*) {Here "inverted coupling" occurs b'coz now μ is positive quantity. ⇒ higher I, lower energy}

Trigonometric Identities

Physics 2

- $\sin^2\theta + \cos^2\theta = 1$
- $\sin(A+B) = \sin A \cos B + \cos A \sin B$
- $\cos(A+B) = \cos A \cos B - \sin A \sin B$
- $\sin 2\theta = 2\sin\theta\cos\theta$
- $\cos 2\theta = \cos^2\theta - \sin^2\theta = 2\cos^2\theta - 1 = 1 - 2\sin^2\theta$
- $\sin A + \sin B = 2\sin\left(\frac{A+B}{2}\right)\cos\left(\frac{A-B}{2}\right)$
- $\sin A - \sin B = 2\sin\left(\frac{A-B}{2}\right)\cos\left(\frac{A+B}{2}\right)$
- $\cos A + \cos B = 2\cos\left(\frac{A+B}{2}\right)\cos\left(\frac{A-B}{2}\right)$
- $\cos A - \cos B = -2\sin\left(\frac{A+B}{2}\right)\sin\left(\frac{A-B}{2}\right)$
- $\sin A \cos B = \frac{1}{2}\left[\sin(A+B) + \sin(A-B)\right]$
- $\sin A \sin B = -\frac{1}{2}\left[\cos(A+B) - \cos(A-B)\right]$
- $\cos A \cos B = \frac{1}{2}\left[\cos(A+B) + \cos(A-B)\right]$
- $\cos A \sin B = \frac{1}{2}\left[\sin(A+B) - \sin(A-B)\right]$

Topic	Chapter (Ghatak)	Lectures	Tut
Basics, Group-Phase Velocities, Oscillation Beats	7, 10, 11, 12 ✓ ✓ ✓ ✓	1, 2, 3, 4	7A 7B
Geometrical Optics	3, 4, 5, 6 ✓ ✓ ✓ ✓	5, 6	8
Interference	13, 14, 15, 16 ✓ ✓ ✓ ✓	7, 8, 9, 10	9
Diffraction, Resolving Power	18, 20 ✓ ✓	11, 12, 13, 14, 15	10, 11
Polarization	22 ✓	15, 16	12
Laser	26 ✓	17	13
Special Topics	17, 27, 21 ✓ ✓	10, 18	14

⊛ Wave Equation usually is "$A \sin(\omega t \pm kx)$" i.e. ωt is always positive.

⊛ For a spherical wave, $I = \left(\frac{W}{4\pi r^2}\right) \Rightarrow a \propto \left(\frac{1}{r}\right)$

b : damping coefficient

c : damping ratio where $\frac{b}{m} = 2c$

OPTICS (1)

05/12/11

- Huygen Principle
- Equation
- Group velocity
- Dispersive Media

Various theories explaining the behaviour of light were prevalent :

330

1600 : Newton - Corpuscular Theory

then Huygen Wave Theory came

1765 : Grimaldi observed diffraction
1802 : Young observed superposition
1835 : Polarization was observed

} Can't be explained by Particle Theory

Fresnel resurrected Huygen's Wave Theory.

1864 : Maxwells EM Wave Theory

1905, 1923 : Photoelectric Effect, Compton Effect observed → Particle theory came up

If medium undergoes change, wave reflects .....

Huygen's Wave Theory

Source of wave sets up disturbance into the medium. As a consequence of this, medium particles vibrates. Locus of all particles vibrating with same phase constitute a wave front.

- If I continuously do the plucking, it becomes a travelling wave.

We know

Wave Equation $y = a \sin(kx - \omega t + \phi_0)$

a ↑ Amplitude or y_{max}

$(kx - \omega t + \phi_0)$ — Phase ϕ

ϕ_0 — initial phase at $t=0$, $x=0$

$k = \left(\frac{2\pi}{\lambda}\right)$

$\omega = \left(\frac{2\pi}{T}\right)$

- As defined, for wavefront phase = const.

$\Rightarrow kx - \omega t + \phi_0 = \text{const.}$

$\Rightarrow d(\phi) = 0$

$\Rightarrow d(kx - \omega t + \phi_0) = 0$

- For monochromatic wave, k and ω are constant

$\Rightarrow k\,dx - \omega dt = 0$

$\Rightarrow \left(\frac{dx}{dt}\right) = v_P = \left[\frac{\omega}{k}\right]$

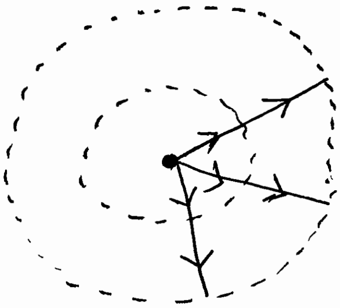
$= \frac{2\pi\nu}{\frac{2\pi}{\lambda}} = \lambda\nu = v$

i.e. {Phase Velocity or Wavefront Velocity = Wave Velocity} For Monochromatic wave only....

- It is wavefront which carries energy and momentum. Velocity of wavefront is wave velocity and also phase velocity.

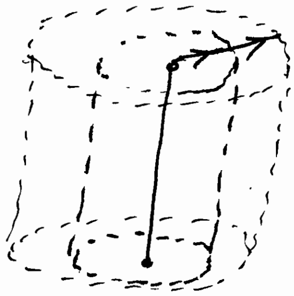
At $t=0$, wavefront position given at source

For point source, spherical wavefront

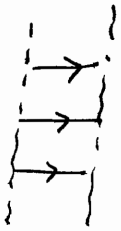


"light never travels backwards"
[Obliquity Factor = $1+\cos\theta$
@ $\theta=\pi$, it is 0]

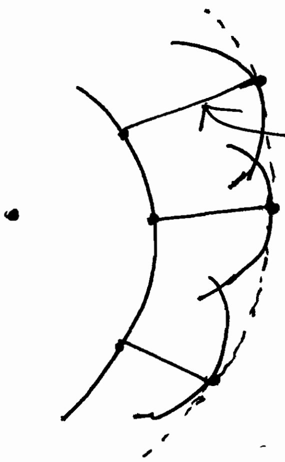
For extended source, cylindrical wavefront



For distant source



Flat Parallel Wavefront
They are "Plane waves"



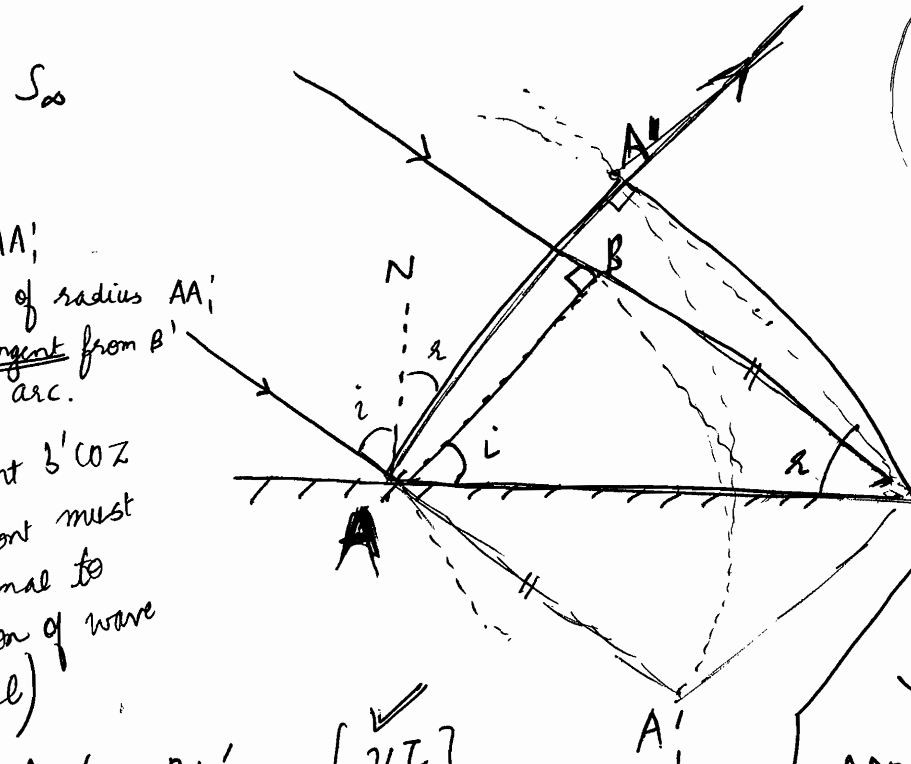
Secondary Waves

All points on wavefront are sources of secondary wavelets which travel with velocity v.
Hence at each point, draw arcs of length vt.
Envelopes of all arcs is the new wavefront.

Wave propagation is ⊥ to wavefront.

Reflection of Waves from Huygen's Principle

Waves can't pass throug. Source is very far off, hence plane wave incident. AB: Plane Wavefront.

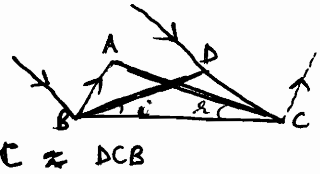


(For better clarity either make the waves very horizontal or very vertical)

BB' = AA'₁
drawing arc of radius AA'₁
drawing tangent from B' to A' on arc.

(Tangent b'coz wavefront must be normal to direction of wave travel)

ढंगा से construction करोगे तो



ABC ≅ DCB

$AA' = BB'$ [✓ VT]

$AB' = AB'$ [common]

$\angle AA'B' = \angle B'BA$

[redacted]

$\Rightarrow$ $\boxed{i = r}$

[refer P- 12.5 of Ghatak]

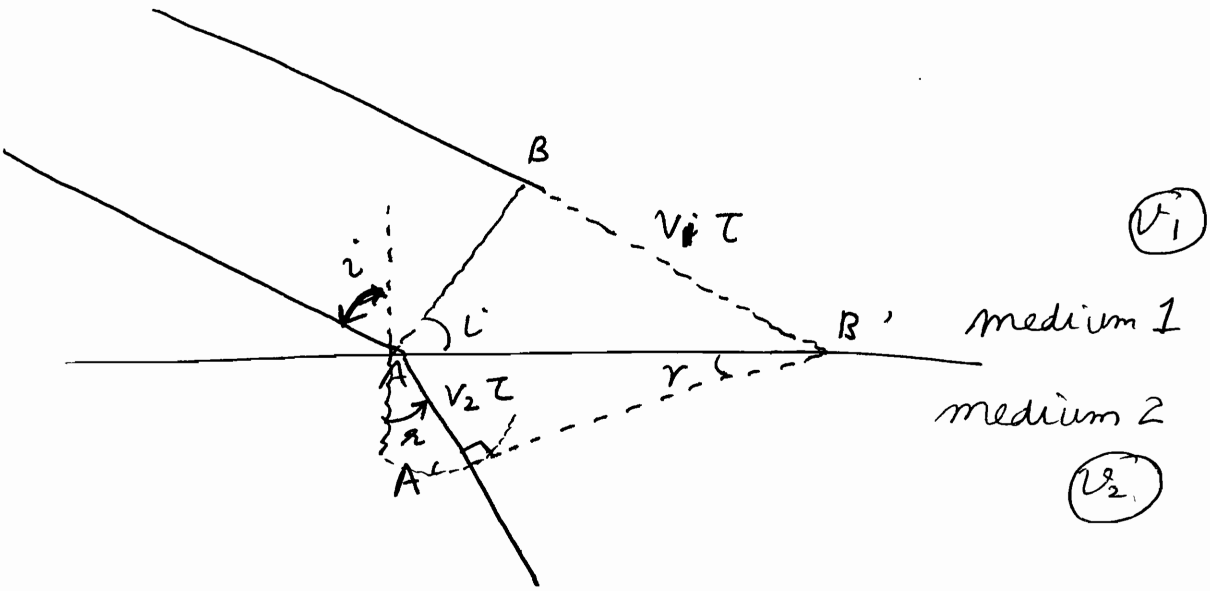
⊛ Angle measured from light rays to normal
= Angle measured from wavefront to horizontal

→ $i = r$ because velocity = same in same medium

$\Rightarrow T_1 = T_2$

$\Rightarrow i = r$

Refraction of Waves



$$\frac{\sin i}{\sin r} = \left(\frac{V_1 \tau}{AB'}\right) \Big/ \left(\frac{V_2 \tau}{AB'}\right) = \left(\frac{V_1}{V_2}\right) = \left(\frac{n_2}{n_1}\right)$$

$$\Rightarrow \boxed{n_1 \sin i = n_2 \sin r}$$

Note that $n_1 V_1 = n_2 V_2 = C$

Huygen's Theory

① Wavefront is the locus of the points which are vibrating in the same phase. Huygen's Theory is essentially based on the geometrical construction which allows us to determine the shape of the wavefront at any time, if the shape of the wavefront at an earlier time is known.

② According to Huygen, each point of a wavefront is source of secondary wavelets. The envelope of these wavelets gives the shape of the new wavefront.

There is however one drawback with this model. It also gives rise to a backwave. To avoid this, later on obliquity factor $\left[\frac{1 + \cos\theta}{2}\right]$ was introduced.

Differential Equation of Monochromatic Wave

$$y = a \sin(kx - \omega t + \phi_0)$$

$$\left(\frac{\partial^2 y}{\partial x^2}\right) = \frac{k^2}{\omega^2}\left(\frac{\partial^2 y}{\partial t^2}\right) = \frac{1}{v_p^2}\left(\frac{\partial^2 y}{\partial t^2}\right)$$

→ Note that $\frac{\omega}{k} = v_p$

Such a wave is called Plane Progressive Wave

If ψ is the direction of displacement of medium particle,

$$\frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} = \frac{1}{v^2}\left[\frac{\partial^2 \psi}{\partial t^2}\right]$$

2d wave
eg. Surface wave

$$\frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} + \frac{\partial^2 \psi}{\partial z^2} = \frac{1}{v^2}\left(\frac{\partial^2 \psi}{\partial t^2}\right)$$

3d wave
eg. Space waves

$$\boxed{\nabla^2 \psi = \frac{1}{v^2}\left[\frac{\partial^2 \psi}{\partial t^2}\right]}$$

For a space wave, the solution of this equation is :

$$\psi(r, t) = \psi_0 \, e^{i(\vec{k}\cdot\vec{r} - \omega t + \phi)}$$

$$\psi(r, t) = \psi_0 \sin(\vec{k}\cdot\vec{r} - \omega t + \phi)$$

v_{wave} on string $= \sqrt{\frac{T}{\rho}}$		T: tension ρ: mass per unit length
solid $= \sqrt{\frac{Y}{\rho}}$		Y: youngs modulus ρ: density
gas $= \sqrt{\frac{\gamma P}{\rho}}$		γ: C_p/C_v P : Pressure ρ : density