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Physics

UNITS AND MEASUREMENTS

- The **SI system:** It is the international system of units. In this system there are seven fundamental and two supplementary quantities and their corresponding units. These are:

Quantity	Unit	Symbol
1. Length	meter	m
2. Mass	kilogram	kg
3. Time	second	s
4. Electric current	ampere	A
5. Temperature	kelvin	K
6. Luminous intensity	candela	Cd
7. Amount of substance	mole	mol
Supplementary		
1. Plane angle	radian	rad
2. Solid angle	steradian	sr

- **Dimensions:** These are the power to which the fundamental units are raised to get the unit of a derived quantity.
- **Use of dimensions**
  i. To check the correctness of a physical relation.
  ii. To derive relationship between different physical quantities.
  iii. To convert one system of unit into another.

  $n_1u_1 = n_2u_2$

  $n_1[M_1^a L_1^b T_1^c] = n_2[M_2^a L_2^b T_2^c]$

- **Significant figures**
  In any measurement, the reliable digits plus the first uncertain digit are known as significant figures.
- **Error:** It is the difference between the measured value and true value of a physical quantity.
- **Absolute error:** The magnitude of the difference between the true value and measured value is called absolute error.

  $\Delta a_1 = \bar{a} - a_1$, $\Delta a_2 = \bar{a} - a_2$, $\Delta a_n = \bar{a} - a_n$

  Mean absolute error

  $$\Delta \bar{a} = \frac{|\Delta a_1| + |\Delta a_2| + ... + |\Delta a_n|}{n} = \frac{1}{n}\sum_{i=1}^{n} |\Delta a_i|$$

- **Relative error :** It is the ratio of the mean absolute error to its true value
  or relative error = $\frac{\Delta \bar{a}}{\bar{a}}$ and

  percentage error = $\frac{\Delta \bar{a}}{\bar{a}}$ x100
- **Percentage error :** It is the relative error in percent.

  Percentage error = $\left(\frac{\Delta \bar{a}}{a_{mean}}\right) \times 100\%$

MOTION IN A STRAIGHT LINE

- Average acceleration, $a_{av} = \frac{a_1 t_1 + a_2 t_2}{t_1 + t_2}$
- The area under the velocity-time curve is equal to the displacement and slope gives acceleration.
- If body falls freely, the distance covered by it in each subsequent second starting from first second will be in the ratio 1 : 3 : 5 : 7 etc.
- If a body is thrown vertically up with an initial velocity u, it takes u/g second to reach maximum height and u/g second to return, if air resistance is negligible.
- If air resistance acting on a body is considered, the time taken by the body to reach maximum height is less than the time to fall back the same height.
- For a particle having zero initial velocity if $s \propto t^{\alpha}$, where $\alpha > 2$, then particle's acceleration increase with time.
- For a particle having zero initial velocity if $s \propto t^{\alpha}$, where $\alpha > 0$, then particle's acceleration decrease with time.
- Kinematic equations :
  $v = u + a_t$ (t) ; $v^2 = u^2 + 2a_t$ (s)
  $S = ut + \frac{1}{2} a_t (t)^2$; $S_n = u + \frac{a}{2}(2n - 1)$
  applicable only when $|\vec{a}_t| = a_t$ is contant.
  a_t = magnitude of tangential acceleration, S = distance
- If acceleration is variable use calculus approach.
- **Relative velocity :** $\vec{v}_{BA} = \vec{v}_B - \vec{v}_A$

MOTION IN A PLANE

- If T is the time of flight, h maximum height, R horizontal range of a projectile, α its angle of projection, then the relations among these quantities.
- $h = \frac{gT^2}{8}$ .....(1);
  $gT^2 = 2R \tan \alpha$ .....(2);
  $R \tan \alpha = 4h$ .....(3)
- $T = \frac{2u \sin\theta}{g}$; $h = \frac{u^2 \sin^2\theta}{2g}$

  $R = \frac{u^2 \sin 2\theta}{g}$
- For a given initial velocity, to get the same horizontal range, there are two angles of projection α and 90°-α

- The equation to the parabola traced by a body projected horizontally from the top of a tower of height y, with a velocity u is $y = gx^2/2u^2$, where x is the horizontal distance covered by it from the foot of the tower.
- Equation of trajectory is $y = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta}$, which is parabola.
- Equation of trajectory of an oblique projectile in terms of range (R) is $y = x\tan\theta \left(1-\frac{x}{R}\right)$
- Maximum height is equal to n times the range when the projectile is launched at an angle $\theta = \tan^{-1}(4n)$
- In a uniform circular motion, velocity and acceleration are constants only in magnitude. Their directions change.
- In a uniform circular motion, the kinetic energy of the body is a constant.
  $W = 0, \quad \vec{a} \neq 0, \ \vec{P} \neq constant, \ \vec{L} = constant$
- Centripetal acceleration, $a_r = \omega^2 r = \frac{v^2}{r} = \omega v$
  (Always applicable)
  $a_r = 4\pi^2 n^2 r = \frac{4\pi^2}{T} r$ (Applicable in uniform circular motion)
  n = frequency of rotation, T = time period of rotation.
  $\vec{a}_r = \vec{\omega} \times \vec{v}$

LAWS OF MOTION

- Newton's second law : $\vec{F} = m\vec{a}$, $\vec{F} = d\vec{p}/dt$
- Impulse : $\Delta\vec{p} = \vec{F}\Delta t$, $p_2 - p_1 = \int_1^2 E\,dt$
- Newton's third law : $\vec{F}_{12} = -\vec{F}_{21}$
- Frictional force $f_s \leq (f_s)_{max} = \mu_s R$; $f_k = \mu_k R$
- Circular motion with variable speed. For complete circles, the string must be taut in the highest position, $u^2 \geq 5ga$. Circular motion ceases at the instant when the string becomes slack, i,e., when T = 0, range of values of u for which the string does go slack is $\sqrt{2ga} < u < \sqrt{5ga}$.
- Conical pendulum : $\omega = \sqrt{g/h}$ where h is height of a point of suspension from the centre of circular motion.
- The acceleration of a lift
  $a = \frac{actual\ weight - apparent\ weight}{mass}$
  If 'a' is positive lift is moving down, and if it is negative the lift is moving up.

WORK, ENERGY AND POWER

- Work done $W = FS\cos\theta$
- Relation between kinetic energy E and momentum, $P = \sqrt{2mE}$
- If a body moves with constant power its velocity (v) is related to distance travelled (x) by the formula $v \propto x^{3/2}$.
- Work due to kinetic force of friction between two contact surface is always negative. It depends on relative displacement between contact surface. $W_{FK} = -F_K (S_{rel})$.
- $\sum W = \sum \Delta K$, $\sum W \Rightarrow$ Total work due to all kinds of forces,
- $\sum \Delta K \Rightarrow$ total change in kinetic energy.
- $\sum W_{conservative} = -\sum \Delta U$; $\sum W_{conservative} \Rightarrow$ Total work due to all kinds of conservative forces.
- $\sum \Delta K \Rightarrow$ Total change in all kinds of potential energy.
- Coefficient of restitution
  $e = \frac{velocity\ of\ separation}{velocity\ of\ approach}$
- The total momentum of a system of particles is a constant in the absence of external forces.

SYSTEM OF PARTICLES AND ROTATIONAL MOTION

- The centre of mass of a system of particles is defined as the point whose position vector is $R = \frac{\sum m_i r_i}{M}$ The centre of gravity of an extended body is that point where the total gravitational torque on the body is zero.
- The angular momentum of a system of n particles about the origin is $L = \sum_{i=1}^{n} r_i \times p_i$; $L = mvr = I\omega$
- The torque or moment of force on a system of n particles about the orgine is $\tau = \sum_i r_i \times F_i$
- The moment of inertia of a rigid body about an axis is defined by the formula $I = \sum m_i r_i^2$
- The kinetic energy of rotation is $K = \frac{1}{2} I\omega^2$
- The theorem of parallel axes : $I_z' = I_z + Ma^2$
  Theorem of perpendicular axes : $I_z = I_x + I_y$
- For rolling motion without slipping $v_{cm} = R\omega$, where v_{cm} is the velocity of translation (i.e. of the centre of mass), R is the radius and m is the mass of the body. The kinetic energy of such a rolling body is the sum of kinetic energies of translation and rotation : $K = \frac{1}{2} m v_{cm}^2 + \frac{1}{2} I\omega^2$

- A rigid body is in mechanical equilibrium if
  (a) It is translational equilibrium i.e., the total external force on it zero $\sum F_i = 0.$
  (b) It is rotational equilibrium i.e., the total external torque on it is zero : $\sum \tau_i = \sum r_i \times F_i = 0.$
- If a body is released from rest on rough inclined plan,
  then for pure rolling $\mu_r \geq \frac{n}{n+1}\tan\theta \left(I_c = nmr^2\right)$
  Rolling with sliding $0 < \mu_s < \left(\frac{n}{n+1}\right)\tan\theta$;
  $$\frac{g\sin\theta}{n+1} < a < g\sin\theta$$
- Gravitational force F = $\frac{Gm_1m_2}{r^2}$
  G = 6.67 x 10^{-11} $\frac{Nm^2}{kg^2}$
- The acceleration due to gravity,
  (a) at a height h above the Earth's surface
  $$g(h) = \frac{GM_E}{(R_E+h)^2} = \frac{GM_E}{R_E^2}\left(1-\frac{2h}{R_E}\right) \quad \text{for } h << R_E$$
  $$g(h) = g(0)\left(1-\frac{2h}{R_E}\right) \quad \text{where } g(0) = \frac{GM_E}{R_E^2}$$
  (b) at depth d below the Earth's surface is
  $$g(d) = \frac{GM_E}{R_E^2}\left(1-\frac{d}{R_E}\right) = g(0)\left(1-\frac{d}{R_E}\right)$$
  (c) with latitude $\lambda \; g^1 = g - R\omega^2\cos^2\lambda$
- Gravity potential $V_g = -\frac{GM}{r}$
- Intensity of gravitational field I = $\frac{GM}{r^2}$
- The gravitational potential energy
  V = - $\frac{Gm_1m_2}{r}$ + constant
- The escape speed from the surface of the Earth is
  $v_e = \sqrt{\frac{2GM_E}{R_E}} = \sqrt{2gR_E}$ and has a value of 11.2 $km\,s^{-1}$
- Orbital velocity, $v_{orbi} = \sqrt{\frac{GM_E}{R_E}} = \sqrt{gR_E}$
- A geostationary (geosynchronous communication) satellite moves in a circular orbit in the equatorial plane at a approximate distance of 4.22 x 10^4 km from the Earth's centre.
- $V_{max} = \sqrt{\frac{GM_s}{a}\left(\frac{1+e}{1-e}\right)}$; $V_{min} = \sqrt{\frac{GM_s}{a}\left(\frac{1-e}{1+e}\right)}$
- Whenever force responsible for orbital motion obeys inverse square law, then only square of time period is directly proportional to cube of average distance between planet and sun. this is Kepler's 3rd law of planetary motion.
  $T^3 \propto a^3$; $\frac{T_1^2}{T_2^2} = \frac{a_1^3}{a_2^3}$
- Hooke's law : stress $\propto$ strain
- Young's modulus of elasticity $Y = \frac{F\,\Delta\ell}{A\ell}$
- Compressibility = $\frac{1}{\text{Bulk modulus}}$
- Y = 3k (1-2σ)
- Y = 2n (1+σ)
- If Sis the stress and Y is Young's modulus, the energy density of the wire E is equal to $S^2/2Y$.
- If α is the longitudinal strain end E is the energy density of a stretched wire, Y Young's modulus of wire, then E is equal to $\frac{1}{2}Y\alpha^2$

MECHANICAL PROPERTIES OF FLUID

- **Pascal's law :** A change in pressure applied to an enclosed fluid is transmitted undiminished to every point of the fluid and the walls of the containing vessel.
- Bernoulli's principle
  $P + \rho v^2/2 + \rho gh = \text{constant}$
- Surface tension is a force per unit length (or surface energy per unit area) acting in the plane of interface.
- Stokes' law states that the viscous drag force F on a sphere of radius a moving with velocity v through a fluid of viscosity η
  F = -6πηav.
- Terminal velocity $V_T = \frac{2}{9}\frac{r^2(\rho-\sigma)g}{\eta}$
- The surface tension of a liquid is zero at boiling point. The surface tension is zero at critical temperature.
- If a drop of water of radius R is broken in to n identical drops, the work done in the process is $4\pi R^2 S(n^{1/3}-1)$.
- Two capillary tubes each of radius r are joined in parallel. The rate of flow is Q. If they are replaced by single capillary tube of radius R for the same rate of flow, then
  R = $2^{1/4}$r.
- Coefficient of viscosity $n = -\frac{F}{A\left(\frac{dv}{dx}\right)}$
- Velocity of efflux $V = \sqrt{2gh}$

THERMAL PROPERTIES OF MATTER

- The coefficient of linear expansion (α_ℓ), superficial (β) and volume expansion (α_v) are defined by the relations :

  $\frac{\Delta \ell}{\ell} = \alpha_\ell \Delta T$; $\frac{\Delta A}{A} = \beta \Delta T$; $\frac{\Delta V}{V} = \alpha_v \Delta T$

  $\alpha_v = 3\alpha_\ell$; $\beta = 2\alpha_\ell$
- In conduction, heat is transferred between neighbouring parts of a body through molecular collisions, without any flow of matter. The rate of flow of heat

  $H = KA\frac{T_C - T_D}{L}$, where K is the thermal conductivity of the material of the bar.
- Convection involves flow of matter within a fluid due to unequal temperature of its parts.
- Radiation is the transmission of heat as electromagnetic waves.
- Stefan's law of radiation : $E = \sigma T^4$, where the constant σ is known as Stefan's constant = $5.67 \times 10^{-8} wm^{-2}k^{-4}$.
- Wein's displacement law : $\lambda_m T$ = constant, where constant is known as Wein's constant = $2.898 \times 10^{-3} mk$.
- Newton's law of cooling : $\frac{dQ}{dt} = -k(T_2 - T_1)$;

  where T_1 is the temperature of the surrounding medium and T_2 is the temperature of the body.
- Heat required to change the temperature of the substance, $Q = mc\Delta\theta$

  c = specific heat of the substance
- Heat absorbed or released during state change Q = mL

  L = latent heat of the substance.

THERMODYNAMICS

- Mayer's formula $c_p - c_v = R$
- First law of thermodynamics : $\Delta Q = \Delta U + \Delta W$, where ΔQ is the heat supplied to the system, ΔW is the work done by the system and ΔU is the change in internal energy of the system.
- In an isothermal expansion of an ideal gas from volume V_1 to V_2 at temperature T the heat absorbed (Q) equals the work done (W) by the gas, each given by

  $Q = W = nRT \ln\left(\frac{V_2}{V_1}\right)$
- In an adiabatic process of an ideal gas

  $PV^\gamma = TV^{\gamma-1} = \frac{T^\gamma}{P^\gamma - 1}$ = constant, where $\gamma = \frac{C_p}{C_v}$
- work done by an ideal gas in an adiabatic change of state from (P_1 , V_1 , T_1) to (P_2 , V_2 , T_2) is

  $W = \frac{nR(T_1 - T_2)}{\gamma - 1}$
- The efficiency of a Carnot engine is given by

  $\eta = 1 - \frac{T_2}{T_1}$
- **Second law of thermodynamic :** No engine operating between two temperature can have efficiency greater than that of Carnot engine.
- Entropy or disorder S = $\frac{\delta Q}{T}$

KINETIC THEORY

- Kinetic theory of an ideal gas gives the relation $P = \frac{1}{3} nm\bar{v}^2$, Combined with the ideal gas equation it yields a kinetic interpretation of temperature.

  $\frac{1}{2} nm\bar{v}^2 = \frac{3}{2} k_B T$, $v_{rms} = (\bar{v}^2)^{1/2} = \sqrt{\frac{3k_B T}{m}}$
- The law of equipartition of energy is stated thus: the energy for each degree of freedom in thermal equilibrium is $1/2(k_B T)$
- The translational kinetic energy $E = \frac{3}{2} k_B NT$. This leads to a relation $PV = \frac{3}{2} E$.
- Root mean square (rms) velocity of the gas

  $C = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3P}{\rho}}$
- Most probable path $\lambda = \frac{KT}{\sqrt{2}\pi d^2 P}$

OSCILLATIONS

- The particle velocity and acceleration during SHM as functions of time are given by,

  $v(t) = -\omega A \sin(\omega + \phi)$ (velocity),

  $a(t) = -\omega^2 A \cos(\omega t + \phi) = -\omega^2 x(t)$ (acceleration)

  Velocity amplitude $v_m = \omega A$ and acceleration amplitude $a_m = \omega^2 A$
- A particle of mass m oscillating under the influence of a Hooke's law restoring force given by F = -kx exhibits simple harmonic motion with $\omega = \sqrt{\frac{k}{m}}$ (angular frequency), $T = 2\pi\sqrt{\frac{m}{k}}$ (period)

  Such a system is also called a linear oscillator.
- A body of mass M is suspended from a spring whose force constant is K and mass is m. The time period of this system will be $2\pi\sqrt{\frac{(M + m/3)}{k}}$
- Time period for conical pendulum $T = 2\pi\sqrt{\left(\frac{\ell\cos\theta}{g}\right)}$

  where θ angle between string & vertical.
- Energy of the particle $E = \frac{1}{2} m\omega^2 A^2$

WAVES

- The displacement in a sinusoidal wave y (x, t) = a sin (kx – ωt + ϕ) where ϕ is the phase constant or phase angle.
- The speed of a transverse wave on a stretched string $v=\sqrt{T/\mu}$.
- Sound waves are longitudinal mechanical waves that can travel through solids, liquids, or gases. The speed v of sound wave in a fluid having bulk modulus B and density μ is $v=\sqrt{B/\rho}$.
- The speed of longitudinal waves in a metallic bar is $v=\sqrt{Y/\rho}$.
  For gases, since B = γP, the speed of sound is $v=\sqrt{\gamma P/\rho}$.
- The interference of two identical waves moving in opposite directions produces standing waves. For a string with fixed ends, standing wave
  y(x, t) = [2a sin kx] cos ωt
- The separation between two consecutive nodes or antinodes is λ/2.
- A stretched string of length L fixed at both the ends vibrates with frequencies $f=\frac{1}{2}\frac{v}{2L}$.
  The oscillation mode with lowest frequency is called the fundamental mode or the first harmonic. The second harmonic is the oscillation mode with n = 2 and so on.
- A pipe of length L ith one end close and other open (such as air columns) vibrates with frequencies given by $f=\left(n+\frac{1}{2}\right)\frac{v}{2L}$, n = 0, 1, 2, 3, …....
  The lowest frequency given by v/4L is the fundamental mode or the first harmonic.
- Beats arise when two waves having slightly different frequencies, f_1 and f_2 and comparable amplitudes, are superposed. The beat frequency $f_{beat}=f_1-f_2$
- The Doppler effect is a change in the observed frequency of a wave when the source S and the observer O moves relative to the medium. $f=f_0\left(\frac{v\pm v_0}{v\pm v_s}\right)$
- Doppler effect formula in light : $\frac{d\lambda}{\lambda}=\frac{v}{c}$, where dλ is change in wavelength of a spectral line of original wave length λ and v, the speed of the source and c is the speed of light.

ELECTROSTATICS

- Coulomb's Law : $\vec{F}_{21}$ = force on q_2 due to $q_1=\frac{k(q_1q_2)}{r_{21}^2}\hat{r_{21}}$ where $k=\frac{1}{4\pi\varepsilon_0}$
  =9 x 10^9 Nm^2C^{-2}
- Electric field due to a point charge q has a magnitude $|q|/4\pi\varepsilon_0 r^2$
- Field of an electric dipole in its equatorial plan
  E= $\frac{-\vec{p}}{4\pi\varepsilon_0}\frac{1}{(a^2+r^2)^{3/2}}\cong\frac{-\vec{p}}{4\pi\varepsilon_0 r^3}$, for r >>a
  Dipole electric field on the axis at a distance r from the centre :
  $\vec{E}=\frac{2\vec{p}r}{4\pi\varepsilon_0(r^2-a^2)^2}\cong\frac{2\vec{p}}{4\pi\varepsilon_0 r^3}$ for r>>a
  Dipole moment $\vec{p}=q2a$
- In a uniform electric field $\vec{E}$, a dipole experience a torque $\vec{\tau}$ given by $\vec{\tau}=\vec{p}\times\vec{E}$ but experiences no net force.
- The flux Δϕ = $\vec{E}.\Delta\vec{S}$
- Gauss's law: The flux of electric field through any closed surface S is $1/\varepsilon_0$ times the total charge enclosed i.e., Q
- Thin infinitely long straight wire of uniform linear charge density λ : $\vec{E}=\frac{\lambda}{2\pi\varepsilon_0 r}\hat{n}$
- Infinite thin plane sheet of uniform surface charge density σ $\vec{E}=\frac{\sigma}{2\varepsilon_0}\hat{n}$
- Thin spherical shell of uniform surface charge density σ : $\vec{E}=\frac{\sigma}{4\pi\varepsilon_0 r^2}\hat{r}$ (r ≥ R) ; $\vec{E}=0$ (r < R)
- Electric Potential : $V(\vec{r})=\frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$.
  For a charge configuration q_1, q_2 ,....., q_n with position vectors r_1, r_2, …..r_n, the potential at a point P is given by the superposition principle
  $V=\frac{1}{4\pi\varepsilon_0}\left(\frac{q_1}{r_{1P}}+\frac{q_2}{r_{2P}}+.....+\frac{q_n}{r_{nP}}\right)$.
- An equipotential surface is surface over which potential has a constant value.
- Potential energy of two charges q_1, q_2 at $\vec{r}_1,\vec{r}_2$ is given by $U=\frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r_{12}}$, where r_{12} is distance between q_1 and q_2 .
- Capacitance C = Q/V, where Q = charge and V = potential difference
- For a parallel plate capacitor (with vacuum between the plates),
  $C=\varepsilon_0\frac{A}{d}$, where A is the area of each plate and d the separation between them.
- The energy U stored in a capacitor C, with charge Q and voltage V is
  $U=\frac{1}{2}QV=\frac{1}{2}CV^2=\frac{1}{2}\frac{Q^2}{C}$
- For capacitors in the series combination,
  $\frac{1}{C_{eq}}=\frac{1}{C_1}+\frac{1}{C_2}+\frac{1}{C_3}+.....$
  In the parallel combination, $C_{eq}=C_1+C_2+C_3+.....$
  where C_1, C_2, C_3, …... are individual capacitances.

CURRENT ELECTRICITY

- Current density j gives the amount of charge flowing per second per unit area normal to the flow, $\vec{J} = nqv_d$
- Resistance R = $\rho \frac{\ell}{A}$
  ρ = resistivity of the material
- Equation $\vec{E} = \rho \vec{J}$ another statement of Ohm's law, i.e., a conducting material obeys Ohm's law when the resistivity of the material does not depend on the magnitude and direction of applied electric field.
  ρ = resistivity of the material.
- (a) Total resistance R of n resistor connected in series
  $R = R_1 + R_2 + ... + R_n$
  (b) Total resistance R of n resistor connected in parallel
  $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + ... + \frac{1}{R_n}$.
- Kirchhoff's Rules – (a) Junction rule: At any junction of circuit element, the sum of currents entering the juction must equal the sum of current leaving it.
  (b) Loop rule: The algebraic sum of changes in potential around any closed loop must be zero.
- The Wheatstone bridge is an arrangement of four resistances R_1 , R_2 , R_3 , R_4 . The null-point condition is given by $\frac{R_1}{R_2} = \frac{R_3}{R_4}$
- The potentiometer is a device to compare potential difference. The device can be used to measure potential difference; internal resistance of a cell and compare emf's of two sources.
  Internal resistance $r = R\left(\frac{\ell_1}{\ell_1}\right) - 1$
- RC circuit : During charging : $q = CE(1 - e^{-t/RC})$
  during discharging : $q = q_0 e^{-t/RC}$

MAGNETISM

- The total force on a charge q moving with velocity v i.e., Lorentz force. $\vec{F} = q(\vec{v} \times \vec{B} + \vec{E})$
- A straight conductor of length ℓ and carrying a steady current I experiences a force $\vec{F}$ in a uniform external magnetic field $\vec{B}$, $\vec{F} = I\vec{\ell} \times \vec{B}$ the direction of ℓ is given by the direction of the current.
- Biot-Savart law $d\vec{B} = \frac{\mu_0}{4\pi} I \frac{d\vec{\ell} \times \vec{r}}{r^3}$.
- The magnitude of the magnetic field due to a circular coil of radius R carrying a current I at an axial distance x from the centre is $B = \frac{\mu_0 IR^2}{2(x^2 + R^2)^{3/2}}$.
- The magnitude of the field B inside a long solenoid carrying a current I is : $B = \mu_0 nI$, where n is the number of turns per unit length. For a toroid one obtains, $B = \frac{\mu_0 NI}{2\pi r}$.
- **Ampere's Circuit law:** $\oint_C \vec{B}.d\vec{\ell} = \mu_0 I$, where I refers to the current passing through S.
- Force between two long parallel wires $F = \frac{\mu_0 I_1 I_2}{2\pi a} Nm^{-1}$
  The force is attractive if current are in the same direction and repulsive current are in the opposite direction.
- For current carrying coil $\vec{M} = NI\vec{A}$;
  torque= $\vec{\tau} = \vec{M} \times \vec{B}$
- The magnetic intensity, $\vec{H} = \frac{\vec{B}_0}{\mu_0}$.
- The magnetisation $\vec{M}$ of the material is its dipole moment per unit volume. The magnetic field B in the material is, $\vec{B} = \mu_0(\vec{H} + \vec{M})$
- For a linear material $\vec{M} = \chi \vec{H}$. So that $\vec{B} = \mu \vec{H}$ and χ is called the magnetic susceptibility of the material.
  $\mu = \mu_0 \mu_r$; $\mu_r = 1 + \chi$.

ELECTROMAGNETIC INDUCTION

- The magnetic flux $\phi_B = \vec{B}.\vec{A} = BA\cos\theta$, where θ is the angle between $\vec{B}$ & $\vec{A}$.
- Faraday's laws of induction : $\varepsilon = -N\frac{d\phi_B}{dt}$
- Lenz's law states that the polarity of the induced emf is such that it tends to produce a current which opposes the change in magnetic flux that produces it.
- The induced emf (motional emf) across end of a rod
  $\varepsilon = B\ell v$
- The self-induced emf is given by, $\varepsilon = -L\frac{dI}{dt}$
  L is the self-inductance of the coil.
  $L = \frac{\mu_0 N^2 A}{\ell}$
- A changing current in a coil (coil 2) can induce an emf in a nearby coil (coil 1).
  $\varepsilon_1 = -M_{12}\frac{dI_2}{dt}$, M_{12} = mutual inductance of coil 1 w.r.t coil2.
  $M = \frac{\mu_0 N_1 N_2 A}{\ell}$
- LR circuit : For growth current, $i = i_0[1 - e^{-Rt/L}]$
  For decay of current, $i = i_0 e^{-Rt/L}$

ALTERNATING CURRENT

- For an alternating current $i = i_m \sin \omega t$ passing through a resistor R, the average power loss P (averaged over a cycle) due to joule heating is $(1/2)i^2_m R$.
- Root mean square (rms) current $I = \frac{i_m}{\sqrt{2}} = 0.707\ i_m$.
- The average power loss over a complete cycle $P = V I \cos\phi$. The term $\cos\phi$ is called the power factor.
- An ac voltage $v = v_m \sin\omega t$ applied to a pure inductor L, drives a current in the inductor : $i = i_m \sin(\omega t - \pi/2)$, where $i_m = v_m/X_L$. $X_L = \omega L$ is called inductive reactance.
- An ac voltage $v = v_m \sin\omega t$ applied to a capacitor drives a current in the capacitor: $i = i_m \sin(\omega t + \pi/2)$. Here, $i_m = \frac{v_m}{X_C}$, $X_C = \frac{1}{\omega C}$ is called capacitive reactance.
- An interesting characteristic of a series RLC circuit is the phenomenon of resonance. The circuit exhibits resonance, i.e., the amplitude of the current is maximum at the resonant frequency, $\omega_0 = \frac{1}{\sqrt{LC}} (X_L = X_C)$.
- Impedance $z = \sqrt{R^2 + (x_L - x_C)^2}$
- Transformation ratio, $K = \frac{N_S}{N_P} = \frac{E_S}{E_P} = \frac{I_P}{I_S}$
- The quality factor Q defined by $Q = \frac{\omega_0 L}{R} = \frac{1}{\omega_0 CR}$ is an indicator of the sharpness of the resonance, the higher valeu of Q indicating sharper peak in the current.

RAY OPTICS

- Reflection is governed by the equation $\angle i = \angle r'$ and refraction by the Sell's law, sin i / sin r = n, where the incident ray, reflected ray and normal lie in the same plan.
- Mirror equation: $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$
- Prism Formula $n_{21} = \frac{n_2}{n_1} = \frac{\sin[(A + D_m)/2]}{\sin(A/2)}$, where D_m is the angle of minimum deviation.
- Dispersion is the splitting of light into its constituent colours. The deviation is maximum for violet and minimum for red.
- Dispersive power $\omega = \frac{\delta_v - \delta_r}{\delta}$, where δ_v , δ_r are deviation of violet and red and δ the deviation of mean ray (usually yellow).
- For refraction through a spherical interface (from medium 1 to 2 of refractive index n_1 and n_2 , respectively.) $\frac{n_2}{v} - \frac{n_1}{v} = \frac{n_2 - n_1}{R}$.
- Thin lens formula $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
- Lens marker's formula : $\frac{1}{f} = \frac{(n_2 - n_1)}{n_1}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$
- The power of a lens P = 1/f. The SI unit for power of a lens is dioptre (D): 1 D = 1 m^{-1}.
- If several thin lenses of focal length f_1, f_2, f_3 ,...are in contact, the effective focal $\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3} + ...$
- The total power of a combination of several lenses $P = P_1 + P_2 + P_3 + ….$
- Chromatic aberration is the colouring of image produced by lenses. This can be avoided by combining a convex and a concave lens of focal lengths f_1 and f_2 and dispersive powers ω_1 , ω_2 respectively satisfying the equation $\frac{\omega_1}{f_1} + \frac{\omega_2}{f_2} = 0$ or in terms of power $\omega_1 P_1 + \omega_2 P_2 = 0$.

WAVE OPTICS

- **Wave front :** It is the locus of all the parcicles vibrating in the same phase.
- The resultant intensity of two waves of intensity $I_0/4$ of phase difference ϕ at any points $I = I_0 \cos^2\left[\frac{\phi}{2}\right]$, where I_0 is the maximum density.
- Condition for dark band : $\delta = (2n - 1)\frac{\lambda}{2}$, for bright band : $\delta = m\lambda$
- Fringe width $\beta = \frac{D\lambda}{d}$
- Athin film of thickness t and refractive index μ appears dark by reflection when viewed at an angle of refraction r if $2\ \mu t \cos r = n\lambda$ (n = 1, 2, 3, etc.)
- A single slit of width a gives a diffraction pattern with a central maximum. The intensity falls to zero at angle of $\pm\frac{\lambda}{a}, \pm\frac{2\lambda}{a}$, etc.
- Amplitude of resultant wave $R = \sqrt{a^2 + b^2 + 2ab\cos\phi}$
- Intensity of wave $I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$

MODERN PHYSICS

- Energy of a photon $E = h\nu = \frac{hc}{\lambda}$
- Momentum of photon $P = \frac{h}{\lambda}$
- Einstein's photoelectric equation
  $\frac{1}{2}mv_{max}^2 = V_0 e = h\nu - \phi_0 = h(\nu - \nu_0)$
- Mass defect,
  $\Delta M = (Zm_p + (A-Z)m_n) - M$; $\Delta E_b = \Delta mc^2$
  1 amu = 931 MeV
- $E_n = -\frac{Z^2}{n^2} \times 13.6 eV$ (For hydrogen like atom)
- Radius of the orbit of electron $r = \frac{n^2 h^2}{4\pi^2 mkze^2}$
- Bragg's law : $2d \sin\theta = n\lambda$.
- Radius of the nucleus $R = R_0 A^{1/3}$
- Law of radioactive decay : $N = N_0 e^{-\lambda t}$.
  Activity = $\frac{dN}{N} = -\lambda N$ (unit is Becquerel)
- Half life period, $T_{1/2} = \frac{0.693}{\lambda}$
- X-rays : $\lambda_{min} = \frac{12400}{v}$ Å

  Characteristics X-rays : $\lambda_{K\alpha} < \lambda_{L\alpha}$
  Moseley law : $\nu = a(Z-b)^2$
- Pure semiconductors are called 'intrinsic semiconductors'. The presence of charge carriers (electrons and holes) number of electrons (n_e) is equal to the number of holes (n_h).
- The number of charge carriers can be changed by 'doping' of a suitable impurity in pure semiconductors known as extrinsic semiconductors (n-type and p-type).
- In n-type semiconductors, $n_e >> n_h$ while in p-type semiconductors $n_h >> n_e$.
- n-type semiconducting Si or Ge is obtained by doping with pentavalent atoms (donors) like As, Sb, P, ect., while p-type Si or Ge can be obtained by doping with trivalent atom (acceptor) like B, A1, In etc.
- p-n junction is the 'key' to all semiconductor devices. When such a junction is made, a 'depletion layer' is formed consisting of immobile ion-cores devoid of their electrons or holes. This is responsible for a junction potential barrier.
- In forward bias (n-side is connected to negative terminal of the battery an p-side is connected to the positive), the barrier is decreased while the barrier increases in reverse bias.
- Diodes can be used for rectifying an ac voltage (restricting the ac voltage to one direction).
- Zener diode is one such specia purpose diode. In reverse bias, after a certain voltage, the current suddenly increases (breakdown voltage) in a Zener diode. This property has been used to obtain voltage regulation.
- The important transistor parameters for CE-configuration are:

  Input resistance, $r_i = \left(\frac{\Delta V_{BE}}{\Delta I_B}\right)_{V_{CE}}$

  Output resistance, $r_0 = \left(\frac{\Delta V_{CE}}{\Delta I_C}\right)_{I_B}$

  Current amplification factor, $\beta = \left(\frac{\Delta I_C}{\Delta I_B}\right)_{V_{CE}}$

  The voltage gain of a transistor amplifier in common emitter configuration is:
  $A_v = \left(\frac{v_0}{v_i}\right) = \beta\frac{R_C}{R_B}$, where R_C and R_B are respectively the resistances in collector and base sides of the circuit.
- The important digital circuits performing special logic operations are called logic gates. These are: OR, AND, NOT, NAND and NOR gates. NAND gate is the combination of NOT and AND gate. NOR gate is the combination of NOT and OR gate.

COMMUNICATION SYSTEMS

- Transmitter, transmission channel and receiver are three basic units of a communication system.
- Two important forms of communication system are: Analog and Digital. The information to be transmitted is generally in continuous waveform for the former while for the latter it has only discrete or quantised levels.
- Low frequencies cannot be transmitted to long distances. Therefore, they are superimposed on a high frequency carrier signal by a process know as modulation.
  In the process of modulation, new frequencies called sidebands are generated on either side,
- If an antenna radiates electromagnetic waves from a height h_T, then the range d_T is given by $\sqrt{2Rh_T}$ where R is the radius of the earth.
- Effective range, $d = \sqrt{2Rh_T} + \sqrt{2Rh_R}$
  h_T = height of transmitting antenna; h_R = height of receiving antenna
- Critical frequency $V_c = 9(N_{max})^{1/2}$
  where N_{max} = no. density of electrons/m^3
- Skip distance, $D_{skip} = 2h\left(\frac{V_{max}}{V_c}\right)^2 - 1$
  h = height of reflecting layer of atmosphere.
- Power radiated by an antenna $\propto \frac{1}{\lambda^2}$

Chemistry

ATOMIC STRUCTURE

- Energy of electron in species with one electron.

$$E_n = \frac{-2\pi^2 me^4 Z^2}{n^2 h^2}$$

For energy in SI system,

$$E_n = \frac{-2\pi^2 me^4 Z^2}{n^2 h^2 (4\pi\varepsilon_0)^2}$$

$$E_n = \frac{-1312 Z^2}{n^2}\ \text{kJ mol}^{-1}$$ where ε_0 is permitivity constant and its value is 8.8542×10^{-12} coulomb^2 newton^{-1} meter^{-2}

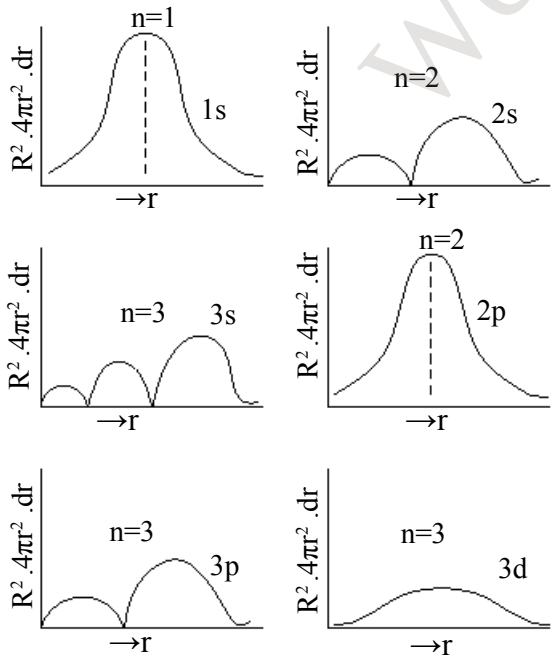
- $r = \frac{n^2 h^2}{4\pi^2 mZe^2} = 0.529\left(\frac{n^2}{Z}\right)$ Å
- Total energy of electron in the nth shell

$$= K.E + P.E = kZ\frac{e^2}{2r_n} + \left(-\frac{kZe^2}{r_n}\right) = -\frac{kZe^2}{2r_n}$$

- $\bar{\upsilon} = \frac{1}{\lambda} = RZ^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$, [R = 1.0968×10^7 m^{-1}]
- No. of spectral lines produced when an electron drops from nth level to ground level = $\frac{n(n-1)}{2}$
- Heinsenberg Uncertainty Princple $(\Delta x)(\Delta p) \geq h/4\pi$
- Nodes (n-1) = total nodes, ℓ = angular nodes, $(n - \ell - 1)$ = Radial nodes
- Orbital angular momentum :

$$\sqrt{\ell(\ell+1)}\frac{h}{2\pi} = \sqrt{\ell(\ell+1)}\,h$$

- Radial probability density curves:



CHEMICAL BONDING

- (a) % ionic character = $\frac{\text{Actual dipole moment}}{\text{Calculated dipol moment}} \times 100$

(b) *Pauling equation % ionic character*

$$= 100\left[1 - \exp^{-\frac{1}{4}(X_A - X_B)}\right]$$

- **Fajan's Factor :** Following factors are helpful in bringing covalent character in Ionic compounds
  (a) Small cation (b) Big anion
  (c) High charge on cation/anion
  (d)Cation having pseudo inert gas configuration ($ns^2p^6d^{10}$) e.g. Cu^+, Ag^+, Zn^{+2}, Cd^{+2}
- M.O. Theory :
  (a) Bond order = ½ $(N_b - N_a)$
  (b) Higher the bond order, higher is the bond dissociation energy, greater is the stability, shorter is the bond length.
  (c)

Species	Bond order	Magnetic properties
H_2	1	Diamagnetic
H_2^+	0.5	Paramagnetic
Li_2	1	Diamagnetic

- **Relative bond strength :** $sp^3d^2 > dsp^2 > sp^3 > sp^2 > sp >$ p-p (Co-axial) > s – p > s – s > p – p (Co-lateral)
- VSEPR theory
  (a) (LP-LP) repulsion > (LP-BP) > (BP-BP)
  (b) $NH_3 \rightarrow$ Bond Angle 106° 45' because (L-BP) repulsion>(BP-BP) $H_2O \rightarrow$ 104° 27' because (LP-LP) repulsion > (LP-LP) > (BP-BP)
- Bond angle :
  (a) $NH_3 > PH_3 > AsH_3$ (b) $H_2O > H_2S > H_2Se$
  (c) $NH_3 > NF_3$ (d) $Cl_2O > OF_2$

CHEMICAL EQUILIBRIUM

- $K_p = K_c(RT)^{\Delta n_g}$ where Δn_g , $n_P - n_R$
- Free Energy change (ΔG)
  (a) If $\Delta G = 0$ then reversible recation would be in equilibrium, $K_c = 0$
  (b) If ΔG = (+)ve then equilibrium will be displace in backward direction; $K_c < 1$
  (c) If ΔG = (-)ve then equilibrium will displace in forward forward direction; $K_c > 1$
- (a) K_c unit $\rightarrow$ (moles/lit)$^{\Delta n}$,
  (b) K_p unit $\rightarrow$ (atm)$^{\Delta n}$

- **Reaction Quotient and Equilibrium Constant**
  Consider the following reversible reaction
  $A + B \rightleftharpoons C + D$
  $\therefore \quad Q_c = \frac{[C][D]}{[A][B]}$
  Case I : If $Q_c < K_c$ then : [Reactants] > [Products] then the system is not at equilibrium
  Case II : If $Q_c = K_c$ then : The system is at equilibrium and concentration of the species C, D, B, A are at equilibrium.
  Case III : If $Q_c > K_c$ then : [Products] > [Reactants] the system is not at equilibrium.
- A relationship between the equilibrium constant K_C, reaction quotient and Gibbs energy.
  $\Delta G = \Delta G° + RT \ln Q$
  At equilibrium $\Delta G = 0$ and $Q = K$ then
  $\Delta G° = -RT \ln K_c$
  $\therefore \quad \Delta G° = -RT \ln K_p$
- Le chatelier's principal
  i. Increase of reactant conc. (Shift forward)
  ii. Decrease of reactant conc. (Shift backward)
  iii. Increase of pressure (from more moles to less moles)
  iv. Decrease of pressure (from less moles to more moles)
  v. For exothermic reaction decrease in temp. (Shift forward)
  vi. For endothermic increase in temp. (Shift backward)

ACID AND BASE

- (a) Lewis Acid (e^- pair acceptor) → CO_2, BF_3, $AlCl_3$, $ZnCl_2$, normal cation
  (b) Lewis Base (e^- pair donor) NH_3, ROH, ROR, H_2O, RNH_2, normal anion
- Dissociation of weak Acid & Weak Base →
  (a) Weak Acid → $K_a = Cx^2/(1-x)$ or $K_a = Cx^2$; $x << 1$
  (b) Weak Base → $K_b = Cx^2/(1-x)$ or $K_b = Cx^2$; $x << 1$
- Buffer solution {Henderson equation} :
  (a) Acidic → $pH = pK_a + \log$ {Salt/Acid}.
  For Maximum buffer action $pH = pK_a$
  Range of Buffer $pH = pK_a \pm 1$
  (b) Alkaline → $pOH = pK_b + \log$ {Salt/Base} for max. buffer action $pH = 14 - pK_b$
  Range $pH = 14 - pK_b \pm 1$
  (c) Buffer Capacity
  $$= \frac{\text{Moles/lit of Acid or Base Mixed}}{\text{change in pH}}$$
- Necessary condition for showing neutral colour of Indicator pH=pKln or $[HIn] = [In^-]$ or $[InOH] = [In^+]$

IONIC EQUILIBRIUM

- Relation between ionisation constant (K_i) & degree of ionisation (α):-
  $$K_i = \frac{\alpha^2}{(1-\alpha)V} = \frac{\alpha^2 C}{(1-\alpha)} \quad \text{(Ostwald's dilution law)}$$
  It is applicable to weak electrolytes for which $\alpha << 1$ then
  $$\alpha = \sqrt{K_i V} = \sqrt{\frac{K_i}{C}} \quad \text{or } V \uparrow C \downarrow \alpha \uparrow$$
- Common ion effect : By addition of X mole/L a common ion, to a weak acid (or weak base) α becomes equal to
  $\frac{K_a}{X}\left(\text{or } \frac{K_b}{X}\right)$ [where α = degree of dissociation]
- (A) if solubility product > ionic product then the solution is unsaturated and more of the substance can be dissolved in it.
  (B) If ionic product > solubility product the solution is super saturated (principle of precipitation).
- Salt of weak acid and strong base :
  $pH = 0.5 (pK_w + pK_a + \log c)$; $h = \sqrt{\frac{K_h}{c}}$; $K_h = \frac{K_w}{K_a}$
  (h = degree of hydrolysis)
  Salt of weak base and strong acid :
  $pH = 0.5 (pK_w - pK_a - \log c)$; $h = \sqrt{\frac{K_w}{K_b \times c}}$
  Salt of weak acid and weak base :
  $pH = 0.5 (pK_w + pK_a - pK_b)$; $h = \sqrt{\frac{K_w}{K_a \times K_b}}$

CHEMICAL KINETICS

- Difference between order and molecularity of reaction:

Order of reaction	*Molecularity*
1. It is experimentally determined quantity	It is a theoretical concept.
2. It can have integral, fractional or negative values	Always integral values only, never zero or negative
3. It cannot be obtained from balanced or stoichiometric equation.	It can be obtained.
4. It tells about the slowest step in the mechanism	It does not tell anything about mechanism
5. It is sum of the powers of the concentration terms in the rate law equation.	It is the number of reacting species undergoing simultaneous collision in the reaction.

- **Unit of Rate constant**
  $k = \text{mole}^{1-n}\ \text{lit}^{n-1}\ \text{sec}^{-1}$
- **Order of reaction** It can be fraction, zero or any whole number.
- **Molecularity of reaction :**
  $$k = \frac{2.303}{t}\log_{10}\frac{a}{(a-x)} \ \&\ t_{1/2} = \frac{0.693}{k}$$
  $[A]_t = [A]_0\, e^{-kt}$
- **Second Order Reaction :**
  When concentration of A and B taking same.
  $$k_2 = \frac{1}{t}\left(\frac{x}{a(a-x)}\right)$$
  When concentration of A and B are taking different -
  $$k_2 = \frac{2.303}{t(a-b)}\log\frac{b(a-x)}{a(b-x)}$$

- **Zero Order Reaction :**

  $x = kt$ & $t_{1/2} \frac{a}{2k}$

  The rate of reaction is independent of the concentration of the reacting substance.
- Time of n^{th} fraction of first order process.

$$t_{1/n} = \frac{2.303}{k} \log \left(\frac{1}{1 - \frac{1}{n}} \right)$$

- **Arrhenius equation :**

  $k = Ae^{-E_a/RT}$ & $\text{slope} = \frac{-E_a}{2.303R}$ & Temperature Coefficient

$$\log \left(\frac{k_2}{k_1} \right) = \frac{E_a}{2.303} \left(\frac{T_2 - T_1}{T_1 T_2} \right)$$

- It has been found that for a chemical reaction with rise in temperature by 10 °C, the rate constant gets nearly doubled.
- Oxidant itself is reduced (gives O_2) Or Oxidant → e (s) Acceptor Reductant itself is oxidised (gives H_2) Or reductant → e^- (s) Donor
- (i) Strongness of acid ∝ O.N
  (ii) Strongness of base ∝ 1/O.N
- (a) Electro Chemical Series:- Li, K, Ba, Sr, Ca, Na, Mg, Al, Mn, Zn, Cr, Fe, Cd, Co, Ni, Sn, Pb, H_2, Cu, Ag, Pt, Au.
  (b) As we move from top to bottom in this series
  (1) Standard Reduction Potential ↑
  (2) Standard Oxidation Potential ↓
  (3) Reducing Capacity ↓
  (4) IP ↑
  (5) Reactivity ↓

VOLUMETRIC ANALYSIS

- Equivalent weight of element $= \frac{\text{Atomic wt of the element}}{\text{Valency of element}}$
- The law of Dulong and Petit
  Atomic wt. x specific heat ≈ 6.4
- Normality (N) $= \frac{\text{number of equivalents}}{\text{volume of the solution in litres}}$
- Molarity (M) $= \frac{\text{number of moles}}{\text{volume of the solution in litres}}$
- Common acid-base indicators

Indicator	Acid colour	Alkaline colour	pH range of change
Methyl orange	Red	Yellow	3.2-4.4
Methyl red	Red	Yellow	4.2-6.2
Litmus	Red	Blue	4.5-8.3
Phenolphthalein	Colourless	Red	08/03/10

THERMODYNAMIC

- First Law : $\Delta E = Q + W$
  Expression for pressure volume work $W = -P\Delta V$
  Maximum work in a reversible expansion :

$$W = -2.303 n RT \log \frac{V_2}{V_1} = -2.303\ nRT \log \frac{P_1}{P_2}$$

  $W_{rev} \geq W_{irr}$
- $q_v = c_v \Delta T = \Delta U$, $q_p = c_p \Delta T = \Delta H$
  Enthapy changes during phase transformation
-
  (i) Enthalpy of Fusion
  (ii) Heat of Vapourisation
  (iii) Heat of Sublimation
- Enthalpy : $\Delta H = \Delta E + P\Delta V = \Delta E + \Delta n_g RT$
- Kirchoff's equation :

$$\Delta E_{T_2} = \Delta E_{T_1} + \Delta C_V (T_2 - T_1) \text{ [constant V]}$$

$$\Delta E_{T_2} = \Delta E_{T_1} + \Delta C_P (T_2 - T_1) \text{ [constant P]}$$

- Entropy(s) : Measeur of disorder or randomness

$$\Delta S = \sum S_p - \sum S_R$$

$$\Delta S = \frac{q_{rev}}{T} = 2.303\ nR \log \frac{V_2}{V_1} = 2.303\ n\ R \log \frac{P_1}{P_2}$$

- Free energy change : $\Delta G = \Delta H - T\Delta S$
  $-\Delta G = W(\text{maximum}) - P\Delta V$

ΔH	ΔS	ΔG	Raction characteristics
−	+	Always negative	Reaction is spontaneous at all temperature.
+	−	Always positive	Reaction is nonspontaneous at all temperature
−	−	Negative at low temperature but positive at high temperature	Spontaneous at low temp. & non spontaneous at high temperature
+	+	Positive at low temp. but negative at high temperature	Non spontaneous at low temp. & spontaneous at high temp.

ELECTRO-CHEMISRY

- $m = Z.I.t$
- Degree of dissociation : $\alpha = \frac{\lambda_{eq}}{\lambda^0_{eq}} = \frac{\text{Equivalent conductance at given concentration}}{\text{equivalent conductance at infinite dilution}}$
- Specific conductance

$$\Lambda_{sp} = \frac{1}{S} = \frac{1}{RA/\ell} = \frac{\ell}{RA} \quad ; \quad \Lambda_m = \frac{1000}{C} \times \Lambda_{sp}.$$

- Kohlrausch's law : $\Lambda_m^0 = x\lambda_A^0 + y\lambda_B^0$
- Nernst Equation $E = E^o - \frac{0.0591}{n}\log_{10}\frac{[\text{Products}]}{[\text{Reactants}]}$

  & $E_{cell}^o = E_{right}^o + E_{left}^o$ & $K_{eq.} = \text{antilog}\left[\frac{nE^o}{0.0591}\right]$

  $\Delta G = -nFE_{cell}$ & $\Delta G^o = -nFE^o$ cell

  & $W_{max} = +nFE^o$ & $\Delta G = \Delta H + \left(\frac{\partial \Delta G}{\partial T}\right)_P$
- Calculation of pH of an electrolyte by using a calomel electrode : $pH = \frac{E_{cell} - 0.2415}{0.0591}$
- Thermodynamic efficiency of fuel cells :

  $\eta = \frac{-\Delta G}{\Delta H} = \frac{-nFE_{cell}^o}{\Delta H}$

  For $H_2 - O_2$ fuel cells it is 95%.

SOLUTION AND COLLIGATIVE PROPERTIES

- Raoult's law : $P = p_A + p_B = p^o_A X_A + p^o_B X_B$
- **Characteristics of an ideal solution:**
  (i) $\Delta_{sol}V = 0$
  (ii) $\Delta_{sol}H = 0$
- Relative lowering of vapour pressure $= \frac{P_A^o - P_A}{P_A^o}$

  $\frac{P_A^o - P_A}{P_A^o} = X_B = \frac{n_B}{n_A + n_B}$
- Colligative properties $\propto$ Number of paticles
  $\propto$ Number of ions (in case of electrolytes)
  $\propto$ Number of moles of solute
- Depression of freezing point, $\Delta T_f = K_f m$
- Elevation in boiling point with relative lowering of vapour pressure

  $\Delta T_b = \frac{1000K_b}{M_1}\left(\frac{p^o - p}{p^o}\right)$ (M_1 = mol. wt. of solvent)
- Osmotic pressure (P) with depression in freezing point ΔT_f

  $P = \Delta T_f \times \frac{dRT}{1000k_f}$
- Relation between Osmotic pressure and other colligative properties:

  (i) $\pi = \left(\frac{p_A^o - p_A}{p_A^o}\right) \times \frac{dRT}{M_B}$ Relative lowering of vapour pressure

  (ii) $\pi = \Delta T_b \times \frac{dRT}{1000k_b}$ Elevation in boiling point

  (iii) $\pi = \Delta T_f \times \frac{dRT}{1000k_f}$ Depression in freezing point
- Degree of association $a = (1-i)\frac{n}{n-1}$

  & degree of dissociation $(\alpha) = \frac{i-1}{n-1}$

GASEOUS STATE

- Ideal gas equation : PV = nRT
  (i) R = 0.0821 liter atm. deg^{-1} $mole^{-1}$
  (ii) R = 2 cals. deg^{-1} $mole^{-1}$
  (iii) R = 8.314 $JK^{-1}mole^{-1}$
- Velocity related to gaseous state

  RMS velocity $C = \sqrt{\frac{3PV}{M}} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3P}{d}}$

  Average speed $= \sqrt{\frac{8RT}{M}}$ & Most probable speed $= \sqrt{\frac{2RT}{M}}$

  Average speed = 0.9213 × RMS speed
  RMS speed = 1.085 × Average speed
  MPS = .816 × RMS; RMS = 1.224 MPS
  MPS : A.V. Speed : RMS = 1 : 1.128 : 1.224
- Rate of diffusion $\propto \frac{1}{\sqrt{\text{density of gas}}}$
- van der Waal's equation

  $\left(P + \frac{n^2 a}{V^2}\right)(V - nb) = nRT$ for n moles
- Z (compressibility factor) $= \frac{PV}{nRT}$; Z=1 for ideal gas

SOLID AND LIQUID STATE

- Available space filled up by hard spheres (packing fraction):

  Simple cubic $= \frac{\pi}{6} = 0.52$

  bcc $= \frac{\pi\sqrt{3}}{8} = 0.68$

  fcc $= \frac{\pi\sqrt{2}}{6} = 0.74$
- Radius ratio and co-ordinary number (CN)

Limiting radius ratio	CN	Geometry
[0.155 – 0.225]	3	[plane triangle]
[0.255 – 0.414]	4	[tetrahedral]
[0.414 – 0.732]	6	[octahedral]
[0.732 - 1]	8	[bcc]

- Atomic radius r and the edge of the nit cell:
  Pure elements:

  $\text{Simple cubic} = r = \frac{a}{2}$; bcc $r = \frac{\sqrt{3}a}{4}$; fcc $= \frac{\sqrt{2}a}{4}$
- Relationship between radius of void (r) and the radius of the sphere (R) : r (tetrahedral) = 0.225 R ; r(octahedral)=0.414 R
- Paramagnetic : Presence of unpaired electrons [attracted by magnetic field]
- Ferromagnetic : Permanent magnetism [↑↑↑↑]
- Antiferromagnetic : magnetic moment is zero [↑↓↑↓]
- Ferromagnetic : net magnetic moment is three [↑↓↓↑↑]

SURFACE CHEMISTRY

- Emulsion : Colloidal soln. of two immiscible liquids [O/W emulsion. W/O emulsion]
- Emulsifier : Long chain hydrocarbons are added to stabilize emulsion.
- Lyophilic colloidal : Starchy gum, gelatin have greater affinity for solvent.
- Lyophobic colloid : No affinity for solvent, special methods are used to prepare sol. [e.g. As_2S_3, $Fe(OH)_3$ sol]
- Preparation of colloidal solution :
  (i) Dispersion method (ii) Condensation method.
- Properties of colloidal solution :
  (i) Tyndall effect (ii) Brownian movement
  (iii) Coagulation (iv) Filtrability.

INORGANIC CHEMISTRY

PERIODIC TABLE

- General electronic configuration (of outer orbits)
  s – block ns^{1-2}
  p – block ns^2np^{1-6}
  d – block $(n-1)d^{1-10}ns^{1-2}$
  f – block $(n-2)\,f^{1-14}s^2p^6d^{10}(n-1)s^2p^6d^{0\text{ or }1}ns^2$
- Property

Property	Pr (L to R)	Gr (T to B)
(a) atomic radius	↓	↑
(b) ionisation potential	↑	↓
(c) electron affinity	↑	↓
(d) electro negativity	↑	↓
(e) metallic character or electropositive character	↓	↑
(f) alkaline character of hydroxides	↓	
(g) acidic character	↑	↓
(h) reducing property	↓	↑
(i) oxidising property	↓	↓
(j) non metallic character	↓	↓

- $IP \propto \dfrac{1}{\text{Metallic character}} \propto \dfrac{1}{\text{Reducing character}}$
- $EA \propto \dfrac{1}{\text{size}} \propto$ nuclear charge.

  Second electron affinity is always negative.
  Electron affinity of chlorine is greater than fluorine (small atomic size).
- The first element of a group has similar properties with the second element of the next group. This is called diagonal relationship. The diagonal relationship disappears after IV group.

s-BLOCK ELEMENTS

- Atomic radii : Li < Na < K < Rb < Cs
- Electronegative : Li > Na > K > Rb > Cs
- Fist ionization potential : Li > Na > K > Rb > Cs
- Melting point Li > Na > K > Rb > Cs
- Colour of the flame Li – Red, Na – Golden, K – Violet, Rb – Red, Cs – blue, Ca – Brick red, Sr – Blood red, Ba – Apple green
- Rb and Cs show photoelectric effecr.
- Stability of hydrides: LiH > NaH > KH > RbH > CsH
- Base nature of hydroxides : LiOH < NaOH < KOH < RbOH < CsOH
- **Hydration energy :** Li > Na > K > Rb > Cs
- **Reducing character :** Li > Cs > Rb > K > Na

BORON FAMILY

- Stability of +3 oxidation state : B > Al > Ga > In > Tl
- Stability of +1 oxidation state : Ga < In < Tl
- Relative strength of Lewis acid : $BB_3 < BCL_3 < BBr_3 < BI_3$
- **Ionisation energy : B > Al < Ga > In < Tl**
- **Electronegative :** Electronegative first decreases from B to Al and then increase marginally.

CARBON FAMILY

- Reactivity : C < Si < Ge < Sn < Pb
- Metallic character : C < Si < Ge < Sn < Pb
- Acidic character of the oxides :
  $CO_2 > SiO_2 > GeO_2 > SnO_2 > PbO_2$
  Weaker acidic (amphoteric)
- Reducing nature of hydrides
  $CH_4 < SiH_4 < GeH_4 < SnH_4 < PbH_4$
- Thermal stability of tetrahalides
  $CCl_4 > SiCl_4 > GeCl_4 > SnCl_4 > PbCl_4$
- Oxidising character of M^{+4} species
  $GeCl_4 < SnCl_4 < PbCl_4$
- Ease of hydrolysis of tetrahalids
  $SiCl_4 < GeCl_4 < SnCl_4 < PbCl_4$

NITROGEN FAMILY

- Acidic strength of trioxides : $N_2O_3 > P_2O_3 > As_2O_3$
- Acidic strength of pentroxides : $N_2O_5 > P_2O_5 > As_2O_5 > Sb_2O_5 > Bi_2O_5$
- Acidic strength of oxides of nitrogen :
  $N_2O < NO < N_2O_3 < N_2O_4 < N_2O_5$
- Basic nature, bond angle, thermal stability and dipole moment of hydrides
  $NH_3 > PH_3 > AsH_3 > SbH_3 > BiH_3$
- Stability of trihalides of nitrogen : $NF_3 > NCl_3 > NBr_3$
- Lewis base strength : $NF_3 < NCl_3 > NBr_3 < NI_3$
- Ease of hydrolysis of trichlodides
  $Ncl_3 > PCl_3 > AsCl_3 > SbCl_3 > BiCl_3$
- Lewis acid strength of trihalides of P, As and Sb
  $PCl_3 > AsCl_3 > SbCl_3$
- Lewis acid strength of among phosphorus trihalides
  $PF_3 > PCl_3 > PBr_3 > PI_3$
- Nitrogen displays a great tendency to form $p\pi - p\pi$ multiple bonds with itself as well as with carbon and oxygen.
- The basic strength of the hydrides
  $NH_3 > PH_3 > AsH_3 > SbH_3$
- The thermal stability of the hydrides decrease as the atomic size increase.

OXIGEN FAMILY

- Melting and boiling point of hydrides
  $H_2O > H_2Te > H_2Se > H_2S$
- Volatility of hydrides
  $H_2O < H_2Te < H_2Se < H_2S$
- Reducing nature of hydrides
  $H_2S < H_2Se < H_2Te <$
- Covalent character of hydrides
  $H_2O < H_2S < H_2Se < H_2Te$
- The acidic character of oxides (element in the same oxidation state)
  $SO_2 > SeO_2 > TeO_2 > PoO_2$; $SO_3 > SeO_3 > TeO_3$
- Acidic character of oxide of a particular element (e.g. S)
  $SO < SO_2 < SO_3$; $SO_2 > TeO_2 > SeO_2 > PoO_2$

HALOGEN FAMILY

- Bond energy of halogens : $Cl_2 > Br_2 > F_2 > I_2$
- Solubility of halogen in water : $F_2 > Cl_2 > Br_2 > I_2$
- Oxidising power : $F_2 > Cl_2 > Br_2 > I_2$
- Enthalpy of hydration X^- ion : $F^- > Cl^- > Br^- > I^-$
- Reactivity of halogens : F > Cl > Br > I
- Ionic character M – X bond in halides
  M – F > M – Cl > M – Br > M – I
- Reducing character of X^- ion : $I^- > Br^- > Cl^- > F^-$
- Acidic strength of halogen acids : HI > HBr > HCL > HF
- Conjugate base strength of halogen halides
  $I^- < Br^- < Cl^- < F^-$
- Reducing property of hydrogen halides
  HF < HCL < HBr < HI
- Oxidising power of oxides of chlorine
  $Cl_2O > ClO_2 > Cl_2O_6 > Cl_2O_7$
- Acidic character of oxyacids of cholrine
  $HClO < HClO_2 < HClO_3 < HClO_4$
- Oxidising power of oxyacids of chlorine
  $HClO > HClO_2 > HClO_3 > HClO_4$
- The element with exceptional configuration are
  $Cr^{24}[Ar]\ 3d^5 4s^1$, $Cu^{29}[Ar]\ 3d^{10}4s^1$, $Mo^{42}[Kr]\ 4d^5\ 5s^1$,
  $Pd^{46}[Kr]\ 4d^{10}5s^0$, $Ag^{47}[Kr]\ 4d^{10}5s^1$, $Pt^{78}[Xe]\ 4f^{14}5d^{10}6s^0$

TRANSITION ELEMENTS (d-and f-BLOCK ELEMENTS)

- Ferromagnetic substance are those in which there are large number of electrons with unpaired spin and whose magnetic moments are aligned in the same direction.
- **Inner Transition Elements**
  (i) Electronic Configuration – The general electronic configuration of these elements is
  $[Xe]4f^{0\text{-}14}\ 5d^{0\text{-}1}\ 6s^2$
  (ii) Magnetic properties – Magnetic properties have *spin and orbit* contributions (Contrast "spin only" of transition metals). Hence magnetic momentums are given by the formula

$$\mu = \sqrt{4S(s+1) + L(L+1)}$$

  where L = Orbital quantum number,
  S = Spin quantum number

COORDINATION COMPOUNDS

- Coordination number is the number of the nearest atoms or groups in the coordination sphere.
- Ligand is a Lewis base donor of electrons that bonds to a central metal atom in a coordination compound.
- Paramagnetic substance is one that attracted to the magnetic field, this result on account of unpaired electrons present in the atom/molecule/ion.
- Effective atomic number
  EAN = (Z–Oxidation number)+(2×Coordination number)
- Factors affecting stability of complex
  (i) Greater the charge on the central metal ion, greater is the stability.
  (ii) Greater the ability of the ligand to donate electron pair (basic strength) greater is the stability.
  (iii) Formation of chelate rings increase the stability.
- Isomerism in coordination compounds :

(i) Structural Isomers *(ii) Ionization Isomers*
(iii) Hydration Isomers *(iv) Linkage Isomers*
(v) Coordination Isomerism *(vi) Ligand isomerism*
(vii) Polymerisation Isomerism *(viii) Valence Isomerism*
(ix) Coordination position isomerism
(x) Stereo isomerism
(a) Geometrical
(I) Square planar complexes of the type MA_2X ; $MABX_2$; MABXY
(II) Octahedral of the type : MA_4XY, MA_4X_2 MA_3X_3 $MA_2X_2Y_2$. $M(AA)_2X_2$ and M(ABCDEF).
(b) Optical isomerism

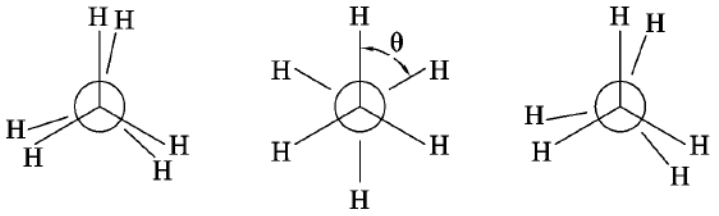
GOC

- The order of decreasing electonegative of hybrid orbitals is $sp > sp^2 > sp^3$
- Conformational isomers are those isomers which arise due to rotation around a single bond.
- A meso compound is optically inactive, even though it has asymmetric centres (due to internal compensation of rotation of plan polarised light)
- An equimolar mixture of enantiomers is called racemic mixture, which is optically inactive.
- Reaction intermediates and reagents :
  Homolytic fission → Free radicals
  Hetetolytic fission → ions (Carbonium, ion carbonium, etc.)
- Nucleophiles – electron rich
  Two types : 1. Anions 2. Neutral molecules with one pair of electrons (Lewis bases)
  Electrophiles : electron deficient.
  Two types : 1. Cations 2. Neutral molecules with vacant orbitals (Lewis acids).
- Inductive effect is due to σ electron displacement along a chain and is permanent effect.
- +I (inductive effect) increase basicity, −I effect increases acidity of compounds.
- Resonance is a phenomenon in which two or more structures can be written for the same compound but non of them actually exists.

ORGANIC CHEMISTRY

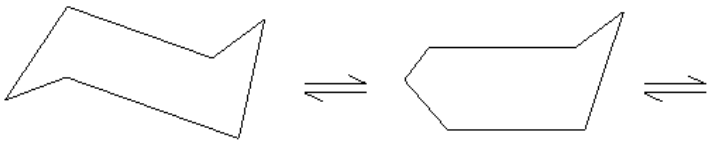
ALKANES

- Pyrolytic cracking is a process in which alkane decomposes to a mixture of smaller hydrocarbons, when it is heated strongly, in the absence of oxygen.
- Ethane can exist in an infinite number of conformation. They are

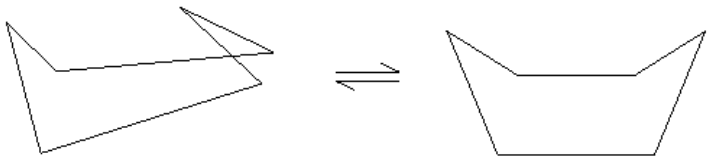


Eclipsed $\theta = 60^o$ Staggered $\theta < 60^o > 0$ Skew

- **Conformations of Cyclohexane :** It exist in two nonplanar, strainless form, the boat and the chain form



Chair from Most Stable Half Chair



Twist Boat Boat form (Least Stable)

ALKYNES

- In dehydration and dehydrohalogenation the preferential order for removal of hydrogen is $3^o > 2^o > 1^o$ (Saytzeff's rule).
- The lower the Δh_h (heat of hydrogenation) the more stable the alkene is.
- Alkenes undergo anti-Markonikov addition only with HBr in the presence of peroxides.
- Alkynes add water molecule in presence of mercuric sulphate and dil. H_2SO_4 and form carbonyl compounds.
- Terminal alkynes have acidic H-atoms, so they form metal alkynides with Na, ammonical cuprous chloride solution and ammoniacal silver nitrate solution.
- Alkynes are acidic because of H-atoms which are attached to sp 'C' atom which (a) has more electronegativity (b) has more 's' character than sp^2 and sp^3 'C' atoms.

ARENES

- All o and p-directing groups are ring activating groups (except – X)
  They are : – OH, – NH_2, –X, –R, –OR, etc.
- All m-directing groups are ring deactivating groups.
  They are : – CHO, – COOH, – NO_2, – CN, $\overset{+}{N}R_3$, etc.

HALOGEN COMPOUNDS

- The order of reactive is
  (a) RI > RBr > RCl > RF
  (b) Allyl halide > Alkyl halide > Vinyl halide
  (c) Alkyl halide > Aryl halide
- S_N1 reaction : Mainly 3^o alkyl halides underg this reaction and form racemic mixture. S_N1 is favoured by polar solvent and low concentration of nucleophile.
- S_N2 reaction : Mainly 1^o alkyl halides undergo this substitution. Walden inversion takes place. S_N^2 reaction is preferred by non-polar solvents and high concentration of nucleophile.
- **Reaction with metals:**
  (i) $\underset{\text{Alkyl halides}}{R-X} + Mg \xrightarrow{\text{Dry ether}} \underset{\text{Grignard reagent}}{R-Mg-X}$
  (ii) **Wurtz reaction:**

$$R-\boxed{X + 2\,Na + X}-R \xrightarrow{\text{Dry ether}} \underset{\text{Alkane}}{R-R} + 2\,Na^+X^-$$

ALCOHOLS

- Alkenes are converted to alcohol in different ways as follows
  Reagent Types of addition
  dil H_2SO_4
  - Markovnikov
  B_2H_6 and H_2O_2, OH^- - Anti-Markovnikov
  Oxymercuration demercuration – Markovnikov
- Oxidation of
  1^o alcohol ⟶ aldehyde (with same no. of C atom) ⟶ carboxylic acid (with same no. of C atom)
  2^o alcohol ⟶ ketone (with same no. of C atom) ⟶ carboxylic acid (with less no. of C atom)
  3^o alcohol ⟶ ketone (with less no. of C atom) ⟶ carboxylic acid (with less no. of C atom)

PHENOLS

- Phenol $\xrightarrow{CHCl_3 / OH^{\Theta}}$ Phenolic aldehyde (Reimer – Tieman reaction)
- s
- Phenol $\xrightarrow[\Delta]{CO_2}$ Phenolic carboxylic acid (Kolbe reaction)
- Acidity of phenols
  (a) Increase by electron withdrawing substituents like
  $-NO_2$, – CN, – CHO, – COOH, – X, $-\overset{+}{N}R_3$
  (b) decrease by electron releasing substituents like
  – R, – OH, – NH_2, – NR_2, – OR

ETHERS

- $2ROH \xrightarrow[250^\circ C]{Al_2O_3} R-O-R + H_2O$
- $RONa + X-R' \longrightarrow ROR' + NaX$ (Williamson's synthesis)
- $ROR + H_2O \xrightarrow[\Delta]{Dil.H_2SO_4} 2ROH$

CARBONYL COMPUNDS

- Formation of alcohols using RmgX

  (a) Formaldehyde + $RMgX \xrightarrow{Hydrolysis}$ 1° alcohol

  (b) Aldehyde + $RMgX \xrightarrow{Hydrolysis}$ 2° alcohol (other than HCHO)

  (c) Ketone + $RMgX \xrightarrow{Hydrolysis}$ 3° alcohol
- Cannizzaro reaction (Disproportionation)

  Aldehyde $\xrightarrow[alkali]{Hot\ conc.}$ Alcohol + Salt of acid

  (no α H-atom)
- Aldol condensation :
  Carbonyl compound + dil. alkali → β-hydroxy carbonyl compound (with α H-atom)
- Benzoin condensation

  Benzaldehyde $\xrightarrow[NaCN]{ethanolic}$ Benzoin
- The relative reactivities of different acid derivatives towards nucleophilic acyl substitution reactions follow the order:

$$\underset{\text{Acid chloride}}{R-\overset{O}{\overset{\|}{C}}-Cl} > \underset{\text{Anhydride}}{R-\overset{O}{\overset{\|}{C}}-O-\overset{O}{\overset{\|}{C}}-R'} > \underset{\text{Ester}}{R-\overset{O}{\overset{\|}{C}}-OR'} > \underset{\text{Amide}}{R-\overset{O}{\overset{\|}{C}}-NH_2}$$

CARBOXYLIC ACIDS, NITROGEN COMPOUNDS

- The rate of esterfication decreases when alcohol, acid or both have branched substituents.
- Ortho effect : All ortho substituted benzoic acids (irrespectiv of type of substituent) are stronger than benzoic acid.
- Order of basicity : (R = - CH_3 or -C_2H_5)
  $2^\circ > 1^\circ > 3^\circ > NH_3$
- Hofmann degradation

  Amides $\xrightarrow{Br_2 / KOH}$ 1° amine
- The basicity of amines is
  (a) decreased by electron withdrawing groups
  (b) incteased by electron releasing groups
- Reduction of nitrobenzene in different media gives different products

Medium	Product
Acidic	Aniline
Basic	Azoxy Azo & finally hydrazobenzene
Neutral	Phenyl hydroxylamine

CARNOHYDRATES, AMINO ACIDS AND POLYMERS

- Carbohydrates are polyhydroxy aldehydes or ketones.
- Monosaccharides are simple sugars containing three to nine carbon atoms.
- Characteristic reactions :
  Homologous series
  Type of reactions

(a) Alkanes Substitution	(Mostly free radical
(b) Alkenes and alkynes	Electrophollic addition
(c) Arenes	Electrophollic substitution
(d) Alkyl halides	Nucleophillic substitution
(e) Aldehyde an ketones	Nucleophillic addition

- Test to differentiate :

1° , 2° and 3° alcohols	(1) Lucas test (2) Victormeyer's test
1° , 2° and 3° amines	Hinsberg test
1° , 2° and 3° nitro compounds	Test with HNO_2 and KOH
Aryl halides and alkyl halides	Test with $AgNO_3$ solution
Aldehydes and ketones	Tollen's test / Fehling's test
Aromatic aldehydes and Aliphatic aldehydes	Fehling's test

IMPORTANT REAGENT

- Dil H_2SO_4 [or Conc. $H_2SO_4 + H_2O$]
  Use → Hydrating agent (+HOH)
- Alc. KOH or $NaNH_2$ (Use → – HX)
  $CH_3CH_2Cl \xrightarrow{alc.\ KOH} CH_2 = CH_2$
- Lucas reagent $ZnCl_2$ + Conc. HCl
  Use → for distinction between 1° , 2° and 3° alc
- Tilden Reagent NOCI (Nitrosy chloride)
  $C_2H_5NH_2 \xrightarrow{NOCl} C_2H_5Cl$
- Alkaline $KmnO_4$ (Strong oxidant)
  Toluene → Benzoic acid
- Bayer's Regent : 1% alkaline $KmnO_4$ (Weak oxidant)
  Use: → For test of > C = C < or – C = C –
  $CH_2 = CH_2 + H_2O + [O] \xrightarrow{BR} CH_2OH - CH_2OH$
- Acidic $K_2Cr_2O_7$ (Strong oxidant) : $RCH_2OH \xrightarrow{[O]} RCHO$
- $SnCl_2$/HCl or Sn/HCL use →for red^n of nitrobenzene in acidic medium.

  $C_6H_5NO_2 \xrightarrow[6H]{SnCl_2/HCl} C_6H_5NH_2$
- s
- Lindlar's Catalyst = $Pd/CaCO_3$
  + in small quantity $(CH_3COO)_2Pb$

  2 – butye + $H_2 \xrightarrow{"}$ Cis-2-butene (main product)
- Ziegler – Natta Catalyst $(C_2H_5)_3Al + TiCl_4$
  Use → In addition polymerisation

IDENTIFICATION TESTS :

(a) Unsaturated compound (Bayer's reagent)
Decolourising the reagent
(b) Alcohols (Ceric ammonium nitrate solution)
Red colouration
(c) Phenols (Neutral $FeCl_3$ solution)
Violet/deep blue colouration
(d) Aldehydes and ketones (2, 4-D.N.P.)
Orange precipitate
(e) Acids ($NaHCO_3$ solution)
Brisk effervescence (CO_2 is evolved)
(f) 1^o amine ($CHCl_3$ + KOH)
Foul smell (isocyanide)
(g) 2^o amine ($NaNO_2$ + HCl)
Yellow oily liquid (Nitrosoamine)

Biology

THE LIVING WORLD & TAXONOMY

- Nomenclature – It is the process of giving scientific names (not vernacular or local names) to the organisms.
- Systematics – This includes the identification, nomenclature and classification of organisms based on various parameters.
- In **bionomial nomenclature** each scientific name has 2-components,
  i. Generic name (Genus)
  ii. Specific name/epithet (Species)
- Various levels of classification are – Kingdom → Phylum (animals)/ Division (plants) → Class → Order → Family → Genus → Species.
  - Species is the basic unit of classification.
- **Artificial system of Classification –** All taxonomists, from Aristotle to Linneaus, classified organisms on the basis of external observable (morphological) characters like floral structure (number of stamens), root modification, leaf venation etc. In this system to weightage was given to natural and phylogenetic relationship.
- **Natural System of Classification –** It uses more number of characters and is based upon natural affinities using homology and comparative study. Bentham – hooker used this system of classification for angiosperms.
- **Phylogenetic Classification (Cladistics) –** This system of classification is based upon evolutionary relationship and uses morphological characters, origin and evolution of the different organisms.

BIOLOGICAL CLASSIFICATION

- Characteristics of five Kingdom system was proposed by R.H. Whittaker (1969). Accordingly a separate Kingdom has been created for Fungi. Thus, these are – Monera, Protista, Fungi, Plantae and Animalia.
- Bactria are prokaryotes. They lack nucleus and other cell organelles of complex cells and prokaryotes ribosome (70 S). Like plants, they possess cell wall.
- The cyanobacteria are the largest and most diverse group of photosynthetic bacteria, *e.g.*, *Nostoc.* Heterocyst is specialised to perform nitrogen fixation.
- Mycoplasma are the smallest known aerobic prokaryotes without cell wall.
- Haeckel (1886) created the kingdom protista to include all unicellular eukaryotic microorganisms. E.g., Euglenoids are photosynthetic in the presence of sunlight, when deprived of sunlight they behave heterotrophs by predating on other smaller organisms.
- Fungi are achlorophyllous, heterotrophic, gametophytic, haploid, multicellular, eukaryotic nucleated, spore producing thallophytes which are surrounded by cell wall of chitin (fungus cellulose). Study of fungi is called Mycology.
- Viruses are obligated parasites, i.e., can live inside living host only. They have either RNA or DNA. Bacterial viruses or bacteriophages (viruses that infect the bacteria) are usually double stranded DNA viruses.
- Viroids contain only very low molecular weight RNA and protein coat cause persistent infections, i.e., never recovered.
- In lichens, there are 2 components; i.e., algal partner called phycobiont and fungal partner called mycobiont.

PLANT AND ANIMAL KINGDOMS

- Bryophytes are terrestrial plants but they require water for dehiscence of antheridia, liberation and swimming of antherozoids, fertilization of egg, opening of archegonial neck and entry of sperms into the archegonium. Because of such peculiar habitat they have been most appropriately called the **amphibians of the plant kingdom.**
- Evolutionarily, Pteridophytes are the first terrestrial plants to possess vascular tissues – xylem and phloem. So known as vascular cryptogams. They are flowerless and seedless plants.
- Gymnosperms are plants which bear naked seeds i.e., the ovules and the seeds that develop from these ovules after fertilization are not enclosed in fruit wall. In most gymnosperms, secondary growth occurs and annual rings are distinct. The xylem is without vessels (except in *Gnetales*) and phloem companion cells.
- In angiosperms, the male sex organs in a flower is the stamen. Each stamen consists of a slender filament with an anther at the tip. The produce pollen grains.
- The female sex organs in a flower is the pistil or the carpel. Pistil consist of an ovary enclosing one to many ovules. Within ovules are present highly reduced female gametophytes termed embryosacs. The embryo-sac formation is preceded by meiosis. Hence, each of the cells of an embryo-sac is haploid. Each embryo-sac has a three-celled egg apparatus – one egg cell and two synergids, three antipodal cells and two polar nuclei. The polar nuclei eventually fuse to produce a diploid secondary nucleus.
- Pollen grain shed at 2-3 celled stage after dispersal from the anthers, are carried by wind or various other agencies to the stigma of a pistil. This is termed as **pollination.**
- The pollen tubes enter the embryo-sac where two male gametes are discharged. One of the male gametes fuses with the egg cell to form a zygote (syngamy). The other male gamete fuses with the diploid secondary nucleus (PEN) known as triple fusion. Because of the involvement of two fusions, this event unique to angiosperms.
- The zygote develops into an embryo (with one or two cotyledons) and the PEN develops into endosperm which provides nourishment to the developing embryo.

- A fruit is a ripened ovary.
- Life cycle in different plant groups differ in following manner:
  Haplontic life cycle: There is no true alternation of generation as sporophytic generation is represented only by one celled zygote. There is no free living sporophyte.
  Diplontic life cycle : The sporophyte is independent photosynthetic phase of the plant. Gametophytic is represented haploid gametes only.
  Haplo-diplontic life cycle : This is intermediate condition where both phases are multicellular and often free living.
- **Animalia –** They are eukaryotic, multicellular and heterotrophic organisms that do not have cell wall. On the basis of extent and type of body design, they are classified as –
  (i) Porifera – E.g., Spongilla, Sycon.
  (ii) Coelenterata – E.g., Jelly fish, Sea anemone
  (iii) Platyhelminthes – E.g., Planaria.
  (iv) Annelida – E.g. Earthworms.
  (v) Arthropoda – E.g. Prawns.
  (vi) Mollusca – E.g. Snails.
  (vii) Echinodermata – E.g. Starfish.
- **Vertebrates are divided into 5 classes :**
  (i) Pisces – Include fishes which are aquatic, E.g. Shark, Rohu.
  (ii) Amphiba – Animals are found both in water and on land, E.g. Toads, Frogs, Salamander.
  (iii) Reptilia – They are cold blooded animals with scales and breathe through lungs. E.g. Snakes, Turtles, Crocodiles etc.
  (iv) Aves – They have feathers and forelimbs are modified for flight. E.g. Pigeon, Sparrow, Ostrich.
  (v) Mammalia – They are warm blooded animals with 4 – chambered heart. They have mammary glands for milk production.

MORPHOLOGY OF FLOWERING PLANTS

- A typical root can be differentiated into five distinct region, region of elongation, region of root hair and mature region.
- Roots are divided into two types :
  (i) Tap root : It form lateral branches or secondary roots which are further branched to form tertiary roots.
  (ii) Adventitious root : These roots develop from any part of the plant instead of radicle.
- Shoot system is an aerial system, usually above the soil and originates from the plumule. It consists of stem, branches, leaves, flowers, fruits and seeds.
- The various types of underground modifications of stem are :
  Rhizome : *Zingber* (ginger).
  Corm : Saffron (*Crocus*)
  Tuber : *Solanum tuberosum* (potato).
  Bulb : (onion)
- An inflorescence is the mode of arrangement of flower on peduncle or mother axis .
  The main axis of *racemose* inflorescence has indefinite growth because there is no terminal flower. In cymose, the growth of the main axis is definite because the growing point of peduncle is used up in the formation of a flower.
- **Symbol For Floral Formula**

Br	Bracteate
	Acrinomorphic
% or †	Zygomorphic
♂	Staminate (male)
♀	Pistillate (female)
	Calyx (K)
	Corolla (C)
	Perianth (P)
	Androecium (A)
	Gynoecium (G)
G(2)	Bicarpellary, syncarpous, infeior
G(2)	Bicarpellary, syncarpous, superior

PLANT TISSUES

- A group of structurally similar or dissimilar cells that perform a common function and have a common origin is called a tissue.
- Cells which are capable of active cell division are called meristematic cells.
- On the basis of position, the meristematic tissues can be divided into the following three types :
  - Apical meristem
  - Intercalary meristem
  - Lateral meristem
- Intercalary meristem is present at the base of internodes, e.g, in grasses (Gramineae) or at the base of leaves, e.g, in *Pinus* or at the base of nodes, e.g., mint or Mentha (Labiatae).

Simple Permanent Tissue

1. Parenchyma : It helps storage of food, conduction of substances, provides turgidity to softer parts of plants.
2. Collenchyma : It is living mechanical tissue, found beneath the epidermis (i.e., hypodermis) of herbaceous dicot stem.
3. Sclerenchyma : These are dead, mechanical tissue and act as skeleton in plants.

Complex Permanent Tissues

1. Xylem is mainly responsible for conduction of water and minerals from the roots to the top of plants (unidirectional). It also provides mechanical support to the plant. Xylem is made of 4 types of cells i.e., tracheae (vessels), xylem fibres and xylem parenchyma.
2. Phloem mainly carries food. It is a complex tissue made up of 4 kinds of cells in angiosperms, these are sieve elements, companion cells phloem fibres, phloem parenchyma.

ANIMAL TISSUES

- **Epithelial tissue –** it forms protective covering in the animal body, covers organs and separates different body systems. Different typed of epithelial tissues on the basis of functions are -
  i. Simple squamous epithelium – Oesophagus, lining of mouth are made of it.
  ii. Stratified squamous epithelium – In the skin epithelial cells are arranged in many layers to prevent wear and tear.
  iii. Columnar epithelium – It is present in the inner lining of intestine, pillar like tall cells.
  iv. Cuboidal epithelium – It forms lining of kidney tubles and ducts of salivary glands.
  v. Glandular epithelium – In glands.
- **Connective Tissue –** The cells are loosely packed and embedded in intercellular matrix.
  i. Areolar tissue – It fills space inside organs, helps in repair of tissues.
  ii. Adipose tissue – It is fat storing, found below the skin and between internal organs.
  iii. Bone – Bone cells lie embedded in hard matrix composed of calcium and phosphorous.
  iv. Ligament – connects two bones.
  v. Tendons – connect muscles to bones.
  vi. Cartilage – It is present in nose, ear, trachea, larynx.
  vii. Blood – It is a fluid connective tissue. Fluid matrix is called plasma that contains red blood cells (RBCs), white blood cells (WBCs) and platelets unit.
- **Muscular tissue –** It consists of elongated cells called muscle fibres. They are responsible for movement in our body. The three types of muscles are -
  i. Striated muscles – E.g. muscles of hands an legs.
  ii. Smooth muscles – E.g. muscles found in iris of eye, ureters, bronchi of lungs, alimentary canal.
  iii. Cardiac muscles – E.g. the muscles of heart.
- **Nervous tissue –** They are found in brain, spinal cord and nerves. They transmit the stimulus. A neuron consists of a cell body with a nucleus and cytoplasm. It has a long part called axon and many short, branched parts called dendrites. Many nerve fibres together form a nerve.

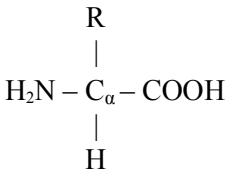
CELL : THE UNIT OF LIFE

- Cell theory was proposed by Schleiden and Schwann.
- All living organisms (animals, plants and microbes) are made up of cells and cell products i.e., cell is the structural unit of life.
- S.J. Singer and G. Nicolson in 1972 proposed the most accepted model of membrane structure only after the advent of electron microscope in 1950. According to this model the lipid bilayer is a semifluid in which the proteins are dispersed to give mosaic appearance to the whole membrane.
- Plasmodesmata are characteristics of multicellular plants that enables the solutes to move considerable distances through the pits without crossing differentially permeable membranes.
- Endoplasmic reticulum is also called as 'endoskeleton of the cell' or 'endomembranous system of the cell. The endoplasmic reticulum is bounded by a single unit membrane. Smooth or agranular ER : They do not have attached ribosomes on their surface. The SER is well developed in those cells which are actively concerned with the synthesis and secretion of steroid of hormone.
  Rough or granular ER: They bear ribosomes on their surface. The cells which are active in protein synthesis have RER in abundance.
- Golgi apparatus or Golgi complex is a stack of flattened, membrane bound, parallely arranged organelles that occur in the accociation of endoplasmic reticulum in the cytoplasmic matrix. It principally performs the function of packaging materials to be delivered either to the intra-cellular targets or secreted outside the cell.
- Lysosomes are originated by Golgi complex and contain many hydrolytic enzymes (amylases, lipases, proteases, carbohydraes) optically active at the acidic pH. They are popularly called “suicide bags”.
- The vacuole is bound by a single membrane called tonoplast. It contains many dissolved solutes such as organic acids, soluble carbohydrates, soluble nitrogenous compounds as nitrates, enzymes, tannins, chlorides, phosphates, amino acids, alkaloids and anthocyanin pigments.
- Cilia and flagella are contractile filamentous or hair-like outgrowths of the cytoplasm, which help in cell movement, excretion, secretion and transportation.
- Centrosome is an organelle usually containing two cylindrical structures called centrioles. Centrioles duplicate before cell division so that dividing cell has a pair of centrioles at each pole.
- Proxisomes are the smallest membrane bound cell organelles. These organelles were named proxisomes because these ate the sites of formation of hydrogen peroxide (H_2O_2).
- A typical nucleus consists of four structures : nuclear membrane, nucleoplasm, chromatin and nucleolus.
- Nucleolus is site of active ribosomal RNA synthesis.
- In interphasic nucleus, the genetic material (DNA) is seen as the thread like structure called chromatin or chromtin fibres. During cell divisions (mitosis and meiosis) chromatin fibre become condensed to form thick structures called chromosomes.
- Based on the position of the centromere, the chromosomes can be classified into four types :
  - metacentric (middle centromere)
  - sub-metacentric centromere (near to one end of the chromosomes)
  - acrocentric (centromere) situated close to its end
  - telocentric (terminal centromere)
- Plastids are found in plants and few protists (*Euglena*). They may be colourless (leucoplastids) or coloured (chromoplastids and chloroplasts). Each chloroplasts has two parts i.e., grana and stroma.

- Stroma : It is the enzymatic part of chloroplasts. Stroma contains proteins, DNA, ribosomes and fewer amount of enzymes. Dark reaction of photosynthesis occurs in this fraction.
- Grana : In chloroplasts several membranes are arranged in the form of stacks of coins. These thylakoids are stacked one above the other to form grana. Due to presence of chlorophyll in granum lamella, the light reaction of photosynthesis takes place in granum.
- Mitochondria are referred as "powerhouse" of the cell as they produce 95% of ATP. This energy is produced during the break down of food molecules which involve glycolysis, oxidative decarboxylation and oxidative phosphorylation (krebs cycle and respiratory chain).

BIOMOLECULES

- Lactose – It is milk sugar.
- Sucrose – It is non-reducing sugar as it does not have free aldehyde or ketose groups.
- Glycogen – It is present in animals (also called animal starch). It is a branched chain compd. and has about 30 α-glucose units.
- Starch – It is present in plants. The natural starch contains a mixture of amylose (10-20%) and amylopectin (80-90%).
- Celulose – It is a fibrous polysaccharide and forms cell wall in plants.
- Proteins contain C, H, O, N. Some contain S (Sulphur) and P (Phosphorus) also. The structural unit of protein is Amino acid. In **Primary structure** only Peptide bonds are present between amino acids. The first (or left) amino acid is called N-terminal ($-NH_2$) amino acid, and the last (or right) amino acid is called C-terminal (–COOH gp.) amino acid. In **Secondary structure,** besides peptide bonds, Hydrogen bonds are also present in polypeptide chain. Such proteins may have helical or pleated structures. The **Tertiary structure** may result from further folding and coiling, and may be stabilized by S-S (disulphide) bond, Hydrophobic bonds and Ionic bonds. In **Quaternary structure,** more than one polypeptide chains are involved to form a large multiunit protein. e.g. Haemoglobin.
- All amino acids contain atleast 1-Amino group and 1-carboxylic group.



- The nucleic acid on hydrolysis yields 1 – Pentose Sugar, 2 – types of heterocyclic nitrogenous bases (Purines and Pyrimidines) and phosphoric acid.

Nucleic Acid	Purines	Pyrimidines
DNA	Adenine and Guanine	Cytosine and Thymine
RNA	Adenine and Guanine	Cytosine and Uracil

- ATP (Adenosine Triphosphate) is also a nucleotide. It contains 1-Adenine base, 1-Ribose sugar and 3-phosphate bonds. It is energy-rich compound, and is also called as 'energy currency'.
- Edwin Chargaff reported that net amount of adenine was equal to thymine (A = T) and amount of Guanine was equal to cytosine (G ≡ C). This means that total number of purines is equal to the total number of pyrimidines (A + G = T + C).
- **Double Helical Structure of DNA :** To explain base equivalence (A / T , G / C) and other properties of DNA, Watson and Crick (1953), based on X-ray diffraction studies, proposed double helical structure of DNA. The two strands of helical are anti-parallel, means 5' → 3' Phosphodiaester bonds (Sugar-phosphate groups) are oriented in opposite direction in 2-strands, there are 2 hydrogen bonds (A = T) and in between C & G there are 3 hydrogen bonds (C ≡ G).
- **RIBONUCLEIC ACID (RNA) :** It has single helical structure and is mainly of 3-types.
  - m-RNA (Messenger RNA)
  - r-RNA (Ribosomal RNA)
  - t-RNA (Transfer RNA)

  The enzymes are tertiary proteins. The energy required for a chemical reaction to proceed is called Activation energy. Higher is the affinity of an enzyme for a substrate the lower is its Km value,

$$\text{i.e. Km value} \propto \frac{1}{\text{affinity}}$$

- The co-factor can be inorganic in nature. The organic factor, if permanently attached to the enzymes, is called Prosthetic group and if temporarily attached (only during reaction), is called Co-enzyme. Most of the co-enzymes are derivatives of vitamin B & C.

CELL CYCLE AND CELL DIVISION

- The interphase is the longest phase of the mitotic cycle, last more than 95% of the duration of cell cycle. It has three sub-phases: G_1 , S and G_2 which occurs in this order followed by M phase.
- **Mitosis :** It is also called as equational division as the number of chromosomes in the parent and progeny cells is the same. So mitosis increase in number of cells without any changes in genetic constitution. It is usually divided into several stages or phases, viz. prophase, metaphase, anaphase, telophase and cytokinesis.
- **Meiosis :** It ensures the production of haploid phase in the life cycle of sexually reproducing organisms whereas fertilisation restores the diploid phase. Thus, meiosis is required to run the reproductive cycle of eukaryotes.

TRANSPORT IN PLANTS

- Diffusion – It is the movement of a substance from a region of higher concentration to a region of lower concentration.
- Osmosis – It is the movement of water through a selectively permeable membrane from a region of high water concentration to a region of low water concentration.

- Osmosis – It is the movement of water through a selectively permeable membrane from a region of high water concentration to a region of low water concentration.
- The difference between free energy of water in a system & free energy of pure water at atmospheric pressure is also called water potential.
- The shrinkage of the protoplast of a living cell from its cell wall due to exosmosis under the influence of a hypertonic solution is called plasmolysis.
- The process of absorption of water by hydrophilic surfaces of a substance without forming a solution is called imbibition. Examples of imbibition are adsorption of water by seeds, dry wood, starch cellulose, agar, gelatin, gum etc.

MINERAL NUTRITION

- Technique of growing plants in a nutrient solution is known as hydroponics or soilless growth. By this method, essential elements were identified and their deficiency symptoms discovered.
- Essential mineral elements are those elements which are required by plants for normal growth and development and without which plants cannot complete their life cycle. e.g. C, H, O, N, P, K, S, Mg, Ca, Fe, B, Mn, Cu, Zn, Mo, Cl. Elements which are present in a plant body and are not so required by plants are called non-essential elements. e.g. Na, Si, Al, Se, Sr, V.
- Plant can not absorb nitrogen in molecular form. It is absorbed by plants in nitrate NO_3^- and ammonium NH_4^+ form.
- Conversion of gaseous nitrogen into nitrogenous compound by living organism like bacteria, cyanobacteria is called biological nitrogen fixation.
- The most prominent among them is the legume-bacteria relationship. Species of rod-shaped *Rhizobium* has such relationship with the roots of several legumes such as alfalfa, sweet clover, sweet pea, lentils, garden pea, broad bean, clover bean, etc. Nodules act as the site for N_2 fixation. It contains leghaemoglobin (a pink pigment) and enzyme nitrogenase (Mo-Fe protein).

LIFE PROCESSES

- Nutrition is a process by which an organism obtains its food.
  i. Autotrophic Nutrition : Synthesising food from the raw materials like carbon dioxide, water and a few minerals. E.g. green plants, Euglena.
  ii. Heterotrophic Nutrition : Derives its nutrition from other organisms, E.g. all animals, most bacteria and fungi.
  iii. Parasitic Nutrition : Live on or inside the body of the host and obtain their food. E.g. Tapeworm, Cuscuta (amarbel).
  iv. Saprophytic Nutrition : Animals depend on dead decaying organic matters. E.g., fungi, bacteria.
  v. Holozoic Nutrition : The complex organic food material is taken into its body by the process of ingestion, e.g., man, cat, dog, fish, *Amoeba,* etc.

- Photosynthesis is the process by which autotrophic chlorophyll containing organisms manufacture their own energy sources (simple sugars) from intracellular chemical reaction of carbon dioxide and water in presence of sunlight and chlorophyll.

$$6CO_2 + 12H_2O \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} C_6H_{12}O_6 + 6H_2O + 6O_2$$

- *Respiration* is a complex process which includes breathing i.e. exchange of O_2 and CO_2 and oxidation of food to release energy.
  (a) Aerobic Respiration

$$\text{Glucose} \xrightarrow[\text{(in cytoplasm)}]{\text{Glycolysis}} \text{Pyruvic acid}$$

$$\xrightarrow[\text{Oxygen (Krebs cycle)}]{\text{(in mitochondria)}} 6CO_2 + H_2O + 38ATP$$

  (b) Anaerobic Respiration

$$\xrightarrow[\text{(in cytoplasm)}]{\text{Glycolysis}} \text{Pyruvic acid}$$

$$\xrightarrow[\text{Yeast fermentation}]{\text{In absence of } O_2} \underset{\text{Ethanol}}{2C_2H_5OH} + 2CO_2 + 2ATP$$

- In human beings respiratory pigment is haemoglobin which remains present in RBC. CO_2 is more soluble in water than oxygen is and hence is mostly transported in the dissolved form in blood. Due to difference in concentration of gases, exchange takes place between tissues and blood capillaries.
- **Transportation** is a process in which substances are absorbed in one part and move to the other parts of the body.
- Arteries are thick-walled and transport blood from heart to the various parts of the body. Veins are thin walled and carry blood from various organs to the heart. Heart is situated in the thoracic cavity between two lungs. Heart is made up of cardiac muscles which works continuously. Human hear has four chamber i.e. two auricles and two ventricles. Normal heart rate is 72/minute.
- The removal of unwanted waste materials from the body is called **excretion.** Excretory system of human being consists of a pair of kidneys, a pair of ureters, urinary bladder, urethra.
- Improper functioning of the kidneys may lead to accumulation of water in the body called Oedema, nephritis, kidney stones, gout.
- An artificial kidney is a device to remove nitrogenous waste products from the blood through dialysis.
- Oxygen is waste product of photosynthesis in plants. Many waste products are stored as resins and gums in plants.

Reproduction in Human Beings

1. The sex organ in males are testes and ova in females.
2. Male reproductive organ consist of a pair of testes, vas deferens, a pair of epididymis , a pair of ejaculatory duct, urethra, pairs of accessory gland. Leydig's cell secrete male sex hormone testosterone which is concerned with the production of male sexual characters.
3. Female reproductive part consist of a pair of ovaries, a pair of fallopian tube, uterus, vagina, external genitalia, mammary glands and accessory glands.
4. If sperms are present, fertilization of ovum takes place in the upper end of the fallopian tube.
5. Fertilization process occurs in fallopian tube. In this process zygote is formed. Umbilical cord is produced which is attached to foetus. During this process two hormones are produced which are estrogen and progesterone. Progesterone stops mensturation and prevents ovulation.

Human Brain:

1. Brain is inside the cavity called cranium. It is filled with cerebrospinal fluid. It is divided into three parts -
   (a) Fore brain (Cerebrum) is the main thinking part of the brain. All our thoughts, sensations, actions and movements are controlled by the cerebrum.
   (b) Midbrain consist of nerve cells, connects forebrain to the hind brain. It has reflex centres for eye movement and hearing response.
   (c) Hind brain (Cerebellum) is the second largest part of brain. The surface is of grey matter, deeper part is of white matter. Cerebellum maintains posture, regulates muscle tone.
2. Medulla oblongata controls involuntary movement, acts as reflex centre for vomiting, coughing, sneezing, swallowing etc.
3. Reflex action : It is rapid, automatic, definite response to stimulus by an organ without involving brain for its initiation. The pathway which is followed by this is called reflex arc. e.g. Knee-jerk reflex, sneezing, yawning, blinking of eye.

MOVEMENT IN PLANTS

- Tropisms (tropic Movements) :
  A growth movement of a plant part int response to an external stimulus in which the direction of stimulus determines the direction of response is called tropism.
  (a) Nastic (Nastic movements) : It is not a directional movement of a plant part with respect to the srimulus.
  (b) Thigmonasty : It is the non-directional movement of a plant part in response to the touch of an object. e.g, - *Mimosa pudica* (Chui-mui).
  (c) Photonasty : The non-directional movement of a plant part (usually petals of flowers) in response to light is called photonasty.

HARMONES

- **Growth hormones** are the natural growth substances which are produced in any part of the plant.
  i. Auxins : It stimulates growth, phototropism, geotropism 2, 4 – D is used to avoid pre-harvest fruit in oranges, apples, used as weedicide.
  ii. Gibberellins : These can increase the height of plant, can induce parthenocarpy, stimulate flowering.
  iii. Cytokinins : Promote cell division, inhibit or delay ageing, organ formation.
  iv. Ethylene : It's a gaseous plant hormone, used in artificial ripening of fruits, promote ageing in plants, breaks dormancy of several organs.
  v. Abscisic Acid (ABA) : Also known as stress hormone. It is a growth inhibitor, inhibit the process of flowering, seed development.
- **Hormones in Animals:**

i. Hypothalamus : The hypothalamic hormones are also called releasing hormones : TSH, ACTH, FSH, LH.
ii. Pituitary gland : It has two lobes anterior (adenohypophysis) and posterior (neurohypophysis).
   (a) Anterior lobe : Secrets TSH (Thyroid Stimulating hormone), ACTH (Adrenocorticotrophic hormone), GH (Growth hormone), FSH (Folliocle stimulating hormone), LH (Luteinizing hormone), Prolactin.
   (b) Intermediate lobe : production of melanin pigment.
   (c) Posterior lobe :
      A) Oxytocin : Released during child birth, during breast feeding.
      B) Vasopressin : It's an antidiuretic hormone which controls the secretion of urine by kidney.
iii. Pineal : It secretes biogenic amine hormone called melatonin. It inhibits ovarian growth and ovulation.
iv. Thyroid : Thyroxine promotes the growth of body tissues. Calcitonin lowers blood calcium level.
v. Parathyroid : It is exocrine as well as endocrine. The endocrine part is called islets of Langerhans. It consists of α and β cells. β cells secrete hormone insulin which regulates blood sugar level. Excess of glucose starts appearing in urine and the disease is called diabetes.

Mendel's laws of inheritance

The first study of inheritance was done by Gregor Mendel on garden pea (*Pisum sativum*). He used a number of contrasting characters like round / wrinkles seeds, tall/short plants, white/violet flowers and so on.

HEREDITY AND EVOLUTION

- Law of Dominance : Out of a pair of allelomorphic characters one is dominant (expressed) and the other is recessive/ unexpressed. The benefit of this law is that recessive (harmful) characters not expressed in hybrid and can exist for several generations.
- Law of Segregation : The factors for each character segregate during gametogenesis. As a result, each gamete receives only one factor for each character and hence is always pure.

- Law of Independent Assortment : The two factors of each trait assort at random and independent of the factors of other trait at the time of meiosis and get randomly as well as independently arranged in the offspring.

SEX DETERMINATION

All human chromosomes are not paired. 22 pairs are called autosomes. Women have a perfect pair of sex chromosomes XX. But men have a mismatched pair XY.

EVOLUTION

It is the sequence of gradual changes which take place in the primitive organisms over millions of years in which new species are produced.

The evidences of evolution are :

i. Homologous organs : The organs which have same fundamental structure but different functions.
ii. Analogous organs : The organs which have similar functions but are different in their structural detail and origin. e.g., wings of insect and wings of bird. The organ which are present in reduced form and do not perform any function in the body but correspond to the fully developed functional organs of related animals called vestigial organs.
iii. Fossils : Fossils are the remains of the past and the study of fossils is known as paleontology. Charles Robert Darwin (1809-1882) explained the evolutionary principle in his famous book "The origin of species". The theory proposed by him is popularly known as theory of natural selection.

Speciation

The process by which new species develop from the existing species is known as speciation.

i. Geographical isolation of a population caused by various types of barriers (such as mountain ranges, rivers and sea).
ii. Genetic drift caused by drastic changes in the frequencies of particular genes is by chance alone.
iii. Variations caused in individuals due to natural selection.

IMPROVEMENT IN FOOD RESOURCES

- Green revolution has increased food grain production while white revolution has increased production of milk.
- Based On the seasons of cultivation, crops are classified in two categories:
  i. Kharif Crops : Crops grown in rainy season from July to October are kharif crops. Example: Paddy, soyabean, maize, cotton, and green gram etc.
  ii. Rabi Crops : Crops grown in winter season from November to April are rabi crops. Example: Wheat, gram, peas, mustard and linseed etc.
- Hybridisation : Crossing between genetically dissimilar plants is hybridization. The crossing may be intervarietal (between different varieties), intergeneric (between different genera), interspecific (between different species of the same genus). The most common type of breeding is intervarietal.
- Manure : It is prepared by decomposition of animal excreta and plant waste. Plants like sunhemp or guar are grown and then mulched by ploughing them into the soil.
- Organic farming: It is a farming system using organic manures, recycled farm-wastes and use of bio-agents such as culture of blue-green algae in preparation of biofertilisers, neem leaves or turmeric specifically in grain-storage as bio-pesticides.
- Irrigation : Various irrigation systems are adopted to supply water to agricultural lands, they are — Wells, canals, rivers, tanks etc. Rain water harvesting and watershed management increases the availability of water.
- Cropping Patterns
  i. Mixed cropping : Growing two or more crops simultaneously on same land is mixed cropping.
  ii. Inter-cropping : Growing two or more crops simultaneously on the same field in a definite pattern is inter cropping.
  iii. Crop-rotation : Growing of different crops on a piece, of land in a pre-planned succession is crop rotation.
- Animal husbandry : It is the scientific management of animal livestock in various aspects such as feeding, breeding and disease control. The animal included are cattle, goat, poultry, sheep and fish.
- Cattle farming: Indian cattle belong to two different species *Bos indicus*, (cows) and *Bos bubalis*, (buffaloes).
- Poultry farming : They are farmed to produce layers for eggs and broilers for meat.
- Fish production: It provides animal protein for us.
  - Capture fishing obtained from natural resources.
  - Culture farming obtained by fish farming.
- Bee-keeping : It has become an agricultural enterprise for honey production. Its a low investment activity and produces wax also. Local varieties of bees used for honey production are – *Apis cerana indica* (Indian bee), *A. dorsata* (Rock bee), *A.florae* (little bee).

PRINCIPLES OF INHERITANCE AND VARIATION

- Incomplete dominance is the phenomenon where dominant allele do not completely express itself. Example, In *Mirabili's Jalapa* (four 0' clock).
- In codominance, both the alleles of a gene are equally dominant i.e. the dominant character is not able to suppress the recessive character & thus both the characters appear side by side in F_1 hybrids. F_1 generation resembles both the parents. E.g.. ABO blood group.
- Linkage is the phenomenon of certain genes staying together during inheritance through generations without any change or separation. This is due to their location on the same chromosomes.
- The rearrangements of linked genes due to crossing over is known as recombination.
- Phenomenon that results in alteration of DNA sequence and consequently results in change in genotype and phenotype of an organism is called mutation. Mutagens are various chemical and physical factors that induce mutations, e.g.. UV radiations, carcinogenic chemicals like nicotine, nitric oxide (NO).

MOLECULAR BASIS OF INHERITANCE

- Formation of new DNA strand from old DNA is called DNA replication or DNA duplication.
- Process of copying genetic information from DNA to RNA is called transcription.
- Transfer of genetic information from a polymer of nucleotides to a polymer of amino acids is called translation. This is accomplished with the help of genetic code which is row of three consecutive nucleotides - coding for 20 amino acids.

HEALTH AND DISEASES

- **AIDS :** Acquired Immuno Deficiency Syndrome, recognized first in USA in 1981. It is caused by HIV (Human immunodeficiency virus), a retro virus having 2-strands of single stranded RNA (RNAss), with reverse transcriptase enzyme.
- **Vaccination :** It is the inoculation/ injection of weak or attenuated antigens, or a toxin, or a protein, into the body. The introduction of antigens stimulates the production of antibodies and memory cells, which protect the body against that antigen/disease.
- The study of cancer is called 'Oncology'. The cancer is unregulated and uncontrolled proliferation of cells, or the breakdown of regulatory mechanism that governs normal cell division.
- The Immunity is the resistance against pathogens. foreign materials and cancer etc. It is of 2-types-I.
  (a) Innate Immunity : This immunity is by birth, and develops by virtue of genes.
  (b) Acquired Immunity : It can be acquired belbre birth (from mother through placenta) or after birth. There is antigen-antibody reaction in this immunity.

Antigens : The 'Antigen' is an acronym for antibody generating material.

Antibodies : They are pure proteins (γ-globulins). Since they participate in the immune system, they are also known as immunoglobulins (Ig).

Drugs : Drugs are chemicals that alter the functioning of the body.

i. Sedatives and tranquillizers - eg. Barbiturates (used in sleeping pills), Valium,
ii. Opiate narcotics (opioids) - eg. Opium, Morphine. Pathedine and Heroin etc.

BIOTECH-NOLOGY

- Biotechnology is the application of techniques using live organism to get desired product of human welfare. It includes recombinant DNA, gene cloning, gene therapy.
- rDNA technology is hybridization of DNA from different sources to achieve desired genotype and phenotype in an organism.
- Restriction endonucleases which can break DNA at specific sites. They are appropriately called molecular scissors or biological scissors.
- Vectors are cloning vehicles required to transfer DNA of interest from one organism to another.
- Plasmids are extra-chromosomal, circular, double stranded autonomously replicating DNA sequence in bacterial cell.
- Cosmid can be defined as the hybrid vectors derived from plasmids which contain cos site of lambda phage.
- *Bt* cotton is the first genetically modified crop of the country.

ORGANISMS AND ENVIRONMENT

- Adaptations the morphological, physiological or behavioural attributes that enable the organisms to survive and reproduce in their habitat.
- The population is a group of individuals of a particular species, which potentially interbreed and live in a well defined geographical area, and also share or compete for similar resources.
- Birth or Natality rate - It is the number of births per thousand of a population per year.
- Death or Mortality rate - It is the number of deaths occurring in a population of one thousand per year.
- The growth of population with time shows specific and predictable patterns. The 2-common patterns are
  - **Exponential growth**

$$\frac{dN}{dt} = (b - d) \times N$$

$$\text{If } (b - d) = r, \text{ then } \frac{dN}{dr} = rN$$

Here 'r' is called 'Intrinsic rate of natural increase' or Biotic potential (maximum capacity of reproduction), Which indicates the impact of biotic and abiotic factors in population growth.

  - **Logistic growth**

$$\frac{dN}{dT} = rN\left(\frac{K - N}{K}\right)$$

K = Nature's carrying capacity in that habitat
(K – N)/K or 1 – N/K = environment ristance

- **Population Interactions**

S.N.	Name of interaction	Species A	Species B
1	Parasitism	+	–
2	Commensalism	+	0
3	Mutualism	+	+
4	Predation	+	–
5	Competition	–	–
6	Amensalism	–	0

ECOSYSTEM

- Ecosystem is the functional unit of nature where living organisms interact with each other and with then environment.
- Productivity refers to the rate of biomass production i.e. the rate at which sunlight is captured by producers for the synthesis of energy rich organic compounds.

- Primary productivity is the amount of biomass produced per unit area over a time period by plants during photosynthesis.
- Gross primary productivity (GPP) - It is the rate of production of biomass or accumulation of energy by green plants per unit area per unit time. GPP depends on the chlorophyll content.
- Net primary productivity = Gross primary productivity - Respiration losses. (or GPP – R = NPP)
- Food chain is an order or sequence of different organisms which are arranged in a way that the food is passed from one type of organism to other organisms such that the organisms of one order or trophic level are the food of the organisms of next order.
- Food web refers to a group of inter- related food chains in a particular community.
- Ecological succession is the successive development of different biotic communities at the same site. The communities develop one after another till the development of a community which is near equilibrium with the environmental conditions. This is called climax community.

BIODIVERSITY AND ITS CONSERVATION

- Biodiversity means diversity or heterogeneity at all levels of biological organization. i.e., from macromolecules of the cells to the Biomass.
  The important levels of biodiversity are
  (i) Genetic diversity,
  (ii) Species diversity
  (iii) Ecological diversity

- Ecological diversity
  It is the diversity at community level. It can be of 3-types
  i. Alpha (α) diversity : It is the diversity of organisms within the same community or habitat.
  ii. Beta (β) diversity : It is the diversity between communities or different habitats.
  iii. Gamma (γ) diversity : It is the diversity of organisms over the entire geographical area, covering several ecosystems or habitats and various trophic levels and food webs.
- **Biosphere reserves** - They represent natural biomes which contain unique biological communities.
- **National Parks** - They are reserved for the betterment of wild life. both fauna and flora.
- **Sanctuaries** - In sanctuaries the protection is given to fauna only. The activity like harvesting of timber, collection of forest products and private ownership rights are permitted so long as they do not interfere with the well being of the animals.

ENVIRONMENTAL ISSUES

- Pollution is an undesirable change in physical, chemical or biological characteristics of air, land, water or soil. The agents that bring about such an undesirable change are called Pollutants.
- In a green house the glass panel lets the light (with long wave- infra red-radiation) in, but does not allow heat (with short wave infra red) to escape.
- The term 'Green House Effect' is derived from this phenomenon of green house. It is a naturally occurring phenomenon that is responsible for heating of earth surface and atmosphere.
- The ozone (O_3) found in upper part of the atmosphere, i.e., Stratosphere, is Good ozone, since, it acts as a shield for absorbing UV-radiations from sun.
- The ozone depletion is occurring widely in the Stratosphere, the depletion is particularly marked over 'Antarctic region'; and this has resulted in the formation of a large area of thinned ozone layer called 'Ozone Hole'.
- Deforestation is the conversion of the forested area into non-forested area.