O. P. JINDAL SCHOOL

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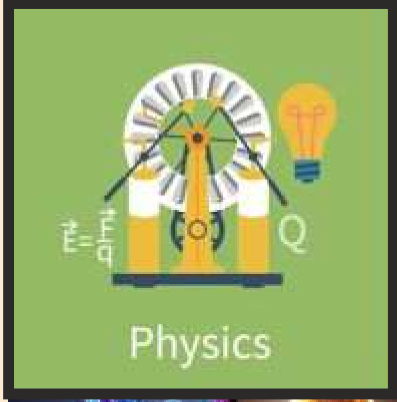
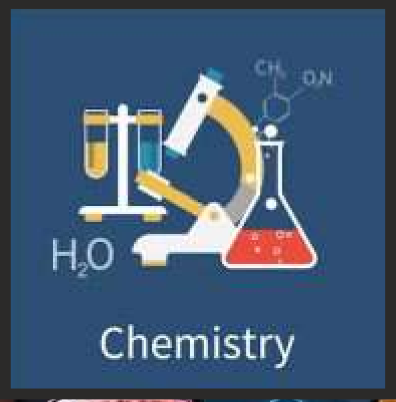
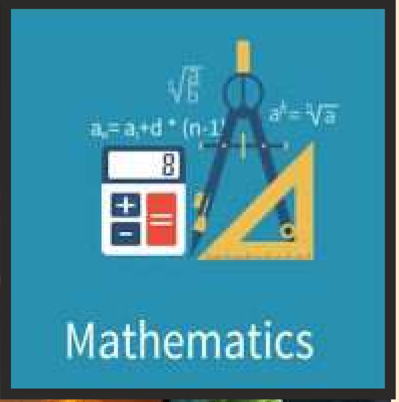
RITHM : A Compendium

Classes IX-XII







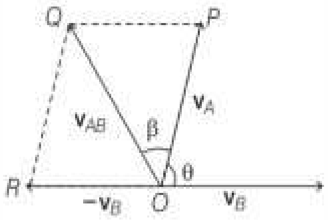
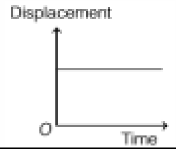
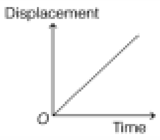
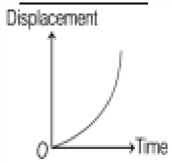
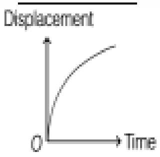
Introducing the essential Handbook for Physics, Chemistry, and Maths, designed for students from classes 9 to 12 following the CBSE curriculum.

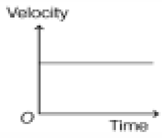
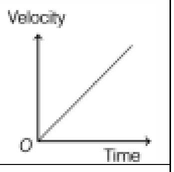
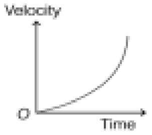
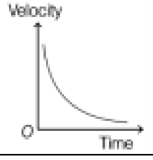
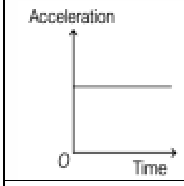
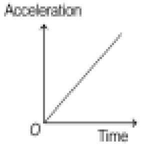
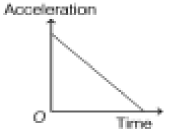
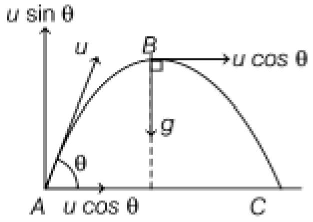
This concise booklet contains all the crucial formulas and equations necessary to excel in these subjects. From Newton's laws to chemical reactions to algebraic expressions, every key concept is succinctly summarized for easy reference and understanding. With this handbook in hand, students can confidently tackle problems and excel in their academic pursuits from middle school to higher secondary levels.

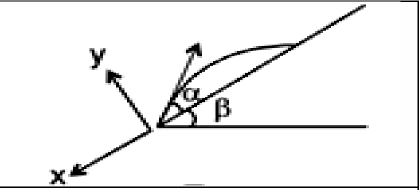
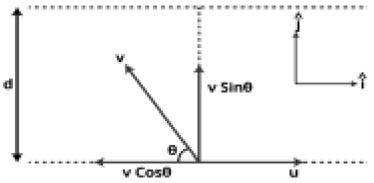
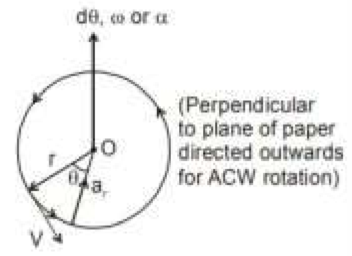
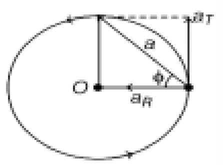
Physics

Physics formula

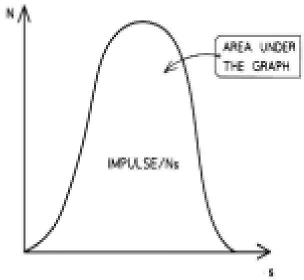
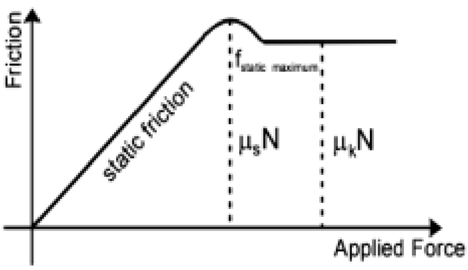
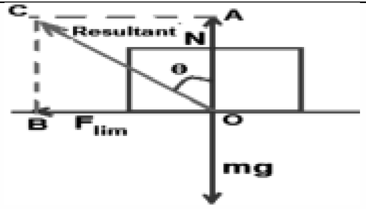
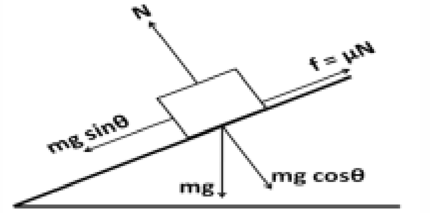
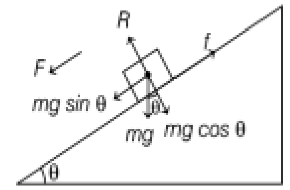
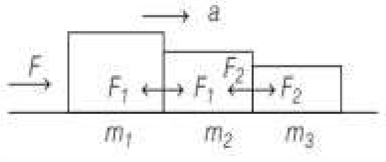
Kinematics

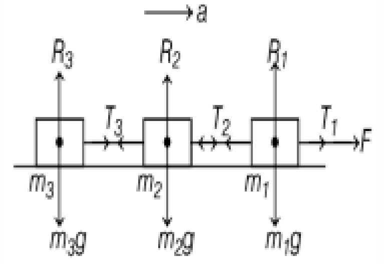
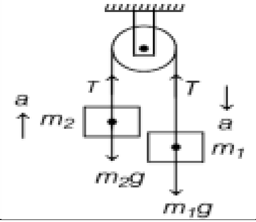
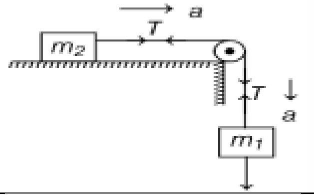
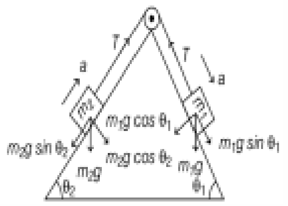
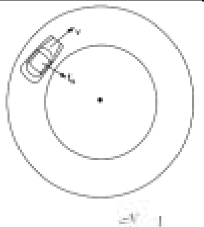
Physical quantity/Phenomenon	Formula/Graph	Diagram/Remarks
Average speed	$\dfrac{\text{Total distance travelled}}{\text{Total time taken}}$	When particle travels distances s_1, s_2 and s_3, with speeds v_1, v_2 and v_3 $= \dfrac{s_1 + s_2 + s_3 + \dots}{\left(\dfrac{s_1}{v_1} + \dfrac{s_2}{v_2} + \dfrac{s_3}{v_3} + \dots\right)}$ When particle travels with speeds v_1, v_2 and v_3 during time intervals t_1, t_2 and t_3 $= \dfrac{v_1 t_1 + v_2 t_2 + v_3 t_3 + \dots}{t_1 + t_2 + t_3 + \dots}$
Instantenous speed	$\lim\limits_{\Delta t \to 0} \dfrac{\Delta s}{\Delta t} = \dfrac{ds}{dt}$	It is the tangent drawn over an x-t graph at a particular time.
Average velocity	$\dfrac{\text{Total displacement}}{\text{Total time taken}}$	Average velocity and average speed are same when a body moves along the straight line with uniform velocity.
Average acceleration	$\dfrac{\text{Change in velocity }(\Delta v)}{\text{Time interval }(\Delta t)}$	When the sign of accelaration and velocity are same then only it speeds up.
Relative Velocity	$\mathbf{v}_{AB} = \mathbf{v}_A - \mathbf{v}_B$	
	$\mathbf{v}_{AB} = \mathbf{v}_A + \mathbf{v}_B$	
	$v_{AB} = \sqrt{v_A^2 + v_B^2 - 2 v_A v_B \cos\theta}$ $\tan\beta = \dfrac{v_B \sin\theta}{v_A - v_B \cos\theta}$	
Displacement-Time Graph	For a stationary body  A constant velocity  A constant acceleration  A constant retardation 	Slope of displacement-time graph= average velocity.

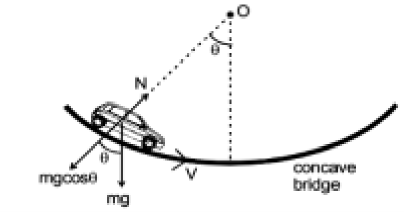
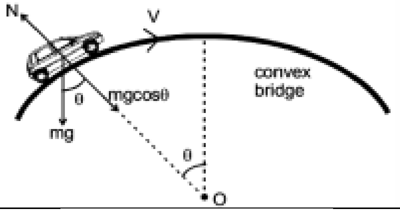
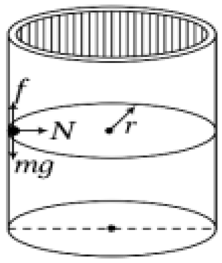
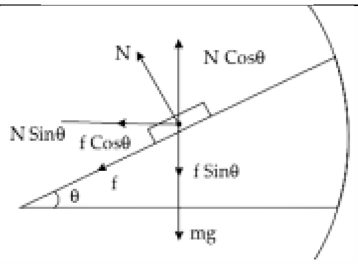
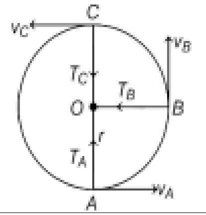
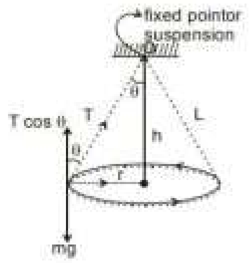
Velocity-Time Graph	A constant velocity  A constant acceleration  Increasing acceleration  Decreasing acceleration  	- The area under the curve is equal displacement of the object in the given time period. - Slope of velocity-time graph = average acceleration.
Acceleration-Time Graph :	Constant acceleration  Constant increasing acceleration  Constant decreasing acceleration  	The area under the curve is equal to the change in the velocity of the object in the given time period.
Uniformly accelerated motion	$v = u + at$ $s = ut + \frac{1}{2} at^2$ $v^2 = u^2 + 2as$ $s_n = u + \frac{a}{2}(2n - 1)$	Motion under gravity is also uniformly accelerated motion. $v = u - gt$ $y = ut - \frac{1}{2} gt^2$ $v^2 = u^2 - 2gy$
Projectile Motion	$T = \frac{2u \sin\theta}{g}$ $H = \frac{u^2 \sin^2\theta}{2g}$ $R = \frac{u^2 \sin 2\theta}{g}$ $y = x \tan\theta - \frac{g}{2u^2 \cos^2\theta} x^2$ $= x \tan\theta \left(1 - \frac{x}{R}\right)$	

Incline plane projection	T=$\frac{2u\sin\alpha}{g\cos\beta}$	
	Range= $\frac{2u^2\sin\alpha\cos(\alpha+\beta)}{g\cos^2\beta}$	
River-Boat Problem	Time to cross= $\frac{d}{v\sin\theta}$	
	Min. Time to cross =$\frac{d}{v}$ And drift in this case=u.$\frac{d}{v}$	
	To cross in shortest path : v$\cos\theta = u$	
Circular Motion	Average angular velocity $\omega_{av} = \frac{\theta_2-\theta_1}{t_2-t_1} = \frac{\Delta\theta}{\Delta t}$	
	Instantaneous angular velocity $\omega = \frac{d\theta}{dt}$	
	Average angular acceleration $\alpha_{av} = \frac{\omega_2-\omega_1}{t_2-t_1} = \frac{\Delta\omega}{\Delta t}$	
	Instantaneous angular acceleration $\alpha = \frac{d\omega}{dt} = \omega\frac{d\omega}{d\theta}$	
	Radial or centripetal acceleration $a_r = \frac{v^2}{r} = \omega^2 r$	
	Linear speed $v = r\omega$	
	Tangential acceleration: A_t=rα	
	Net acceleration $a = \sqrt{a_R^2 + a_T^2}$ $\tan\phi = \frac{a_T}{a_R}$	
Uniformly accelarated motion in a circle	$\omega = \omega_0 + \alpha t$	For retardation α will be taken as negative.
	$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$	
	$\omega^2 = \omega_0^2 + 2\alpha\theta$	

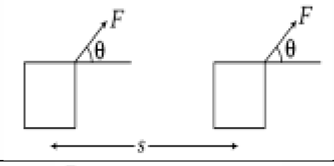
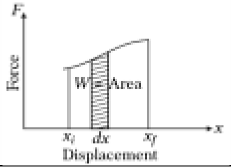
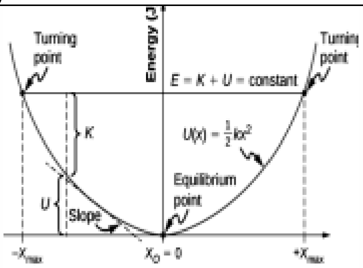
NEWTON'S LAWS OF MOTION

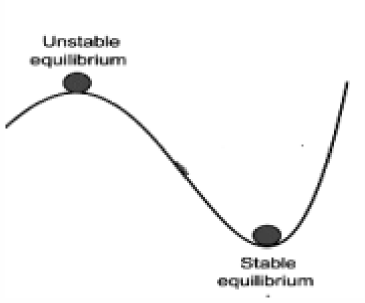
Newton’s second law	$\mathbf{F} = \frac{md\mathbf{v}}{dt} = m\mathbf{a}$	When Mass remains constant
Impulse	Force * Time = Change in momentum	
Impulse during period t_1 to t_2	Area under the F- t curve from t_1 to t_2	
Thrust on the rocket at any instant	$F = -u\frac{dM}{dt}$	Rocket is an example of variable mass following law of conservation of momentum.
Max. Static friction and Kinetic friction	$f_{max} = \mu_s N$ $0 \leq f_s \leq f_{smax}$	
	$f_k = \mu_k N$	
Angle of Friction(θ)	It is the angle which the resultant of the force of limiting friction and the normal reaction(N) makes with the direction of N. μ=tanθ	
Angle of Repose(α)	It is the minimum angle of inclination of a plane with the horizontal, such that a body placed on it, just begins to slide down. μ=tanα	
Acceleration on a rough incline plane	$a = g(\sin\theta - \mu\cos\theta)$	
Common acceleration and contact normal forces	$= \frac{net\ pulling\ force}{total\ mass}$ $= \frac{F}{(m_1 + m_2 + m_3)}$	

	$F_1 = \dfrac{(m_2 + m_3)F}{(m_1 + m_2 + m_3)}$	
	$F_2 = \dfrac{m_3 F}{(m_1 + m_2 + m_3)}$	
Common acceleration and tension	$a = \dfrac{F}{(m_1 + m_2 + m_3)}$ $T_1 = F$ $T_2 = (m_2 + m_3)\,a = \dfrac{(m_2 + m_3)F}{(m_1 + m_2 + m_3)}$ $T_3 = m_3 a = \dfrac{m_3 F}{(m_1 + m_2 + m_3)}$	
Common acceleration and tension	$a = \dfrac{(m_1 - m_2)}{(m_1 + m_2)}\,g,$ $T = \dfrac{2m_1 m_2}{(m_1 + m_2)}\,g$	
Common acceleration and tension	$a = \dfrac{m_1 g}{(m_1 + m_2)}$ $T = \dfrac{m_1 m_2\, g}{(m_1 + m_2)}$	
Common acceleration and tension	$a = \dfrac{(m_1 \sin\theta_1 - m_2 \sin\theta_2)\,g}{m_1 + m_2}$ $T = \dfrac{m_1 m_2}{m_1 + m_2}(\sin\theta_1 + \sin\theta_2)\,g$	
Centripetal Force	$F = \dfrac{mv^2}{r} = mr\omega^2$	“centripetal force” means “force towards the centre”. Its not a new kind of force. This force must originate from some external source such as gravitation, tension, friction, coulomb force, etc.
Circular Turning of Roads:	By friction only : $v_{\max} = \sqrt{\mu r g}$	
	By bending of road only : $v = \sqrt{rg \tan\theta}$	

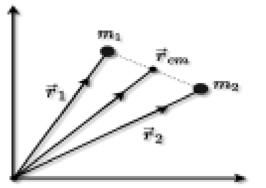
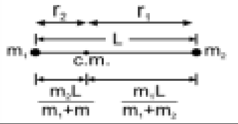
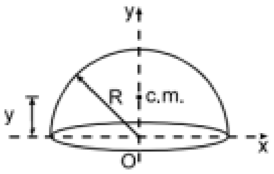
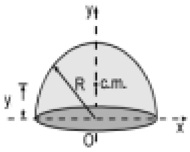
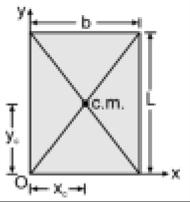
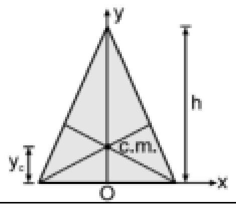
Radius of curvature	$R = \frac{v^2}{a_\perp} = \frac{mv^2}{F_\perp}$	-
Normal reaction of road on a concave bridge	$N = mg\cos\theta + \frac{mv^2}{r}$	
Normal reaction on a convex bridge	$N = mg\cos\theta - \frac{mv^2}{r}$	
Skidding of an object on a rotating platform	$v = \sqrt{\frac{gr}{\mu}}$	
Maximum and minimum safe speed on a banked frictional road	$V_{max} = \left[\frac{rg(\mu + \tan\theta)}{(1-\mu\tan\theta)}\right]^{1/2}$ $V_{min} = \left[\frac{rg\ (\tan\theta - \mu)}{(1+\mu\tan\theta)}\right]^{1/2}$	
Min. Speed to complete the vertical loop and tension at highest and lowest point	At A=$\sqrt{5gr}$ At C=$\sqrt{gr}$, speed at C =$\sqrt{3gr}$ Tension at A= 6mg Tension at C= zero	
Conical pendulum	$T\cos\theta = mg$ $T\sin\theta = m\omega^2 r$ Time period = $2\pi\sqrt{\frac{L\cos\theta}{g}}$	

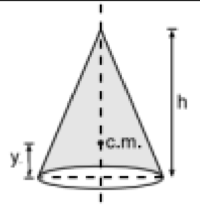
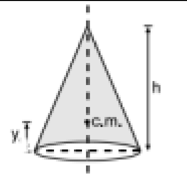
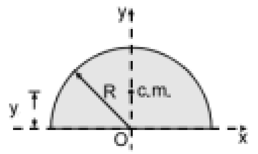
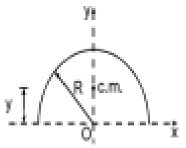
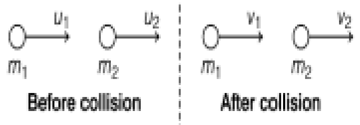
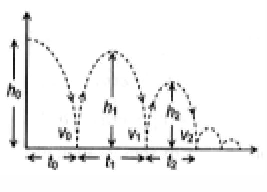
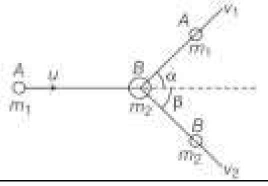
WORK , POWER AND ENERGY

Work done by constant force	W= FS cosθ	
Work done by a variable force	dw=F.dx Total workdone= area under F vs x curve	
Relation between momentum and kinetic energy	P =$\sqrt{2mK}$	-
Potential energy	$\int_{U_1}^{U_2} dU = -\int_{r_1}^{r_2} \vec{F}\cdot d\vec{r}$	$U_2 - U_1 = -\int_{r_1}^{r_2} \vec{F}\cdot d\vec{r} = -W$ $U = -\int_{\infty}^{r} \vec{F}\cdot d\vec{r} = -W$ W=work done by conservative force
Conservative forces	$F = -\frac{\partial U}{\partial r}$	Potential energies are defined only for conservative forces as work done by these forces is independent of path. Ex. Gravitational, spring and electric forces.
Work-energy theorem	$W_C + W_{NC} + W_{PS} = \Delta K$	If only conservative forces do work then, $U_f - U_i = -W = -(K_f - K_i)$ $U_f + K_f = U_i + K_i$ We can't apply the principle of conservation of energy in presence of non-conservative forces. The work-energy theorem is still valid even in the presence of non-conservative forces.
Gravitational Potential Energy	mgh.	Always negative as the gravitational force is always attractive in nature.
Elastic Potential Energy	$\frac{1}{2}Kx^2$	
Electric Potential Energy	$U = \frac{1}{4\pi\varepsilon_0}\cdot\frac{q_1q_2}{r}$	Positive as well as negative as the electric force is repulsive as well as attractive in nature.
Avg. Power	$P_{av} = \frac{W}{t}$	Represents how fast or slow work is being done.
Instantaneous power	$P = \frac{\vec{F}\cdot d\vec{S}}{dt} = \vec{F}\cdot\frac{d\vec{S}}{dt} = \vec{F}\ .\ \vec{v}$	-

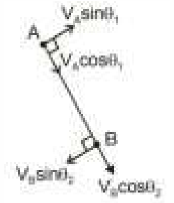
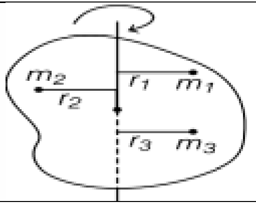
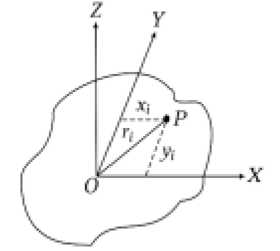
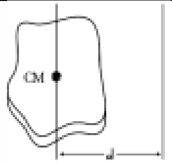
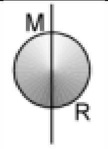
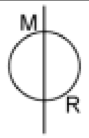
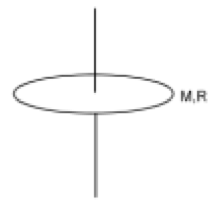
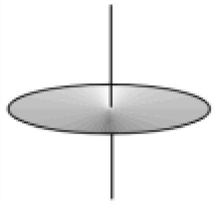
Equilibrium(Translational)	$F_{net} = 0 \Rightarrow \frac{-dU}{dr} = 0 \text{ or } \frac{dU}{dr} = 0$	
	Stable equilibrium (U=min.) $\frac{d^2U}{dr^2} = \text{positive}$	
	Unstable equilibrium (U=max) $\frac{d^2U}{dr^2} = \text{negative}$	
	Neutral equilibrium $\frac{d^2U}{dr^2} = 0$	

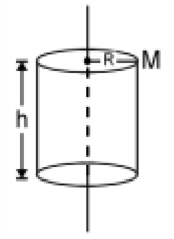
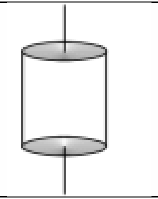
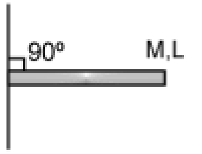
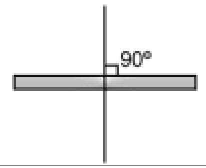
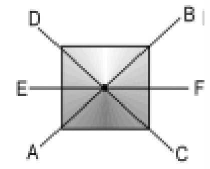
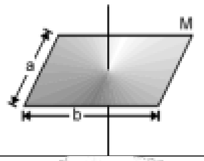
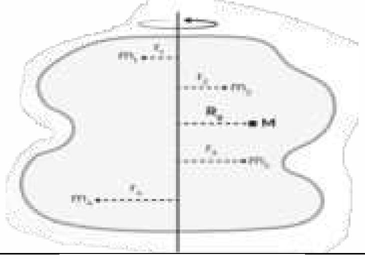
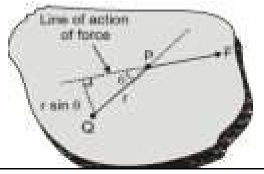
CENTRE OF MASS

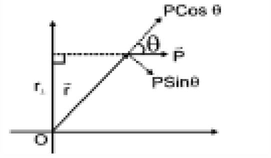
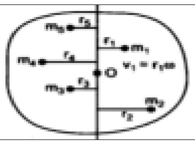
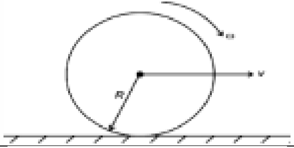
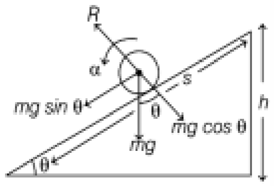
Centre of mass of a system of 'n' discrete particles:	$\vec{r}_{cm} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2 + \dots\dots + m_n\vec{r}_n}{m_1 + m_2 + \dots\dots + m_n}$	
Centre of mass of a continuous mass distribution	$x_{cm} = \frac{\int x\,dm}{\int dm},\ y_{cm} = \frac{\int y\,dm}{\int dm},\ z_{cm} = \frac{\int z\,dm}{\int dm}$	-
COM of two particle system	COM lies closer to the heavier mass.	
A hemispherical shell	$y = \frac{R}{2} \quad x = O$	
A solid hemisphere	$y = \frac{3R}{8} \quad x = O$	
COM of Rectangular plate	$x_c = \frac{b}{2} \quad y_c = \frac{L}{2}$	
A triangular plate	$y_c = \frac{h}{3}$	

A circular cone (solid)	$y=\frac{h}{4}$	
A circular cone (hollow)	$y = \frac{h}{3}$	
A semi-circular disc	$y = \frac{4R}{3\pi} \quad x = O$	
A semi-circular ring	$y = \frac{2R}{\pi} \quad x = O$	
Coefficient of restitution	$(e)=\frac{v_{separation}}{v_{approach}}$	(a) e = 1 ⇒Velocity of separation = Velocity of approach ⇒ Kinetic Energy is conserved ⇒ Elastic collision. (b) e = 0⇒ Velocity of separation = 0 ⇒ Kinetic Energy is not conserved ⇒ Perfectly Inelastic collision. (c) 0 < e < 1 ⇒ Velocity of separation < Velocity of approach ⇒ Kinetic Energy is not conserved ⇒ Inelastic collision.
Perfectly Elastic One Dimensional Collision	$v_1 = \frac{(m_1 - m_2)\, u_1 + 2m_2u_2}{(m_1 + m_2)}$ $v_2 = \frac{(m_2 - m_1)\, u_2 + 2m_1u_1}{(m_1 + m_2)}$	
Vertical inelastic collision	$e = \frac{v_1}{v_0} = \sqrt{\frac{2gh_1}{2gh_0}} = \sqrt{\frac{h_1}{h_0}}$ Height covered by the body after nth rebound $h_n = e^{2n}\, h_o$	
Two Dimensional (elastic) or Oblique Collision	$m_1u = m_1v_1 \cos\alpha + m_2v_2 \cos\beta$ $0 = m_1v_1 \sin\alpha - m_2v_2 \sin\beta$ If $m_1=m_2$ then $\alpha+\beta=90$	

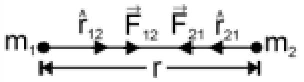
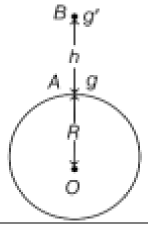
RIGID BODY DYNAMICS

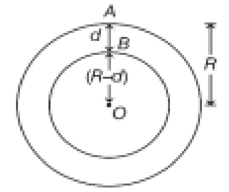
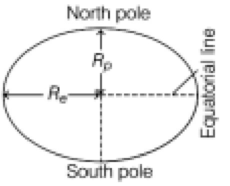
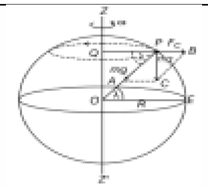
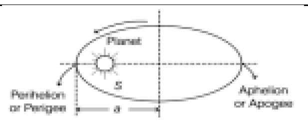
Condition for being a rigid body	$V_a\cos\theta_1 = V_B\cos\theta_2$ 		
MOI: For many particles (system of particles)	$I = \sum_{i=1}^{n} m_i r_i^2$		
For a continuous object	$I = \int dmr^2$		
Perpendicular Axis Theorem [Only applicable to plane lamina (that means for 2-D objects only)].	(when object is in x-y plane) $I_z = I_x + I_y$		
Parallel Axis Theorem (Applicable to any type of object)	$I_{AB} = I_{cm} + Md^2$		
Moment of Inertia of some symmetrical objects	Solid Sphere	$\frac{2}{5}MR^2$	
	Hollow Sphere	$\frac{2}{3}MR^2$	
	Ring	MR^2	
	Disc	$\frac{MR^2}{2}$	

	Hollow cylinder	MR^2	
	Solid cylinder	$\frac{MR^2}{2}$	
	Thin rod	$\frac{ML^2}{3}$	
	Thin rod	$\frac{ML^2}{12}$	
	Square Plate	$I_{AB} = I_{CD} = I_{EF} = \frac{Ma^2}{12}$	
	Square Plate	$I = \frac{M(a^2+b^2)}{12}$	
Radius of gyration	$I = MK^2$ $K = \sqrt{\frac{r_1^2 + r_2^2 + \ldots + r_n^2}{n}}$		
Torque	Torque about a point: $\vec{\tau} = \vec{r} \times \vec{F}$ For arigid body: τ=Iα		
Relation between 'τ' & 'L '	$\tau = \frac{d\mathbf{L}}{dt}$		For rotational eqilibrum τ=0

Angular momentum	about a point: $L = rp\sin\theta$ For arigid body L=Iω	
Conservation of Angular Momentum	$I_1\omega_1 = I_2\,\omega_2$	Revolution of earth around sun
Impulse of Torque	$J = \int_0^{\Delta L} \tau\, dt = L_f - L_i$	-
Rotational K.E.	$K = \frac{1}{2} I\omega^2$	
Total K.E.	$\frac{1}{2}Mv_{cm}^2 + \frac{1}{2}I_{cm}\,\omega^2$	
Motion of a Body Rolling Down Without Slipping on an Inclined Plane	$a = \dfrac{mg\sin\theta}{m + \dfrac{I}{r^2}} = \dfrac{g\sin\theta}{1 + \dfrac{K^2}{r^2}}$ $v = \sqrt{\dfrac{2gh}{1 + \dfrac{K^2}{r^2}}}$ $\text{Time} = \sqrt{\dfrac{2s\left(1 + \dfrac{k^2}{r^2}\right)}{g\sin\theta}}$	
Work done by torque	$W = \int_{\theta_1}^{\theta_2} \tau\, d\theta$	-
Power delivered by torque	$P = \tau \cdot \omega$	-

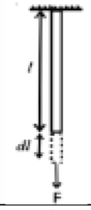
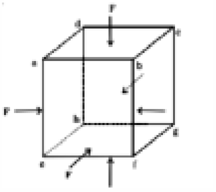
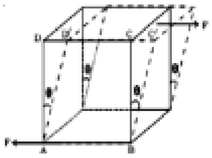
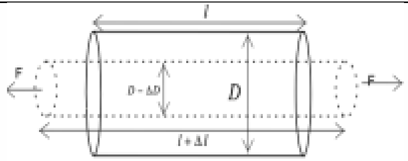
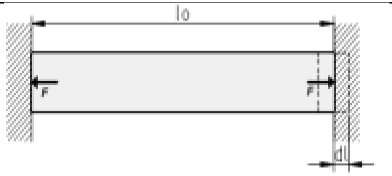
GRAVITATION

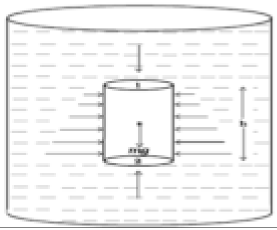
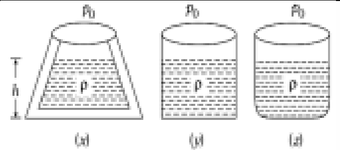
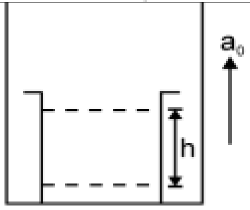
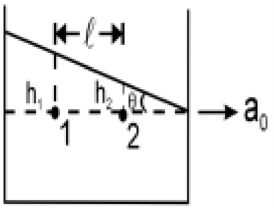
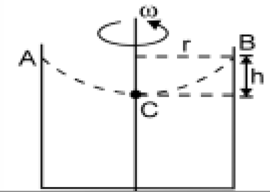
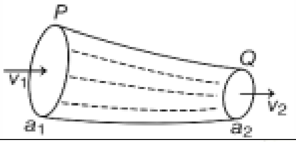
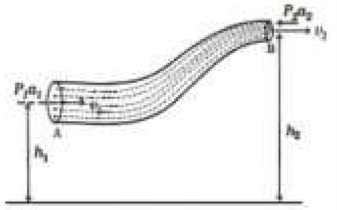
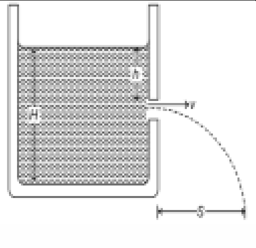
Universal Law of Gravitation	$\vec{F}_{12} = \frac{Gm_1m_2}{r^2}\,\hat{r}_{12} \quad \vec{F}_{21} = \frac{Gm_1m_2}{r^2}$	
Gravitational Field	$E = \frac{F}{m} = \frac{GM}{r^2}$	Gravitational field on earth surface is acceleration due to gravity
Gravitational potential	$V = -\frac{GM}{r} \quad E = -\frac{dV}{dr}$	
Variation Of Acceleration Due To Gravity	Effect of Altitude <u>When h is comparable to R</u> $g_h = \frac{GM_e}{(R_e + h)^2}$ $\simeq g\left(1 - \frac{2h}{R_e}\right)$ when h << R.	

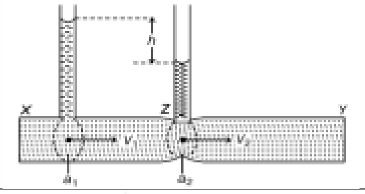
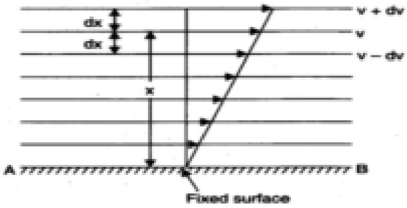
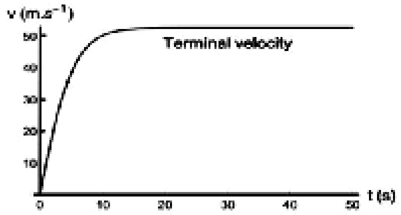
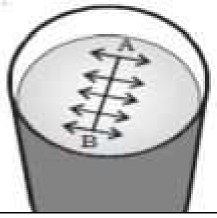
	Effect of depth $g_d = g\left(1 - \frac{d}{R_e}\right)$	
	Effect of the surface of Earth $g_{pole} > g_{equator}$	
	Effect of the Earth's rotation $g' = g - R\omega^2 \cos^2 \lambda$	
ORBITAL VELOCITY	$v_0 = \left[\frac{GM_e}{(R_e + h)}\right]^{\frac{1}{2}}$ $h << R_e$ then $v_0 = \sqrt{gR_e}$	Minimum velocity to put an object in any circular orbit.
Escape velocity	$v_e = \sqrt{\frac{2GM}{R}} = \sqrt{2gR}$	Minimum velocity to be imparted such that Kinetic energy of a body becomes equal to its potential energy.
Energy of a Satellite	$U = \frac{-GM_e m}{r}$ K.E. $= \frac{GM_e m}{2r}$ $E = -\frac{GM_e m}{2R_e}$ Binding Energy $BE = +\frac{GMm}{2r}$	Negative total energy indicates the satellite is bounded to the earth.
Gravitational Potential Energy between any two point masses	$U = -\frac{GMm}{r}$	Always negative as force is always attractive in nature.
Kepler's Laws	Law of orbit: Every planet revolves around the sun in an elliptical orbit and sun is at its one focus.	
	Law of area: Areal velocity = constant $\frac{dA}{dt} = \frac{L}{2m} = \text{constant}$	
	Law of periods: $\frac{T^2}{R^3} = \text{constant}$	

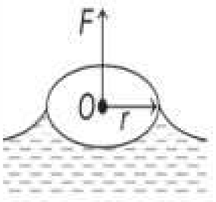
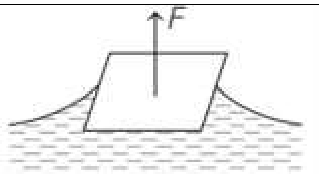
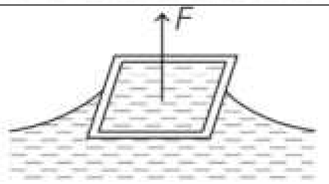
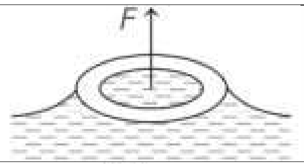
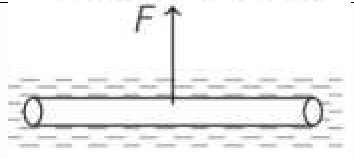
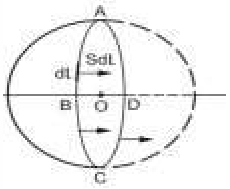
PROPERTIES OF MATTER

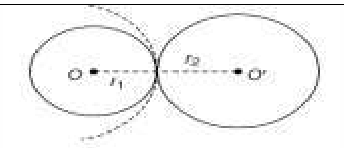
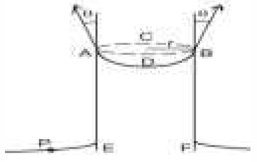
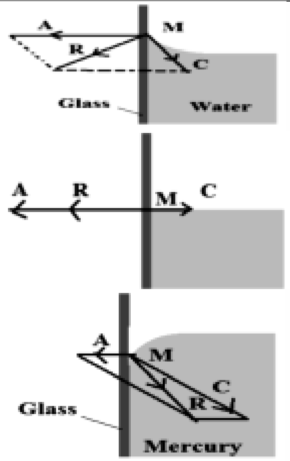
Stress	$\frac{\text{restoring force}}{\text{area of the body}}$	The magnitude of restoring force is taken equal to that of applied force.

Strain	$\frac{\text{change in configuration}}{\text{original configuration}}$		
	Longitudinal strain	$\frac{\Delta L}{L}$	
	Volume strain	$\frac{\Delta V}{V}$	
	Shear Strain	$\phi = \frac{x}{\ell}$	
Hooke's Law	$\text{Stress} \propto \text{Strain}$		Hooke's law is valid within elastic limit.
Elastic Modulus	Young's modulus $Y = \frac{F/A}{\Delta L/L}$ Bulk Modulus $K = -\frac{FV}{A\Delta V}$ Modulus of Rigidity/Shear Modulus) $\eta = \frac{F}{A\theta}$		-
Poisson's Ratio	$\frac{\text{Lateral strain}}{\text{Longitudinal strain}} = \frac{-\Delta R/R}{\Delta l/l}$		
Compressibility	$\frac{1}{K}$		K-bulk modulus
Force Constant of Wire	$k = \frac{YA}{l}$		If a spring is cut two equal parts then effective spring constant of each part will be 2k as k is inversely proportional to its length.
Potential Energy per unit volume	$\frac{1}{2}(\text{stress} \times \text{strain})$		-
Thermal stress	$Y\alpha\Delta\theta$ Y-young's modulus α-coefficient of linear expansion Δθ-change in temperature		

Pressure Exerted by the Liquid	***P=hρg***	
Hydrostatic Paradox	$p_x = p_y = p_z = p_0 + \rho g h$ $w_x \neq w_y \neq w_z$	
Liquid placed in elevator	$p = \rho h \, [g + a_0]$	
Free surface of liquid in horizontal acceleration	$\tan\theta = \frac{a_0}{g}$ $h_1 - h_2 = \frac{\ell a_0}{g}$	
Free surface of liquid in case of rotating cylinder	$h = \frac{v^2}{2g} = \frac{\omega^2 r^2}{2g}$	
Equation of Continuity	$a_1 v_1 = a_2 v_2$	
Bernoulli's Theorem	$p + \frac{1}{2}\rho v^2 + \rho g h = \text{constant}$ p-pressure v-speed of liquid h-height	
Torricelli's theorem – (speed of efflux)	$v = \sqrt{2gh}$ $t = \sqrt{\frac{2(H-h)}{g}}$ $S = \sqrt{4h(H-h)}$	

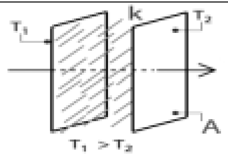
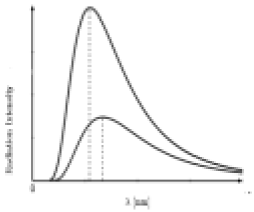
Venturimeter	$v = a_1 a_2 \sqrt{\dfrac{2gh}{a_1^2 - a_2^2}}$	
Newton’s Law of viscosity	$F = -\eta A \dfrac{dv}{dx}$	
Stoke’s Law	$F = 6\pi\eta r v$	Applicable for spherical objects falling through a viscous medium. η-coefficient of viscosity r-radius of the ball v-speed of the object
Terminal velocity	$\dfrac{2}{9}\dfrac{r^2(\rho-\sigma)g}{\eta}$	
Reynold’s Number .	$\dfrac{v_c \rho r}{\eta}$	R<2000 – streamlined flow When 2000 < R< 3000, the flow is variable between streamlined and turbulent. K > 3000 turbulent flow
Relative density	$\dfrac{\text{Density of substance}}{\text{Density of water at } 4°\text{C}}$	$\dfrac{\text{Weight of substance in air}}{\text{Loss of weight in water}}$
Laws of Floatation	(a) If W> w, then body will sink to the bottom of the liquid. (b) If W < w, then body will float partially submerged in the liquid. (c) If W =w, then body will float in liquid if its whole volume is just immersed in the liquid.	W=weight of the body w= weight of displaced water
Poiseuille’s Formula (rate of flow)	$\dfrac{\pi}{8}\dfrac{pr^4}{\eta l}$	p-pressure difference r-radius of the tube η-coefficient of viscosity l-length of the tube.
Surface tension	$\dfrac{\text{Total force on either of the imaginary lin}}{\text{Length of the line (l)}}$ $= \dfrac{\text{Surface energy or work done}}{\text{Increase surface area}}$	

Force of Surface Tension on Different Shape	Thin ring of radius r $F = 2\pi(r + r) \cdot S$	
	Circular plate or disc of radius r $F = 2\pi r \cdot S$	Liquid is only in contact with circumference of the disc.
	Square frame of side a $F = 8a \cdot S$	
	Square plate of side a $F = 4aS$	
	Hollow disc of inner radius r1 and outer radius r2 $F = 2\pi(r_1 + r_2) \cdot S$	
	Wire of length l $F = 2 \cdot l \cdot S$	
Work Done in Blowing a Liquid Drop	$W = S \cdot 4\pi(r_2^2 - r_1^2)$	S=surface tension r_1 =initial radius r_2= final radius
Work Done in Blowing a Soap Bubble.	$W = S \cdot 8\pi(r_2^2 - r_1^2)$	S=surface tension r_1 =initial radius r_2= final radius
Work Done in Splitting a Bigger Drop into n Smaller Droplets	$r = R \cdot (n)^{-1/3}$ $W = 4\pi S(nr^2 - R^2)$ $= 4\pi SR^2 (n^{1/3} - 1)$	S=surface tension R =initial radius r= final radius
Coalescence of Drops	$R = n^{1/3} \cdot r,$ $\Delta U = S \cdot 4\pi(nr^2 - R^2)$ $= 4\pi Sr^2 n (1 - n^{-1/3})$	S=surface tension r =initial radius R= final radius
Excess pressure	Inside a bubble $\frac{4S}{R}$	
	Inside the drop $\frac{2S}{R}$	

<table>
<tr><td></td><td colspan="3">Inside air bubble in a liquid
$\frac{2S}{R}$</td><td></td></tr>
<tr><td>Radius r of common interface</td><td colspan="3">$\frac{1}{r} = \frac{1}{r_1} - \frac{1}{r_2}$</td><td> </td></tr>
<tr><td>Capillary Rise</td><td colspan="3">$h = \frac{2S\cos\theta}{r\rho g} - \frac{r}{3}$
If a glass of insufficient length is dipped in water then water rises till the top and changes its radius of curvature such that (water does not overflow)
$R_1h_1 = R_2h_2$</td><td> </td></tr>
<tr><td rowspan="5">Variation in angle of contact</td><td><u>Angle of Contact < 90°</u></td><td><u>Angle of Contact = 90 °</u></td><td><u>Angle of Contact >90°</u></td><td rowspan="5"> </td></tr>
<tr><td>• Meniscus shape-Concave</td><td>Meniscus shape-Plane</td><td>Meniscus shape-Convex</td></tr>
<tr><td>• Capillary action - Liquid rises</td><td>No effect</td><td>Capillary action-Liquid falls</td></tr>
<tr><td>• Stick/wets</td><td>Does not wet</td><td>Does not wet</td></tr>
<tr><td>• $F_a > \frac{F_c}{\sqrt{2}}$</td><td>$F_a = \frac{F_c}{\sqrt{2}}$</td><td>$F_a < \frac{F_c}{\sqrt{2}}$</td></tr>
</table>

THERMAL PROPERTIES OF MATTER

<table>
<tr><td>Temperature scales</td><td>$\frac{C}{100} = \frac{F-32}{180} = \frac{K-273}{100}$</td><td>C, F and K are respectively temperatures a in Celsius, Fahrenheit and Kelvin scale</td></tr>
<tr><td>Linear Expansion</td><td>$l_2 = l_1(1 + \alpha\,\Delta t)$</td><td>α=coefficient of linear expansion.Δt= change in temperature.</td></tr>
<tr><td>Variation of time period of pendulum</td><td>$\Delta T = \frac{1}{2}\alpha\,\Delta\theta\,T$</td><td>T’ < T - clock-fast : time-gain T’ > T - clock slow : time-loss</td></tr>
<tr><td>Superficial Expansion</td><td>$A_2 = A_1(1 + \beta\,\Delta t)$</td><td>β=coefficient of superficial expansion.Δt= change in temperature.</td></tr>
<tr><td>Volume expansion</td><td>$V_2 = V_1(1 + \gamma\,\Delta t)$</td><td>γ=coefficient of superficial expansion.Δt= change in temperature.
$\alpha : \beta : \gamma = 1 : 2 : 3$</td></tr>
<tr><td rowspan="2">Expansion of Liquids</td><td>Coefficient of Apparent expansion
$\gamma_a = \frac{\text{Apparent Increase in volume}}{\text{original volume} * \text{original volume}}$</td><td rowspan="2">$\gamma_r = \gamma_a + \gamma_g$</td></tr>
<tr><td>Coefficient of real expansion
$\gamma_r = \frac{\text{Rea Increase in volume}}{\text{original volume} * \text{original volume}}$</td></tr>
</table>

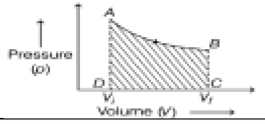
Variation of Density with Temperature	$\rho' \approx \rho(1-\gamma\Delta T)$	γ=coefficient of superficial expansion.Δt= change in temperature
Specific heat	$S = \frac{Q}{m.\Delta T}$	Depends on nature of the substances.
Molar specific heat	$C = \frac{\Delta Q}{n.\Delta T}$	Process dependent quantity for gases.
Latent heat	$Q = mL$	Heat required to change the phase of a substance at a constant temperature.
Water equivalent	$\frac{\boldsymbol{m.s}}{\boldsymbol{s_w}}$	m_w=water equivalent S_w=sp. Heat of water
Thermal Conduction	$\frac{dQ}{dt} = -KA\frac{dT}{dx}$	
Thermal Resistance	$R = \frac{\ell}{KA}$	Electric resistance $R=\rho\frac{l}{A}$
Series and parallel combination of rod	Series $\frac{\ell_{eq}}{K_{eq}} = \frac{\ell_1}{K_1} + \frac{\ell_2}{K_2} + \ldots$	When $A_1 = A_2 = A_3 = \ldots$
	Parallel $K_{eq}A_{eq} = K_1A_1 + K_2A_2 + \ldots$	When $l_1 = l_2 = l_3 = \ldots$
Emissive power	$E = \frac{\Delta U}{\Delta A \Delta t}$	A black body is a body which absorbs 100% incident energy neither reflects nor transmits. Only can emit radiations at some higher temperature.
Emissivity	$e=\frac{\text{E of a body at T temp.}}{\text{E of a black body at T temp.}}$	
Wein's Displacement law	$\lambda_m . T = b$ λ_m-the wavelength at which maximum emission takes place T- absolute temperature of the body	
Stefan Boltzmann law	Rate of heat loss= $e\sigma A(T^4 - T_0^4)$	T-temperature of the body T_0-temperture of the body

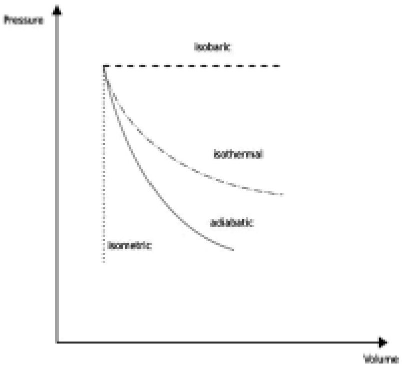
KTG & THERMODYNAMICS

Pressure of a gas	$P=\frac{1}{3}\rho\ V_{rms}^2$	
Speed of gas molecules	$V_{rms} = \sqrt{\frac{3P}{\rho}} = \sqrt{\frac{3KT}{m}}$	$V_{rms} > \overline{V} > V_p$
	$\overline{V} = \sqrt{\frac{8KT}{\pi m}}$	
	$V_p = \sqrt{\frac{2KT}{m}}$	
Maxwell's law of	Total K.E. of the molecule = 1/2 f KT	f=degrees of freedom

equipartition of energy		K=Boltzman constant T=absolute temperature.
Internal energy of n moles gas	$U = \frac{f}{2} nRT$	

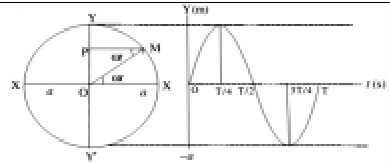
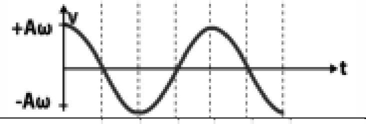
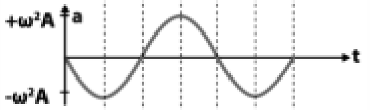
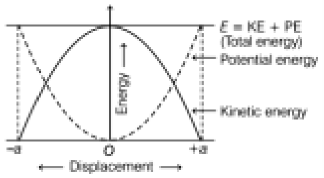
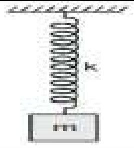
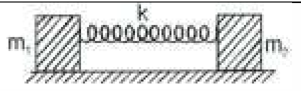
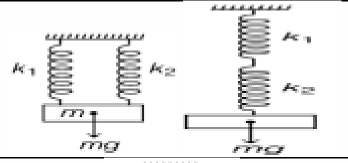
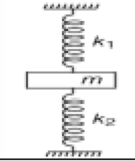
Ratio of C_p and C_v	Gas	Degrees of freedom	$U = \frac{f}{2} RT$	$C_v = \frac{dU}{dT} =$	$C_p = C_v + R$	$\gamma = \frac{C_p}{C_v} = 1 + \frac{2}{f}$
	Monoatomic	3 (trans)	$\frac{3}{2} RT$	$\frac{3}{2} R$	$\frac{5}{2} R$	1.67
	Diatomic &Triatomic (linear)	3(trans)+2 (rot)	$\frac{5}{2} RT$	$\frac{5}{2} R$	$\frac{7}{2} R$	1.4
	Triatomic (non linear)	3(trans)+3 (rot)	$3RT$	$3R$	$4R$	1.33

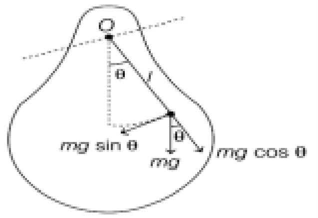
Mean Free Path	$\lambda = \frac{kT}{\sqrt{2} \pi \sigma^2 p}$	T-absolute tem. σ- diameter p-pressure k-Boltzmann constant
Mayer's equation	Cp – Cv = R	C_p=Molar specific heat at constant pressure C_v=Molar specific heat at constant volume
Work Done	$\int_{V_i}^{V_f} pdV = \text{Area } ABCDA$	
First Law of Thermodynamics	$dQ = dU + dW$	• Its conservation of energy in thermodynamics. • workdone(dw)- is taken positive when the gas expands and negative when it gets compressed.

Thermodynamic processes	Process	Work done	Change in internal energy	Sp. heat	
	Isobaric	$nR(T_f - T_i)$	$nC_v \Delta T$	C_p	
	Isochoric	Zero	Heat supplied	C_v	
	Adiabatic	$\frac{nR(T_i - T_f)}{\gamma - 1}$	-	Zero	
	Isothermal	$nRT \log_{10} \frac{V_f}{V_i}$	Zero	Infinity	

Adiabatic relations	$pV^{\gamma} = TV^{\gamma - 1} = \frac{T^{\gamma}}{p^{\gamma - 1}} = \text{Constant}$		
Mixture of non-reacting gases	Mol. Wt.	C_v	γ
	$\frac{n_1 M_1 + n_2 M_2}{n_1 + n_2}$	$\frac{n_1 C_{v_1} + n_2 C_{v_2}}{n_1 + n_2}$	$\frac{n_1 C_{p_1} + n_2 C_{p_2} + \ldots}{n_1 C_{v_1} + n_2 C_{v_2} + \ldots}$

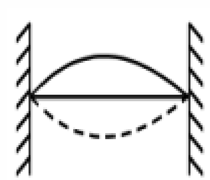
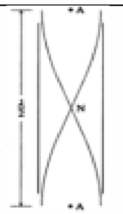
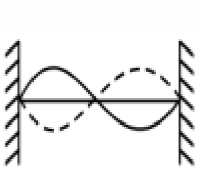
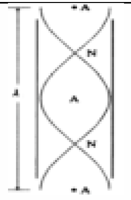
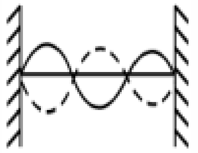
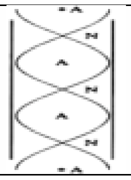
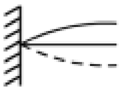
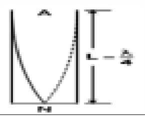
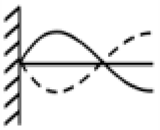
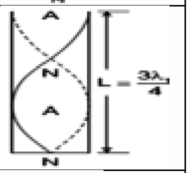
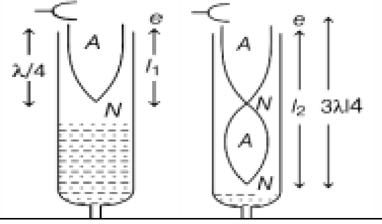
SIMPLE HARMONIC MOTION

S.H.M.	$F = -kx$	SHM occurs when the body is in stable equilibrium only.
Displacement in SHM	Y=a sinωt (body starts vibrating from mean position) Y=a cosωt(body starts vibrating from extreme position) where $\omega = \frac{2\pi}{T} = 2\pi f$	
Speed	$v = \omega\sqrt{A^2 - x^2}$	
Acceleration	$a = -\omega^2 x$	
Energy in SHM	Kinetic Energy $\frac{1}{2}k(A^2 - x^2)$ Potential Energy $\frac{1}{2}Kx^2$ Total Mechanical Energy $\frac{1}{2}KA^2$	
SPRING-Block SYSTEM	$T = 2\pi\sqrt{\frac{m}{k}}$	
	$T = 2\pi\sqrt{\frac{m}{k}}$	
	$T = 2\pi\sqrt{\frac{\mu}{K}}$ $\mu = \frac{m_1 m_2}{(m_1 + m_2)}$	
	Series Combination $1/k_{eq} = 1/k_1 + 1/k_2$	
	Parallel combination $k_{eq} = k_1 + k_2$	
SIMPLE PENDULUM	$T = 2\pi\sqrt{\frac{l}{g}}$ In a horizontally accelerated vehicle $T = 2\pi\sqrt{\frac{l}{\sqrt{(a^2+g^2)}}}$	Oscillates in uniform electric field(acting upwards)

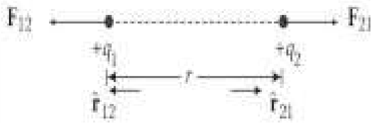
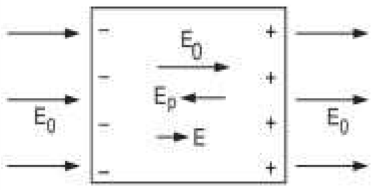
	Oscillates in a fluid $T' = 2\pi\sqrt{\frac{\rho l}{(\rho - \rho_0)g}}$	In a vehicle sliding down an inclined plane $T = 2\pi\sqrt{\frac{l}{g\cos\theta}}$	$T = 2\pi\sqrt{\frac{l}{g - \frac{qE}{m}}}$
COMPOUND PENDULUM / PHYSICAL PENDULUM	$T = 2\pi\sqrt{\frac{I}{mg\ell}}$ $I = I_{CM} + m\ell^2$ L=distance between center of mass and point of suspension		
TORSIONAL PENDULUM	$T = 2\pi\sqrt{\frac{I}{C}}$		C=torsional constant

WAVES

Speed of sound	$\sqrt{\frac{\gamma P}{\rho}} = \frac{\sqrt{\gamma RT}}{\sqrt{M}}$	M= Molar mass
Speed of Transverse wave	$\sqrt{\frac{T}{\mu}}$	T=tension μ=mass per unit length
Simple Harmonic Wave eqn.	$y = a\sin\frac{2\pi}{\lambda}(vt - x)$	• Waves travelling along negative X axis=sign of x and t are same • Waves travelling along positive X axis=sign of x and t are opposite
Wave velocity & Angular wave number	$\frac{\omega}{k}$, $k = \frac{2\pi}{\lambda}$	ω=angular frequency k=propagation constant/angular wave number
Particle velocity	$v_p = -v_{wave}\frac{dy}{dx}$	Max particle velocity (at mean position)=ωA Min particle velocity(at extreme position)=zero
Variation of phase	$\Delta\phi = \frac{2\pi}{\lambda}\Delta x$	At a particular time between particle at different position
	$\Delta\phi = \frac{2\pi}{T}\Delta t$	For a particular particle (at a fixed position) between a time interval
Intensity	$I = \frac{1}{2}\rho\omega^2A^2V$	ρ= volume mass density ω=angular frequency A=amplitude V=volume
Reflection & refraction of Wave	$y_i = A_i\sin(\omega t - k_1x)$ Rarer to denser $y_t = A_t\sin(\omega t - k_2x)$ $y_r = -A_r\sin(\omega t + k_1x)$	$A_r = \frac{\lvert k_1 - k_2\rvert}{k_1 + k_2}A_i$ $A_t = \frac{2k_1}{k_1 + k_2}A_i$
	Denser to rarer $y_t = A_t\sin(\omega t - k_2x)$ $y_r = A_r\sin(\omega t + k_1x)$	
Stationary or Standing Waves eqn.	$y = 2a\sin\frac{2\pi t}{T}\cos\frac{2\pi x}{\lambda}$	• Distance between two successive nodes and antinodes=$\frac{\lambda}{2}$ • Distance between one node and next antinode = $\frac{\lambda}{4}$ • In a loop particles vibrate in same phase but with different amplitudes

Vibrations of strings fixed at both ends & open organ pipe	1st mode (1st harmonic or fundamental)	L =		
	2nd mode (2nd harmonic or first overtone)	L =		
	3rd mode(3rd harmonic or 2nd overtone)	L =		
String free at one end & close organ pipe	1st mode(1st harmonic or fundamental)	L =		
	2nd mode(3rd harmonic or first overtone)	L =		
Resonance Tube	$v = n\lambda = 2n\,(l_2 - l_1)$			
Beat frequency	Number of beats heard per second = $n_1 - n_2$ = difference of frequencies	Beats are heared when the frequency difference is not more than 10 Hz.		

ELECTROSTATICS

Coulomb force	$F_e = \frac{K\|q_1 q_2\|}{r^2}$	
Dielectric constant or relative permittivity	$\varepsilon_r = \frac{\varepsilon}{\varepsilon_0}$ $\vec{E} = \frac{\vec{E}_0}{K}$	
Electric field intensity	$E = \frac{F}{q}$	Force per unit test charge. q=test charge

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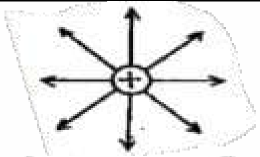
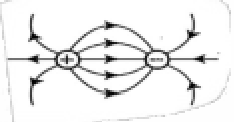
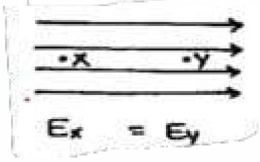
<td>Properties of electric field lines</td>
<td colspan="2">


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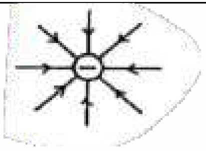
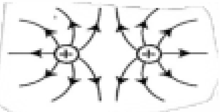
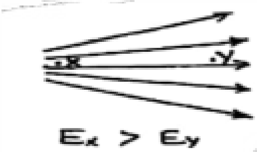
<td colspan="2">


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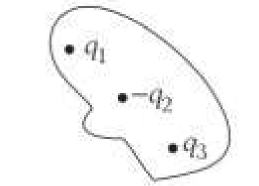
<tr>
<td>Electric Potential</td>
<td colspan="2">$V_P = \frac{(W_{\infty P})_{ext}}{q}\Big]_{acc\to 0}$</td>
<td colspan="2">Work done by an external agent to bring a unit positive charge from infinity to a point without accelerating the charge. Potential at infinity can be taken zero.</td>
</tr>
<tr>
<td>Potential Gradient</td>
<td colspan="2">$E = -\left(\frac{dV}{dr}\right)$ $V_B - V_A = -\int_A^B \vec{E}\cdot d\vec{r}$</td>
<td colspan="2">Potential decreases in the direction of electric field.</td>
</tr>
<tr>
<td>Gauss's law</td>
<td colspan="2">The electric flux=
$\phi_E = \oint \vec{E}\cdot d\vec{S} = \frac{q_{in}}{\varepsilon_0}$
$\phi = \frac{q_{in}}{\varepsilon_0} = \frac{q_1 - q_2 + q_3}{\varepsilon_0}$</td>
<td colspan="2">
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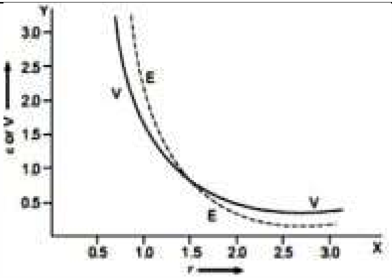
<tr>
<td rowspan="3">Electric field and potential due to some symmetrical objects</td>
<td>Point charge</td>
<td>$E = \frac{Kq}{|\vec{r}|^2}\cdot\hat{r}$</td>
<td>$V = \frac{Kq}{r}$</td>
<td>
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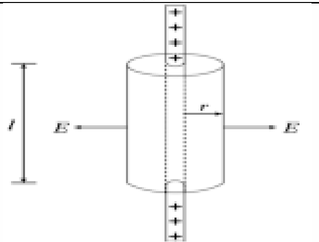
<tr>
<td>Line charge</td>
<td>$\frac{\lambda}{2\pi\varepsilon_0 r}\hat{r}$</td>
<td>$V_B - V_A = -2K\lambda\ \ln(r_B / r_A)$</td>
<td>
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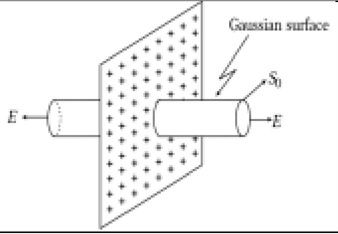
<tr>
<td>Thin sheet</td>
<td>$\frac{\sigma}{2\varepsilon_0}\hat{n}$</td>
<td>$V_B - V_A = -\frac{\sigma}{2\varepsilon_0}(r_B - r_A)$</td>
<td>
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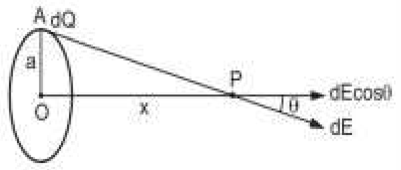
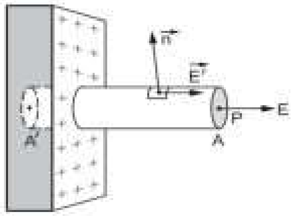
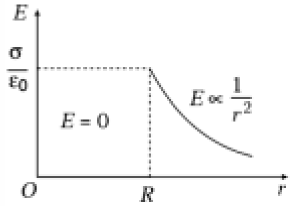
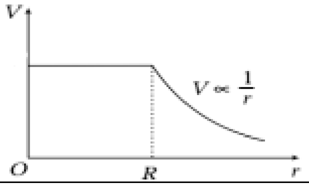
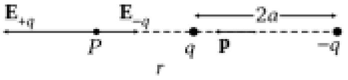
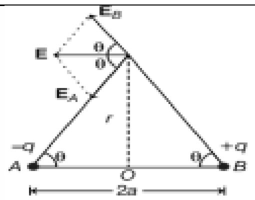
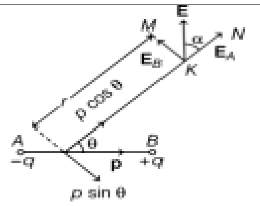
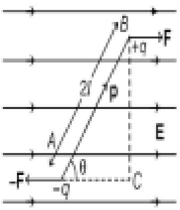
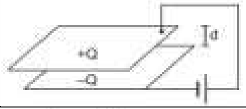
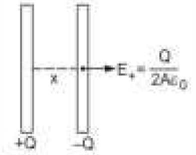
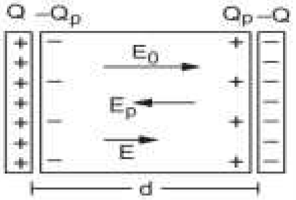
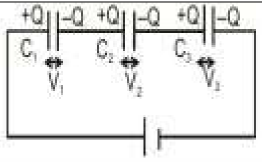
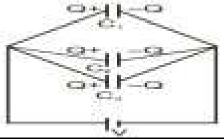
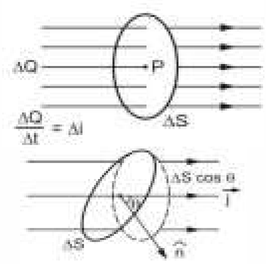
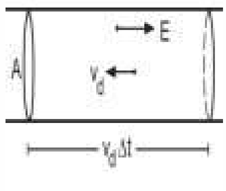
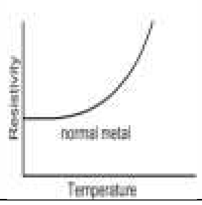
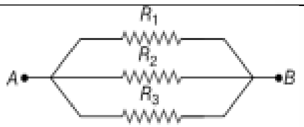
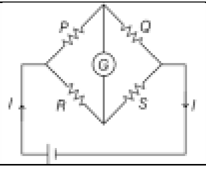
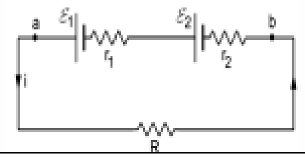
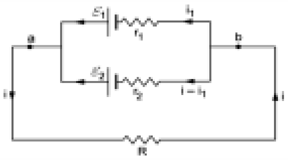
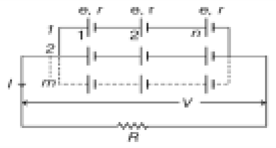
	Charged ring	$E_{axis} = \frac{KQx}{(R^2+x^2)^{3/2}}$	$V_{axis} = \frac{KQ}{\sqrt{R^2+x^2}}$	
	Conducting sheet	$\frac{\sigma}{\varepsilon_0}\hat{n}$	$V_B - V_A = -\frac{\sigma}{\varepsilon_0}(r_B - r_A)$	
	Hollow conducting/ non-conducting /solid conducting sphere	$\vec{E} = \frac{kQ}{\lvert \vec{r} \rvert^2}\hat{r}$	$V = \frac{KQ}{r}$	
		$\vec{E} = 0$	$V = \frac{KQ}{R}$	
Electrostatic potential energy	$U = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r}$			Negative for opposite charges and positive for similarcharges.
Energy Density	$\frac{1}{2}\varepsilon E^2$			E=Electric field due to any configuration.
Dipole	Axial point	$\vec{E} = \frac{2K\vec{P}}{r^3}$	$V = \frac{1}{4\pi\varepsilon_0}\frac{p}{r^2}$	
	Equtorial point	$\vec{E} = -\frac{K\vec{P}}{r^3}$	Zero	
	General point	$E_{res} = \frac{KP}{r^3}\sqrt{1+3\cos^2\theta}$	$V = \frac{P\cos\theta}{4\pi\varepsilon_0 r^2}$	
	Potential Energy	$U = -\vec{p}.\vec{E}$		Dipole placed in the direction of electric field=P.E becomes minimum=stable equilibrium Dipole placed in opposite direction of electric field=P.E becomes maximum=stable equilibrium

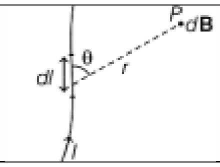
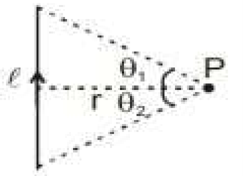
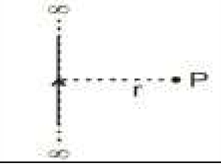
	Torque	$\vec{\tau} = \vec{p} \times \vec{E}$	
Capacitance		$C = \frac{q}{V}$	C is independent of charge and voltage.
Energy stored		$U = \frac{1}{2}CV^2 = \frac{Q^2}{2C} = \frac{QV}{2}$	During charging a capacitor half of the supplied energy is dissipated as heat.
Parallel plate capacitor		$C = \frac{KA\varepsilon_0}{d}$ K- dielectric constant of the material	
Force experienced by any plate		$F = \frac{Q^2}{2A\varepsilon_0}$	
Capacitance of an Isolated Spherical Conductor		C=4πε₀R	R-radius of the conductor
Capacitor with dielectric		$C = \frac{A\varepsilon_0}{\left(d - t + \frac{t}{K}\right)}$ Bound charge= $Q_p = Q\left(1 - \frac{1}{K}\right)$	
Capacitor with metal sheet		$C = \frac{A\varepsilon_0}{(d - t)}$	t=thickness of metalsheet d= separation between the plates A=area of crossection of the plates
Series Combination		$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$ $V_1 : V_2 : V_3 = \frac{1}{C_1} : \frac{1}{C_2} : \frac{1}{C_3}$ $V = V_1 + V_2 + V_3 + \ldots$	
Parallel Combination		$C_{eq} = C_1 + C_2 + C_3$ $Q_1 : Q_2 : Q_3 = C_1 : C_2 : C_3$ $q = q_1 + q_2 + q_3 + \ldots$	
Charges on connecting two charged capacitors		$V = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}$ $Q_1' = C_1V = \frac{C_1}{C_1 + C_2}(Q_1 + Q_2)$ $Q_2' = C_2V = \frac{C_2}{C_1 + C_2}(Q_1 + Q_2)$	Heat loss= $\Delta H = U_i - U_f$ $= \frac{1}{2}\frac{C_1C_2}{C_1 + C_2}(V_1 - V_2)^2$

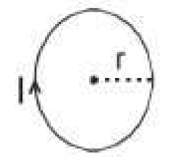
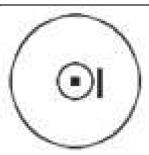
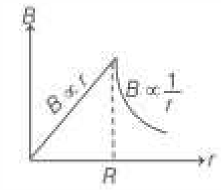
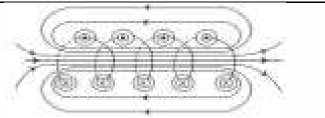
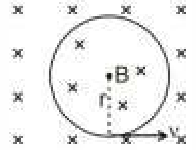
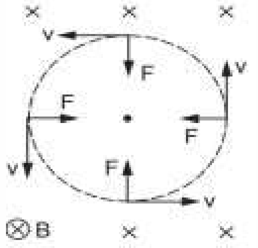
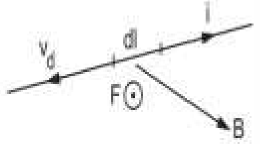
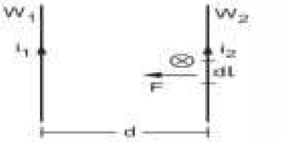
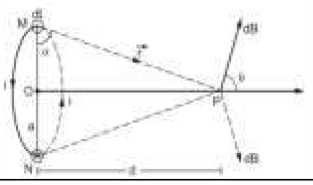
CURRENT ELECTRICITY

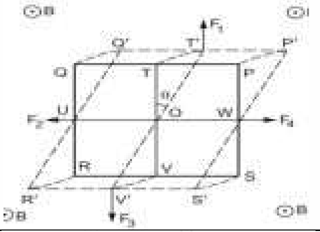
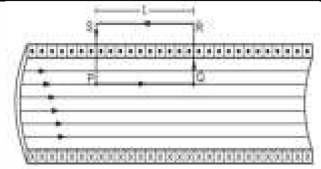
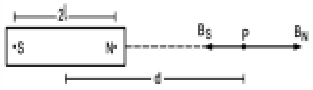
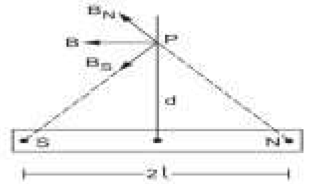
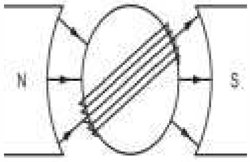
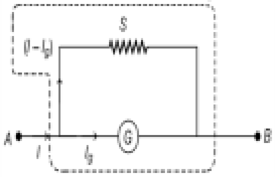
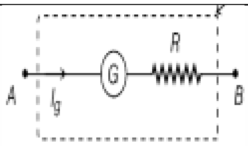
Electric current&Current Density	$i = \lim_{\Delta t \to 0} \frac{\Delta Q}{\Delta t} = \frac{dQ}{dt}$ $j = \frac{\Delta i}{\Delta S \cos\theta}$		
Electric current in a conductor	$I = neAV_d$	$(J) = \frac{I}{A} = nev_d$	
Drift Velocity& mobility	$v_d = \frac{eE\tau}{m} = \frac{eV\tau}{ml}$	$(\mu) = \frac{v_d}{E} = \frac{e\tau}{m}$	
Ohm's Law	$V = IR$ $R = \frac{ml}{Ane^2\tau}$		Resistance is the property of a conductor it depends on length, area of cross-section, temperature of the conductor. Resistivity is the property of the material of a conductor. It depends on temperature of the material.
Dependence of Resistance on Temperature	$R = R_o(1 + \alpha\theta)$		
Resistances in Series	$R = R_1 + R_2 + R_3$		
Resistances in Parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$		
Kirchhoff's laws	Kirchhoff's Current Law (Junction law) $\Sigma I = 0$		Based on Conservation of charge.
	Kirchhoff's Voltage Law (Loop law) $\Sigma IR + \Sigma EMF = 0$		Based on Conservation of energy.
Wheatstone network	$\frac{P}{Q} = \frac{R}{S}$		
EMF, Terminal voltage & internal resistance	Open circuit $E=V_T$,I=0		

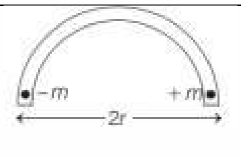
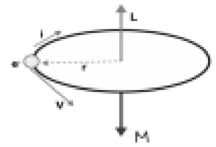
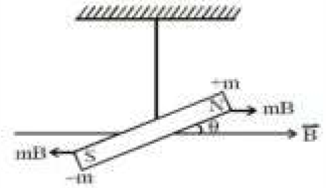
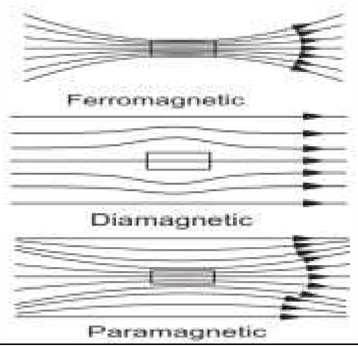
	Discharging circuit $E=V_T+Ir$	
	Charging circuit $E=V_T-Ir$	
Cells in Series	$E_{eq}=E_1+E_2+\dots\dots+E_n$ $r_{eq}=r_1+r_2+r_3$	
Cells in Parallel	$E_{eq}=\frac{\frac{\varepsilon_1}{r_1}+\frac{\varepsilon_2}{r_2}+\dots+\frac{\varepsilon_n}{r_n}}{\frac{1}{r_1}+\frac{1}{r_2}+\dots+\frac{1}{r_n}}$ $\frac{1}{r_{eq}}=\frac{1}{r_1}+\frac{1}{r_2}+\dots$	
Mixed Grouping of Cells	$I=\frac{mne}{mR+nr}$ Current in this circuit will be maximum when external resistance is equal to the equivalent internal resistance, $R=\frac{nr}{m}$	
Electric power and heat	**P=VI** $P=I^2R$ $=\frac{V^2}{R}$ $H=VIt=I^2Rt$	**H=Pt** H=heat dissipated I=current V=voltage R=resistance T=time

MAGNETIC EFFECT OF CURRENT

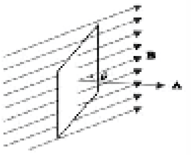
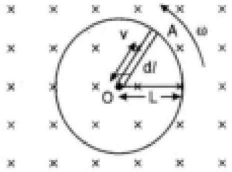
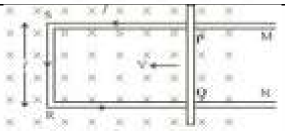
Biot-savart's Law	$\vec{dB}=\frac{\mu_0 I}{4\pi}\cdot\left(\frac{\vec{d\ell}\times\vec{r}}{r^3}\right)$	
Magnetic field due to a moving point charge	$\vec{B}=\frac{\mu_0}{4\pi}\cdot\frac{q(\vec{v}\times\vec{r})}{r^3}$	-
Magnetic field due to a straight wire	$B=\frac{\mu_0}{4\pi}\ \frac{I}{r}\ (\sin\theta_1+\sin\theta_2)$	
Magnetic field due to infinite straight wire	$B=\frac{\mu_0}{2\pi}\ \frac{I}{r}$	

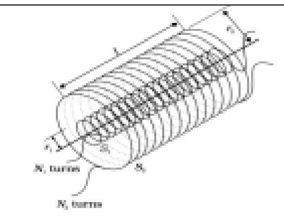
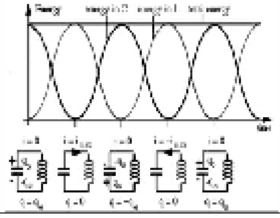
Magnetic field at the centre of a circular loop	$B = \frac{\mu_0 NI}{2r}$	
Ampere's Law	$\oint \vec{B}.d\vec{\ell} = \mu_0 I$	
Magnetic Field Due to a Current Carrying Long Circular Cylindrical Wire	Outside the wire $B = \frac{\mu_0}{2\pi} \frac{I}{r}$	
	Inside the wire $B = \frac{\mu_0}{2\pi} \frac{Ir}{R^2}$	
Solenoid	$B = \mu_0 nI$	
Magnetic force acting on a moving point charge	$\vec{F} = q(\vec{v} \times \vec{B})$ $r = \frac{mv}{qB}$ $T = \frac{2\pi m}{qB}$	
Lorentz force and motion of chargedparticle	$\vec{F} = q\vec{v} \times \vec{B}.$ $r = \frac{mv}{qB}$ $T = \frac{2\pi r}{v} = \frac{2\pi m}{qB}$	
Magnetic force acting on a current carrying wire	$\vec{F} = I(\vec{\ell} \times \vec{B})$	
Force between two long parallel.	$F = \frac{\mu_0}{2\pi} \cdot \frac{I_1 I_2}{r} l$	
Magnetic field due to a coil	At an axial pont: $\frac{\mu_0 ia^2}{2(a^2 + d^2)^{3/2}}$	

<table>
<tr><td>Torque acting on a loop</td><td colspan="2">$\vec{\tau} = \vec{M} \times \vec{B}$</td><td>
</td></tr>
<tr><td>Solenoid</td><td colspan="2">$B = \mu_0 ni$</td><td>
</td></tr>
<tr><td rowspan="2">Magnetic field due to a bar magnet</td><td>Axial point
$B = \frac{\mu_0}{4\pi} \cdot \frac{2M}{r^3}$</td><td>Equatorial line
$B = \frac{\mu_0}{4\pi} \cdot \frac{M}{r^3}$</td><td>
</td></tr>
<tr><td colspan="2">At a general point
$B = \frac{\mu_0}{4\pi} \frac{M}{r^3} \sqrt{1+3\cos^2\theta}$</td><td>
</td></tr>
<tr><td rowspan="2">Moving Coil Galvanometer</td><td colspan="2">$NBIA = k\theta$</td><td rowspan="2">
</td></tr>
<tr><td>Current sensetivity
$\frac{\theta}{I} = \frac{NBA}{k}$</td><td>Voltage sensetevity
$\frac{\theta}{V} = \frac{NBA}{kr}$</td></tr>
<tr><td rowspan="2">Conversion of galvanometer</td><td colspan="2">Into a ammeter(connecting a small resistance in parallel with the galvanometer)
$I_g \times G = (I - I_g) \times S$</td><td>
</td></tr>
<tr><td colspan="2">Into a voltmeter(connecting a high resistance in series with the galvanometer)
$V = I_g\ (G + R)$</td><td>
</td></tr>
<tr><td rowspan="2">Bar magnet</td><td colspan="2">Cut into two equal pieces such that the length of each piece becomes half
$M' = m \cdot \frac{2l}{2} = \frac{M}{2}$</td><td rowspan="2">Pole strength is directly proportional to area of cross sectionof the bar magnet.</td></tr>
<tr><td colspan="2">cut into two equal pieces such that the width of each piece becomes half
$M' = \left(\frac{m}{2}\right)(2l) = \frac{M}{2}$</td></tr>
</table>

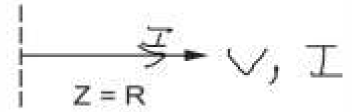
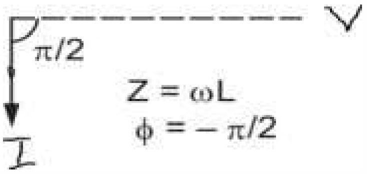
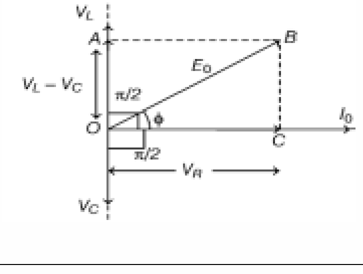
	If bar magnet is bent in the form of semi-circle $M' = m(2r)[\because 2l = \pi r]$ $M' = m \times 2\left(\frac{2l}{\pi}\right) = \frac{2M}{\pi}$	
Magnetic moment associated with the revolving electron	**M=$\frac{evr}{2}$** $\mathbf{M} = -\left(\frac{e}{2m_e}\right)\mathbf{L}$ $M = n\frac{eh}{4\pi m}$	
Oscillations of a Freely Suspended Magnet	$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{I}{MB}}$	
Magnetic materials	Permeability $(\mu) =$ Magnetisation $(\mathbf{I}) = \frac{\mathbf{M}}{V} = \frac{m}{A}$ Suceptibility $(\chi_m$ Relation between suceptibility and permeabilty $\mu = \mu_0(1+\chi_m)$	

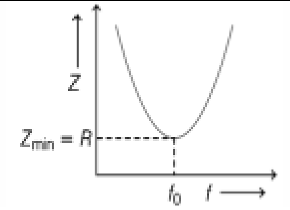
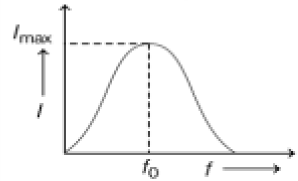
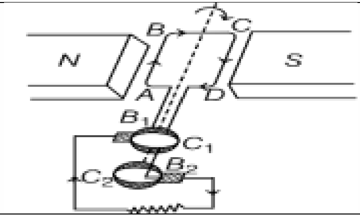
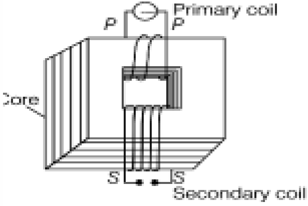
ELECTROMAGNETIC INDUCTION

Magnetic flux	$\Phi = \mathbf{B} \cdot \mathbf{A} = BA\cos\theta$	
Gauss's Law in Magnetism	$\oint_S \mathbf{B} \cdot d\mathbf{S} = 0$	B=magnetic field. **S**=area vector - Monopoles do not exis.
Faraday's law	$e = -\frac{d\phi}{dt}$	Induced charge is independent of time
Induced emf due to rotation	$e = \frac{1}{2}B\omega l^2$	
Motional Emf	$e = Bvl$	
Self-inductance of a long solenoid	$\phi = Li$ $L = \frac{\mu_0 N^2 A}{l} = \mu_0 n^2 Al$	Self-inductance is called electrical inertia.

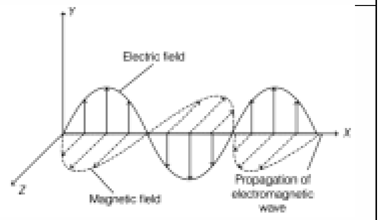
Mutual Inductance	$M = \frac{\mu_0 N_1 N_2 A}{l} = \mu_0 n_1 n_2 A l$ $= \mu_0 n_1 n_2 \pi r_1^2 l$	
LC Oscillations	$\omega^2 = \frac{1}{LC}$ ω=angular freqency of the LC oscillation	

ALTERNATING CURRENT

Mean and rms value	$I_m = \frac{2I_0}{\pi}$ $I_{rms} = \frac{I_0}{\sqrt{2}}$	$\overline{i^2} = \frac{\int_0^T i^2\, dt}{\int_0^T dt}$ $i_{rms} = \sqrt{\overline{i^2}}$
Power in AC	$V_{rms}\, I_{rms} \cos\phi$	Cos ϕ is called Power factor
Purely resistive Circuit	$= I_m \sin \omega t$ $\langle P \rangle = V_{rms} I_{rms} \cos \phi$	 $Z = R$ $\phi = 0$
Purely capacitivecircuit	$I = \ = \frac{V_m}{1/\omega C} \cos \omega t$ $\langle P \rangle = V_{rms}\ I_{rms} \cos \phi = 0$	 $Z = 1/\omega C$ $\phi = \pi/2$
Purely inductive Circuit	$I = I_0 \sin(\omega t - \pi/2)$ $\langle P \rangle = V_{rms}\ I_{rms} \cos \phi = 0$	 $Z = \omega L$ $\phi = -\pi/2$
Series LCR	$I = I_0 \sin(\omega t \pm \phi)$ $V = \sqrt{V_R^2 + (V_L - V_C)^2}$ $Z = \sqrt{R^2 + (X_L - X_C)^2}$ $\cos \theta = \frac{R}{Z}$	

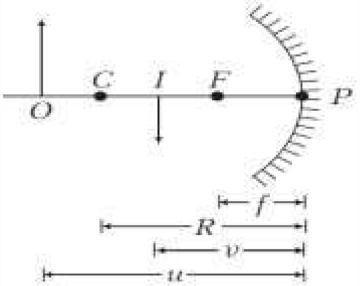
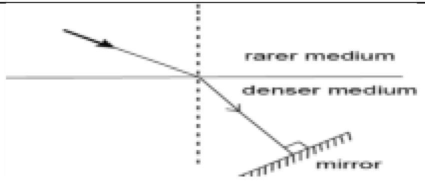
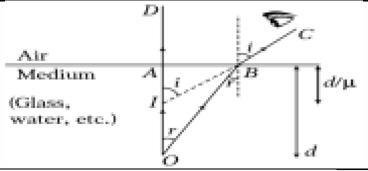
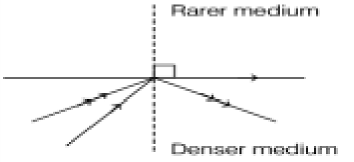
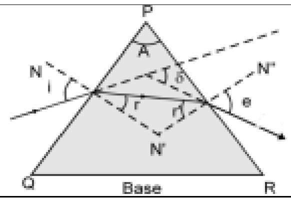
	At resonance, $X_L = X_C$ Resonance frequency $f = \frac{1}{2\pi\sqrt{LC}}$	 
AC Generator	$e = NBA\omega \sin \omega t$	
Transformer	Transformation ratio $\frac{N_S}{N_P} = \frac{E_S}{E_P} = \frac{I_P}{I_S}$	

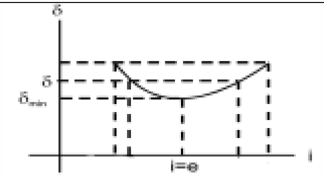
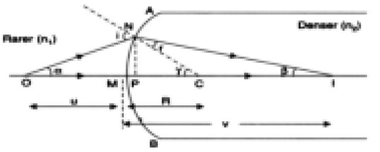
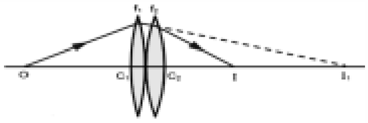
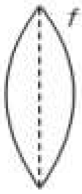
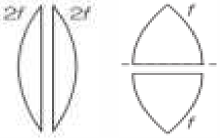
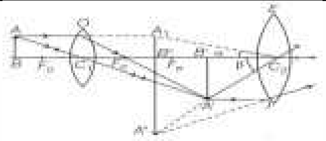
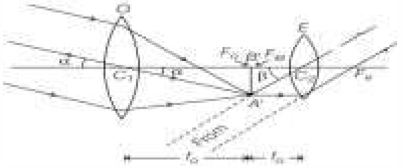
ELECTROMAGNETIC WAVES

Displacement Current	$I_D = \varepsilon_0 \cdot \frac{d\phi_E}{dt}$	When displacement current is taken then conduction current becomes zero and vice versa.
Maxwell's Equations	$\oint_S \mathbf{E} \cdot d\mathbf{S} = \frac{q}{\varepsilon_0}$ $\oint_S \mathbf{B} \cdot d\mathbf{S} = 0$ $\oint_S \mathbf{E} \cdot d\mathbf{l} = -\frac{d\phi_B}{dt}$ $\oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 (I_C + I_D)$	Gauss's law in electrostatics Gauss's law in magnetism Faraday's law Modified Amperes law
Electromagnetic Waves	✓ EM wave propagating along positive X axis: ✓ $E = E_0 \sin \omega\left(t - \frac{x}{c}\right)$ ✓ $B = B_0 \sin \omega\left(t - \frac{x}{c}\right)$ ✓ $c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$ ✓ $c = \frac{E_0}{B_0}$ ✓ Poynting vector: (Direction of EM wave propagation) $\mathbf{S} = \frac{1}{\mu_0}(\mathbf{E} \times \mathbf{B})$ ✓ Intensity:	 ✓ Poynting vector represents the direction of EM wavepropagation ✓ Energy is equally shared between electric and magnetic fields. ✓ Average energy

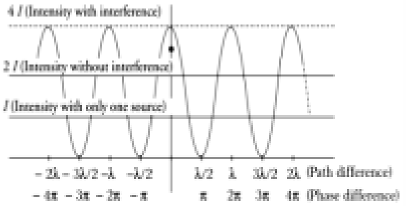
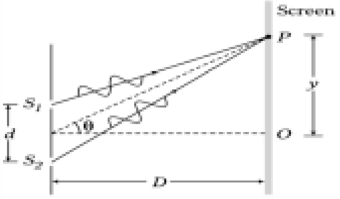
	$$I = \langle u \rangle c = \frac{1}{2}\varepsilon_0 E_0^2 c$$ ✓ Linear momentum $$p = \frac{U}{c}$$ ✓ Magnitude of the total momentum delivered:(complete absorption) $$= \frac{U}{c}$$ ✓ Magnitude of the total momentum delivered:(complete absorption) $$p = \frac{2U}{c}$$	density=$\langle u_E \rangle = \langle u_B \rangle = \frac{1}{4}\varepsilon_0 E_0^2$ ✓ Total energy density=$\langle u \rangle = \frac{1}{2}\varepsilon_0 E_0^2$ ✓ $U = \langle u \rangle$.volume

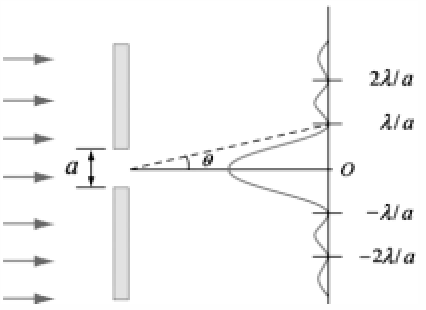
GEOMETRICAL OPTICS

Spherical Mirror	$$\frac{1}{v} + \frac{1}{u} = \frac{2}{R} = \frac{1}{f}$$ $$m = \frac{h_2}{h_1}$$ $$m = -\frac{v}{u}$$ Image and object speed $$\frac{dv}{dt} = -\frac{v^2}{u^2}\frac{du}{dt}$$	
Snell's Law	Refracted index= $\frac{c}{v}$ $$\frac{\text{Sin } i}{\text{Sin } r} = \frac{n_2}{n_1}$$	$\frac{n_2}{n_1}$= refractive index of medium 2 w.r.t. medium 1
Principle of Reversibility of Light Rays	A ray travelling along the path of the reflected ray is reflected along the path of the incident ray. A refracted ray reversed to travel back along its path will get refracted along the path of the incident ray	
Apparent Depth	$$d' = \frac{d}{\mu}$$	
Critical Angle and Total Internal Reflection	$$C = \sin^{-1}\frac{n_r}{n_d}$$ (a) Light is incident on the interface from denser medium. (b) Angle of incidence should be greater than the critical angle	
Refraction Through Prism	$$r_1 + r_2 = A$$ $$\delta = i + e - A.$$ ✓ When $\delta = \delta_{min}$, the angle of minimum deviation, then i = e and $r_1 = r_2$	

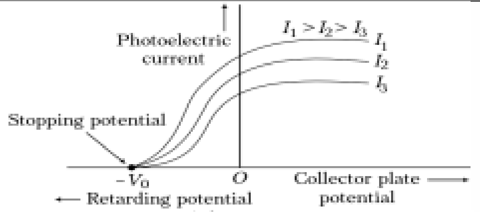
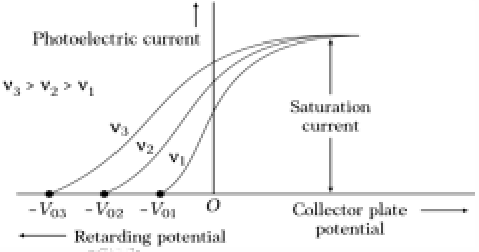
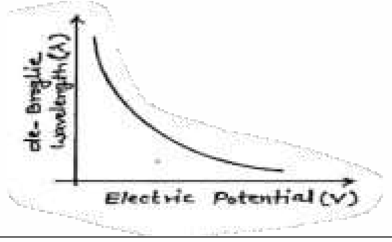
		$n_{rel} = \dfrac{\sin\left[\dfrac{A+\delta_m}{2}\right]}{\sin\left[\dfrac{A}{2}\right]}$ ✓ ✓ For a thin prism (A ≤10°) $\delta = (n_{rel} - 1)A$	
Refraction at Spherical Surfaces & lens makers formula		$\dfrac{n_2}{v} - \dfrac{n_1}{u} = \dfrac{n_2 - n_1}{R}$ $\dfrac{1}{f} = (n_{rel} - 1)\left(\dfrac{1}{R_1} - \dfrac{1}{R_2}\right)$	
Focal Length of a Lens Combination		$\dfrac{1}{F} = \dfrac{1}{f_1} + \dfrac{1}{f_2}$	
Cutting of a Lens			
Optical instrument	Compound microscope	$M_\infty = \dfrac{V_0 D}{U_0 f_e}$	
		$M_D = \dfrac{V_0}{U_0}\left(1 + \dfrac{D}{f_e}\right)$	
	Telescope	$M_\infty = \dfrac{f_0}{f_e}$	
		$M_D = \dfrac{f_0}{f_e}\left(1 + \dfrac{f_e}{D}\right)$	

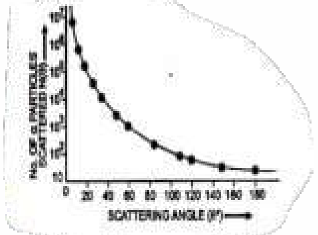
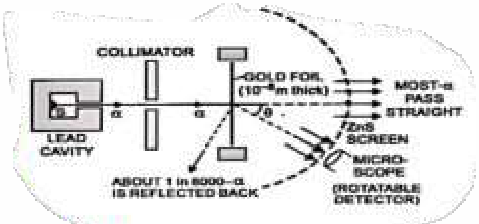
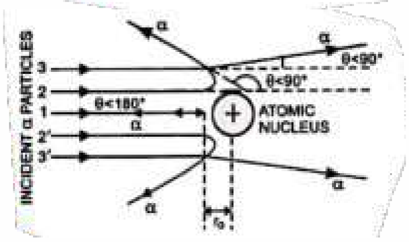
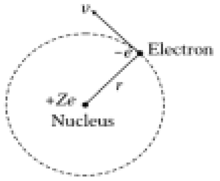
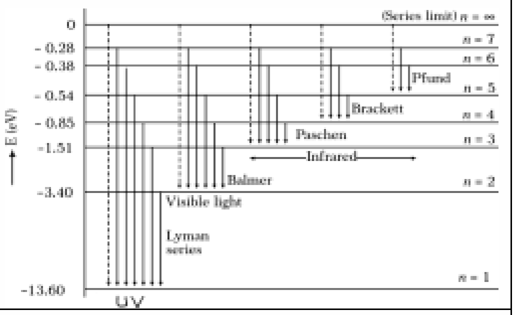
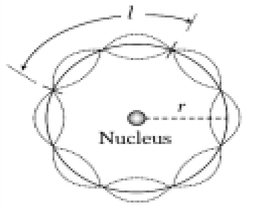
WAVE OPTICS

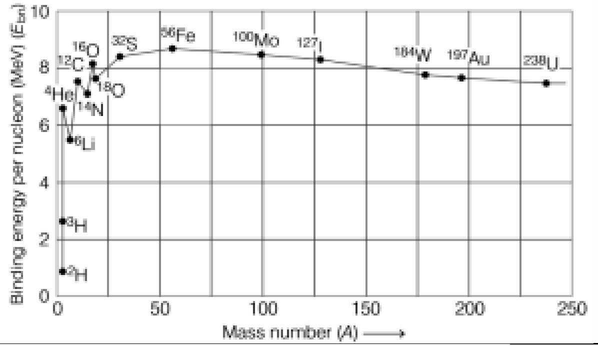
Resultant intensity	$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos(\Delta\phi)$ $I_1 = I_2,\ I = 4I_1\cos^2\left(\dfrac{\Delta\phi}{2}\right)$ Incoherent sources $I = I_1 + I_2$		
	Constructive Interference $I_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2$	Destructive interference $I_{min} = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2$	
YDSE	Path difference $\Delta p = S_2P - S_1P$ $= d\sin\theta$	Fringe width β $\beta = \dfrac{\lambda D}{d}$	
	Highest order maxima $n_{max} = \left[\dfrac{d}{\lambda}\right]$ Total number of maxima $= 2n_{max} + 1$	Highest order minima $n_{max} = \left[\dfrac{d}{\lambda} + \dfrac{1}{2}\right]$ Total number of minima $= 2n_{max}$	

	Position of bright fringe= $y_{\text{bright}} = \frac{n\lambda}{d} D$	Position of dark fringe= $y_{\text{dark}} = \frac{(2n-1)\lambda D}{2d}$	
	Nearest point to central maxima where the bright fringes coincide: $y = n_1\beta_1 = n_2\beta_2$		
Diffraction	For maxima $a\sin\theta=(2n+1)\frac{\lambda}{2}$	For minima $a\sin\theta=n\lambda$	
	Linear width of central maxima $\frac{2D\lambda}{a}$ Linear width of any other secondary maxima $\frac{D\lambda}{a}$	Angular width of central maxima $\frac{2\lambda}{a}$ angular width of any other secondary maxima $\frac{\lambda}{a}$	
	No. of interference fringes inside diffraction maxima $= \frac{2d}{a}$ d= distance between two slits a=width of each slit		
Fresnel's Distance	$Z_F = \frac{a^2}{\lambda}$		Ray optics is valid up to this distance ignoring broadening oflight beam due to diffraction.

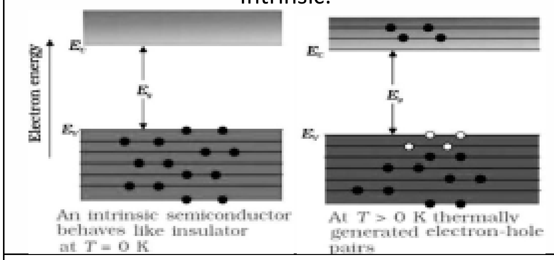
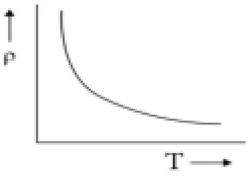
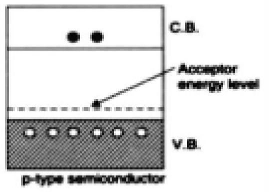
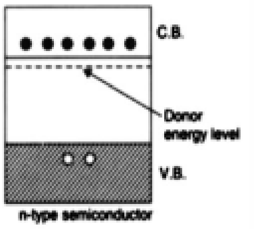
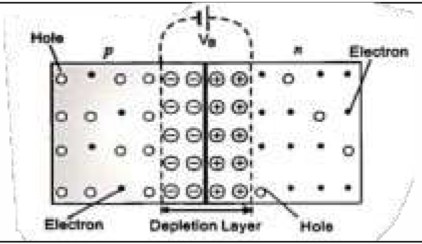
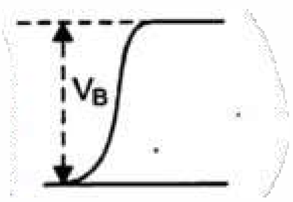
MODERN PHYSICS

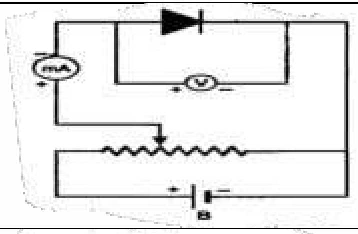
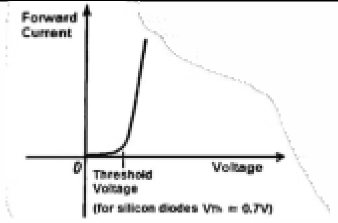
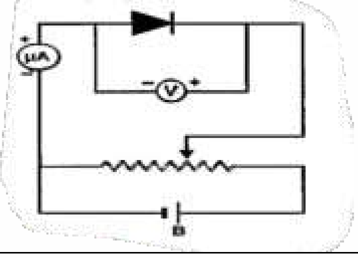
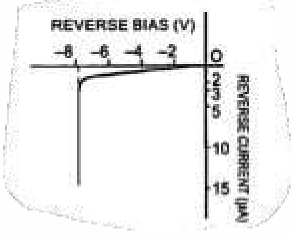
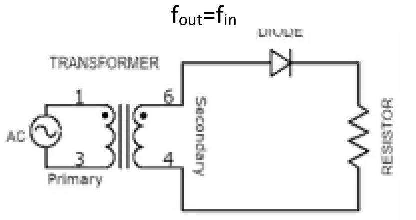
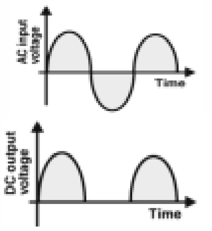
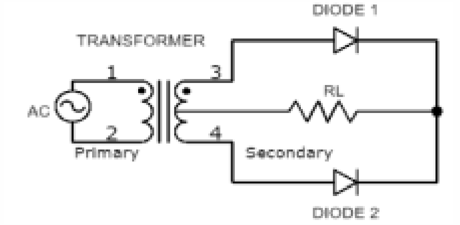
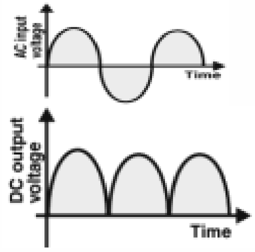
Photoelectric effect	✓ Work function $W = h\nu_0$ ✓ Photoelectric current is directly proportional to intensity of incident radiation. (ν – constant) ✓ Photoelectrons ejected from metal have kinetic energies ranging from 0 to KE_{max} ✓ Stopping potential is independent of intensity of light used (ν-constant) ✓ Einstein equation for photoelectric effect $h\nu = w_0 + k_{max}$ ✓ De Broglie wavelength: $\lambda = \frac{h}{mv}$ $= \frac{h}{\sqrt{2mKE}}$	  

<table>
<tr><td>Rutherford expt.</td><td colspan="2">
Impact Parameter (b)
$\boxed{b = \frac{1}{4\pi\epsilon_0}\frac{Ze^2 \cot\theta/2}{K.E.}}$
Distance of Closest Approach
$\boxed{r_0 = \frac{Ze \times 2e}{4\pi\epsilon_0\left(\frac{1}{2}mv^2\right)}}$</td><td>
 </td></tr>
<tr><td rowspan="3">Radius, Energy and speed of electron in hydrogen like atoms.</td><td>$r_n = \frac{n^2}{Z} a_0$</td><td>$a_0 = 0.529$ Å</td><td rowspan="3"> </td></tr>
<tr><td>$v_n = \frac{Z}{n} v_0$</td><td>$v_0 = 2.19 \times 10^6$ m/s</td></tr>
<tr><td>$E_n = E_1 \cdot \frac{Z^2}{n^2}$</td><td>$E_1 = -13.6$ eV</td></tr>
<tr><td>Wavelength corresponding to spectral lines</td><td colspan="2">$\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$
• Total number of possible transitions= $\frac{n(n-1)}{2}$</td><td>n_1= level of a lower energy orbit
n_2= level of a higher energy orbit
 </td></tr>
<tr><td>Moseley's Law</td><td colspan="2">$\sqrt{v} = a(z-b)$</td><td>Not valid for H atom</td></tr>
<tr><td>De-Broglie explanation of Bohr's second postulate of quantisation</td><td colspan="2">$2\pi r_n = n\lambda$</td><td> </td></tr>
<tr><td>Minimum wavelength for x-rays</td><td colspan="2">$\lambda_{min} = \frac{hc}{eV_0} = \frac{12400}{V_0(\text{volt})}$ Å</td><td>V_0-accelerating potential</td></tr>
<tr><td>Nuclear Physics</td><td colspan="2">✓ $R = R_0 A^{1/3}$
✓ Nuclear density is independent of mass no.
✓ Mass Energy Relation $E = mc^2$</td><td>R-radius of nucleus
R_0-radius of hydrogen nucleus
A-mass no.</td></tr>
</table>

	$E_b = [Zm_p + (A-Z)\,m_n - m_N]c^2$	
Binding Energy Curve		
Nuclear Fission	${}_{92}U^{235} + {}_{0}n^{1} \longrightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} + 3\,{}_{0}n^{1} + \text{energy}$	
Nuclear Fusion	${}_{1}H^{2} + {}_{1}H^{2} + {}_{1}H^{2} \longrightarrow {}_{2}He^{4} + {}_{1}H^{1} + {}_{0}n^{1} + 21.6\text{ MeV}$	

SEMICONDUCTORS

Intrinsic and extrinsic	Intrinsic:  An intrinsic semiconductor behaves like insulator at T = 0 K At T > 0 K thermally generated electron-hole pairs	$n_e=n_h=n_i$ 
	Extrinsic: p type 	$n_e.n_h=n_i^2$
	Extrinsic: n type 	
p-n diode		

Forward bias		
Reverse bias		
Rectifier	Half-wave: $f_{out}=f_{in}$ 	
	Full-wave: $f_{out}=2f_{in}$ 	

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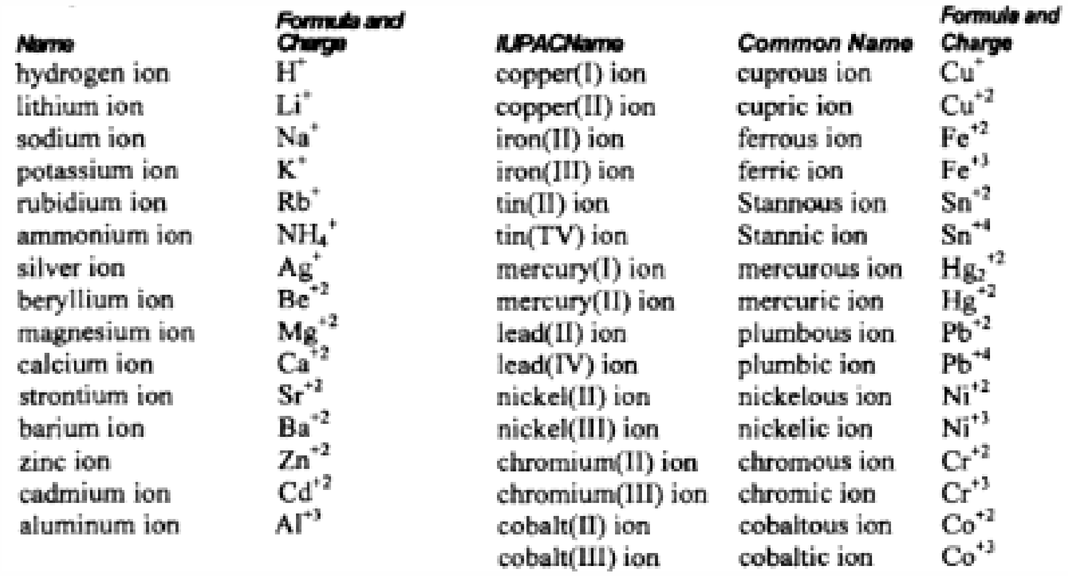
Chemistry

Cations are positively-charged ions (atoms or groups of atoms that have more protons than electrons due to having lost one or more electrons). Anions are negatively-charged ions (meaning they have more electrons than protons due to having gained one or more electrons).

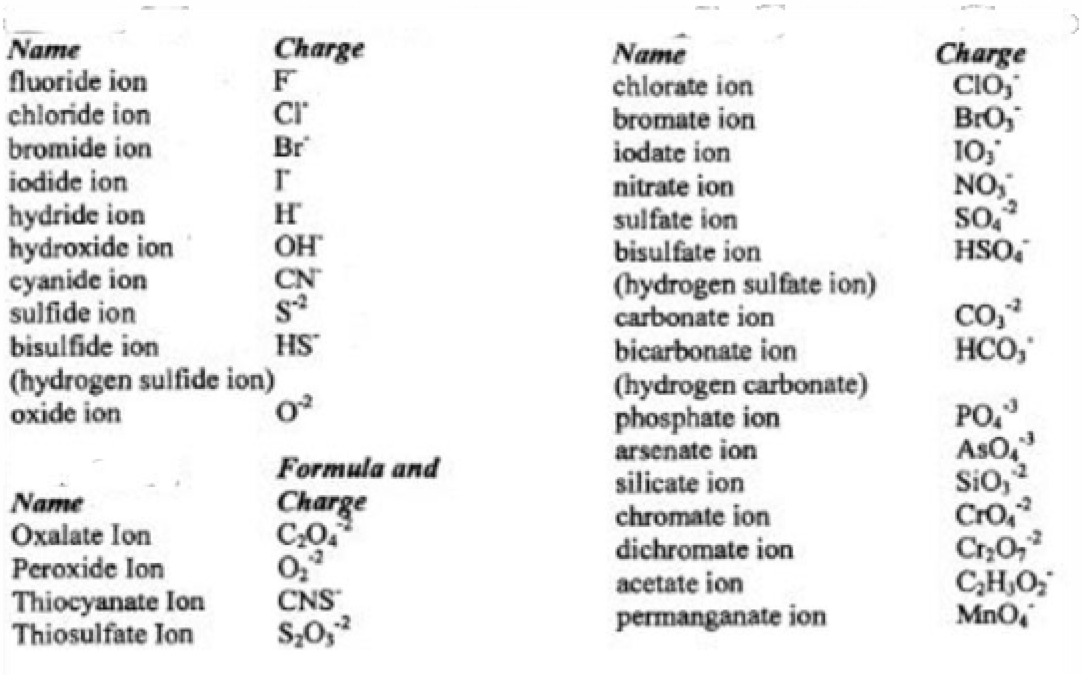
Cations



Name	Formula and Charge
hydrogen ion	H^+
lithium ion	Li^+
sodium ion	Na^+
potassium ion	K^+
rubidium ion	Rb^+
ammonium ion	NH_4^+
silver ion	Ag^+
beryllium ion	Be^{+2}
magnesium ion	Mg^{+2}
calcium ion	Ca^{+2}
strontium ion	Sr^{+2}
barium ion	Ba^{+2}
zinc ion	Zn^{+2}
cadmium ion	Cd^{+2}
aluminum ion	Al^{+3}

IUPACName	Common Name	Formula and Charge
copper(I) ion	cuprous ion	Cu^+
copper(II) ion	cupric ion	Cu^{+2}
iron(II) ion	ferrous ion	Fe^{+2}
iron(III) ion	ferric ion	Fe^{+3}
tin(II) ion	Stannous ion	Sn^{+2}
tin(TV) ion	Stannic ion	Sn^{+4}
mercury(I) ion	mercurous ion	Hg_2^{+2}
mercury(II) ion	mercuric ion	Hg^{+2}
lead(II) ion	plumbous ion	Pb^{+2}
lead(IV) ion	plumbic ion	Pb^{+4}
nickel(II) ion	nickelous ion	Ni^{+2}
nickel(III) ion	nickelic ion	Ni^{+3}
chromium(II) ion	chromous ion	Cr^{+2}
chromium(III) ion	chromic ion	Cr^{+3}
cobalt(II) ion	cobaltous ion	Co^{+2}
cobalt(III) ion	cobaltic ion	Co^{+3}

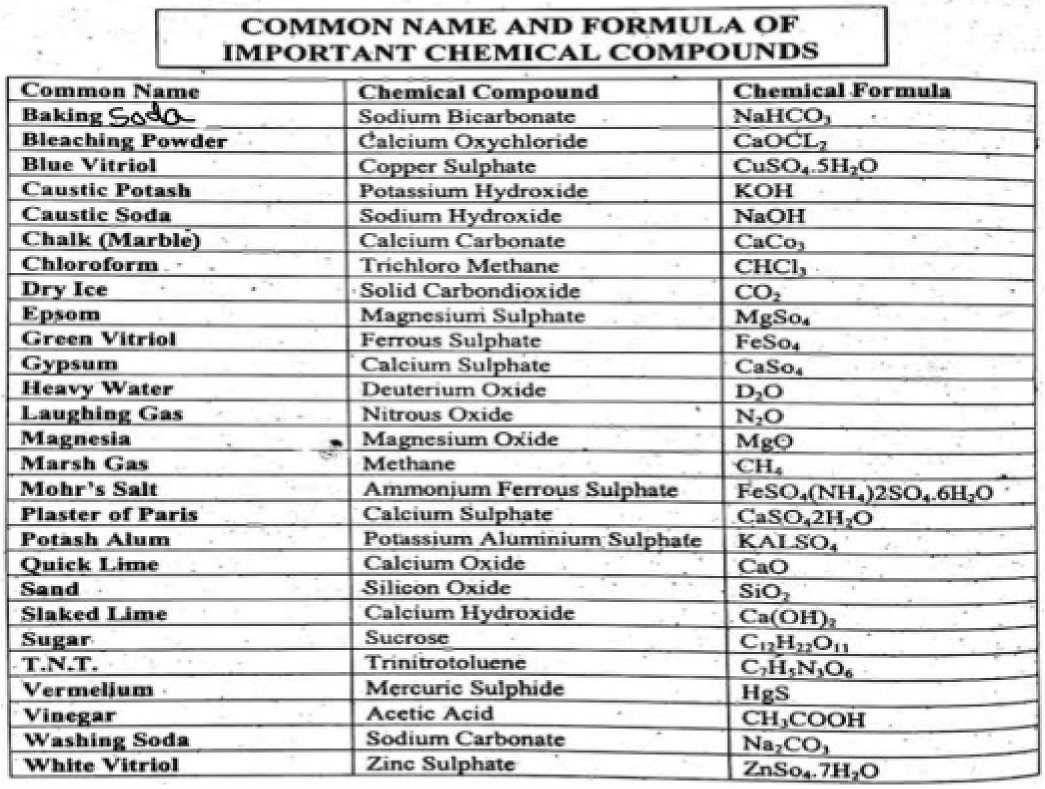
Anions



Name	*Charge*
fluoride ion	F^-
chloride ion	Cl^-
bromide ion	Br^-
iodide ion	I^-
hydride ion	H^-
hydroxide ion	OH^-
cyanide ion	CN^-
sulfide ion	S^{-2}
bisulfide ion (hydrogen sulfide ion)	HS^-
oxide ion	O^{-2}

Name	*Formula and Charge*
Oxalate Ion	$C_2O_4^{-2}$
Peroxide Ion	O_2^{-2}
Thiocyanate Ion	CNS^-
Thiosulfate Ion	$S_2O_3^{-2}$

Name	*Charge*
chlorate ion	ClO_3^-
bromate ion	BrO_3^-
iodate ion	IO_3^-
nitrate ion	NO_3^-
sulfate ion	SO_4^{-2}
bisulfate ion (hydrogen sulfate ion)	HSO_4^-
carbonate ion	CO_3^{-2}
bicarbonate ion (hydrogen carbonate)	HCO_3^-
phosphate ion	PO_4^{-3}
arsenate ion	AsO_4^{-3}
silicate ion	SiO_3^{-2}
chromate ion	CrO_4^{-2}
dichromate ion	$Cr_2O_7^{-2}$
acetate ion	$C_2H_3O_2^-$
permanganate ion	MnO_4^-

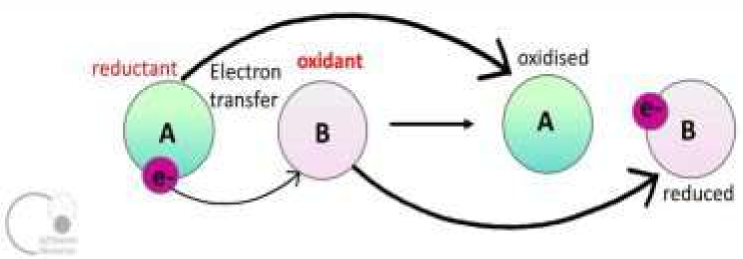


COMMON NAME AND FORMULA OF IMPORTANT CHEMICAL COMPOUNDS

Common Name	Chemical Compound	Chemical Formula
Baking Soda	Sodium Bicarbonate	$NaHCO_3$
Bleaching Powder	Calcium Oxychloride	$CaOCL_2$
Blue Vitriol	Copper Sulphate	$CuSO_4.5H_2O$
Caustic Potash	Potassium Hydroxide	KOH
Caustic Soda	Sodium Hydroxide	NaOH
Chalk (Marble)	Calcium Carbonate	$CaCo_3$
Chloroform	Trichloro Methane	$CHCl_3$
Dry Ice	Solid Carbondioxide	CO_2
Epsom	Magnesium Sulphate	$MgSo_4$
Green Vitriol	Ferrous Sulphate	$FeSo_4$
Gypsum	Calcium Sulphate	$CaSo_4$
Heavy Water	Deuterium Oxide	D_2O
Laughing Gas	Nitrous Oxide	N_2O
Magnesia	Magnesium Oxide	MgO
Marsh Gas	Methane	CH_4
Mohr's Salt	Ammonium Ferrous Sulphate	$FeSO_4(NH_4)2SO_4.6H_2O$
Plaster of Paris	Calcium Sulphate	$CaSO_42H_2O$
Potash Alum	Potassium Aluminium Sulphate	$KALSO_4$
Quick Lime	Calcium Oxide	CaO
Sand	Silicon Oxide	SiO_2
Slaked Lime	Calcium Hydroxide	$Ca(OH)_2$
Sugar	Sucrose	$C_{12}H_{22}O_{11}$
T.N.T.	Trinitrotoluene	$C_7H_5N_3O_6$
Vermelium	Mercuric Sulphide	HgS
Vinegar	Acetic Acid	CH_3COOH
Washing Soda	Sodium Carbonate	Na_2CO_3
White Vitriol	Zinc Sulphate	$ZnSo_4.7H_2O$

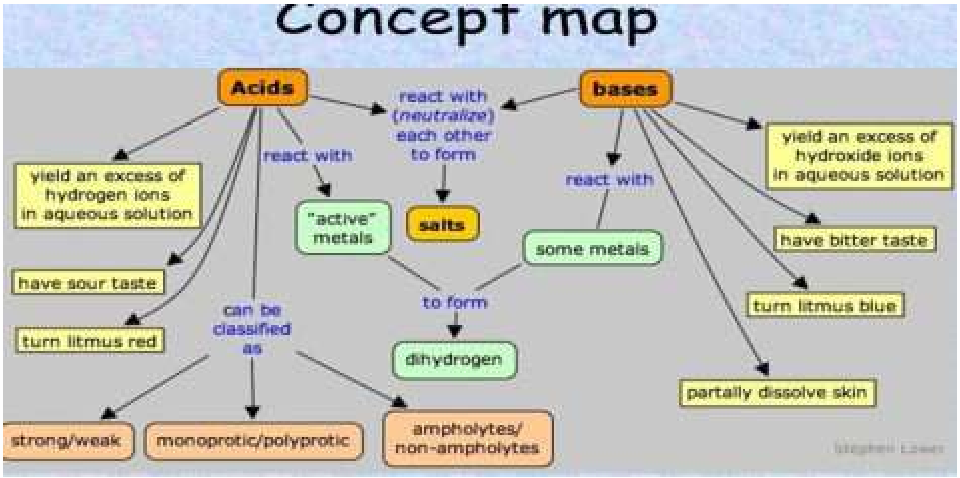
Atomic Number	Name of the Element	Electronic Configuration (subshell wise)	Valency	Electronic Configuration (shell wise)
1	Hydrogen (H)	$1s^1$	1	1
2	Helium (He)	$1s^2$	0	2
3	Lithium (Li)	$1s^2\ 2s^1$	1	2, 1
4	Beryllium (Be)	$1s^2\ 2s^2$	2	2, 2
5	Boron (B)	$1s^2\ 2s^2\ 2p^1$	3	2, 3
6	Carbon (C)	$1s^2\ 2s^2\ 2p^2$	4	2, 4
7	Nitrogen (N)	$1s^2\ 2s^2\ 2p^3$	3	2, 5
8	Oxygen (O)	$1s^2\ 2s^2\ 2p^4$	2	2, 6
9	Fluorine (F)	$1s^2\ 2s^2\ 2p^5$	1	2, 7
10	Neon (Ne)	$1s^2\ 2s^2\ 2p^6$	0	2, 8
11	Sodium (Na)	$1s^2\ 2s^2\ 2p^6\ 3s^1$	1	2, 8, 1
12	Magnesium (Mg)	$1s^2\ 2s^2\ 2p^6\ 3s^2$	2	2, 8, 2
13	Aluminium (Al)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$	3	2, 8, 3
14	Silicon (Si)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$	4	2, 8, 4
15	Phosphorus (P)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$	5, 3	2, 8, 5
16	Sulphur (S)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$	2	2, 8, 6
17	Chlorine (Cl)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$	1	2, 8, 7
18	Argon (Ar)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$	0	2, 8, 8
19	Potassium (K)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1$	1	2, 8, 8, 1
20	Calcium (Ca)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$	2	2, 8, 8, 2
21	Scandium (Sc)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^1\ 4s^2$	3	2, 8, 9, 2
22	Titanium (Ti)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^2\ 4s^2$	4	2, 8, 10, 2
23	Vanadium (V)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^3\ 4s^2$	5, 4	2, 8, 11, 2
24	Chromium (Cr)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^1$	2	2, 8, 13, 1
25	Manganese (Mn)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^2$	7, 4, 2	2, 8, 13, 2
26	Iron (Fe)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6\ 4s^2$	2, 3	2, 8, 14, 2
27	Cobalt (Co)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^7\ 4s^2$	3, 2	2, 8, 15, 2
28	Nickel (Ni)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^8\ 4s^2$	2	2, 8, 16, 2
29	Copper (Cu)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^1$	2, 1	2, 8, 18, 1
30	Zinc (Zn)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2$	2	2, 8, 18, 2

REDOX REACTION

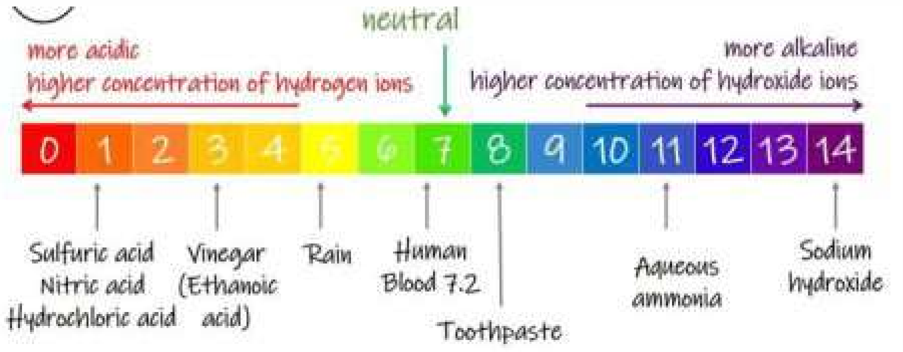


LEO (loss electrons oxidation) A	GER (gain electrons reduction) B
Reductant	Oxidant
Acts as a reducing agent to B	Acts as an oxidising agent to A
☐ is oxidised	☐ is reduced
☐ loses electrons	☐ gains electrons

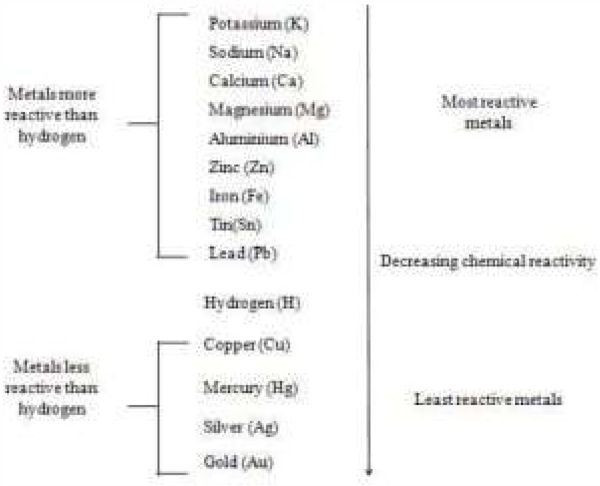
Acids & Bases

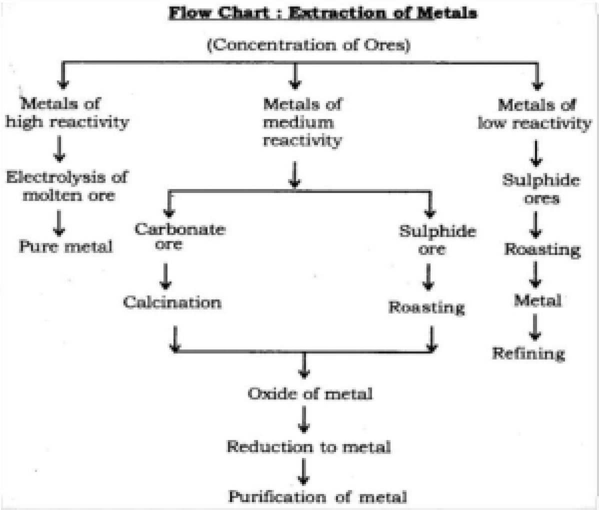


pH and its scale



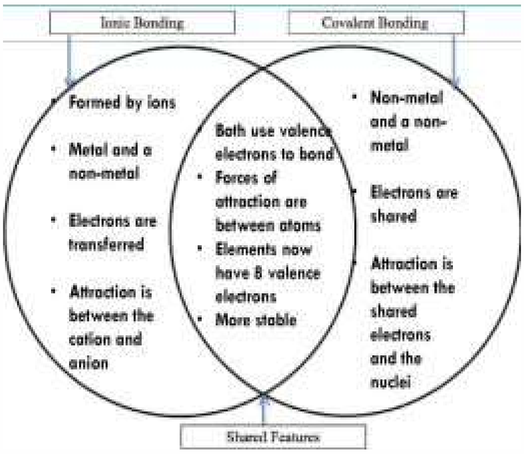
Reactivity of Metals -

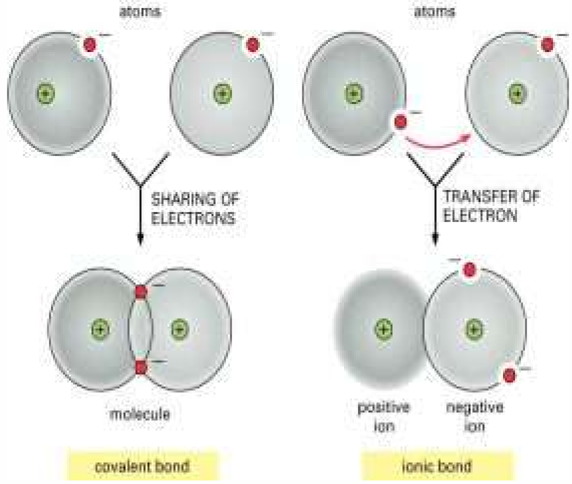




Metals	Non - Metals
(i) Have a tendency to donate electrons.	**(i)** Have a tendency to receive electrons.
(ii) Displace hydrogen gas from dilute acids. $Zn + 2HCl \rightarrow ZnCl_2 + h_2$	**(ii)** Don't displace hydrogen gas from dilute acids.
(iii) React with oxygen to produce basic oxides. $4Na + O_2 \rightarrow 2Na_2O$	**(iii)** React with oxygen to produce acidic oxides. $C + O_2 \rightarrow CO_2$
(iv) React with hydrogen to produce Hydrides. $Ca + H_2 \rightarrow CaH_2$	**(iv)** React with hydrogen to produce covalent compounds. $C + 2H_2 \rightarrow CH_4$

Chemical Properties	Metals	Non-metals
1. Reaction with oxygen	Metals react with oxygen to form basic oxides which form bases when dissolve in water.	Non-metals react with oxygen to form acidic oxides which form acids when dissolve in water.
2. Reaction with water	Metals react with water to form their oxides or hydroxides.	Non-metals do not react with water.
3. Reaction with acids	Metals react with acids to produce respective salts along with evolution of hydrogen gas. Some metals like Cu, Ag, Au, etc., do not liberate hydrogen gas.	Non-metals do not react with acids except sulphur which react with hot, concentrated acid.
4. Reaction with bases	Most of the metals do not react with bases. However, some metals like Al, Pb, Zn react with strong bases like NaOH to form complex salts and hydrogen gas.	Generally, non-metals do not react with bases. Sometimes, some complex reactions take place between non-metals and bases.





IMPORTANT FACTS TO MEMORIZE

Most abundant element in human body	Oxygen
Most abundant gas in sun	H_2
Most abundant gases in universe	H_2, He
Element having maximum tendency for catenation	Li
Most abundant metal of earth	Al
Rarest element of earth	Astatine (At)
Most abundant element of earth	Oxygen (O)
Element containing no neutron	$_1H^1$
Amphoteric metals	Zn, Al, Sn, Pb
Noble metals	Au, Pt
Elements having highest tensile strength	Boron
Metals showing highest oxidation number	Ru, Os
Non-metal having highest m.p., b.p.	Diamond
Lightest element	H
Heaviest naturally occurring element	^{238}U

Highest ionization potential	He
Lowest ionization potential	Cs
Lowest electron affinity	Noble gases (zero)
Highest electron affinity	Cl
Non-metals having metallic lusture	iodine, graphite
Element sublime on heating	I
Coolant in nuclear reactors	D_2O
Most poisonous element	Pu
Liquid non-metal	Br_2
Total number of radioactive elements in periodic table	25
Volatile d-block elements	Zn, Cd, Hg
Liquid metals s	Hg, Ga, Cs, Fr, Eka
Element kept in water	P
Elements kept in kerosene oil	Na, K, I_2, Cs
Metal with highest	W

Strongest basic hydroxide	CsOH
Strongest basic oxide	CsO_2 (caesium peroxide)
Most stable metal carbonate	Cs_2CO_3
Element with highest radioactivity	Ra
Strongest reducing agent	Azide (N_3^-)
Strongest oxidising agent	OF_2
Smallest anion	H^- (hydrides)
Smallest atomic size	H
Largest atomic size	Cs
Element with maximum number of isotopes	Ag (46)
Element with minimum number of isotopes	H (3)
Element with maximum number of allotropes	Sn
Liquid element of radioactive nature	Francium (Fr)
Poorest conductor of current	Pb (metal), S (non-metal)

Best electricity conductor among metals	Ag
Best conductor among non metals	Graphite
Most reactive solid element	Li
Most reactive liquid element	Cs
Most reactive gaseous element	F
Amphoteric non metal	Si
Elements showing diagonal relationship	Li-Mg, Be-Al, B-Si
Highest electronegativity	F

m.p.	
Metal with lowest m.p.	Hg
Non metal with highest refractive index	Diamond
Lowest refractive index	Air
Lowest b.p.	H_2
Heaviest solid metal	Os
Lightest solid metal	Li
Lightest solid non metal	B
Hardest naturally occurring non metal	Diamond
Hardest artificial substance good conductor of heat	B_4C (norbide)

Metalloids elements	B, Si, Ge, As, Sb, Te
Dry ice	CO_2
Most recently elements name by IUPAC	Ds (atomic number = 110)
'All purpose' grease	Lithium stearate
Old name of astatine	Albamine
Most abundant gas in atmosphere	N_2
Rarest gas in atmosphere	Rn
Lightest gas in atmosphere	H_2

Groups containing higher no. of gaseous elements	Group 18 (Noble gases)
Most electrovalent compound	CsF
Bad conductor of electricity	Mica
Lightest radio isotope	Tritium ($_1H^3$)

Compound with maximum covalent nature	H_2, N_2, O_2, Cl_2 (diatomic gases)
First noble prize in chemistry	Van't Hoff
Softest form of carbon	Lamp black
Latest allotrope of carbon	fullerene or bucky ball

Strongest acid	HSO_3F + 90 % SbF_5 called magic acid
Most reactive form of P	White
Least reactive form of P	Red
Purest form of silica	Quartz
Most ductile metal	Gold

IMPORTANT CHEMICAL COMPOUNDS

Fe

Magnetite → Fe_3O_4
Limonite → $3\ Fe_2O_3.3H_2O$
Iron Pyrite → FeS_2
Haematite → Fe_2O_3
Copper Pyrite → $CuFeS_2$
Spathic Iron → $FeCO_3$

Cu

Cuprite or Ruby copper → Cu_2O
Copper Glance → Cu_2S
Malachite → $Cu(OH)_2.CuCO_3$
Azurite → $Cu(OH)_2.2CuCO_3$

Pb

Galena → PbS
Anglesite → $PbSO_4$
Stolzite → $PbWO_4$
Cerrusite → $PbCO_3$
Wulfenite → $PbMnO_4$

Ag

Argentite or Silver Glance → Ag_2S
Pyragurite → $3\ Ag_2S.\ Sb_2S_3$
Proustite → $3Ag_2S.\ As_2O_3$
Horn Silver → $AgCl$

Mg

Magnesite → $MgCO_3$
Carnalite → $MgCl_2.\ KCl.\ 6H_2O$
Kiesserite → $MgSO_4.\ H_2O$
Schonite → $MgSO_4.\ K_2SO_4.6H_2O$
Dolomite → $MgCO_3.CaCO_3$
Epsomite → $MgCO_3.7H_2O$
Kainite → $MgSO_4.\ KCl.\ 3H_2O$
Olivine → Mg_2SiO_4
Spinel → $Mg_2Al_2O_4$

Al

Corundum → Al_2O_3
Diaspore → $Al_2O_3.H_2O$
Bauxite → $Al_2O_3.\ 2H_2O$
Cryolite → Na_3AlF_6
Felspar → $KAlSi_3O_8$
Talc → $Mg_3\ H_2\ (SiO_3)_4$
Asbestos → $CaMg_3\ (SiO_3)_4$
Mica → $K\ Al\ Si_3\ O_{10}\ (OH)_2$
Kaolinite → $Al(OH)_4\ Si_2O_5$
Turquoise → $AlPO_4.Al(OH)_3.\ H_2O$
Alum Stone or Alunite → $K_2SO_4.\ Al_2(SO_4)_3.\ 4Al(OH)_3$

Be

Beryl → $3BeO\ Al_2O_3.6SiO_2$ or $Be_3Al_2Si_6O_8$
Phenacite → $2BeO\ SiO_2$ or Be_2SiO_4
Cryso beryl → $BeO\ Al_2O_3$

Ca

Anhydrite → $CaSO_4$
Dolomite → $CaCO_3\ .MgCO_3$
Fluorapatite → $3Ca_3\ (PO_4)_2.\ CaF_2$
Gypsum → $CaSO_4.2H_2O$

Sr

Strontionite → $SrCO_3$
Celestite → $SrSO_4$

Ores of Ba

Barytes → $BaSO_4$
Whitherite → $BaCO_3$

Ores of Ra

Carnotite → $K_2O.\ U_2O_3.\ (VO_4)_2\ .3H_2O$
Pitch blende → Uranium oxide

Ores of Zn

Zinc blends or Sphalerite → ZnS
Zincite or Red zinc → ZnO
Calamine or Zinc spar → $ZnCO_3$
Franklinite → $ZnO.Fe_2O_3$
Willemite → Zn_2SiO_4
Hg → HgS (Cinabar)
Cassetirite or Tin Stone → SnO_2
Rutile → TiO_2
Ilmenite → $FeOTiO_2$
Beryl → $3BeO.Al_2O_3.\ 6SiO_2$
Florapatite → $3Ca_3\ (PO_4)_2\ .CaF_2$

WATER SOLUBILITY OF SOME COMMON INORGANIC COMPOUNDS

1. All Na^+, K^+ and NH_4^+ compounds are soluble.
2. All nitrates, nitrites and acetates are soluble.
3. All chlorides, except $AgCl$, $PbCl_2$ and Hg_2Cl_2 are soluble. $PbCl_2$ is soluble in hot water.
4. All bromides, except $AgBr$, $PbBr_2$, Hg_2Br_2 and $HgBr_2$ are soluble.
5. All iodides, except AgI, PbI_2, Hg_2I_2 and HgI_2 are soluble.
6. All sulphates except $BaSO_4$, $CaSO_4$, $SrSO_4$, $PbSO_4$, Hg_2SO_4 and Ag_2SO_4 are soluble.
7. All carbonates except those of group 1 elements and $(NH_4)_2CO_3$ are insoluble.
8. All hydroxides except those of group 1 elements, $Ba(OH)_2$, $Ca(OH)_2$ and $Sr(OH)_2$ are insoluble.
9. All sulphides except those of group 1 & 2 elements and $(NH_4)_2S$ are insoluble.
10. All phosphates except those of group 1 elements and $(NH_4)_3PO_4$ are insoluble.
11. All sulphites, except those of group 1 elements and $(NH_4)_2SO_3$ are insoluble.

SOME IMPORTANT ALLOYS

1. *Alclad* It is an alloy of aluminium and used in making sea planes.
2. *Alnico* It is an alloy of steel (77%), nickel (2%), aluminium (20%) and cobalt (1%). It is used in making permanent magnets.
3. *Aluminium bronze* It is an alloy of 90% copper and 10% aluminium. It is used in making coins, trays and picture frames.
4. *Aluminium bronze* contains 90% Cu and 10% Al phosphor bronze consisting of 94% Cu, 5% Sn and 1% P is hard, elastic and used for pump rods, valves, axle bearing and certain other equipments. These are malleable, corrosion resistant and suitable for cold working.
5. *Babbit metal* It is an alloy of Sn (88-90%), Sb (7-4%) and Cu (3-7%). Hard babbit composition is (a) Sn = 91%, Pb = 4.5% and Sb = 4.5% and (b) Sn = 83%, Cu = 8.5% and Sb = 8.5%. It is used as bearing metal.
6. *Bell metal* It is an alloy of Cu and Sn having 80% Cu and 20% Sn. It is hard, brittle and sonorous. It is used for fabricating machine parts and bells, gongs etc.
7. *Brass* It is an alloy of 70% copper and 30% zinc. It is used in making utensils etc.
8. *Britania metal or pewter* It is an alloy of Sn (85-95%), Sb (6-10%), and Cu (1-3%). It is used for making cups, mugs and other utensils.
9. *Bronzes* These are mostly the alloys of copper and tin and contain 75–90% Cu and 25-10% Sn. These bronzes are mainly used for making coins, statues an special type of utensils.
10. *Constantan* It is an alloy of nickel (40%) and copper (60%). It is used in electrical work such as for making resistance boxes and thermo couples etc.
11. *Delta metal* It is an alloy of Cu (55%), Zinc (41%) and Fe(4%). It is used in making ships, bearing, and properllers.
12. *Duralumin* It is an alloy of Al(95.5%), Copper(4%), Mg(0.5%) and Mn(0.5%). It is used in making aeroplanes parts.
13. *Dutch metal* It is an alloy of copper and Zinc and is used in gold coverings.
14. *Electron* It is an alloy of Mg and Zn with small amounts of Al, Cu and Mn. It is a hard metal alloy used for making propellers of engines and air-crafts.
15. *Ferro alloys – Ferro molubdenum* is an alloy of Mo. Usually the percentage of Mo is less than 1%, but about 1.5-2% Mo has been used for high speed steel and 5% Mo in resisting steels. 6-10% Mo is used for preparing special steels. *Ferro silicon* has a composition of Si = 90-95%, C = 0.15%, S = 0.01% and P = 0.05%.
16. *Ferro manganese or Spiegeleisen* has average composition Mn = 78-82%, C = 7.5%, P = 0.35%, S = 0.5% and Si = 1.25%.
17. *Ferro nikel* contains Ni = 2.5-5%. It is hard, tough and rustless. It is used in the manufacture of cables. Propeller shaft, armor plates etc.
18. *Ferro titanium* has a composition of Ti = 38-45%, C = 0.1-6%, Si = 15-25% and Al = 9-10%, *Ferro tungsten* is hard and strong and contains W = 14-20%. It is used in the manufacture of high speed tools.
19. *Ferro vanadium* has composition V = 30-40%, C = 3.5%, P = 0.25%, S = 0.4%, Si = 13% and Al = 1.5%. It has high tensils strength and is used for making springs, axles, shafts etc. Both tungsten and vanadium make steel hard. Such hard steel is used for making high speed tools.
20. *German silver or Nickel silver* These are Cu–Zn–Ni alloys containing about 50% Cu, 25% Zn and 25% Ni. Nickel is used for fancy articles, forks, spoons, cigarette cases etc.
21. *Gun metal* It is an alloy of Cu, Sn and Zn. It contains 88% Cu, 10%Sn and 2%Zn. It is used in making guns. Gears and bearings.
22. *Invar* It has 64% Fe, 35% Ni and some traces of Mn, C. It is used in making pendulum rods.
23. *Magnalium* It is an alloy of 90% Al and 10% Mg. It is used in making balance beams.
24. *Monel metal* It is an alloy of 30% Cu, 67%Ni and 3%Mn or Fe. It is used for the construction of household sinks and containers and alkali-resisting equipments.
25. *Nichrome* It is an alloy of Ni(60%), Cr(15%) and Fe(25%) and is used in making electrical resistance.
26. *Nickel coinage alloy* for coinage purpose, an alloy of Ni(25%) and Cu (75%) is used. Another coinage alloy is silver coinage which contains 5% nickel.
27. *Pewter* It is an alloy of 24% Pb and 76% Sn and used for making utensils.
28. *Rose metal* It is an alloy of Bi(50%), Pb(25%) and Sn(25%). It is used in making stereo metal in printing and safety Plugs in boilers.
29. *Silicon Bronze* contains upto 4% Si and upto 1% Fe, Mn. Zn and Al, but does not contain Sn. They have strength like mild steel, excellent corrosion resistance and also have welding prop.
30. *Solder* It is an alloy of 67% Sn and 33% Pb. It is used in soldering. Soft solder contains 3-80% Pb and 97-20% Sn. This tin-lead alloy is used for joining metal parts because of its low melting point.
31. *Stainless steel* It contains Cr (about 11%) and Ni (about 7%). It is used in making utensils and surgical instruments.
32. *Sterite* It is an alloy of chromium, tungsten and nickel and is used for the manufacture of high speed tools and cutlery. This alloy is also used for making surgical instruments.
33. *Tiscor* It contains maximum 0.1% carbon, Mn = 0.1 - 0.4% (maximum), Cr = 0.7 – 1.1%, Cu = 0.3 - 0.5%, Si = 0.5 – 1.0% , P = 0.1 – 0.2 % and S = 0.05% .These two alloys (Tiscorn and Tiscor) are high strength engineering steels prepared by *Tata Iron and Steel company* in India.
34. *Tiscorn* It contains maximum 0.3% carbon, Mn = 0.5-1.3%, Cr = 1.00%, Ca = 0.25-0.6%, Si = 0.3% (maximum), P = 0.05% (maximum) and S = 0.05% (maximum).
35. *Type metal* It is an alloy of Pb(82%), Sb(15%) and Sn(3%) and is used for making type for printing.
36. *Wood metal* It is alloy of Pb(25%), Sn (12.5%), Cd (12.5%) and Bi (50%). It is used as automatic sprinkles. It melts in hot water as its melting point is 68°C.

IMPORTANT COMPOUNDS

1. Agate is silicon dioxide, SiO_2.
2. Ammonal is a mixture of ammonium nitrate and Al powder ($NH_4NO_3 + Al$). It is used as an explosive.
3. Alum is $(NH_4)_2SO_4.Al_2(SO_4)_3.24H_2O$. It is used as mordant by dyers of clothes. Potash alum is $K_2SO_4.Al_2(SO_4)_3.24H_2O$.
4. Aqua fortis is nitric acid, HNO_3.
5. Antichlor is sodium thiosulphate, $Na_2S_2O_3.5H_2O$. It is also called Hypo.
6. Aqua-Regia is a mixture of conc. HNO_3 and conc. HCl in the ratio of 1 : 3. It is also known as kingly water.
7. Baking soda is sodium bicarbonate, $NaHCO_3$.
8. Barytes is barium sulphate, $BaSO_4$.
9. Brine is sodium chloride (NaCl) solution.
10. Blue vitriol is copper sulphate, $CuSO_4.5H_2O$.
11. Bone ash is mainly calcium phosphate, $Ca_3(PO_4)_2$.
12. Borax is the name of sodium tetraborate hydrate $Na_2B_4O_7.10H_2O$. Borax ($Na_2B_4O_7$) is also called tincal.
13. $B(OH)_3$ is an acid.
14. Brown Ring is of $FeSO_4.NO$
15. Butter of tin is $SnCl_4.5H_2O$.
16. B.O.D. is biological oxygen demand.
17. Cuprite is Cu_2O.
18. Calomel is Hg_2Cl_2.
19. Caustic potash is KOH.
20. Caustic soda is sodium hydroxide, NaOH.
21. Chile saltpeter is sodium nitrate, $NaNO_3$.
22. Cinnabar is HgS.
23. Carbonic acid is hydrogen carbonate, H_2CO_3.
24. Carbolic acid is phenol, C_6H_5OH.
25. Carborundum is silicon carbide, SiC.
26. Copper glance is Cu_2S.
27. Carbogen is a mixture of 1% CO_2 and O_2. It is used as antidote for for CO poisoning.
28. Corrosive sublimate is mercuric chloride, $HgCl_2$.
29. Corundum is aluminium oxide, Al_2O_3.
30. Chromyl chloride is CrO_2Cl_2.
31. Cream of tartar is $KHC_4H_4O_6$.
32. Cyanogen is C_2N_2.
33. Dead burnt plaster is anhydrous $CaSO_4$.
34. Dry ice is solid carbon dioxide (CO_2).
35. Epsom salt is the name of magnesium sulphate, $MgSO_4.7H_2O$.
36. Energy is a mixture of Al_2O_3 and Fe_2O_3.
37. Eka aluminium is gallium.
38. Fluorspar is CaF_2.
39. Freon is CCl_2F_2.
40. Formalin is 40% formaldehyde (HCHO).
41. Fremy's salt is potassium hydrogen fluoride KHF_2.
42. Foul air is nitrogen, N_2. It is also called azote.
43. Fischer's salt is potassium cobalt nitric $K_3[Co(NO_2)_6]$.
44. Fowler's solution is $NaAsO_2$ solution.
45. Fusion mixture is $Na_2CO_3 + K_2CO_3$.
46. Fluorine is called super halogen.
47. Fulminating gold is $Au(NH_2) = NH$.
48. Grain alcohol is ethyl alcohol, C_2H_5OH.
49. Grape sugar is dextrose, $C_6H_{12}O_6$.
50. Glauber's salt is the name of sodium sulphate, $Na_2SO_4.10H_2O$.
51. Gypsum is calcium sulphate, $CaSO_4.2H_2O$
52. Green vitriol is ferrous sulphate, $FeSO_4.7H_2O$
53. Gammexane is benzene hexachloride (BHC), $C_6H_6Cl_6$.
54. Gun powder is a mixture of sulphur, charcoal and nitre.
55. Graham's salt is $(NaPO_3)_3$.
56. Hydrolith is calcium hydride, CaH_2.
57. Halite is common rock salt (NaCl).
58. Horn silver is AgCl.
59. Hair salt is $Al_2(SO_4)_3.18H_2O$.
60. Hypo is $Na_2S_2O_3 5H_2O$.
61. King of chemicals is H_2SO_4.
62. Kali : Germans used the word 'Kali' for Potash.
63. Limestone is calcium carbonate, $CaCO_3$.
64. Lunar caustic is silver nitrate, $AgNO_3$.
65. Laughing gas is nitrous oxide, N_2O. It is also known as laughing grites.
66. Lithia water is aqueous solution of lithium bicarbonate ($LiHCO_3$).
67. Lapis Lazuli is blue coloured mineral used as semi-precious stone. It is sodium alumino silicate.
68. Milk of magnesia is magnesium hydroxide, $Mg(OH)_2$.
69. Marshall's acid is persulphuric acid, $H_2S_2O_8$.
70. Milk of lime is calcium hydroxides, $Ca(OH)_2$. It is also called slaked lime.
71. Magnesite is $MgCO_3$.
72. Microscopic salt is $Na(NH_4)HPO_4.4H_2O$.
73. Mica is $KH_2Al_2(SiO_4)_3$
74. Magnesia is MgO.
75. Mosaic gold is SnS_2.
76. Marsh gas or fire damp is CH_4.
77. Mohr's salt is $FeSO_4(NH_4)_2SO_4.6H_2O$.
78. Muriatic acid is hydrochloric acid, HCl
79. Nessler's reagent is K_2HgI_4. It contains $HgCl_2$, KI and NaOH. The ions present in it is HgI_4^{2-}.
80. Nitre Cake is $NaHSO_4$
81. Nitrolim is $CaCN_2 + C$ (graphite)
82. Norweigian saltpetre is basic calcium nitrate, $Ca(NO_3)_2$.
83. Oxone is sodium peroxide, Na_2O_2.
84. Oil of vitriol is sulphuric acid, H_2SO_4.
85. Oleum is fuming sulphuric acid, concentrated $H_2SO_4 + SO_3$.
86. Oil of mirbane is $C_6H_5NO_2$.
87. Oil of winter green is methyl salicylate.
88. Plaster of paris is calcium sulphate hemihydrate, $CaSO_4.\frac{1}{2}H_2O$.
89. Philosopher's wool is zinc oxide, ZnO.
90. Phosgene is carbonyl chloride, $COCl_2$.
91. Picric acid is 2,4,6-trinitrophenol.
92. Paris green is double salt of copper acetate and copper arsenate.
93. Pearl white is BiOCl and is used as a pungent.
94. Prussian blue is $Fe_4[Fe(CN)_6]_3$.
95. Pearl ash is K_2CO_3.
96. Perhydrol is 30% H_2O_2.
97. Prussic acid HCN.
98. Quick lime is calcium oxide, CaO.
99. Quartz is silicon dioxide, SiO_2.
100. Quick silver is mercury, Hg.
101. Realgar is As_2S_3.
102. Rectified spirit is 95% ethyl alcohol, C_2H_5OH.
103. Reagar is As_4S_4.
104. Red lead is lead tetroxide, Pb_3O_4. It is also called Minium.
105. Red liquor is aluminium acetate, $(CH_3COO)_3Al$.
106. Rochelle salt is sodium potassium tartrate, $NaKC_4H_4O_6$.
107. Rock salt is NaCl.
108. Ruby or sapphire or Emery is Al_2O_3.
109. Salt cake is sodium sulphate, Na_2SO_4.
110. Sand is silicon dioxide, SiO_2.
111. Scheeb's green is $CuHAsO_3$.
112. Selidlitz powder is $NaHCO_3$.
113. Smelting salt is $(NH_4)_2CO_3$.
114. Soda lime is a mixture of NaOH and CaO.
115. Soda ash is sodium carbonate, Na_2CO_3.
116. Sodamide is $NaNH_2$.
117. Spirit of wine is C_2H_5OH.
118. Spirit of salt is HCl.
119. Sterling silver is a solution of Cu and Ag.
120. Stranger gas is xenon (Xe).
121. Sugar of lead is lead acetate, $(CH_3COO)_2Pb$.
122. Super phosphate of lime contains $Ca(H_2PO_4).H_2O$ and $2CaSO_4.2H_2O$
123. Syvine is KCl.
124. Tartar emetic is potassium antimony tartrate, $K(SbO)C_4H_4O_6$.
125. TNT is trinitrotoluene, an explosive.
126. Tear gas is chloropicrin, CCl_3NO_2.
127. TEL is tetra ethyl lead, $Pb(C_2H_5)_4$.
128. Thomas slag is calcium phosphate, $Ca_3(PO_4)_2$.
129. Tincture of iodine is I_2 and KI solution in alcohol.
130. Thermite is a mixture of iron oxide (Fe_3O_4) and Al powder.
131. Tinstone or Cassiterite is SnO_2.
132. Vinegar is dilute acetic acid, CH_3COOH.
133. Washing soda is Na_2CO_3.
134. Water glass is sodium silicate, Na_2SiO_3.
135. White lead is $Pb(OH)_2.2PbCO_3$
136. Wackenroder's liquid is $H_2SO_4 + H_2S$.
137. White vitriol is Zinc sulphate, $ZnSO_4.7H_2O$
138. Wood spirit is CH_3OH.
139. Verdigris is the name of basic copper acetate, $(CH_3COO)_2Cu\,Cu(OH)_2$.
140. Yellow ammonium sulphide is $(NH_4)_2Sx$.
141. Zincite is ZnO.

ACTION OF HEAT ON SOME SALTS

$ZnCO_3$ (white) $\longrightarrow ZnO + CO_2$ (yellow-hot; white-cold)
$CuCO_3$ (green) $\longrightarrow CuO + CO_2$ (black)
$CaCO_3 \longrightarrow CaO + CO_2$
$2Ag_2CO_3 \longrightarrow 4Ag + 2CO_2 + O_2$
$2NaHCO_3 \longrightarrow Na_2CO_3 + CO_2 + H_2O$
$NH_4HCO_3 \longrightarrow NH_3 + CO_2 + H_2O$
$2FeSO_4 \longrightarrow Fe_2O_3 + SO_2 + SO_3$
$2CaSO_4.2H_2O$ 393K $2CaSO_4.\frac{1}{2} H_2O + 3H_2O$ (Plaster of paris)
$CuSO_4.5H_2O$ (blue) $\longrightarrow CuSO_4 + 5H_2O$ (white)
$CuSO_4 \longrightarrow CuO + SO_3$
$(NH_4)_2Cr_2O_7$ (orange) $\longrightarrow N_2 + Cr_2O_3 + 4H_2O$ (green)
$2KMnO_4 \longrightarrow K_2MnO_4 + MnO_2 + O_2$
$2KClO_3 \longrightarrow 2KCl + 3O_2$
$4K_2Cr_2O_7 \longrightarrow 4K_2CrO_4 + 2Cr_2O_3 + 3O_2$
$(COO)_2Fe \longrightarrow FeO + CO + CO_2$ (black)
$2Ag_2O \longrightarrow 4Ag + O_2$
$2HgO$ (red) $\longrightarrow 2Hg + O_2$ (silver deposit)
$2Pb_3O_4$ (red) $\longrightarrow 6PbO + O_2$ (yellow)
$2PbO_2$ (brown) $\longrightarrow 2PbO + O_2$ (black)
$2NaNO_3 \longrightarrow 2NaNO_2 + O_2$
$NH_4NO_2 \longrightarrow N_2 + 2H_2O$
$2AgNO_3 \longrightarrow 2Ag + 2NO_2 + O_2$
$2Cu(NO_3)_2$ (brown) $\longrightarrow 2CuO + 4NO_2 + O_2$
$2Zn(NO_3)_2$ (white) $\longrightarrow 2ZnO + 4NO_2 + O_2$ yellow-hot white-cold (brown)
$2Ca(NO_3)_2 \longrightarrow 2CaO + 4NO_2 + O_2$
$2Pb(NO_3)_2$ (white) $\longrightarrow 2PbO + 4NO_2 + O_2$ (yellow) (brown)
$2Mg(NO_3)_2 \longrightarrow 2MgO + 4NO_2 + O_2$
$NH_4NO_3 \longrightarrow N_2O + 2H_2O$

IMPORTANT PROCESSES

1. **1.** Bosch process $\longrightarrow H_2$
2. Down, Castner $\longrightarrow$ Na
3. Nelson, Castner – Kellner, Solvey Droney, Lowing $\longrightarrow$ NaOH
4. Ammonia soda process (Solvay process) $\longrightarrow Na_2CO_3, NaHCO_3$
5. Leblanc, Pretch process $\longrightarrow K_2CO_3$
6. MacArthur forest or Cyanidation $\longrightarrow$ Ag, Au
7. Perk, Pattinson $\longrightarrow$ Ag
8. Cupellation $\longrightarrow$ Ag (Purification)
9. Mund's process $\longrightarrow$ Ni (Purification)
10. Baeyer's or Serpeck's process $\longrightarrow$ Al
11. Hoope's process $\longrightarrow$ Al (Purification)
12. Hall, Heroult Process $\longrightarrow$ Al
13. Gold schmidt crocess $\longrightarrow$ Thermite Welding
14. Carter's process $\longrightarrow$ White lead
15. Haeber's process $\longrightarrow NH_3$
16. Deacon's process $\longrightarrow Cl_2$
17. Contact, Lead Chamber process $\longrightarrow H_2SO_4$
18. Berkland-Eyde, Ostwald $\longrightarrow HNO_3$, NO
19. Kaldo, L.D. $\longrightarrow$ steel
20. Corey – House $\longrightarrow$ Alkane
21. Oxo $\longrightarrow$ R – OH
22. Dow's process $\longrightarrow$ Mg
23. Pidgeon $\longrightarrow$ Mg
24. Cyanamide $\longrightarrow NH_3$
25. IMI $\longrightarrow$ Ti
26. frash $\longrightarrow$ 'S'
27. Siemene, Basemer Thomass $\longrightarrow$ Steel.
28. Lane's process $\longrightarrow H_2$
29. Gossage process $\longrightarrow$ NaOH

MINERALS WITH METALLIC LUSTURE

Mineral (Formula)	Colour	Crystal System	Uses and Their Properties
Augite [(Ca, Na) (Mg, Fe, Al) (Al, Si)$_2$ O$_6$]	Black	Monoclinic	Square or 8-sided cross section
Bornite [Cu_5FeS]	Bronze, tarnishes to dark blue, purple	Tetragonal	Source of copper; called "Peakcock ore" due to its purple shine when it tarnishes
Chalcopyrite ($CuFeS_2$)	Brassy to golden yellow	Tetragonal	Main ore of copper
Chromite ($FeCr_2O_4$)	Black or brown	Cubic	Ore of chromium, stainless steel, metallurgical bricks
Copper (Cu)	Copper red	Cubic	Pipes, coins, gutters, wire, cooking utensils, jewellery, decorative plaques; malleable and ductile
Corundum (Al_2O_3)	Colourless, blue, brown, green, white, pink, red	Hexagonal	Gemstones; ruby is red, sapphire is blue, industrial abrasive
Feldspar (orthoclase) ($KAlSi_3O_8$)	Colourless, white to gray, green and yellow	Monoclinic	Insoluble in acids, used in the manufacture of porcelain

Mineral (Formula)	Colour	Crystal System	Uses and Their Properties
Feldspar (plagioclase) ($NaAlSi_3O_8$) ($CaAl_2Si_2O_8$)	Gray, green white	Triclinic	Used in ceramics; striations present on some faces
Fluorite (CaF_2)	Colourless, white, blue, green, red, yellow, purple	Cubic	Used in the manufacture of optical equipment, glows under ultraviolet light
Galena (PbS)	Gray	Cubic	Source of lead, shields for X-rays, fishing equipment sinkers, used in pipes
Garnet (Mg, Fe, Ca)$_3$ ($Al_2Si_3O_{12}$)	Deep yellow-red, green, black	Cubic	Used in jewellery, also used as an abrasive
Gold (Au)	Pale to golden	Cubic	Medicines, jewellery, money, gold leaf, fillings for teeth, does not tarnish
Graphite (C)	Black to grey	Hexagonal	Pencil lead, rods to control some small nuclear reactions, lubricants for locks, battery poles
Haematite (Fe_2O_3)	Black or reddish brown	Hexagonal	Source of iron; roasted in a blast furnace, converted to "pig" iron, made into steel
Hornblende [Ca Na (Mg, Al, Fe)$_5$ (Al, Si)$_2$ Si_6 O_{22} (OH)$_2$]	Green to black	Monoclinic	Will transmit light on thin edges; 6-sided cross section
Limonite (hydrous iron oxides)	Yellow, brown, black	-	Source of iron, weathers easily colouring matter of soils
Magnetite (Fe_3O_4)	Black	Cubic	Source of iron, naturally magnetic, called lodestone
Olivine [(Mg, Fe)$_2$ SiO_4]	Olive green	Ortho-rhombic	Gemstones, refractory sand
Pyrite (FeS_2)	Light, brassy, yellow	Cubic	Source of iron, "fools's gold" alters to limonite
Pyrrhotite (FeS)	Bronze	Hexagonal	Often found with pentlandite, an ore of nickel; may be magnetic
Quartz (SiO_2)	Colourless, various colorus	Hexagonal	Used in glass manufacture, electronic equipment, radios, computers, watches, gemstones
Silver (Ag)	Silvery white, tarnishes to black	Cubic	Coins, jewellery, silverplate, fillings for teeth, wires, malleable and ductile
Topaz [(Al_2SiO_4) (F, OH)$_2$]	White, pink yellow, pale blue, colourless	Ortho-rhombic	Valuable gemstone
Bauxite (hydrous aluminium compound)	Gray, red, white, brown	-	Source of aluminum; used in paints, aluminium foil, and airplane parts
Biotite [K(Mg,Fe)$_3$ $AlSi_3O_{10}$ (OH)$_2$]	Black to dark brown	Monoclinic	Occurs in large flexible plates
Calcite ($CaCO_3$)	Colourless, white pale, blue	Hexagonal	Fizzes when HCl is added; used in cement and other building materials
Dolomite [$CaMg(CO_3)_2$]	Colourless, white, pink, green, gray, black	Hexagonal	Concrete and cement, used as an ornamental building stone
Gypsum ($CaSO_4.2H_2O$)	Colourless, gray, white, brown	Monoclinic	Used extensively in the preparation of plaster of paris, alabaster, and dry wall for building construction
Halite (NaCl)	Colourless, red, white, blue	Cubic	Salt; very soluble in water; a preservative
Kaolinite [$Al_4Si_2O_5(OH)_4$]	White, red, reddish brown, black	Triclinic	Clays; used in ceramics and in china dishes; common in most soils; often microscopic sized particles
Muscovite [$KAl_2Si_3O_{10}(OH)_2$]	White, light gray, yellow, rose, green	Monoclinic	Occurs in large flexible plates, used as an insulator in electrical equipment, lubricant
Sphalerite (ZnS)	Brown	Cubic	Main ore of zinc; used in paints, dyes, and medicine
Sulphur (S)	Yellow	Ortho-rhombic	Used in medicine, fungicides for plants, vulcanisatoin of rubber, production of sulphuric acid
Talc [$Mg_3(OH)_2$ Si_4O_{10}]	White, greenish	Monoclinic	Easily cut with fingernail; used for talcum powder; soapstone is used in paper and for table tops

MOLE CONCEPT

SOME USEFUL CONVERSION FACTORS

1 Å = 10^{-10} m, 1 nm = 10^{-9} m

1 pm = 10^{-12} m

1 litre = 10^{-3} m³ = 1 dm³

1 atm = 760 mm or torr

= 101325 Pa or Nm^{-2}

1 bar = 10^5 Nm^{-2} = 10^5 Pa

1 calorie = 4.184 J

1 electron volt(eV) = 1.6022×10^{-19} J

(1 J = 10^7 ergs)

(1 cal > 1 J > 1 erg > 1 eV)

ATOMIC MASS OR MOLECULAR MASS

Mass of one atom or molecule in a.m.u.

C → 12 amu

H_2O → 18 amu

ACTUAL MASS

mass of one atom or molecule in grams

C → $12 \times 1.6 \times 10^{-24}$ g

H_2O → $18 \times 1.6 \times 10^{-24}$ g

RELATIVE ATOMIC MASS OR RELATIVE MOLECULAR MASS

Mass of one atom or molecule w.r.t. 1/12th of ^{12}C atom

C → 12

H_2O → 18

It is unitless

GRAMS ATOMIC MASS OR GRAM MOLECULAR MASS

Mass of one mole of atom or molecule

C → 12 g

H_2O → 18 g

It is also called molar mass

DEFINITION OF MOLE

One mole is a collection of that many entities as there are number of atoms exactly in 12 gm of C-12 isotope.

The number of atoms present in exactly 12 gm of C-12 isotope is called Avogadro's number [$N_A = 6.022 \times 10^{23}$]

$$1u = 1\text{ amu} = (1/12)^{th} \text{ of mass of 1 atom of } C^{12} = \frac{1g}{N_A} = 1.66 \times 10^{-24}\text{ g}$$

For elements

- 1 g atom = 1 mole of atoms = N_A atoms
- g atomic mass (GAM) = mass of N_A atoms in g
- Mole of atoms = $\frac{\text{Mass(g)}}{\text{GAM or molar mass}}$

For molecule

- 1 g molecule = 1 mole of molecule = N_A molecule
- g molecular mass (GMM) = mass of N_A molecule in g.
- Mole of molecule = $\frac{\text{Mass(g)}}{\text{GMM or molar mass}}$

For ionic compounds

- 1 g formula unit = 1 mole of formula unit = N_A formula unit.
- g formula mass (GFM) = mass of N_A formula unit in g.
- Mole of formula unit = $\frac{\text{Mass(g)}}{\text{GFM or molar mass}}$

1 mole of substance

- Contains 6.022×10^{23} particles
- Weighs as much as molecular mass / atomic mass/ionic mass in grams
- If it is a gas, one mole occupies a volume of 22.4 L at 1 atm & 273 K or 22.7 L at STP

Average or mean molar mass

The average molar mass of the different substance present in the container $M_{avg} = \frac{M_1n_1 + M_2n_2 + ...}{n_1 + n_2 + ...}$

Here M_1, M_2 are molar mass of substances and n_1, n_2 are mole of substances present in the container.

DENSITIES

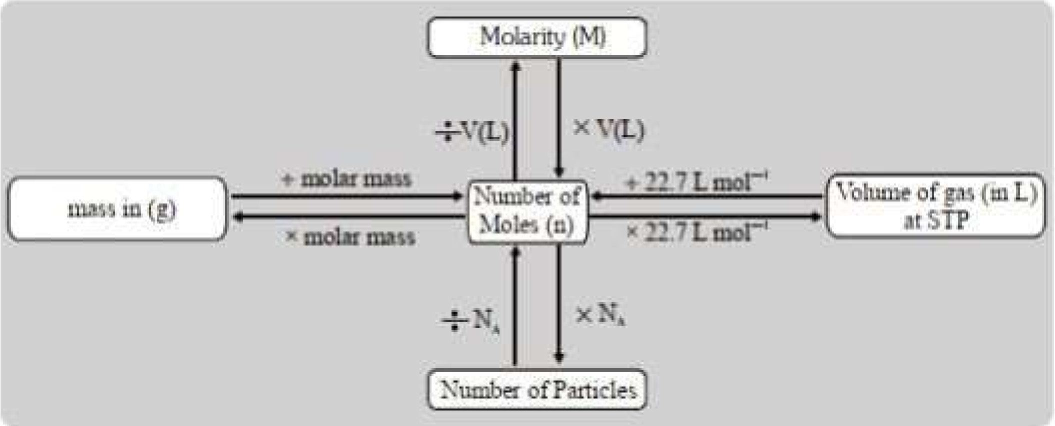
Density = $\frac{\text{Mass}}{\text{volume}}$

Relative Density = $\frac{\text{Density of any substance}}{\text{Density of reference substance}}$

VAPOUR DENSITY

Ratio of density of vapour to the density of hydrogen at similar pressure and temperature.

Vapour density = $\frac{\text{Molar mass}}{2}$



STOICHIOMETRY BASED CONCEPT

$aA + bB \rightarrow cC + dD$

a,b,c,d, represents the ratios of moles, volumes [for gaseous] molecules in which the reactants react or products formed.

a,b,c,d, does not represent the ratio of masses.

The stoichiometric amount of components may be related as

$$\frac{\text{Moles of A reacted}}{a} = \frac{\text{Moles of B reacted}}{b} = \frac{\text{Moles of C reacted}}{c} = \frac{\text{Moles of D reacted}}{d}$$

[Concept of limiting reagent]

If data of more than one reactant is given then first convert all the data into moles then divide the moles of reactants with their respective stoichiometric coefficient. The reactant having minimum ratio will be L.R. then find the moles of product formed or excess reagent left by comparing it with L.R. through stoichiometric concept.

PERCENTAGE YIELD:

$$\boxed{\%\,\text{yield} = \frac{\text{Actual yield}}{\text{Theoretical yield}} \times 100}$$

PERCENTAGE PURITY :

The percentage of a specified compound or

$$\boxed{\%\,\text{purity} = \frac{\text{Actual mass of compound}}{\text{Total mass of sample}} \times 100}$$

DEGREE OF DISSOCIATION, (α) :

It represents the mole of substance dissociated per mole of the substance taken.

$A \rightarrow n$ particles; $\alpha = \dfrac{M_o - M}{(n-1)M}$

where, n = number of product particles per particle of reactant

M_o = Molar mass of 'A'

M = Molar mass of final mixture

Dissociation decreases the average molar mass of system while association increases it.

If impurity is unknown, it is always considered as inert (unreactive) material.

PERCENTAGE DETERMINATION OF ELEMENTS IN COMPOUNDS

Mass % of an element in a compound

$$= \frac{\text{atomicity of an element} \times \text{atomic mass of an element}}{\text{molecular mass of compound}} \times 100$$

EMPIRICAL AND MOLECULAR FORMULA

Empirical formula : Formula depicting constituent atoms in their simplest ratio.

Molecular formula : Formula depicting actual number of atoms in one molecule of the compound.

The molecular formula is generally an integral multiple of the empirical formula.

i.e. molecular formula = empirical formula × n

where $n = \dfrac{\text{molecular formula mass}}{\text{empirical formula mass}}$

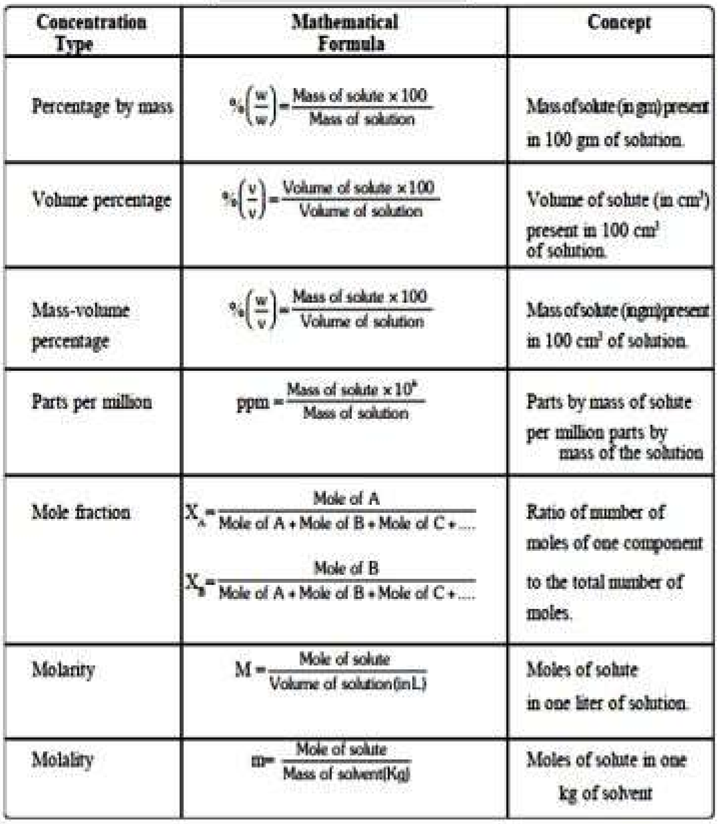
For determination of atomic mass :

Dulong's & Petit's law :

Atomic weight of metal × specific heat capacity (cal/gm°-C) ≈ 6.4.

It should be remembered that this law is an empirical observation and this gives an approximate value of atomic weight. This law gives better result for heavier solid elements, at high temperature conditions.

CONCENTRATION TERMS



Concentration Type	Mathematical Formula	Concept
Percentage by mass	$\%\left(\frac{w}{w}\right) = \frac{\text{Mass of solute} \times 100}{\text{Mass of solution}}$	Mass of solute (in gm) present in 100 gm of solution.
Volume percentage	$\%\left(\frac{v}{v}\right) = \frac{\text{Volume of solute} \times 100}{\text{Volume of solution}}$	Volume of solute (in cm^3) present in 100 cm^3 of solution.
Mass-volume percentage	$\%\left(\frac{w}{v}\right) = \frac{\text{Mass of solute} \times 100}{\text{Volume of solution}}$	Mass of solute (in gm) present in 100 cm^3 of solution.
Parts per million	$\text{ppm} = \frac{\text{Mass of solute} \times 10^6}{\text{Mass of solution}}$	Parts by mass of solute per million parts by mass of the solution
Mole fraction	$X_A = \frac{\text{Mole of A}}{\text{Mole of A} + \text{Mole of B} + \text{Mole of C} + ...}$ $X_B = \frac{\text{Mole of B}}{\text{Mole of A} + \text{Mole of B} + \text{Mole of C} + ...}$	Ratio of number of moles of one component to the total number of moles.
Molarity	$M = \frac{\text{Mole of solute}}{\text{Volume of solution (in L)}}$	Moles of solute in one liter of solution.
Molality	$m = \frac{\text{Mole of solute}}{\text{Mass of solvent (Kg)}}$	Moles of solute in one kg of solvent

MIXING OF SOLUTIONS:

It is based on law of conservation of moles.

Two solutions having same solute:

$$\text{Final molarity} = \frac{\text{Total moles}}{\text{Total volume}} = \frac{M_1V_1 + M_2V_2}{V_1 + V_2}$$

Dilution Effect

$$\text{Final molarity, } M_2 = \frac{M_1V_1}{V_1 + V_2}$$

REDOX

OXIDISING AND REDUCING AGENT

Oxidizing agent or Oxidant:

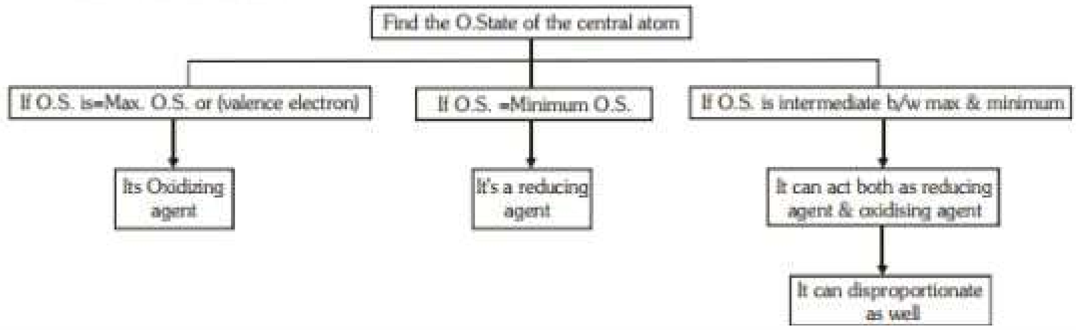
Oxidizing agents are those compounds which can oxidize others and reduced itself during the chemical reaction. Those reagents whose O.N. decrease or which gain electrons in a Redox reaction are termed as oxidants.

$KMnO_4$, $K_2Cr_2O_7$, HNO_3, conc. H_2SO_4 etc, are powerful oxidizing agents.

Reducing agent or Reductants:

Reducing agents are those compounds which can reduce others and oxidize itself during the chemical reaction. Those reagents whose O.N. increase or which loses electrons in a Redox reaction is termed as reductants. e.g. KI, $Na_2S_2O_3$ are powerful reducing agents.

❑ HOW TO IDENTIFY WHETHER A PARTICULAR SUBSTANCE IS AN OXIDISING OR REDUCING AGENT



REDOX REACTION

A reaction in which oxidation and reduction simultaneously take place.

In all redox reactions the total increase in oxidation number must equal the total decrease in oxidation number.

e.g. $10\overset{+2}{Fe}SO_4 + 2K\overset{+7}{Mn}O_4 + 8H_2SO_4 \longrightarrow 5\overset{+3}{Fe_2}(SO_4)_3 + 2\overset{+2}{Mn}SO_4 + K_2SO_4 + 8H_2O$

Equivalent weight (E) :

$$\text{Eq. wt (E)} = \frac{\text{Molecular weight}}{\text{valency factor (v.f)}} = \frac{\text{Mol. wt.}}{\text{n}-\text{factor}}$$

$$\text{no of Equivalents} = \frac{\text{mass of a sample}}{\text{eq. wt. of that species}}$$

- Equivalent mass is a pure number when expressed in gram, it is called gram equivalent mass.
- The equivalent mass of substance may have different values under different conditions.

n-FACTOR IN VARIOUS CASES

In Non Redox Change

- n-factor for element : Valency of the element
- For acids: Acids will be treated as species which furnish H+ ions when dissolved in a solvent.
- The n-factor of an acid is the no. of acidic H+ ions that a molecule of the acid would give when dissolved in a solvent (Basicity).
- For example, for HCl (n = 1), HNO_3 (n = 1), H_2SO_4 (n = 2), H_3PO_4 (n = 3) and H_3PO_3 (n = 2)
- For bases: Bases will be treated as species which furnish OH– ions when dissolved in a solvent. The n-factor of a base is the no. of OH– ions that a molecule of the base would give when dissolved in a solvent (Acidity).
  For example, NaOH (n = 1), $Ba(OH)_2$ (n = 2), $Al(OH)_3$ (n = 3), etc.
- For salts: A salt reacting such that no atom of the salt undergoes any change in oxidation state.
- For example, $2AgNO_3 + MgCl_2 \dashrightarrow Mg(NO_3)_2 + 2AgCl$
- In this reaction, it can be seen that the oxidation state of Ag, N, O, Mg and Cl remains the same even in the product. The n-factor for such a salt is the total charge on cation or anion.

SOME OXIDIZING AGENTS/REDUCING AGENTS WITH EQ. WT.

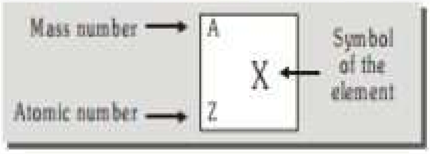
Species	Changed to	Reaction	Electrons exchanged or change in O.N.	Eq. wt.
MnO_4^-(O.A.)	Mn^{+2} in acidic medium	$MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$	5	$E = \frac{M}{5}$
MnO_4^-(O.A.)	MnO_2 in neutral medium	$MnO_4^- + 3e^- + 2H_2O \longrightarrow MnO_2 + 4OH^-$	3	$E = \frac{M}{3}$
MnO_4^-(O.A.)	MnO_4^{2-} in basic medium	$MnO_4^- + e^- \longrightarrow MnO_4^{2-}$	1	$E = \frac{M}{1}$
$Cr_2O_7^{2-}$(O.A.)	Cr^{3+} in acidic medium	$CrO_7^{2-} + 14H^+ + 6e^- \longrightarrow 2Cr^{3+} + 7H_2O$	6	$E = \frac{M}{6}$
MnO_2(O.A.)	Mn^{2+} in acidic medium	$MnO_2 + 4H^+ + 2e^- \longrightarrow Mn^{2+} + 2H_2O$	2	$E = \frac{M}{2}$
Cl_2(O.A.) in bleaching powder	Cl^-	$Cl_2 + 2e^- \longrightarrow 2Cl^-$	2	$E = \frac{M}{2}$
$CuSO_4$(O.A.) in iodometric titration	Cu^+	$Cu^{2+} + e^- \longrightarrow Cu^+$	1	$E = \frac{M}{1}$
$S_2O_3^{2-}$ (R.A.)	$S_4O_6^{2-}$	$2S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + 2e^-$	2	$E = \frac{2M}{2} = M$

ATOMIC STRUCTURE

IMPORTANT DEFINITIONS

Proton (m_p) /anode rays	**Neutron (m_n)**	**Electron(m_e) / cathode rays**
mass =1.67 × 10^{-27} kg	mass = 1.67 × 10^{-27} kg	mass = 9.1 × 10^{-31} kg
mass = 1.67 × 10^{-24} g	mass = 1.67 × 10^{-24} g	mass = 9.1 × 10^{-28} g
mass = 1.00750 amu	mass = 1.00850 amu	mass = 0.000549 amu
e/m value is dependent on the nature of gas taken in discharge tube.		e/m of electron is found to be independent of nature of gas & electrode used.

REPRESENTATION OF AN ELEMENT



Terms associated with elements :

- Atomic Number (Z) : = No. of protons

  Electron = Z – C (charge on atom)

- Mass number (A) = Total number of neutron and proton present

  A = Number of proton + Number of Neutrons

- **Isotopes :** Same atomic number but different mass number

  Ex. : $_6C^{12}$, $_6C^{13}$, $_6C^{14}$

- **Isobars :** Same mass number but different atomic number

  Ex. $_1H^3$, $_2He^3$

- **Isodiaphers :** Same difference of number of Neutrons & protons

  Ex. $_5B^{11}$, $_6C^{13}$

- **Isotones** : Having same number of neutron

  Ex. $_1H^3$, $_2He^4$

- **Isosters**: They are the molecules which have the same number of atoms & electrons

  Ex. CO_2, N_2O

- **Isoelectronic**: Species having same no. of electrons

  Ex. Cl^-, Ar

ATOMIC MODELS

- **Thomson** : An atom considered to be positively charged sphere where e^- is embedded inside it.
- **Drawback** : Cannot explain stability of an atom.
- **Rutherford Model of an atoms :**

  Electron is revolving around the nucleus in circular path.

  $R_N = R_0(A)^{1/3}$, $R_0 = 1.33 \times 10^{-13}$ cm

  [A = mass number, R_N = Radius of nucleus]

SIZE OF NUCLEUS

- The volume of the nucleus is very small and is only a minute fraction of the total volume of the atom. Nucleus has a diameter of the order of 10^{-12} to 10^{-13} cm and the atom has a diameter of the order of 10^{-8} cm.
- Thus, diameter (size) of the atom is 1,00,000 times the diameter of the nucleus.

ELECTROMAGNETIC SPECTRUM

- RW → MW → IR → Visible → UV → X-rays → CR (Radiowaves → Microwaves → Infrared rays → Visible rays → Ultraviolet rays → X-rays → Cosmic rays)
- Wavelength decreases ⟶
- Frequency increases ⟶
- • $c = \nu\lambda$ • $\lambda = \frac{c}{\nu}$ • $\bar{\nu} = \frac{1}{\lambda} = \frac{\nu}{c}$

  • $T = \frac{1}{\nu}$ • $E = \frac{hc}{\lambda} = h\nu$, $h = 6.626 \times 10^{-34}$ Js

  • $E(ev) = \frac{12400}{\lambda(\text{Å})}$

  • Total amount of energy transmitted

  $E = nh\nu = \frac{nhc}{\lambda}$

BOHR'S ATOMIC MODEL

Theory based on quantum theory of radiation and the classical laws of physics

- $\frac{K(Ze)(e)}{r^2} = \frac{mv^2}{r}$
- $mvr = \frac{nh}{2\pi}$ or $mvr = n\hbar$
- Electron remains in stationary orbit where it does not radiate its energy.
- **Radius :** $r = 0.529 \times \frac{n^2}{Z}$ Å

HYDROGEN SPECTRUM

- **Rydberg's Equation** :

  $$\frac{1}{\lambda} = \bar{\nu} = R_H\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] \times Z^2$$

  $R_H \cong 109700\ \text{cm}^{-1}$ = Rydberg constant

- For first line of a series $n_2 = n_1 + 1$
- Limiting spectral line (series limit) means $n_2 = \infty$

- **Velocity :** $v = 2.188 \times 10^6 \frac{Z}{n} ms^{-1}$
- Energy(KE + PE)

  =Total energy $= -13.6 \times \frac{Z^2}{n^2}$ eV/atom
- $TE = -\frac{KZe^2}{2r}, PE = \frac{-KZe^2}{r}, KE = \frac{KZe^2}{2r}$

  $PE = -2KE, KE = -TE, PE = 2TE$
- Revolutions per sec $= \frac{v}{2\pi r}$
- Time for one revolution $= \frac{2\pi r}{v}$
- Energy difference between n_1 and n_2 energy level

$$\Delta E = E_{n_2} - E_{n_1} = 13.6Z^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)\frac{eV}{atom} = IE \times \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

  where IE = ionization energy of single electron species.
- **Ionization energy** $= E_\infty - E_{G.S.} = 0 - E_{G.S.}$

  $E_{G.S.}$ = Energy of electron in ground state

- H_α line means $n_2 = n+1$; also known as line of longest λ, shortest ν, least E
- Similarly H_β line means $n_2 = n_1 + 2$
- When electrons de-excite from higher energy level (n) to ground state in atomic sample, then number of spectral lines observed in the spectrum $= \frac{n(n-1)}{2}$
- When electrons de-excite from higher energy level (n_2) to lower energy level (n_1) in atomic sample, then number of spectral line observed in the spectrum

$$= \frac{(n_2 - n_1)(n_2 - n_1 + 1)}{2}$$

- No. of spectral lines in a particular series $= n_2 - n_1$

DE-BROGLIE HYPOTHESIS

- All material particles posses wave character as well as particle character.
- $\lambda = \frac{h}{mv} = \frac{h}{p}$
- The circumference of the nth orbit is equal to n times of wavelength of electron i.e., $2\pi r_n = n\lambda$

  Number of waves = n = principal quantum number
- Wavelength of electron $(\lambda) \cong \sqrt{\frac{150}{V(\text{volts})}}$ Å
- $\lambda = \frac{h}{\sqrt{2mKE}}$

HEISENBERG UNCERTAINTY

- According to this principle, " it is impossible to measure simultaneously the position and momentum of a microscopic particle with absolute accuracy"

  If one of them is measured with greater accuracy, the other becomes less accurate.
- $\Delta x.\Delta p \geq \frac{h}{4\pi}$ or $(\Delta x)(\Delta v) \geq \frac{h}{4\pi m}$

  where
  Δx =Uncertainty in position
  Δp = Uncertainty in momentum
  Δv = Uncertainty in velocity
  m = mass of microscopic particle
- Heisenberg replaced the concept of orbit by that of orbital.

QUANTUM NUMBER

- **Principal Quantum number (By Bohr)**
  - ⇒ Indicates = Size and energy of the orbit, distance of e^- from nucleus
  - ⇒ Values n = 1, 2, 3, 4, 5.....................
  - ⇒ Angular momentum = $n \times \frac{h}{2\pi}$
  - ⇒ Total number of e^-s in an orbit = $2n^2$
  - ⇒ Total number of orbitals in an orbit = n^2
  - ⇒ Total number of subshell in an orbit = n
- **Azimuthal/Secondary/Subsidiary/Angular momentum quantum number (ℓ)**
  - ⇒ Given by = Sommerfeld
  - ⇒ Indicates = Sub shells/sub orbit/sub level
  - ⇒ Values ⇒ 0, 1..............(n–1)
  - ⇒ Indicates shape of orbital/Sub shell

Value of n	Values of ℓ [Shape]	Initial from word
eg. If n = 4	ℓ = 0 (s) [Spherical] ℓ=1 [p] [Dumb bell] ℓ=2 [d] [Double dumb bell] ℓ=3 [f] [Complex]	Sharp Principal Diffused Fundamental

- ⇒ Total no. of e^-s in a suborbit = 2(21 + 1)
- ⇒ Total no. of orbitals in a suborbit = (21 + 1)
- ⇒ Orbital angular momentum

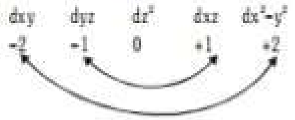
$$= \sqrt{\ell(\ell+1)}\frac{h}{2\pi} = \sqrt{\ell(\ell+1)}\hbar$$

h = Planck's constant

- ⇒ For H & H like species all the subshells of a shell have same energy.
  i.e. 2s = 2p 3s = 3p = 3d
- **Magnetic Quantum number (m)**
  - ⇒ Given by Linde
  - ⇒ Indicates orientation of orbitals i.e. direction of electron density.
  - ⇒ Value of m = $-\ell$ ....0.........$+\ell$
  - ⇒ Maximum no of e's in an orbital = 2 (with opposite spin)

m for p sub shell =

m for d sub shell =



- **Spin Quantum Number (m_s or s)**
  Given by Uhlenback & Goudsmit
  Values of s = ±½
  Total value of spin in an atom = ±½ ×number of unpaired electrons

Spin Angular momentum = $\sqrt{s(s+1)}\frac{h}{2\pi}$

RULES FOR FILLING OF ORBITALS

- **Aufbau principle :** The electrons are filled up in increasing order of the energy in subshells.
  $1s^22s^22p^63s^23p^64s^23d^{10}4p^65s^24d^{10}5p^66s^24f^{14}5d^{10}6p^67s^25f^{14}6d^{10}$
- **(n + ℓ) rule :** The subshell with lowest (n + ℓ) value is filled up first, but when two or more subshells have same (n + ℓ) value then the subshell with lowest value of n is filled up first.
- **Pauli exclusion principle :** Pauli stated that no two electrons in an atom can have same values of all four quantum numbers.
- **Hund's rule of maximum multiplicity :** Electrons are distributed among the orbitals of subshell in such a way as to give maximum number of unpaired electrons with parallel spin.

THERMODYNAMICS

Deals with interaction of one body with another in terms of energy.

System: Part of universe under investigation.

Surrounding: Rest part of universe except system.

Boundary: Divide system & surrounding.

State function	Path function
Properties which depends only on initial & final state of system & not on process or path. e.g. U, H etc.	Depends on path or process. e.g. work, heat

THERMODYNAMIC PROPERTIES	
Extensive	**Intensive**
Properties which are dependent of matter (size & mass) present in system	Properties which are independent of matter (size & mass) present in system

SYSTEM

Open	Closed	isolated
Energy and matter can exchange	Only energy can exchange	Neither energy nor matter

PROCESSES

Isothermal	Isochoric	Isobaric	Adiabatic	Cyclic
T = const.	V = const.	P = const.	No heat exchange dq = 0	Initial & final state of system are same

Extensive Properties	Intensive Properties
Volume	Molar volume
Number of moles	Density
Mass	Refractive index
Free Energy (G)	Surface tension
Entropy (S)	Viscosity
Enthalpy (H)	Free energy per mole
Internal energy (E & U)	specific heat
Heat capacity	Pressure
	Temperature
	Boilling point, freezing point etc

Reversible process	Irreversible process
• Slow process	• Fast process
• At any time system and surrounding are in equilibrium	• No equilibrium between system and surrounding
• $P_{sys} = P_{surr} \pm dP$	• $P_{sys} = P_{surr} \pm \Delta P$

HEAT (q)

Energy exchange due to temperature difference :

$q = C\Delta T$, $q = nC_m\Delta T$, $q = ms\Delta T$

C = heat capacity

Cm = molar heat capacity

s = specific heat capacity

m = Amount of substance

WORK (W)

Reversible	Irreversible
$W_{rev} = -\int_{V_1}^{V_2} P_{ext} \cdot dV$	$W_{irr} = -P_{ext}(V_2 - V_1)$

INTERNAL ENERGY (E & U)

Every system having some quantity of matter is associated with a definite amount of energ internal energy.

$U = U_{Kinetics} + U_{Potential} + U_{Electronic} + U_{nuclear} + \ldots\ldots$

U is a state function & is an extensive property.

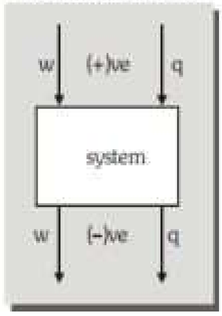
$\Delta U = U_{final} - U_{initial}$

For a given closed system

$U = f(T, V)$

$$dU = \left(\frac{\partial U}{\partial T}\right)_V dT + \left(\frac{\partial U}{\partial V}\right)_T dV$$

SIGN CONVENTION



FIRST LAW OF THERMODYNAMICS (FLOT)

Law of conservation of energy

$$\boxed{\Delta U = q + W}$$

ENTHALPY

Chemical reactions are generally carried out at constant pressure (atmospheric pressure) so it has been found useful to define a new state function **Enthalpy** (H) as.

$$H = U + PV$$

$$\Delta H = \Delta U + \Delta(PV)$$

at constant pressure $\Delta H = \Delta U + P\,\Delta V$

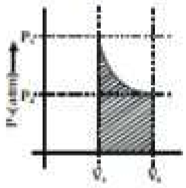
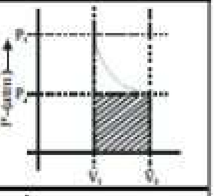
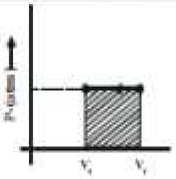
combining with first law. $\Delta H = q_p$

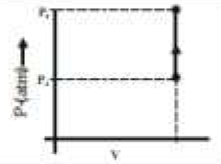
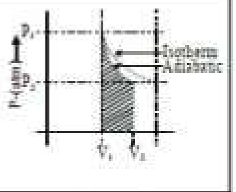
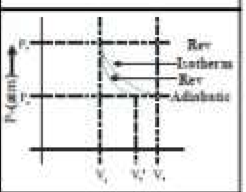
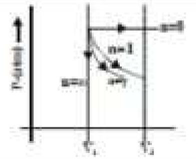
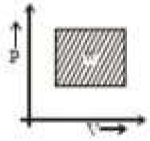
RELATIONSHIP BETWEEN ΔH & ΔU

The difference between ΔH & ΔU becomes significant only when gases are involved (insignificant in solids and liquids) $\Delta H = \Delta U + \Delta(PV)$

If substance is not undergoing chemical reaction or phase change. $\Delta H = \Delta U + nR\Delta T$

In case of chemical reaction $\Delta H = \Delta U + (\Delta n_g)RT$

Process	Expression for w	Expression for q	ΔU	ΔH	Work on PV-graph
Reversible isothermal	$w = -nRT\ln\frac{V_2}{V_1}$ $= -nRT\ln\frac{P_1}{P_2}$	$q = nRT\ln\left(\frac{V_2}{V_1}\right)$ $q = nRT\ln\left(\frac{P_1}{P_2}\right)$	0 process	0	
Irreversible isothermal	$w = -P_{ext}(V_2 - V_1)$ $= -P_{ext}\left(\frac{nRT}{P_2} - \frac{nRT}{P_1}\right)$	$q = P_{ext}(V_2 - V_1)$	0	0	
Isobaric process	$w = -P_{ext}(V_2 - V_1)$ $= -nR\Delta T$	$q = \Delta H = nC_P\Delta T$	$\Delta U = nC_V\Delta T$	$\Delta H = nC_P\Delta T$	

Isochoric process	$w = 0$	$q = \Delta U = nC_V\Delta T$	$\Delta U = nC_V\Delta T$	$\Delta H = nC_P\Delta T$	
Reversible adiabatic process	$w = nC_V(T_2 - T_1)$ $= \dfrac{P_2V_2 - P_1V_1}{\gamma - 1}$	$q = 0$ PV^{γ}=constant $TV^{\gamma-1}$=constant $TP^{1-\gamma/\gamma}$=constant	$\Delta U = nC_V\Delta T$	$\Delta H = nC_P\Delta T$	
Irreversible adiabatic process	$w = nC_V(T_2 - T_1)$ $= \dfrac{P_2V_2 - P_1V_1}{\gamma - 1}$	$q = 0$ $nC_v(T_2 - T_1) =$ $-P_{ext}\left(\dfrac{nRT_2}{P_2} - \dfrac{nRT_1}{P_1}\right)$	$\Delta U = nC_V\Delta T$	$\Delta H = nC_P\Delta T$	
Polytropic	$w = \dfrac{P_2V_2 - P_1V_1}{n - 1}$ $w = \dfrac{R(T_2 - T_1)}{(n-1)}$	$q = \int_{T_1}^{T_2} C_V dT$ $w = \dfrac{R(T_2 - T_1)}{(n-1)}$	$\Delta U = nC_V\Delta T$	$\Delta H = nC_P\Delta T$	
Cyclic Process	Area encolsed in PV-diagram For clockwise it is –ive it is +ive	$q = -w$	0	0	

Entropy (denoted by S) is state function

$$\Delta S = \int \frac{q_{rev}}{T}$$

In an irreversible process entropy of universe increases but it remains constant in a reversible process.

$\Delta S_{sys} + \Delta S_{surr} = 0$ for rev. process

$\Delta S_{sys} + \Delta S_{surr} > 0$ for irrev. process

$\Delta S_{sys} + \Delta S_{surr} \geq 0$ (In general)

PHYSICAL SIGNIFICANCE OF ENTROPY

One can think entropy as a measure of the degree of randonness or disorder in a system. The greater the disorder in a system, the higher is the entropy.

(i) The entropies of substance follow the order,

$S(g) > S(l) > S(s)$

(ii) If more no. of gaseous moles are present on product side, $\Delta_r S$ will be +ive (since gas is more disordered than solid or liquid).

(iii) Entropy rises with increasing mass, other thing being same e.g. atomicity in gas phase.

e.g.	$F_2(g)$	$S^\circ = 203$ J/K-mole
	$Cl_2(g)$	$S^\circ = 223$ J/K-mole
	$Br_2(g)$	$S^\circ = 245$ J/K-mole

(iv) Entropy increases with chemical complexity

For $CuSO_4.nH_2O$

	n = 0	n = 1	n = 3	n = 5
S° =	113	150	225	305

ENTROPY CALCULATION

Process	$\Delta S_{Sys.}$	$\Delta S_{Surr.}$
Isothermal reversible	$\Delta S_{Sys.} = nR\ell n\frac{V_2}{V_1}$	$\Delta S_{Surr.} = -\Delta S_{Sys.}$
Isothermal irreversible	$\Delta S_{Sys.} = nR\ell n\frac{V_2}{V_1}$	$\Delta S_{Surr.} = \frac{-q_{Sys}}{T} = \frac{W_{Sys}}{T} = \frac{-P_{ext}(V_2 - V_1)}{T}$
Adiabatic reversible	$\Delta S_{Sys.} = 0$	$\Delta S_{Surr.} = 0$
Adiabatic irreversible	$\Delta S_{Sys.} = nC_P\ell n\frac{T_2}{T_1} + nR\ell n\frac{P_1}{P_2}$	$\Delta S_{Surr.} = 0$
Isochoric reversible	$\Delta S_{Sys.} = nC_V\ell n\frac{T_2}{T_1}$	$\Delta S_{Surr.} = -\Delta S_{Sys.}$
Isochoric irreversible	$\Delta S_{Sys.} = nC_V\ell n\frac{T_2}{T_1}$	$\Delta S_{Surr.} = \frac{-q_{sys}}{T_{surr}} = \frac{-nC_V\Delta T}{T_{surr}}$

GIBBS FREE ENERGY (G) AND SPONTANEITY :

A new thermodynamic state function G, the Gibbs free energy is defined as :

$$G = H - TS$$

at constant temperature and pressure

$$\Delta G = \Delta H - T\,\Delta S$$

If $(\Delta G)_{T,P} < 0$ Process is irreversible (spontaneous)

$(\Delta G)_{T,P} = 0$ Process is reversible

$(\Delta G)_{T,P} > 0$ process is impossible (non spontaneous)

The equation $\Delta G = \Delta H - T\,\Delta S$ takes both the factors into consideration.

$(\Delta H_r)_{T,P}$	$(\Delta S_r)_{T,P}$	(ΔG_r)	Remarks
– ve	+ ve	Always –ve	Reaction is spontaneous
+ ve	– ve	Always +ve	Reaction non spontaneous
+ ve	+ ve	At low temperature, ΔG = + ve	Non spontaneous
		At high temperature, ΔG = – ve	Spontaneous
– ve	– ve	At low temperature, – ve	Spontaneous
– ve	– ve	At high temperature, + ve	Non spontaneous

THERMOCHEMISTRY

ENTHALPY OF REACTION (ΔH_R)

Amount of heat evolved or absorbed during a reaction at constant pressure.

ENTHALPY OF FORMATION ($\Delta_f H$)

(May be endothermic or exotherm ic)

Change in enthalpy when one mole of a substance is formed from its constituent elements present in standard state.

* For elements $\Delta_f H^\circ = 0$ (for standard state)

Ex. $\Delta_f H^\circ [O_2(g)] = 0$, $\Delta_f H^\circ = S_{8(rhombic)} = 0$

$\Delta_f H^\circ [P_{4\,(white)}] = 0$, $\Delta_f H^\circ = C_{(graphite)} = 0$

ENTHALPY OF COMBUSTION ($\Delta_c H$)

(always exothermic)

Change in enthalpy when 1 mole of a substance is completely burnt in oxygen.

$$C_2H_6(g) + \frac{7}{2}O_2(g) \rightarrow 2CO_2(g) + 3H_2O(\ell)\,;\ \Delta_c H_{[C_2H_6(g)]}$$

$$\Delta_r H^\circ = \sum \Delta_c H^\circ(\text{react.}) - \sum \Delta_c H^\circ(\text{prod.})$$

$$\text{Calorific value} = \frac{\Delta H_{comb}}{\text{molecular wt}}$$

ENTHALPY OF TRANSITION

Enthalpy change when one mole of one allotropic form changes to another.

$$C_{(graphite)} \rightarrow C_{(diamond)}\ \ \Delta_{tran}H^\circ = 1.9\ \text{kJ mol}^{-1}$$

$$H_2O_{(\ell)} \rightarrow H_2O_{(g)};\ \Delta_{vap}H^\circ\,(H_2O_{(\ell)})$$

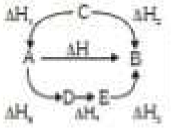
$$H_2O_{(s)} \rightarrow H_2O_{(\ell)};\ \Delta_{fus}H^\circ\,(H_2O_{(s)})$$

$$H_2O_{(s)} \rightarrow H_2O_{(g)};\ \Delta_{sub}H^\circ\,(H_2O_{(s)})$$

LAWS OF THERMOCHEMISTRY

(i) $\left.\begin{array}{ll} A \rightarrow B & \Delta_r H = x\ \text{kJ mol}^{-1} \\ B \rightarrow A & \Delta_r H = -x\ \text{kJ mol}^{-1} \end{array}\right\}$ Lavoisier & Laplace law

(ii) Hess Law of Constant Heat summation



$\Delta H = \Delta H_1 + \Delta H_2$

or $\Delta H = \Delta H_3 + \Delta H_4 + \Delta H_5$

or $\Delta H = \Delta H_1 + \Delta H_2 = \Delta H_3 + \Delta H_4 + \Delta H_5$

BOND ENTHALPY

Average amount of enthalpy required to dissociate one mole gaseous bond into separate gaseous atoms.

$$\Delta_r H = \begin{pmatrix}\text{Sum of bond enthalpy} \\ \text{of gaseous reactant}\end{pmatrix} - \begin{pmatrix}\text{Sum of bond enthalpy} \\ \text{of gaseous product}\end{pmatrix}$$

RESONANCE ENERGY

$$\Delta H^\circ_{resonance} = \Delta_f H^\circ\ (\text{experimental}) - \Delta_f H^\circ\,(\text{calculated})$$

$$= \Delta_C H^\circ(\text{calculated}) - \Delta_C H^\circ(\text{experimental})$$

ENTHALPY OF NEUTRALIZATION (ΔH_{neut})

(Always exothermic)

Change in enthalpy when one gram equivalent of an acid is completely neutralized by one g-equivalent of a base in dilute solution.

$SA + SB \rightarrow \text{salt} + \text{water}\ ;\ \Delta H^\circ_{neut}$

$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(\ell)}\ ;$

$\Delta H = -13.7\ \text{kCal eq}^{-1} = 57.3\ \text{kJ eq}^{-1}$

In case of weak acid / base or both $|\Delta H^\circ_N| < 13.7\,\frac{\text{Kcal}}{\text{eq}}$ and the difference is enthalpy of ionisation of ionisation of weak species except in case of HF when $|\Delta H_N| > 13.7$ due to hydration of F^-.

ENTHALPY OF ATOMISATION (ΔH_{atom})

(always endothermic)

Change in enthalpy when one mole of gaseous molecules converts into gaseous atoms.

ENTHALPY OF SOLUTION (ΔH_{sol})

(may be endo or exothermic)

Change in enthalpy when 1 mol of a substance is dissolved in excess of water so that further dilution does not involve any heat change.

$$CuSO_{4(s)} \xrightarrow{aq} CuSO_{4(aq)}\,;\ \Delta H^\circ_{sol.}$$

ENTHALPY OF HYDRATION (ΔH_{hydra})

(always exothermic)

Enthalpy change when 1 mole of anhydrous salt combine with requisite amount of water to form hydrated salt.

$$\underset{\text{(anhy. salt)}}{CuSO_{4(s)}} + 5H_2O_{(\ell)} \rightarrow \underset{\text{(hydra.salt)}}{CuSO_4.5H_2O_{(s)}}\,;\ \Delta H^\circ_{hyd}$$

ENTHALPY OF HYDROGENATION (ΔH_{hydro})
(Always exothermic)

Enthalpy change during the complete hydrogenation of one mole unsaturated organic compound into its saturated compound.

$$\underset{(= \text{ or } \equiv \text{ bond})}{\text{unsaturated organic compound}} \xrightarrow{\Delta} \underset{(-\text{bond})}{\text{saturated organic compound}}$$

$$C_2H_2 + 2H_2 \rightarrow C_2H_6;\ \Delta H_{hydro}$$

NOTE :

If in a reaction heat of reactant & products are given then heat of that reaction can be measured as follows:

(a) For heat of combustion & for bond enthalpy

$$\Delta_r H = \sum(\Delta H_C)_{reactant} - \sum(\Delta H_C)_{product}$$

(b) For heat of formation

$$\Delta_r H = \sum(\Delta H_f)_{product} - \sum(\Delta H_f)_{reactant}$$

CHEMICAL EQUILIBRIUM

- Equilibrium represents the state of a process in which the measurable properties like :- temperature, pressure, color, concentration of the system do not show any change with the passage of time.
- Equilibrium is a dynamic process, chemical equilibrium can be approached from both sides.
- The state of equilibrium is not affected by the presence of catalyst. It only helps to attain the equilibrium state in less or more time.
- Equilibrium can be attained both in homogeneous & heterogenous system.

Consider a reversible reaction,

$$aA + bB \underset{r_b}{\overset{r_f}{\rightleftharpoons}} cC + dD$$

AT EQUILIBRIUM STATE

Rate of forward reaction (r_f)

= rate of backward reaction (r_b)

So, at equilibrium,

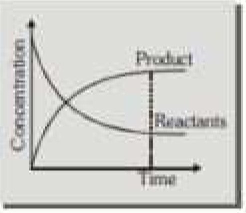
$K_c = \dfrac{[C]^c[D]^d}{[A]^a[B]^b} = \dfrac{K_f}{K_b}$ In terms of active mass

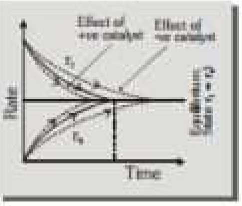
$K_p = \dfrac{[P_C]^c[P_D]^d}{[P_A]^a[P_B]^b}$ In terms of partial pressure

$K_X = \dfrac{[X_C]^c[X_D]^d}{[X_A]^a[X_B]^b}$ In terms of mole fraction

- Partial pressure of solid is taken as unity & in calculation of partial pressure of solids, their number of moles are not considered.
- $K_p = K_c(RT)^{\Delta n_g}$ then $K_p = K_c$
  when $\Delta n_g = 0$ then $K_p = K_c$
  when $\Delta n_g > 0$ then $K_p > K_c$
  when $\Delta n_g < 0$ then $K_p < K_c$
- While determining Δn_g take only gaseous species.
- The active mass of solid & pure liquid is a constant quantity (unity) because it is an intensive property.

GRAPHS





- **Unit of Equilibrium constant:**

  $K_C = (\text{mol L}^{-1})^{\Delta n_g}$; $K_P = (\text{atm})^{\Delta n_g}$

- **Application of K_c or K_p**
  - More is the value of K_p or K_c more is the extent of reaction.
  - Stability of reactant increases when value of K decreases
  - Stability of Product increases when value of K increases.

CHARACTERISTICS OF EQUILIBRIUM CONSTANT

Equilibrium constant depends upon temperature & way of writing the reaction

(i) Temperature :

Let K_1 & K_2 be equilibrium constant at T_1 & T_2 then

$$\text{Log}\left(\frac{K_2}{K_1}\right) = \frac{\Delta H^\circ}{2.303R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$$

(Van't Hoff equation)

(ii) Way of writing the reaction :

For $A + B \rightleftharpoons C + D$ $K_c = K$ then

(a) $C + D \rightleftharpoons A + B$; $K_c' = \dfrac{1}{K}$

(b) $nA + nB \rightleftharpoons nC + nD$; $K_c'' = K^n$

- **Predicting the direction of reaction :**

Reaction Quotient (Q) is expressed in the same way as for equilibrium constant, except that the concentrations may not necessarily be at equilibrium.

In general for the reversible reaction :

$$aA + bB \rightleftharpoons cC + dD$$

$$Q = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

$$Q = \frac{[P_C]^c[P_D]^d}{[P_A]^a[P_B]^b} \text{ (in terms of pressure)}$$

If $Q = K_{eq}$ then system is in equilibrium

If $Q > K_{eq}$ then system proceed in backward direction to attain equilibrium.

when n=2, then $K_C'' = K^2$

$n = \frac{1}{3}$ then $K_C'' = K^{1/3}$

(c) $A \rightleftharpoons B$ $K_c = K_1$

$B \rightleftharpoons C$ $K_c = K_2$

$C \rightleftharpoons D$ $K_c = K_3$ then

$A \rightleftharpoons D$ $K_c = K_1 \times K_2 \times K_3$

(d) $A \rightleftharpoons B$ $K_c = K_1$

$2C \rightleftharpoons 2B$ $K_c = K_2$

$D \rightleftharpoons C$ $K_c = K_3$ then

$A \rightleftharpoons D$ $K_C = \frac{K_1}{\sqrt{K_2} \cdot K_3}$

If $Q < K_{eq}$ then system proceed in forward direction to attain equilibrium.

- **Degree of dissociation (α)**

$$\frac{\text{No. of moles of reactant dissociated}}{\text{No. of mole of reactant present initially}}$$

- **Degree of Dissociation from Vapour pressure**

$n_1A \rightleftharpoons n_2B + n_3C$

$$\alpha = \frac{n_1}{\Delta n}\left(\frac{D_T - D_0}{D_0}\right);\ \Delta n = (n_2 + n_3) - (n_1)$$

D_T = theoretical vapour density = $\frac{\text{Molecular weight}}{2}$

D_0 = Observed vapour density

LE-CHATELIER'S PRINCIPLE

If a system at equilibrium is subjected to a change of any one of the factors such as concentration, pressure or temperature then the equilibrium is shifted in such a way as to nullify the effect of change.

Le-Chatelier's principle is applicable for both chemical and physical equilibrium.

CHEMICAL EQUILIBRIUM

S. No.	Effect due to change in		$\Delta n_g = 0$ $A \rightleftharpoons B$	$\Delta n_g > 0$ $A \rightleftharpoons 2B$	$\Delta n_g < 0$ $2A \rightleftharpoons B$
a)	Concentration	(i) ↑ [A] (ii) ↓ [A]	Forward direction Backward direction	Forward direction Backward direction	Forward direction Backward direction
b)	Pressure	(i) ↑ in pressure (ii) ↓ in pressure	Unchanged Unchanged	Backward direction Forward direction	Forward direction Backward direction
c)	Temperature	(i) ↑ in Endothermic (ii) ↑ in Exothermic	Forward direction Backward direction	Forward direction Backward direction	Forward direction Backward direction
d)	Dissociation	(i) ↑ in pressure (ii) ↑ in volume	Unchanged Unchanged	Dissociation Decreases Dissociation Increases	Dissociation Increases Dissociation Decreases
e)	Mixing of inert gas	(i) at constant P (ii) at constant V	Unchanged Unchanged	Dissociation Increases Unchanged	Dissociation Decreases Unchanged

CHEMICAL KINETICS

- **Rate of reaction** (ROR) = $\frac{\text{Rate of disappearance of reactant (appearance of products)}}{\text{Stoichiometric coefficient of reactant (products)}}$

- **For a reaction :**

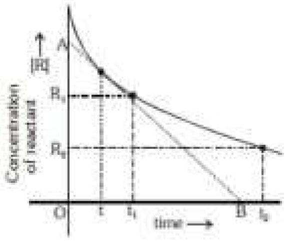
  $aA + bB \longrightarrow cC + dD$

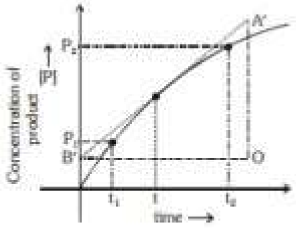
- **Instantaneous rate :** $-\frac{1}{a}\left(\frac{d[A]}{dt}\right) = -\frac{1}{b}\left(\frac{d[B]}{dt}\right) = \frac{1}{c}\left(\frac{d[C]}{dt}\right) = \frac{1}{d}\left(\frac{d[D]}{dt}\right)$

Relationship between rate of reaction and rate of disappearence of reactant (rate of appearance of product).

- **Average rate :** $-\frac{1}{a}\left(\frac{\Delta[A]}{\Delta t}\right) = -\frac{1}{b}\left(\frac{\Delta[B]}{\Delta t}\right) = \frac{1}{c}\left(\frac{\Delta[C]}{\Delta t}\right) = \frac{1}{d}\left(\frac{\Delta[D]}{d\Delta t}\right)$

⇒ Graphical method for determining rate :



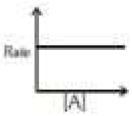
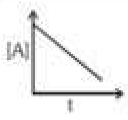
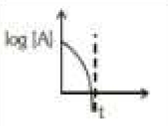
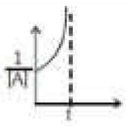
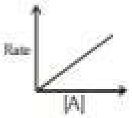
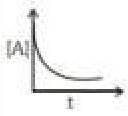
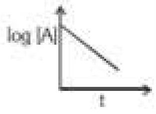
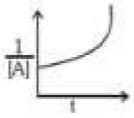
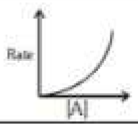
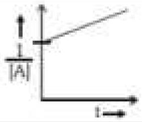


$$\text{Avg. Rate} = -\left(\frac{[R]_2-[R]_1}{t_2-t_1}\right) = \frac{([P]_2-[P]_1)}{t_2-t_1}$$

➢ **Important kinetic expression for reaction of type A ⟶ B :**

Order	**Zero**	**1st**	**2nd**	**nth**
Differential rate law	Rate = k	Rate= k[A]	Rate = $k[A]^2$	Rate = $k[A]^n$
Integrated rate law	$[A_0]-[A] = kt$	$kt = \ln\frac{[A]_0}{[A]}$	$kt = \frac{1}{[A]} - \frac{1}{[A]_0}$	$kt = \frac{1}{(n-1)}\left[\frac{1}{[A]^{n-1}} - \frac{1}{[A]_0^{n-1}}\right]$
Half life ($t_{1/2}$)	$t_{1/2} = \frac{[A]_0}{2k}$	$t_{1/2} = \frac{\ln 2}{k}$	$t_{1/2} = \frac{1}{[A]_0 k}$	$t_{1/2} = \frac{1}{k(n-1)}\left[\frac{2^{n-1}-1}{[A_0]^{n-1}}\right]$
($t_{3/4}$)	$t_{3/4} = 1.5\ t_{1/2}$	$t_{3/4} = 2\ t_{1/2}$	$t_{3/4} = 3\ t_{1/2}$	$t_{3/4} = (2^{n-1}+1)\ t_{1/2}$

➢ **Graphs of various order**

Order	Rate vs [A]	[A] vs t	log [A] vs t	$\frac{1}{[A]}$ vs t
Zero order				
First order				
Second order				

➢ **Temperature dependence :**

– Arrhenious equation : $k = A\,e^{-Ea/RT}$

– E_a = minimum energy over and above the avg. energy of reactant which must be possesed by reacting molecule for collision to be succesful.

$$\ln k = \ln A - \frac{E_a}{RT}$$

$$\ln\frac{k_2}{k_1} = \frac{E_a}{R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$$

Solid State

Packing efficiency

$$= \frac{\text{Volume occupied by two spheres in the unit cell}}{\text{Total volume of the unit cell}} \times 100$$

- Mass of the atoms of unit cell = Number of atoms in a unit cell (Z) × Mass of atom (M_{atom})
- Mass of one atom = $\frac{\text{Molar mass } (M)}{\text{Avogadro's constant } (N_A)}$
- Density (ρ) of unit cell of a cubic crystal = $\frac{ZM}{V \times N_A} = \frac{ZM}{a^3 N_A}$

- Bragg's equation : $2d \sin\theta = n\lambda$
- Number of octahedral voids = No. of particles present in the close packing
- Number of tetrahedral voids = 2 × No. of octahedral voids

Characteristics of Different Types of Unit Cells

Crystal	No. of atom(s)/ unit cell	Packing efficiency	C.No.	Relation in d, a and r
scc	1	52.4%	6	$r = d/2 = a/2$
bcc	2	68%	8	$r = d/2 = \sqrt{3}a/4$
fcc	4	74%	12	$r = d/2 = a/2\sqrt{2}$

Void	Radius Ratio
Triangular	$0.155 \le r^+/r^- < 0.225$
Tetrahedral	$0.225 \le r^+/r^- < 0.414$
Octahedral	$0.414 \le r^+/r^- < 0.732$
Body-centred cubic	$0.732 \le r^+/r^- < 1$

Solids on the Basis of Electrical Properties

- **Conductors :** Electrical conductivity, 10^4 to 10^7 ohm^{-1} m^{-1}
- **Insulators :** Electrical conductivity, 10^{-20} to 10^{-10} ohm^{-1} m^{-1}
- **Semiconductors :** Electrical conductivity, 10^{-6} to 10^4 ohm^{-1} m^{-1}
  - ***n*-type semiconductors :** Group 14 elements doped with group 15 elements, free electrons increase conductivity.
  - ***p*-type semiconductors :** Group 14 elements doped with group 13 elements, holes increase conductivity.

Solutions

- Molality (m) = $\frac{M}{\rho - \frac{MM_2}{1000}}$
- Molarity (M) = $\frac{n_1}{(n_1M_1 + n_2M_2)/\rho}$

- **Henry's law :** $p_A = K_H \cdot x_A$: K_H increases with increase of temperature implying that solubility decreases with increase of temperature at the same pressure.
- **Raoult's law :** $p_1 = p_1^{\circ} x_1$, this law is applicable only if the two components form a homogeneous mixture.
- **Dalton's law of partial pressure :** $p_{total} = p_1 + p_2 + ... p_n$ and for two components system, $p_{total} = p_1^{\circ} + (p_2^{\circ} - p_1^{\circ})x_2$

Ideal and Non-ideal Solutions

Ideal Solutions	Non-ideal Solutions
$p_1 = x_1p_1^{\circ} ; p_2 = x_2p_2^{\circ}$ $\Delta H_{mix} = 0, \Delta V_{mix} = 0$ $A - B$ interactions = $A - A$ and $B - B$ interactions.	$p_1 \ne x_1p_1^{\circ} ; p_2 \ne x_2p_2^{\circ}$ $\Delta H_{mix} \ne 0, \Delta V_{mix} \ne 0$ $A - B$ interactions ≠ $A - A$ and $B - B$ interactions.

Non-ideal Solutions Showing Positive and Negative Deviations from Raoult's Law

Solutions showing positive deviation	Solutions showing negative deviation
$A - B << A - A$ or $B - B$ interactions. $\Delta H_{mix} > 0, \Delta V_{mix} > 0$ $p_1 > p_1^{\circ}x_1$	$A - B >> A - A$ or $B - B$ interactions. $\Delta H_{mix} < 0, \Delta V_{mix} < 0$ $p_1 < p_1^{\circ}x_1$

Colligative Properties

- **Relative lowering of vapour pressure :** $(p_A^{\circ} - p_A)/p_A^{\circ} = x_B$
- **Elevation in boiling point :** $\Delta T_b = T_b - T_b^{\circ} = K_b m$
- **Depression in freezing point :** $\Delta T_f = T_f^{\circ} - T_f = K_f m$
- **Osmotic pressure :** $\pi = CRT = (n/V)RT$

van't Hoff Factor and its Significance

$$i = \frac{\text{Observed value of colligative property}}{\text{Calculated value of colligative property}}$$

- **For association of solute :** $nA \rightarrow (A)_n$

  Degree of association (α) = $(1 - i)\, n/n - 1; i < 1$
- **For dissociation of solute :** $(A)_n \rightarrow nA$

  Degree of dissociation (α) = $i - 1/n - 1; i > 1$
- **Modified colligative properties :**

  $p_A^{\circ} - p_A/p_A^{\circ} = ix_B ; \Delta T_b = iK_b m; \Delta T_f = iK_f m; \pi = iCRT$

Ionic Equilibrium

The concept of ionic equilibria as equilibria involving ions in solution

(i) Arrhenius theory of electrolytes.

(ii) Ostwards dilution law for weak electrolyte $K_a = \left(\frac{\alpha^2}{1-\alpha}\right)\left(\frac{1}{V}\right)$

(iii) Acid & Bases

(a) Arrhenius H^+/OH^- theory.

(b) Bronsted lowery - protonic concept.

(c) Lewis concept - electronic concept of acids and bases.

Some basic concept

pH scale : $pH = -\log[H^+]$.

(i) Water as amphiprotic solvent.

(ii) Autoionization of water : $K_W = [H^+][OH^-]$.

(iii) $K_a[H_2O] = K_w/[H_2O]$

(iv) Change in pH of neutral H_2O with temperature.

Homogenons Ionic equilibria

(i) Acid/ base equilibrium

(a) Strong acid $[H^+] = c/2 + \sqrt{\frac{c^2}{4} + K_W}$;c=conc. of (acid)

(b) pH due to polyprotic weak acids

(c) Weak monobasic acid $[H^+] = \sqrt{K_a.c}$ (if $\alpha < 0.1$)

(d) Mixture of S.A. & W.A.

(e) Mixture of two W.A. $[H^+] = \sqrt{K_1c_1 + K_2c_2}$

(f) Buffer solutions : $pH = pK_a + \log\left(\frac{salt}{acid}\right)$

$pOH = pK_b + \log\left(\frac{salt}{base}\right)$

(g) Salt hydrolysis – (W.A. & S.B) $pH = \frac{1}{2}(pK_w + pK_a + \log c)$

(W.B & S.A.) $pH = \frac{1}{2}(pK_w - pK_b - \log c)$

(W.A. & W.B.) $pH = \frac{1}{2}(pK_w + pK_a - pK_b)$

Heterogenons equilibria

Solubility of sparingly soluble salt's $(AB, AB_2, A_xB_y)K_{sp} = (S^{x+y})X^xY^y$

(i) Effect of pH on solubility.

(ii) Simultaneous solubility.

Application of both heterogenous and homogenous equilibrium

(i) Extent of hydrolysis in buffer solution.

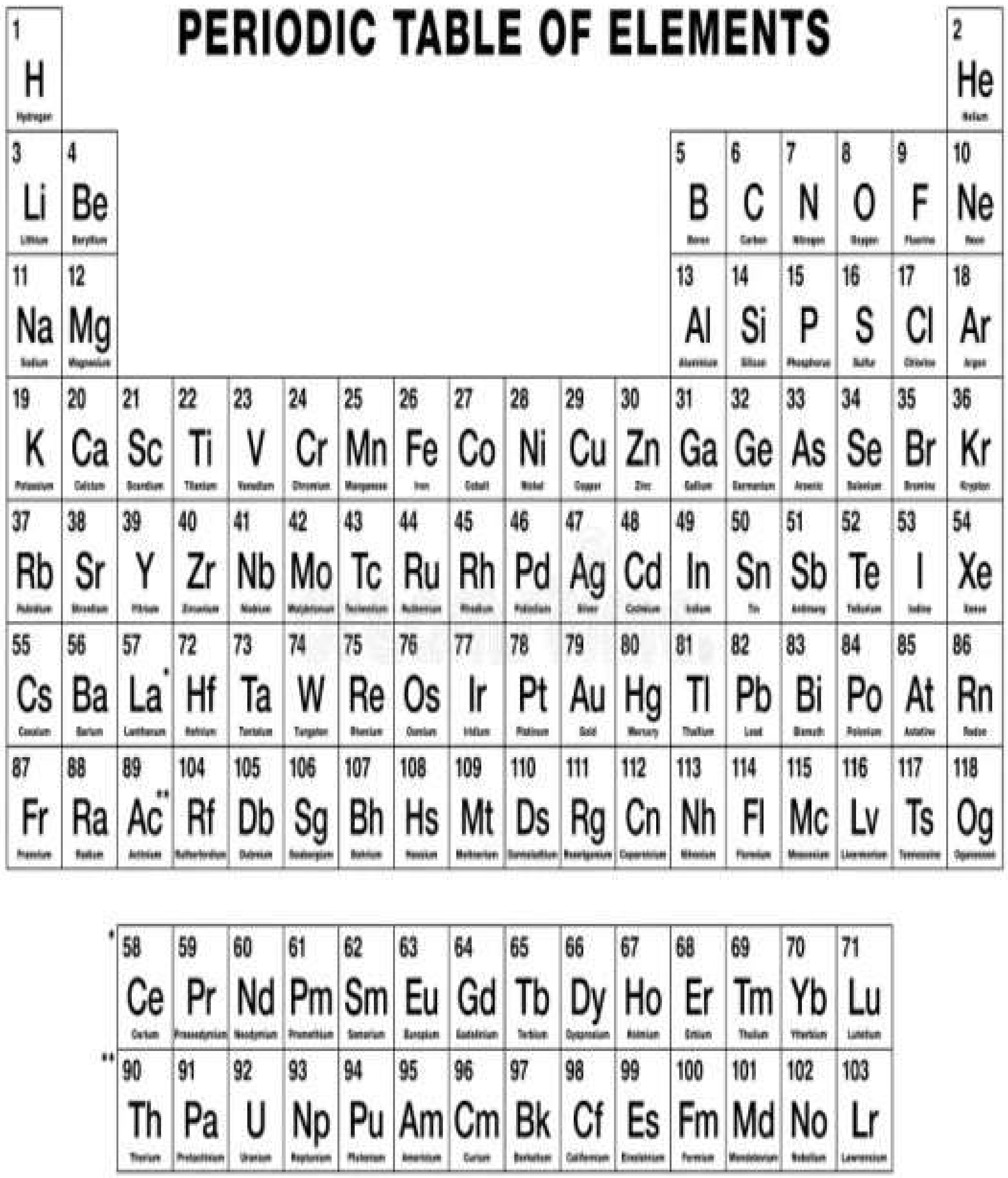
(ii) Change in solubility due to complex formation.

(iii) Solubility and hydrolysis.

Inorganic chemistry

Classification of elements

1. **CLASSIFICATION OF ELEMENTS**

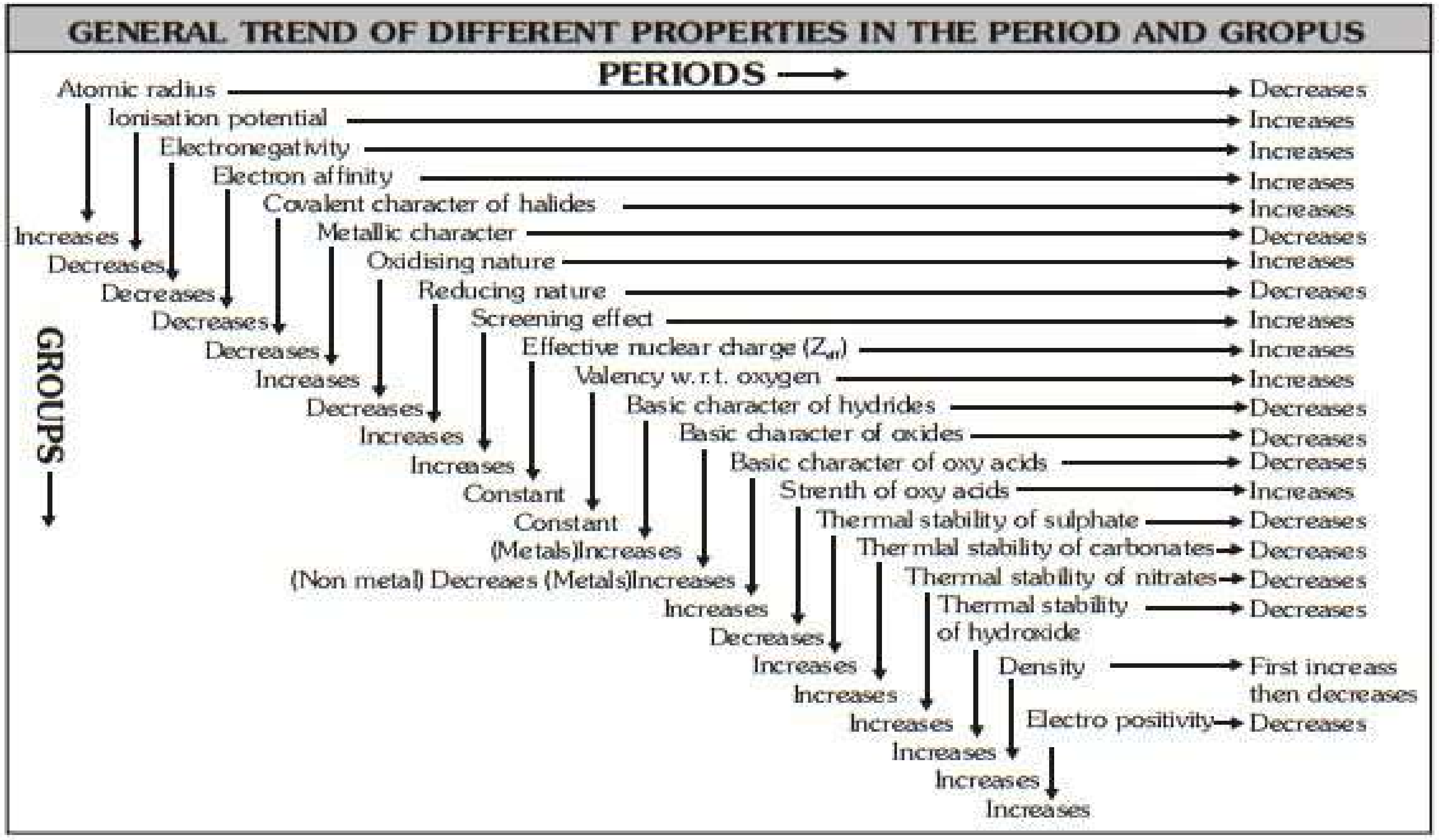


PERIODIC TABLE OF ELEMENTS

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La*	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac**	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og

*	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
**	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

Some Important Increasing Order



GENERAL TREND OF DIFFERENT PROPERTIES IN THE PERIOD AND GROPUS

	PERIODS ⟶	GROUPS ⟶
Atomic radius	Decreases	Increases
Ionisation potential	Increases	Decreases
Electronegativity	Increases	Decreases
Electron affinity	Increases	Decreases
Covalent character of halides	Increases	Decreases
Metallic character	Decreases	Increases
Oxidising nature	Increases	Decreases
Reducing nature	Decreases	Increases
Screening effect	Increases	Increases
Effective nuclear charge (Z_{eff})	Increases	Constant
Valency w.r.t. oxygen	Increases	Constant
Basic character of hydrides	Decreases	(Metals)Increases
Basic character of oxides	Decreases	(Non metal) Decreaes (Metals)Increases
Basic character of oxy acids	Decreases	Increases
Strenth of oxy acids	Increases	Decreases
Thermal stability of sulphate	Decreases	Increases
Thermlal stability of carbonates	Decreases	Increases
Thermal stability of nitrates	Decreases	Increases
Thermal stability of hydroxide	Decreases	Increases
Density	First increass then decreases	Increases
Electro positivity	Decreases	Increases

Periodicity :

Repetition of properties after regular interval is known as periodicity and these properties are known as periodic properties.

1. Effective Atomic Number
2. Atomic Radius
3. Ionisation Potential
4. Electron Affinity
5. Electro Negativity

ATOMIC RADIUS

Distance between centre of nucleus to outermost electron.

Accurate value of atomic radius cannot be measured therefore operational definations are used.

(i) Covalent radius
(ii) Metallic radius
(iii) Vander Waal's radius

$r_{cov} < r_{metallic} < r_{vw}$

Vander wall radius mainly used for noble gases.

Electron affinity & Electron gain enthalpy :

Electron affinity	Electron gain enthalpy
$A_{(g)} \xrightarrow{+e^-} A^-_{(g)}$ amount of energy released when an e^- is added to isolated gaseous atom.	$A_{(g)} + e^- \longrightarrow A^-$ Change in enthalpy when an e^- is added to isolated gaseous atom. $\Delta H_{eg} = H_P - H_R$

Successive electron affinity :

$A_{(g)} \xrightarrow{EA_1} A^-_{(g)} \xrightarrow{EA_2} A^{2-}_{(g)} \xrightarrow{EA_3} A^{3-}_{(g)}$

EA_1 is generally exothermic except N, Be, Mg and Noble gas

EA_2, EA_3 ..... always endothermic

Factors affecting :

(1) $EA \propto Z_{eff}$
(2) $EA \propto \frac{1}{\text{size}}$
(3) Nature of subshell
(4) half and full filled

Periodic trend :

(1) Generally decreases on moving down the group
(2) Generally increase when moving left to right in the period.

Note : III^rd period element having greater EA than II^nd period element except alkali metal.

O < Te < Se < S ,   I < Br < F < Cl

Note : $|IE_A| = |EA_{A^+}|$ and $|EA_A| = |IE_{A^-}|$

Electronegativity :

Tendency to attract shared pair of e^- towards itself in covalent bond.

Factors affecting :

(1) $EN \propto Z_{eff}$
(2) $EN \propto \frac{1}{\text{size}}$
(3) $EN \propto \frac{1}{(-)\text{charge}}$
(4) $EN \propto (+)$charge,
(5) EN ∝ % s-characters of hybrid orbital

Periodic trend :

(1) Generally decreases on moving down the group
(2) Generally increase when moving left to right in the period.

Application of electronegative

(1) Polarity of bond

$\Delta EN = 0$ non-polar bond

$\Delta EN \neq 0$ polar bond

(2) Bond parameter

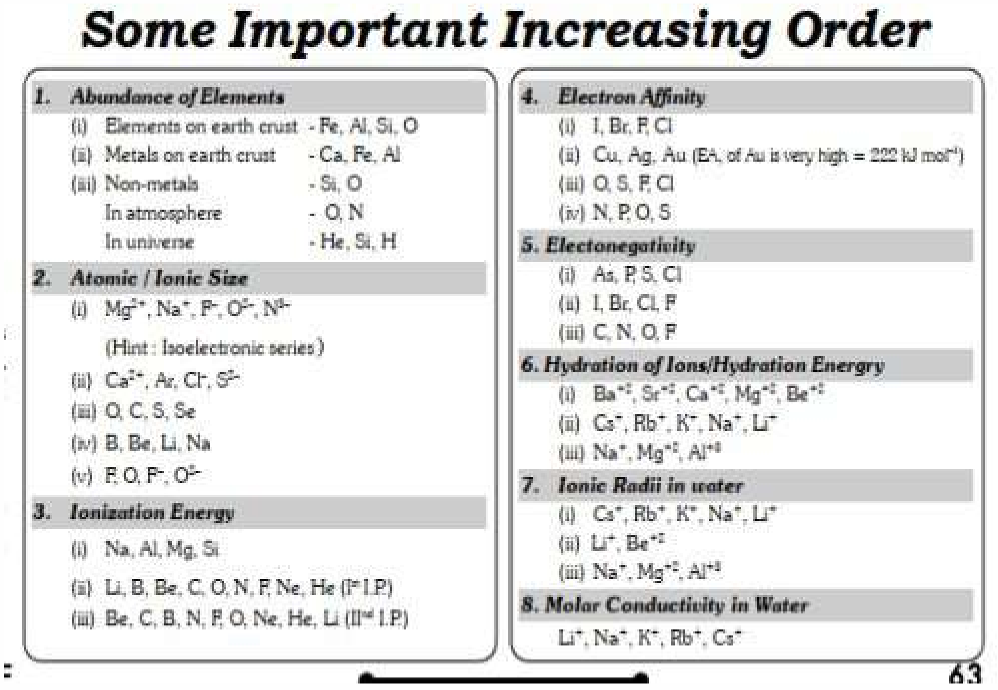
$\Delta EN \uparrow$ Ionic character ↑

$\Delta EN \uparrow$ bond length ↓

$\Delta EN \uparrow$ bond strength ↑

(3) Nature of oxide & oxyacid :

E.N. of central atom increase acidic character of oxide and oxyacid increases.



Some Important Increasing Order

1. Abundance of Elements

(i) Elements on earth crust - Fe, Al, Si, O

(ii) Metals on earth crust - Ca, Fe, Al

(iii) Non-metals - Si, O

In atmosphere - O, N

In universe - He, Si, H

2. Atomic / Ionic Size

(i) $Mg^{2+}, Na^{+}, F^{-}, O^{2-}, N^{3-}$

(Hint : Isoelectronic series)

(ii) $Ca^{2+}, Ar, Cl^{-}, S^{2-}$

(iii) O, C, S, Se

(iv) B, Be, Li, Na

(v) F, O, F^{-}, O^{2-}

3. Ionization Energy

(i) Na, Al, Mg, Si

(ii) Li, B, Be, C, O, N, F, Ne, He (I^{st} I.P.)

(iii) Be, C, B, N, F, O, Ne, He, Li (II^{nd} I.P.)

4. Electron Affinity

(i) I, Br, F, Cl

(ii) Cu, Ag, Au (EA_1 of Au is very high = 222 kJ mol^{-1})

(iii) O, S, F, Cl

(iv) N, P, O, S

5. Electonegativity

(i) As, P, S, Cl

(ii) I, Br, Cl, F

(iii) C, N, O, F

6. Hydration of Ions/Hydration Energry

(i) $Ba^{+2}, Sr^{+2}, Ca^{+2}, Mg^{+2}, Be^{+2}$

(ii) $Cs^{+}, Rb^{+}, K^{+}, Na^{+}, Li^{+}$

(iii) Na^{+}, Mg^{+2}, Al^{+3}

7. Ionic Radii in water

(i) $Cs^{+}, Rb^{+}, K^{+}, Na^{+}, Li^{+}$

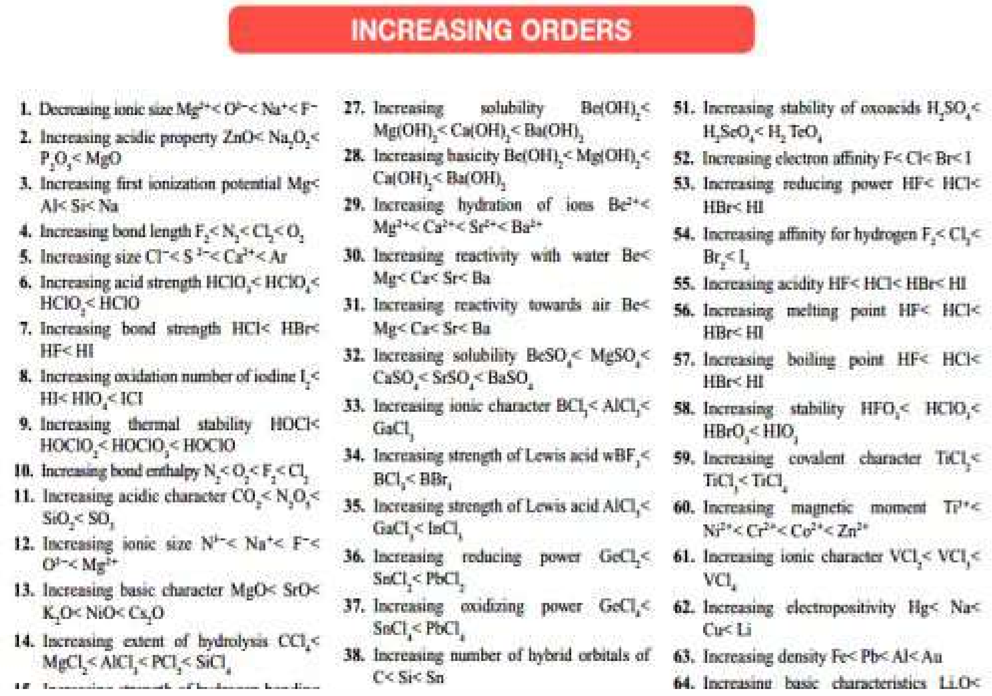
(ii) Li^{+}, Be^{+2}

(iii) Na^{+}, Mg^{+2}, Al^{+3}

8. Molar Conductivity in Water

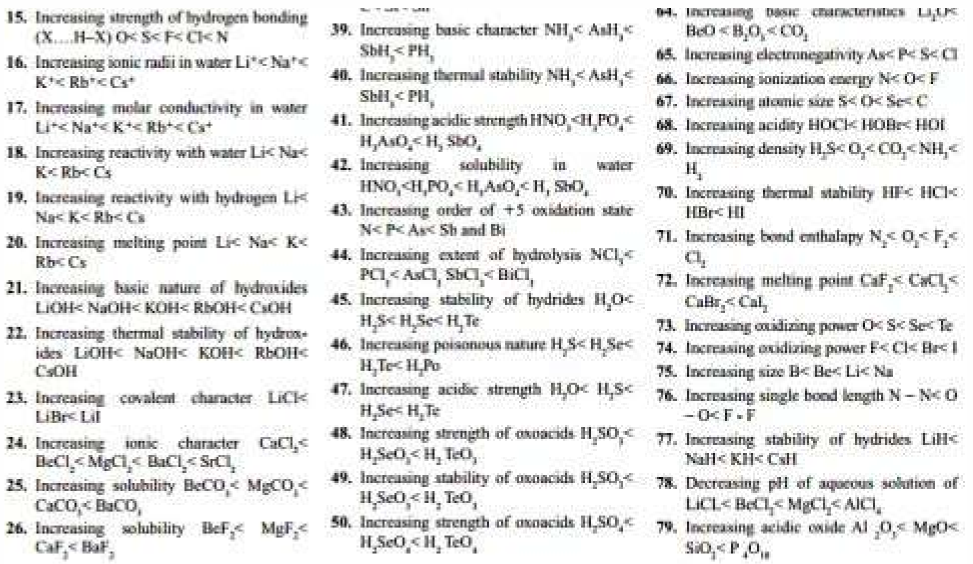
$Li^{+}, Na^{+}, K^{+}, Rb^{+}, Cs^{+}$

63

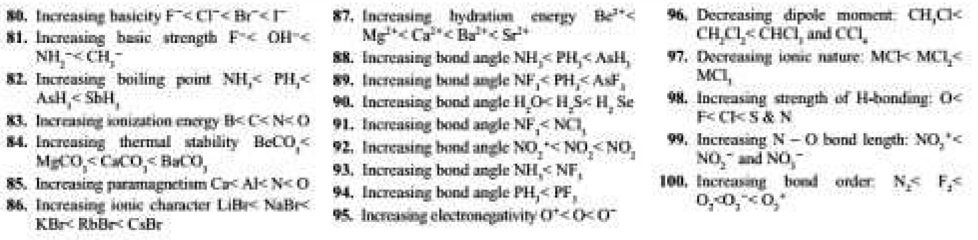


INCREASING ORDERS

1. Decreasing ionic size $Mg^{2+}< O^{2-}< Na^{+}< F^{-}$
2. Increasing acidic property $ZnO< Na_2O_2< P_2O_5< MgO$
3. Increasing first ionization potential Mg< Al< Si< Na
4. Increasing bond length $F_2< N_2< Cl_2< O_2$
5. Increasing size $Cl^{-}< S^{2-}< Ca^{2+}< Ar$
6. Increasing acid strength $HClO_3< HClO_4< HClO_2< HClO$
7. Increasing bond strength HCl< HBr< HF< HI
8. Increasing oxidation number of iodine $I_2< HI< HIO_4< ICl$
9. Increasing thermal stability $HOCl< HOClO_2< HOClO_3< HOClO$
10. Increasing bond enthalpy $N_2< O_2< F_2< Cl_2$
11. Increasing acidic character $CO_2< N_2O_5< SiO_2< SO_3$
12. Increasing ionic size $N^{3-}< Na^{+}< F^{-}< O^{2-}< Mg^{2+}$
13. Increasing basic character $MgO< SrO< K_2O< NiO< Cs_2O$
14. Increasing extent of hydrolysis $CCl_4< MgCl_2< AlCl_3< PCl_5< SiCl_4$
15. Increasing strength of hydrogen bonding
27. Increasing solubility $Be(OH)_2< Mg(OH)_2< Ca(OH)_2< Ba(OH)_2$
28. Increasing basicity $Be(OH)_2< Mg(OH)_2< Ca(OH)_2< Ba(OH)_2$
29. Increasing hydration of ions $Be^{2+}< Mg^{2+}< Ca^{2+}< Sr^{2+}< Ba^{2+}$
30. Increasing reactivity with water Be< Mg< Ca< Sr< Ba
31. Increasing reactivity towards air Be< Mg< Ca< Sr< Ba
32. Increasing solubility $BeSO_4< MgSO_4< CaSO_4< SrSO_4< BaSO_4$
33. Increasing ionic character $BCl_3< AlCl_3< GaCl_3$
34. Increasing strength of Lewis acid $wBF_3< BCl_3< BBr_3$
35. Increasing strength of Lewis acid $AlCl_3< GaCl_3< InCl_3$
36. Increasing reducing power $GeCl_2< SnCl_2< PbCl_2$
37. Increasing oxidizing power $GeCl_4< SnCl_4< PbCl_4$
38. Increasing number of hybrid orbitals of C< Si< Sn
51. Increasing stability of oxoacids $H_2SO_4< H_2SeO_4< H_2TeO_4$
52. Increasing electron affinity F< Cl< Br< I
53. Increasing reducing power HF< HCl< HBr< HI
54. Increasing affinity for hydrogen $F_2< Cl_2< Br_2< I_2$
55. Increasing acidity HF< HCl< HBr< HI
56. Increasing melting point HF< HCl< HBr< HI
57. Increasing boiling point HF< HCl< HBr< HI
58. Increasing stability $HFO_3< HClO_3< HBrO_3< HIO_3$
59. Increasing covalent character $TiCl_2< TiCl_3< TiCl_4$
60. Increasing magnetic moment $Ti^{3+}< Ni^{2+}< Cr^{2+}< Co^{2+}< Zn^{2+}$
61. Increasing ionic character $VCl_2< VCl_3< VCl_4$
62. Increasing electropositivity Hg< Na< Cu< Li
63. Increasing density Fe< Pb< Al< Au
64. Increasing basic characteristics $Li_2O<$

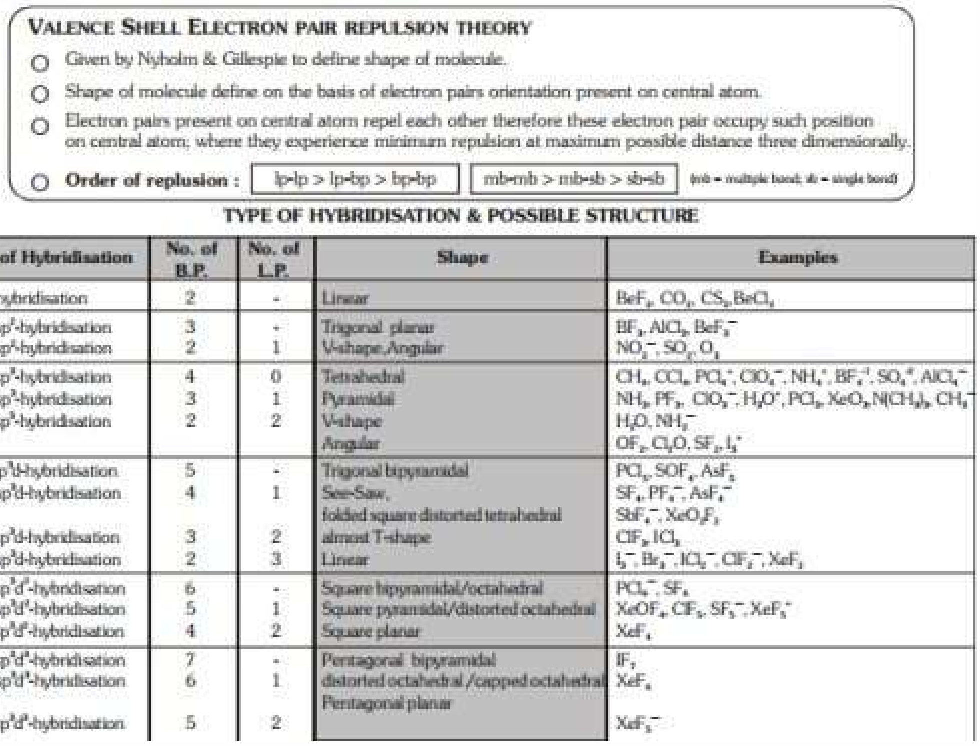


15. Increasing strength of hydrogen bonding (X….H–X) O< S< F< Cl< N
16. Increasing ionic radii in water $Li^+ < Na^+ < K^+ < Rb^+ < Cs^+$
17. Increasing molar conductivity in water $Li^+ < Na^+ < K^+ < Rb^+ < Cs^+$
18. Increasing reactivity with water Li< Na< K< Rb< Cs
19. Increasing reactivity with hydrogen Li< Na< K< Rb< Cs
20. Increasing melting point Li< Na< K< Rb< Cs
21. Increasing basic nature of hydroxides LiOH< NaOH< KOH< RbOH< CsOH
22. Increasing thermal stability of hydroxides LiOH< NaOH< KOH< RbOH< CsOH
23. Increasing covalent character LiCl< LiBr< LiI
24. Increasing ionic character $CaCl_2$< $BeCl_2$< $MgCl_2$< $BaCl_2$< $SrCl_2$
25. Increasing solubility $BeCO_3$< $MgCO_3$< $CaCO_3$< $BaCO_3$
26. Increasing solubility BeF_2< MgF_2< CaF_2< BaF_2
39. Increasing basic character NH_3< AsH_3< SbH_3< PH_3
40. Increasing thermal stability NH_3< AsH_3< SbH_3< PH_3
41. Increasing acidic strength HNO_3<H_3PO_4< H_3AsO_4< H_3SbO_4
42. Increasing solubility in water HNO_3<H_3PO_4< H_3AsO_4< H_3SbO_4
43. Increasing order of +5 oxidation state N< P< As< Sb and Bi
44. Increasing extent of hydrolysis NCl_3< PCl_3< $AsCl_3$ $SbCl_3$< $BiCl_3$
45. Increasing stability of hydrides H_2O< H_2S< H_2Se< H_2Te
46. Increasing poisonous nature H_2S< H_2Se< H_2Te< H_2Po
47. Increasing acidic strength H_2O< H_2S< H_2Se< H_2Te
48. Increasing strength of oxoacids H_2SO_3< H_2SeO_3< H_2TeO_3
49. Increasing stability of oxoacids H_2SO_3< H_2SeO_3< H_2TeO_3
50. Increasing strength of oxoacids H_2SO_4< H_2SeO_4< H_2TeO_4
64. Increasing basic characteristics Li_2O< BeO < B_2O_3 < CO_2
65. Increasing electronegativity As< P< S< Cl
66. Increasing ionization energy N< O< F
67. Increasing atomic size S< O< Se< C
68. Increasing acidity HOCl< HOBr< HOI
69. Increasing density H_2S< O_2< CO_2< NH_3< H_2
70. Increasing thermal stability HF< HCl< HBr< HI
71. Increasing bond enthalapy N_2< O_2< F_2< Cl_2
72. Increasing melting point CaF_2< $CaCl_2$< $CaBr_2$< CaI_2
73. Increasing oxidizing power O< S< Se< Te
74. Increasing oxidizing power F< Cl< Br< I
75. Increasing size B< Be< Li< Na
76. Increasing single bond length N – N< O – O< F - F
77. Increasing stability of hydrides LiH< NaH< KH< CsH
78. Decreasing pH of aqueous solution of LiCL< $BeCl_2$< $MgCl_2$< $AlCl_3$
79. Increasing acidic oxide Al_2O_3< MgO< SiO_2< P_4O_{10}



80. Increasing basicity $F^- < Cl^- < Br^- < I^-$
81. Increasing basic strength F^-< OH^-< NH_2^-< CH_3^-
82. Increasing boiling point NH_3< PH_3< AsH_3< SbH_3
83. Increasing ionization energy B< C< N< O
84. Increasing thermal stability $BeCO_3$< $MgCO_3$< $CaCO_3$< $BaCO_3$
85. Increasing paramagnetism Ca< Al< N< O
86. Increasing ionic character LiBr< NaBr< KBr< RbBr< CsBr
87. Increasing hydration energy Be^{2+}< Mg^{2+}< Ca^{2+}< Ba^{2+}< Sr^{2+}
88. Increasing bond angle NH_3< PH_3< AsH_3
89. Increasing bond angle NF_3< PH_3< AsF_3
90. Increasing bond angle H_2O< H_2S< H_2Se
91. Increasing bond angle NF_3< NCl_3
92. Increasing bond angle NO_2^+< NO_2< NO_2
93. Increasing bond angle NH_3< NF_3
94. Increasing bond angle PH_3< PF_3
95. Increasing electronegativity $O^+ < O < O^-$
96. Decreasing dipole moment: CH_3Cl< CH_2Cl_2< $CHCl_3$ and CCl_4
97. Decreasing ionic nature: MCl< MCl_2< MCl_3
98. Increasing strength of H-bonding: O< F< Cl< S & N
99. Increasing N – O bond length: NO_2^+< NO_2^- and NO_3^-
100. Increasing bond order: N_2< F_2< O_2<O_2^-< O_2^+

Chemical bonding



VALENCE SHELL ELECTRON PAIR REPULSION THEORY

○ Given by Nyholm & Gillespie to define shape of molecule.

○ Shape of molecule define on the basis of electron pairs orientation present on central atom.

○ Electron pairs present on central atom repel each other therefore these electron pair occupy such position on central atom; where they experience minimum repulsion at maximum possible distance three dimensionally.

○ **Order of replusion :** lp-lp > lp-bp > bp-bp | mb-mb > mb-sb > sb-sb (mb = multiple bond; sb = single bond)

TYPE OF HYBRIDISATION & POSSIBLE STRUCTURE

pe of Hybridisation	No. of B.P.	No. of L.P.	Shape	Examples
sp-hybridisation	2	-	Linear	BeF_2, CO_2, CS_2, $BeCl_2$
(a) sp^2-hybridisation	3	-	Trigonal planar	BF_3, $AlCl_3$, BeF_3^-
(b) sp^2-hybridisation	2	1	V-shape,Angular	NO_2^-, SO_2, O_3
(a) sp^3-hybridisation	4	0	Tetrahedral	CH_4, CCl_4, PCl_4^+, ClO_4^-, NH_4^+, BF_4^{-1}, $SO_4^{=}$, $AlCl_4^-$
(b) sp^3-hybridisation	3	1	Pyramidal	NH_3, PF_3, ClO_3^-, H_3O^+, PCl_3, XeO_3, $N(CH_3)_3$, CH_3^-
(c) sp^3-hybridisation	2	2	V-shape	H_2O, NH_2^-
			Angular	OF_2, Cl_2O, SF_2, I_3^+
(a) sp^3d-hybridisation	5	-	Trigonal bipyramidal	PCl_5, SOF_4, AsF_5
(b) sp^3d-hybridisation	4	1	See-Saw,	SF_4, PF_4^-, AsF_4^-
			folded square distorted tetrahedral	SbF_4^-, XeO_2F_2
(c) sp^3d-hybridisation	3	2	almost T-shape	ClF_3, ICl_3
(d) sp^3d-hybridisation	2	3	Linear	I_3^-, Br_3^-, ICl_2^-, ClF_2^-, XeF_2
(a) sp^3d^2-hybridisation	6	-	Square bipyramidal/octahedral	PCl_6^-, SF_6
(b) sp^3d^2-hybridisation	5	1	Square pyramidal/distorted octahedral	$XeOF_4$, ClF_5, SF_5^-, XeF_5^+
(c) sp^3d^2-hybridisation	4	2	Square planar	XeF_4
(a) sp^3d^3-hybridisation	7	-	Pentagonal bipyramidal	IF_7
(b) sp^3d^3-hybridisation	6	1	distorted octahedral /capped octahedral	XeF_6
(c) sp^3d^3-hybridisation	5	2	Pentagonal planar	XeF_5^-

DIPOLE MOMENT

Measurement of Polarity in a molecule

$\boxed{\vec{\mu} = q \times d}$ debye = esu-cm
1D = 10^{-18} esu.cm

(A) Identification of polar or Non-polar molecule.

Molecule : Symmetrical distribution of electron cloud- Non-polar.
Molecule : Unsymmetrical distribution of electron cloud- Polar.

Diatomic Molecule

(a) Homoatomic $\Delta EN = 0 \rightarrow \vec{\mu} = 0 \rightarrow$ Non-polar
H_2, F_2, Cl_2, N_2 etc.

(b) Heteroatomic $\Delta EN \neq 0 \rightarrow \vec{\mu}_{net} = 0 \rightarrow$ polar
$HF > HCl > HBr > HI$

Polyatomic molecule :

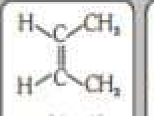
$\mu_R \rightarrow$ Vector sum of bond moment
$\mu_R = \sqrt{\mu_1^2 + \mu_2^2 + 2\mu_1\mu_2 \cos\theta}$

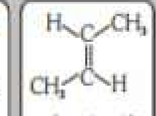
Important Order

$NH_3 > NI_3 > NBr_3 > NCl_3 > NF_3$
$NH_3 > SbH_3 > AsH_3 > PH_3$
$H_2O > H_2S$
$CH_3Cl > CH_3F > CH_3Br > CH_3I$
$CH_3Cl > CH_2Cl_2 > CHCl_3 > CCl_4$

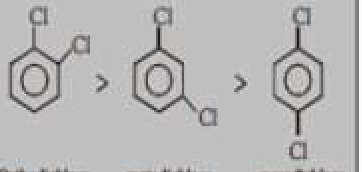
Applications

Predict shape and polarity of molecule
Symmetrical geometry → $\mu = 0$ → non-polar
Unsymmetrical geometry → $\mu \neq 0$ → polar
Distinguish between cis & trans form


maleic acid
$\mu \neq 0$


fumaric acid
$\mu = 0$

Dipole moment in Aromatic Compounds



Orthodichloro benzene **metadichloro benzene** **paradichloro benzene**

$\mu \propto \frac{1}{\text{bond angle}}$

SOLUBILITY

For s-block
same group cation depends upon
Lattice Energy and Hydration Energy

Increasing order of solubility

(i) $BaCO_3$, $SrCO_3$, $CaCO_3$, $MgCO_3$, $BeCO_3$

(ii) $Be(OH)_2$, $Sr(OH)_2$, $Mg(OH)_2$, $Ca(OH)_2$, $Ba(OH)_2$

(iii) $BaSO_4$, $SrSO_4$, $CaSO_4$, $MgSO_4$, $BeSO_4$

(iv) Li_2CO_3, Na_2CO_3, K_2CO_3, Rb_2CO_3, $CsCO_3$

(v) LiOH, NaOH, KOH, RbOH, CsOH

(vi) LiF, LiCl, LiBr, LiI

(vii) LiF, NaF, KF, RbF, CsF

(viii) BaF_2, SrF_2, MgF_2, CaF_2, BeF_2

(ix) CaF_2, $CaCl_2$, $CaBr_2$, CaI_2

For all **solubility $\propto \frac{1}{\text{cov. char.}}$**

solubility in org. solvent $\propto$ cov. char $\propto \frac{1}{\text{ionic char}}$

[CCl_4, benzene, ether, alcohol, acetone]

Eg. (i) $PbF_2 > PbCl_2 > PbCl_2 > PbI_2$
(Anion size↑, cov. char.↑, solubility ↓)

(ii) $Fe^{+2}(OH)_2 > Fe^{+3}(OH)_3$
(+) charge↑, PP↑, CC ↑, solubility ↓

(iii) $ZnCl_2 > CdCl_2 > HgCl_2$
Z_{eff}↑, PP↑, CC ↑, solubility ↓

(iv) $Na_2SO_4 > MgSO_4$
(+)charge↑, PP↑, CC ↑, solubility ↓

(v) $ZnCl_2 > CdCl_2 > HgCl_2$
Z_{eff}↑, PP↑, CC ↑, solubility ↓

(vi) NaCl > CuCl
PP↑, CC ↑, solubility ↓

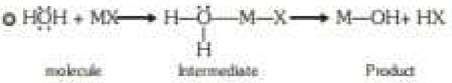
(vii) AgF > AgCl > AgBr > AgI
Anionic Size↑, PP ↑, CC↑, solubility ↓

HYDROLYSIS

Hydro - Water
lysis - break down

Break down of a molecule through water and formation of new product is known as hydrolysis.

- It is nucleophilic substitution reaction.
-



$$H\ddot{O}H + MX \longrightarrow H{-}\underset{\displaystyle H}{\underset{|}{\ddot{O}}}{-}M{-}X \longrightarrow M{-}OH + HX$$

molecule Intermediate Product

extent of hydrolysis ∝ covalent character.

$BeCl_2 + 2HOH \rightarrow Be(OH)_2 + 2HCl$

$BCl_3 + 3HOH \rightarrow B(OH)_3 + 3HCl$

$AlCl_3 + 3HOH \rightarrow Al(OH)_3 + 3HCl$

$SiCl_4 + 4HOH \rightarrow Si(OH)_4 + 4HCl$

$SF_6 + H_2O \rightarrow$ No hydrolysis due to crowding

$CCl_4 + HOH \xrightarrow[\text{conditions}]{\text{ordinary}}$ No hydrolysis

$BF_3 + 3HOH \rightarrow B(OH)_3 + 3HF$

$3BF_3 + 3HF \rightarrow 3H^+[BF_4]^-$

$4BF_3 + 3H_2O \rightarrow 3H[BF_4]$

(partially hydrolysis)

Similarly

$SiF_4 + 4HOH \rightarrow Si(OH)_4 + 4HF$

$2SiF_4 + 4HF \rightarrow H_2^+[SiF_6]^{2-}$

hydrolysis followed by Lewis acid-base reaction.

15th Group Halides

$NF_3 + HOH \xrightarrow[\text{conditions}]{\text{ordinary}}$ No hydrolysis

$NCl_3 + HOH \longrightarrow NH_3 + 3HOCl$

$PCl_3 + HOH \longrightarrow H_3PO_3 + 3HCl$

$AsCl_3 + HOH \longrightarrow As(OH)_3 + 3HCl$

$SbCl_3 + HOH \longrightarrow SbOCl + 2HCl$ (partial hydrolysis)

$BiCl_3 + HOH \longrightarrow BiOCl + 2HCl$ (partial hydrolysis)

$PCl_5 + HOH \longrightarrow \underset{\text{partial}}{POCl_3} \xrightarrow{H_2O} \underset{\text{completely}}{H_3PO_4}$

Hydrolysis of higher covalent character containing salt

$Be_2C + 4HOH \longrightarrow 2Be(OH)_2 + CH_4$

$Mg_2C_3 + 4HOH \longrightarrow 2Mg(OH)_2 + C_3H_4$

$CaC_2 + 2HOH \longrightarrow Ca(OH)_2 + C_2H_2$

$Al_4C_3 + 12HOH \longrightarrow 4Al(OH)_3 + 3CH_4$

$Mg_3N_2 + 6HOH \longrightarrow 3Mg(OH)_2 + 2NH_3$

$AlN + 3HOH \longrightarrow Al(OH)_3 + NH_3$

$Ca_3P_2 + 6HOH \longrightarrow 3Ca(OH)_2 + 2PH_3$

$LiH + HOH \longrightarrow LiOH + H_2$

$CaH_2 + 2HOH \longrightarrow Ca(OH)_2 + H_2$

Hydrolysis of Interhalogen Compounds

$AX + HOH \longrightarrow HX + HOA$

$AX_3 + HOH \longrightarrow 3HX + HAO_2$

$AX_5 + HOH \longrightarrow 5HX\ HAO_3$

$AX_7 + HOH \longrightarrow 7HX + HAO_4$

HX Hydrohalic acid
HOA, HAO_2, HAO_3, HAO_4
oxyacid of halogen

Some specific hydrolysis

$XeF_2 \xrightarrow{HOH} Xe + 2HF + \frac{1}{2}O_2$

$6XeF_4 \xrightarrow{HOH} 4Xe + 2XeO_3 + 24HF + 3O_2$

$XeF_6 \xrightarrow{HOH} 2HF + \underset{\text{partial}}{XeOF_4} \xrightarrow{HOH} 2HF + \underset{\text{partial}}{XeO_2F_2} \xrightarrow{HOH} 2HF + \underset{\text{complete}}{XeO_3}$

Some Important Increasing Order

1. *Acidic property*

- (i) $SiO_2, CO_2, N_2O_5, SO_3$
- (ii) $MgO, Al_2O_3, SiO_2, P_4O_{10}$
- (iii) $HClO, HClO_2, HClO_3, HClO_4$
- (iv) CH_4, NH_3, H_2O, HF
- (v) SiH_4, PH_3, H_2S, HCl
- (vi) H_2O, H_2S, H_2Se, H_2Te
- (vii) HF, HCl, HBr, HI
- (viii) $InCl_3, GaCl_3, AlCl_3$
- (ix) BF_3, BCl_3, BBr_3, BI_3

2. *Bond Angle*

- (i) CH_4, C_2H_4, C_2H_2
- (ii) H_2O, NH_3, CH_4, CO_2
- (iii) H_2O, NH_3, CH_4, BH_3
- (iv) NO_2^-, NO_2, NO_2^+
- (v) H_2Se, H_2S, H_2O
- (vi) AsH_3, PH_3, NH_3
- (vii) PF_3, PCl_3, PBr_3, PI_3

5. *Ionic Character*

- (i) LiBr, NaBr, KBr, RbBr, CsBr
- (ii) LiF, NaF, KF, RbF, CsF
- (iii) $BeCl_2, MgCl_2, CaCl_2, SrCl_2, BaCl_2$
- (iv) $BCl_3, AlCl_3, GaCl_3$
- (v) VCl_4, VCl_3, VCl_2
- (vi) AlF_3, MgF_2, NaF
- (vii) AlN, Al_2O_3, AlF_3
- (viii) HI, HBr, HCl, HF
- (ix) CuCN, AgCN
- (x) AgCl, KCl

6. *Oxidizing Power*

- (i) $Cr_2O_7^{2-}, MnO_4^-$
- (ii) MnO_4^{2-}, MnO_4^-
- (iii) WO_3, MoO_3, CrO_3
- (iv) $GeCl_4, SnCl_4, PbCl_4$
- (v) I_2, Br_2, Cl_2, F_2
- (vi) $Zn^{+2}, Fe^{+2}, Pb^{2+}, Cu^{2+}, Ag^+$

(viii) NF_3, NCl_3
(ix) NF_3, NH_3, NCl_3
(x) OF_2, OH_2, Cl_2O

3. Basic Character

(i) LiOH, NaOH, KOH, RbOH, CsOH
(ii) $Be(OH)_2$, $Mg(OH)_2$, $Ca(OH)_2$, $Ba(OH)_2$
(iii) BeO, MgO, CaO, SrO
(iv) NiO, MgO, SrO, K_2O, Cs_2O
(v) CO_2, B_2O_3, BeO, Li_2O
(vi) SiO_2, Al_2O_3, MgO, Na_2O
(vii) SbH_3, AsH_3, PH_3, NH_3
(viii) F^-, OH^-, NH_2^-, CH_3^-

4. Thermal Stability

(i) Li_2CO_3, Na_2CO_3, K_2CO_3, Rb_2CO_3, Cs_2CO_3
(ii) $BeCO_3$, $MgCO_3$, $CaCO_3$, $BaCO_3$
(iii) $Be(OH)_2$, $Mg(OH)_2$, $Ca(OH)_2$, $Sr(OH)_2$, $Ba(OH)_2$
Polarisation
(iv) LiOH, NaOH, KOH, RbOH, CsOH
(v) $BeSO_4$, $MgSO_4$, $CaSO_4$
(vi) CsH, RbH, KH, NaH, LiH
(vii) SbH_3, AsH_3, PH_3, NH_3
(viii) H_2Te, H_2Se, H_2S, H_2O
(ix) HI, HBr, HCl, HF

7. Melting Point

(i) Cs, Rb, K, Na, Li
(ii) Mg, Ba, Sr, Ca, Be
(iii) CaI_2, $CaBr_2$, $CaCl_2$, CaF_2
(iv) $BeCl_2$, $MgCl_2$, $CaCl_2$, $SrCl_2$, $BaCl_2$
(v) NaI, NaBr, NaCl, NaF
(vi) CsCl, RbCl, KCl, NaCl
(vii) $AlCl_3$, $MgCl_2$, NaCl

8. Density

(i) Na, Al, Fe, Pb, Au
(ii) Li, K, Na, Rb, Cs
(iii) Ca, Mg, Be, Sr, Ba
(iv) Highest Density = Os/Ir
(v) Lowest density = H
(vi) Metal of lowest Density = Li

9. Boiling Point

(i) PH_3, AsH_3, NH_3, SbH_3
(ii) H_2S, H_2Se, H_2O
(iii) HCl, HBr, HI, HF
(iv) NH_3, HF, H_2O
(v) He, Ne, Ar, Kr
(vi) H_2O, D_2O
(vii) H_2, Cl_2, Br_2

10. Electrical Conductivity

Cr, Pt, Fe, Al, Au, Cu, Ag

11. Reactivity with water

(i) Li, Na, K, Rb, Cs
(ii) Be, Mg, Ca, Sr, Ba

12. Extent of Hydrolysis

(i) CCl_4, $MgCl_2$, $AlCl_3$, $SiCl_4$, PCl_5
(ii) $BiCl_3$, $SbCl_3$, $AsCl_3$, PCl_3, NCl_3

13. Bond Strength

(i) HI, HBr, HCl, HF
(ii)

$-\overset{|}{\underset{|}{C}}-I,\ -\overset{|}{\underset{|}{C}}-Br,\ -\overset{|}{\underset{|}{C}}-Cl,\ -\overset{|}{\underset{|}{C}}-F$
(iii) $N-N$, $N=N$, $N\equiv N$
(iv) $As-H$, $Sb-H$, $P-H$, $N-H$
(v) N_2^{2-}, N_2^-, N_2^+, N_2
(vi) O_2^{2-}, O_2^-, O_2, O_2^+, O_2^{2+}
LiI, LiBr, LiCl, LiF   NaI, NaBr, NaCl, NaF
CsCl, RbCl, KCl, NaCl   BaO, SrO, CaO, MgO
(vii) F_2, H_2, O_2, N_2
(viii) NO^-, NO, NO^+
(ix) I_2, F_2, Br_2, Cl_2
(x) O–O, S–S
(xi) F – F, O – O, N – N, C – C, H – H

16. Strength of Hydrogen bonding (X...H–X)

(i) S, Cl, N, O, F
(ii) NH_3, H_2O, HF

17. Reactivity with Hydrogen

(i) Cs, Rb, K, Na, Li
(ii) Ba, Sr, Ca, Mg, Be

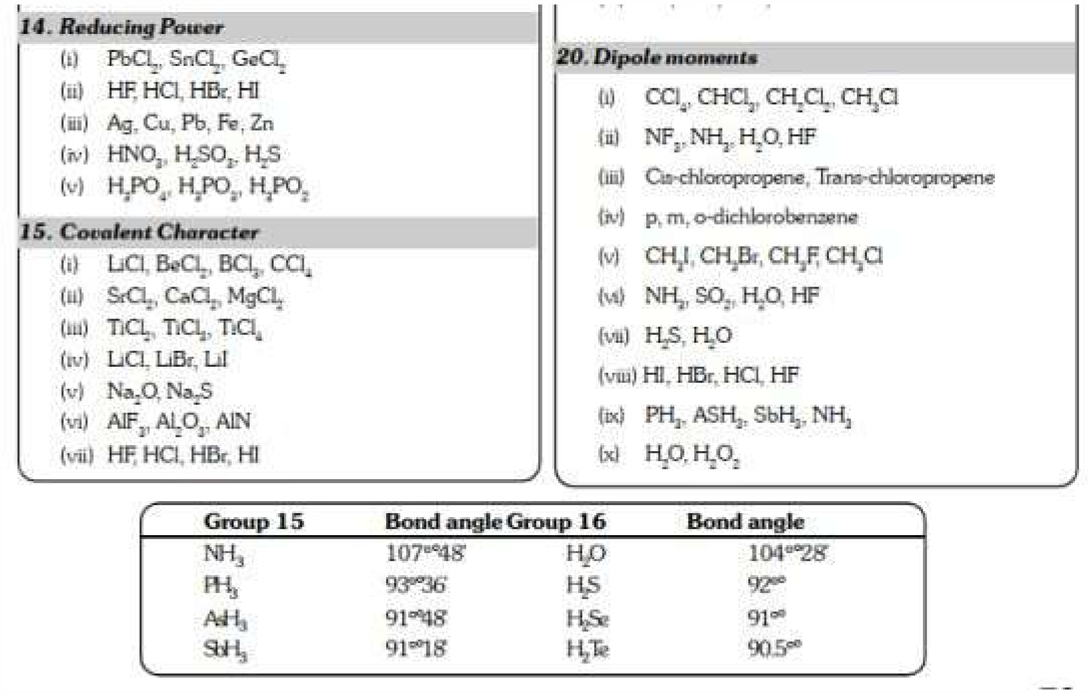
18. Reactivity Towards Air

Be, Mg, Cs, Sr, Ba

19. Bond Length

(i) N_2, O_2, F_2, Cl_2
(ii) N–N, C–N, C–C
(iii) CO,

$\overset{\diagdown}{\underset{\diagup}{C}}=O,\ -\overset{|}{\underset{|}{C}}-O-$
(iv) NO^+, NO, NO^-
(v) O_2, O_3, H_2O_2 (O-O bond length)
(vi) CO, CO_2, CO_3^{-2}
(vii) N_2, N_2^-, N_2^{-2}
(viii) O_2^{+2}, O_2, O_2^-, O_2^{-2}
(ix) HF, HCl, HBr, HI



14. Reducing Power

(i) $PbCl_2$, $SnCl_2$, $GeCl_2$
(ii) HF, HCl, HBr, HI
(iii) Ag, Cu, Pb, Fe, Zn
(iv) HNO_3, H_2SO_3, H_2S
(v) H_3PO_4, H_3PO_3, H_3PO_2

15. Covalent Character

(i) LiCl, $BeCl_2$, BCl_3, CCl_4
(ii) $SrCl_2$, $CaCl_2$, $MgCl_2$
(iii) $TiCl_2$, $TiCl_3$, $TiCl_4$
(iv) LiCl, LiBr, LiI
(v) Na_2O, Na_2S
(vi) AlF_3, Al_2O_3, AlN
(vii) HF, HCl, HBr, HI

20. Dipole moments

(i) CCl_4, $CHCl_3$, CH_2Cl_2, CH_3Cl
(ii) NF_3, NH_3, H_2O, HF
(iii) Cis-chloropropene, Trans-chloropropene
(iv) p, m, o-dichlorobenzene
(v) CH_3I, CH_3Br, CH_3F, CH_3Cl
(vi) NH_3, SO_2, H_2O, HF
(vii) H_2S, H_2O
(viii) HI, HBr, HCl, HF
(ix) PH_3, ASH_3, SbH_3, NH_3
(x) H_2O, H_2O_2

Group 15	Bond angle	Group 16	Bond angle
NH_3	107°48'	H_2O	104°28'
PH_3	93°36'	H_2S	92°
AsH_3	91°48'	H_2Se	91°
SbH_3	91°18'	H_2Te	90.5°

NITROGEN FAMILY

1. Nitrogen and phosphorus are **non-metals**, arsenic and antimony **metalloids** and bismuth is a **typical metal**.
2. Except nitrogen all the elements show allotropy.
3. Bismuth hardly forms any compound in –3 oxidation state.
4. The only well characterised Bi (V) compound is BiF_5.
5. In the case of nitrogen, all oxidation states from +1 to +4 tend to disproportionate in acid solution. For example,
   (i) $3HNO_2 \rightarrow HNO_3 + H_2O + 2NO$
6. In case of phosphorus nearly all intermediate oxidation states disproportionate into +5 and –3 both in alkali and acid.
7. The oxides of the type E_2O_3 of nitrogen and phosphorus are purely acidic, that of arsenic and antimony amphoteric and those of bismuth predominantly basic.
8. In case of nitrogen, only NF_3 is known to be stable.
9. Trihalides except BiF_3 are predominantly covalent in nature.

⇒ The only well characterised Bi (V) compound in BiF_5

⇒ All the oxidation states from +1 to + 4 tend to disproportionate in acidic solution :

exp: $3HNO_2 \longrightarrow HNO_3 + 2NO$

⇒ All the intermidiate oxidation states disproportionate into +5 and – 3

$4H_3PO_3 \xrightarrow{\Delta} 3H_3PO_4 + PH_3$

$H_3PO_2 \xrightarrow{\Delta} H_3PO_4 + PH_3$

⇒ Hydride of 15th group elements :

$NH_3 > PH_3 > AsH_3 > SbH_3 \geq BiH_3$	Basic character
$NH_3 > PH_3 > AsH_3 > SbH_3 > BiH_3$	Stability
$PH_3 < AsH_3 < NH_3 < SbH_3 < BiH_3$	Boiling Point
$PH_3 < AsH_3 < SbH_3 < NH_3$	Melting Point
$NH_3 > PH_3 > AsH_3 > SbH_3$	Bond Energy

⇒ Penta oxide of 15th group element is acidic. N_2O_3, P_2O_3 are acidic, As_2O_3 , Sb_2O_3 are amphoteric with Bi_2O_3 is basic.

⇒ Trihalide of 15th group elements are covalent except BiF_3

Oxides of Nitrogen

Name	Formula	Oxidation state of nitrogen	Common methods of preparation	Physical appearance and chemical nature
Dinitrogen oxide [Nitrogen oxide]	N_2O	+1	$NH_4NO_3 \xrightarrow{Heat} N_2O + 2H_2O$	Colourless gas, neutral
Nitrogen monoxide [Nitrogen (II) oxide]	NO	+2	$2NaNO_2 + 2FeSO_4 + 3H_2SO_4 \rightarrow Fe_2(SO_4)_3 + 2NaHSO_4 + 2H_2O + 2NO$	Colourless gas, neutral
Dinitrogen trioxide [Nitrogen (III) oxide]	N_2O_3	+3	$2NO + N_2O_4 \xrightarrow{250K} 2N_2O_3$	Blue solid, acidic blue liquid (–30°C)
Nitrogen dioxide [Nitrogen (IV) oxide]	NO_2	+4	$2Pb(NO_3)_2 \xrightarrow{673K} 4NO_2 + 2PbO + O_2$	brown gas, acidic
Dinitrogen tetroxide [Nitrogen (IV) oxide]	N_2O_4	+4	$2NO_2 \underset{Heat}{\overset{Cool}{\rightleftharpoons}} N_2O_4$	Colourless solid/ liquid, acidic
Dinitrogen pentaoxide [Nitrogen(V) oxide]	N_2O_5	+5	$4HNO_3 + P_4O_{10} \rightarrow 4HPO_3 + 2N_2O_5$	colourless solid, acidic

COMPOUNDS OF NITROGEN FAMILY

AMMONIA (NH_3)

Colorless, Pungent Smell, basic in nature liquified easily, uses as coolant

Preparation

(i) $2NH_4Cl + Ca(OH)_2 \longrightarrow CaCl_2 + 2NH_3 + 2H_2O$

(ii) $Mg_3N_2 + HOH \longrightarrow Mg(OH)_2 + 2NH_3$

Manufacturing Haber Process

$N_2 + 3H_2 \underset{\substack{750K \\ 200\text{-}300atm}}{\overset{Fe+Mo}{\rightleftharpoons}} 2NH_3 + 24KCal$

MOP $\longleftarrow NH_3 \longrightarrow$ properties

$4NH_3 + 3O_2 \longrightarrow N_2 + 6H_2O$

$4NH_3 + 5O_2 \xrightarrow[1100K]{Pt/Rh} 4NO + 6H_2O$ Ostwald's process

$\underset{excess}{8NH_3} + 3Cl_2 \longrightarrow 6NH_4Cl + N_2$

$NH_3 + \underset{excess}{3Cl_2} \longrightarrow NCl_3 + 3HCl$

NITRIC ACID (HNO_3)

Prepration :

Ostwald's process :

(i) $4NH_3(g) + \underset{(From\ air)}{5O_2(g)} \xrightarrow[500K,\ 9bar]{Pt/Rh\ gauge\ catalyst} 4NO(g) + 6H_2O(g)$

(ii) $2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$

(iii) $3NO_2(g) + H_2O(\ell) \longrightarrow 2HNO_3(aq) + NO(g)$

Properties :

HNO_3, nitric acid was earlier called as aqua fortis (meaning strong water).

It usually acquires yellow colour. due to its decomposition by sunlight into NO_2.

It acts as a strong oxidising agent.

Reaction with $FeSO_4$:

$FeSO_4 + 8\ HNO_3 \rightarrow Fe_2(SO_4)_3 + 2NO + 4H_2O$

Reaction with non-metals :

Non-metals converted into highest oxyacids by hot and conc.

HNO_3. NO_2 gas is evolved (S to H_2SO_4; P to H_3PO_4; C to H_2CO_3; I_2 to HIO_3; As to H_3AsO_4; Sb to H_3SbO_4 and Sn to H_2SnO_3). Most of the metals except noble metals are attacked by HNO_3. It plays double role in action on metals, i.e., it acts as an acids as well as an oxidising agent.

Reaction with metals :

$3Cu + 8\ HNO_3(dilute) \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$

$Cu + 4HNO_3(conc.) \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$

$4Zn + 10HNO_3(dilute) \rightarrow 4\ Zn(NO_3)_2 + 5H_2O + N_2O$

$Zn + 4HNO_3(conc.) \rightarrow Zn(NO_3)_2 + 2H_2O + 2NO_2$

Concentration of nitric acid	Metal	Main products
Very Dilute HNO_3	Mg, Mn	H_2+ metal nitrate
	Fe, Zn, Sn	NH_4NO_3 + metal nitrate
	Cu, Ag, Hg	No reaction
Dilute HNO_3	Fe, Zn	N_2O + metal nitrate
	Pb, Cu, Ag	NO + metal nitrate
Conc. HNO_3	Sn	$NO_2 + H_2SnO_3$ (Metastannic acid)
Conc. HNO_3	Fe, Co, Ni, Cr, Al	rendered passive

PHOSPHINE (PH_3)

Preparation :

(i) $Ca_3P_2 + 6H_2O \longrightarrow 3Ca(OH)_2 + 2PH_3$

(ii) $PH_4I + NaOH \longrightarrow NaI + H_2O + PH_3$

Laboratory preparation :

$P_4 + 3NaOH + 3H_2O \longrightarrow 3NaH_2PO_2 + PH_3$

Uses :

As Holme's signals in deep seas and oceans.

For the production of smoke screens.

Physical properties :

Colourless gas having smell of garlic or rotten fish, slightly soluble in water and slightly heavier than air.

Chemical properties :

(i) $2PH_3 + 4O_2 \longrightarrow P_2O_5 + 3H_2O$

(ii) $4PH_3 \xrightarrow{713K} P_4 + 6H_2$

(iii) $PH_3 + 4Cl_2 \longrightarrow PCl_5 + 3HCl$

d-BLOCK (Transition Elements)

DEFINITION

Trasition elements are those d-block elements which has partialy filled (n–1)d subshell either in their ground state or in their stable oxidation states. Therefore Zn, Cd & Hg – are d-block elements but not transition elements.

GENERAL ELECTRONIC CONFIGURATION

$ns^{0-2}\ (n-1)d^{1-10}$

Exceptions $\begin{cases} Cr = 4s^1\ 3d^5 \\ Cu = 4s^1\ 3d^{10} \end{cases}$, $Pd = 5s^0 4d^{10}$

TRANSITION SERIES

1st	3d series	$Sc_{21} — Zn_{30}$	9 + 1 = 10
2nd	4d series	$Y_{39} — Cd_{48}$	9 + 1 = 10
3rd	5d series	La_{57}, $Hf_{72} — Hg_{80}$	9 + 1 = 10
4th	6d series	Ac_{89}, $Unq_{104} — Uub_{112}$	9 + 1 = 10

ATOMIC RADIUS

3d series Sc > Ti > V > Cr > Mn ≥ Fe = CO = Ni ≤ Cu < Zn

In a group 3d to 4d series increases but 4d and 5d series nearly same due to poor shielding of f electron. (Lanthanide contraction)

$$\boxed{3d < 4d = 5d}$$

$$\text{e.g.: Ti} < \text{Zr} = \text{Hf} \left| \begin{array}{l} \text{Smallest radius – Ni} \\ \text{Largest radius – La} \end{array} \right.$$

Melting point :s-block metals < d-block metals

In a series on increasing number of unpaired e^- mpt increases and therefore m.p. increase upto Cr then decreases.

$$\text{Sc} < \text{Ti} < \text{V} < \underset{\substack{\text{Half filled } d^5 \\ \text{weak metallic bond}}}{\text{Cr}} > \text{Mn} < \text{Fe} > \text{Co} > \text{Ni} > \underset{\substack{\text{Fully filled } d^{10} \\ \text{weak metallic bond}}}{\text{Cu}} > \text{Zn}$$

$$\text{Melting point} \left| \begin{array}{l} \text{Zn} > \text{Cd} > \text{Hg} \\ \text{Cu} > \text{Ag} \le \text{Au} \end{array} \right. \text{(data based)}$$

E.N. Exception Zn < Cd < Hg

Density : s-block metals < d-block metals

3d series

$$\boxed{\text{Sc} < \text{Ti} < \text{V} < \text{Cr} < \text{Mn} < \text{Fe} < \text{Co} \le \text{Ni} < \text{Cu} > \text{Zn}}$$

Density in a Group 3d < 4d << 5d

Metallic character : They are solid, hard, ductile, malleable, good conductor of heat and electricity and exhibit metallic lusture, high tensile strength. Hg is liquid

$$\text{Electrical conductor } \underbrace{\text{Ag} > \text{Cu} > \text{Au}}_{\text{d-block}} > \underset{\text{p-block}}{\text{Al}}$$

OXIDATION STATE

Transition elements exhibit variable oxidation state due to small energy difference of ns and (n–1)d electrons.

- Sc(+3) and Zn(+2) exhibit only one oxidation state
- Common oxidation state is +2 & +3
- In 3d series highest oxidation state is +7 (Mn)
- In d-block series highest oxidation state is +8 (Os, Ru)
- In carbonyl compound the zero oxidation state of metals is stablize by synergic effects.
- Their higher oxidation states are more stable in fluoride and oxides.
- Higher oxidation states in oxides are normally more stable than fluorides due to capability of oxygen to form multiple bonds.

  eg. stable fluoride in higher oxidation state of Mn is MnF_4 while oxide is Mn_2O_7

⇒ Mn show maximum number of oxidation state (+2 to +7) among 3d series.

⇒ Beyong Mn trihalide are not observe except FeX_3 (X = Cl/Br/I) & CoF_3

⇒	V_2O_3 basic	V_2O_4 basic	V_2O_5 amphoteric
⇒	CrO basic	Cr_2O_3 amphoteric	CrO_3 acidic
⇒	MnO basic	MnO_2 amphoteric	Mn_2O_7 acidic

⇒ CuI_2 does not exist

$$CuI_2 \longrightarrow CuI + \frac{1}{2}I_2$$

⇒ In aqueous Cu^+ disproportinated into Cu & Cu^{+2}.

In p-block lower oxidation states of heavier elements are more stable while in d-block heavier element, higher oxidation state are more stable.

eg. In VIB gp Mo(+6) & W(+6) are more stable than Cr(+6)

Important reactions of d-block elements

(a) $Cu^{2+} + 4I^- \longrightarrow Cu_2I_{2(s)} + I_2$

(b) $CuSO_4 + \underset{\text{Excess}}{KCN} \longrightarrow K_2SO_4 + \underset{\text{Unstable}}{Cu(CN)_2}$

$2Cu(CN)_2 \longrightarrow 2CuCN + \underset{\text{Cyanogen}}{(CN)_2}$

$CuCN + 3KCN \longrightarrow K_3[Cu(CN)_4]$

(c) $Cu \xrightarrow[\text{moist air}]{H_2O + CO_2} \underset{\text{green}}{CuCO_3 . Cu(OH)_2}$

$Au \xrightarrow[(3HCl + HNO_3)]{\text{Aqua regia}} H[AuCl_4] + NOCl + H_2O$

(d) $AgNO_3(s) \xrightarrow{\text{Heating}} Ag + NO_2 + \frac{1}{2}O_2$

$AgCO_3(s) \xrightarrow{\text{Heating}} Ag + CO_2 + \frac{1}{2}O_2$

(e) $CuSO_4.5H_2O \xrightarrow{100°C} \underset{\text{light greenish blue}}{CuSO_4.H_2O} \xrightarrow{230°C} \underset{\text{Colourless}}{CuSO_4}$

$\xrightarrow{720°C} CuO + SO_2 + \frac{1}{2}O_2$

(f) $Hg_2Cl_2 + NH_4OH \longrightarrow Hg\begin{smallmatrix} \diagup NH_2 \\ \diagdown Cl \end{smallmatrix} + \underset{\text{Black}}{Hg}$

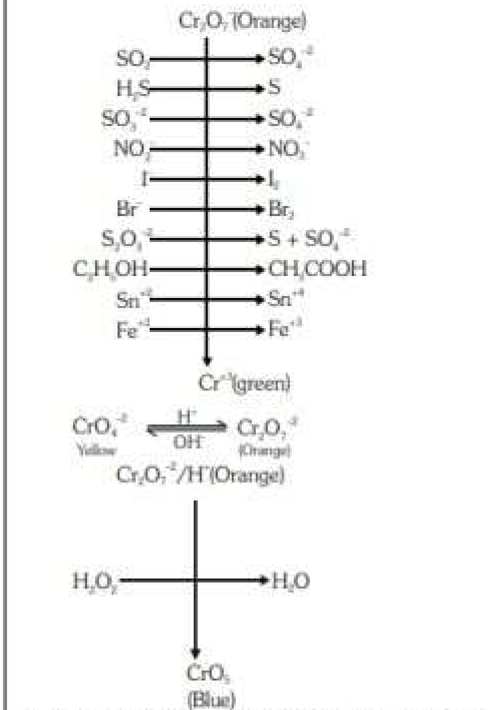
(g) $NO_3^- / NO_2^- \xrightarrow{FeSO_4 + H_2SO_4} \underset{\text{Brown ring complex}}{\left[Fe(H_2O)_5 NO^+\right]SO_4}$

(h) $AgBr + 2Na_2S_2O_3 \longrightarrow \underset{\text{Photographic complex}}{Na_3[Ag(S_2O_3)_2]} + NaBr$

(i) Chemical volcano :

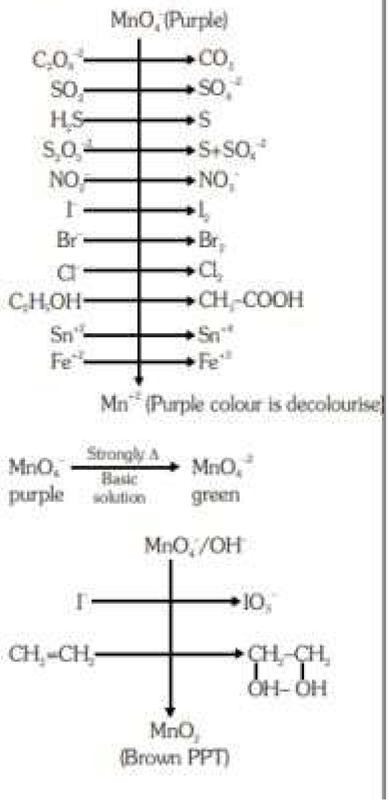
$(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} N_2 + 4H_2O + Cr_2O_3$

Reactions of $Cr_2O_7^{-2}$:



(Stablize in the presence of organic solvent such as pyridine etc.)

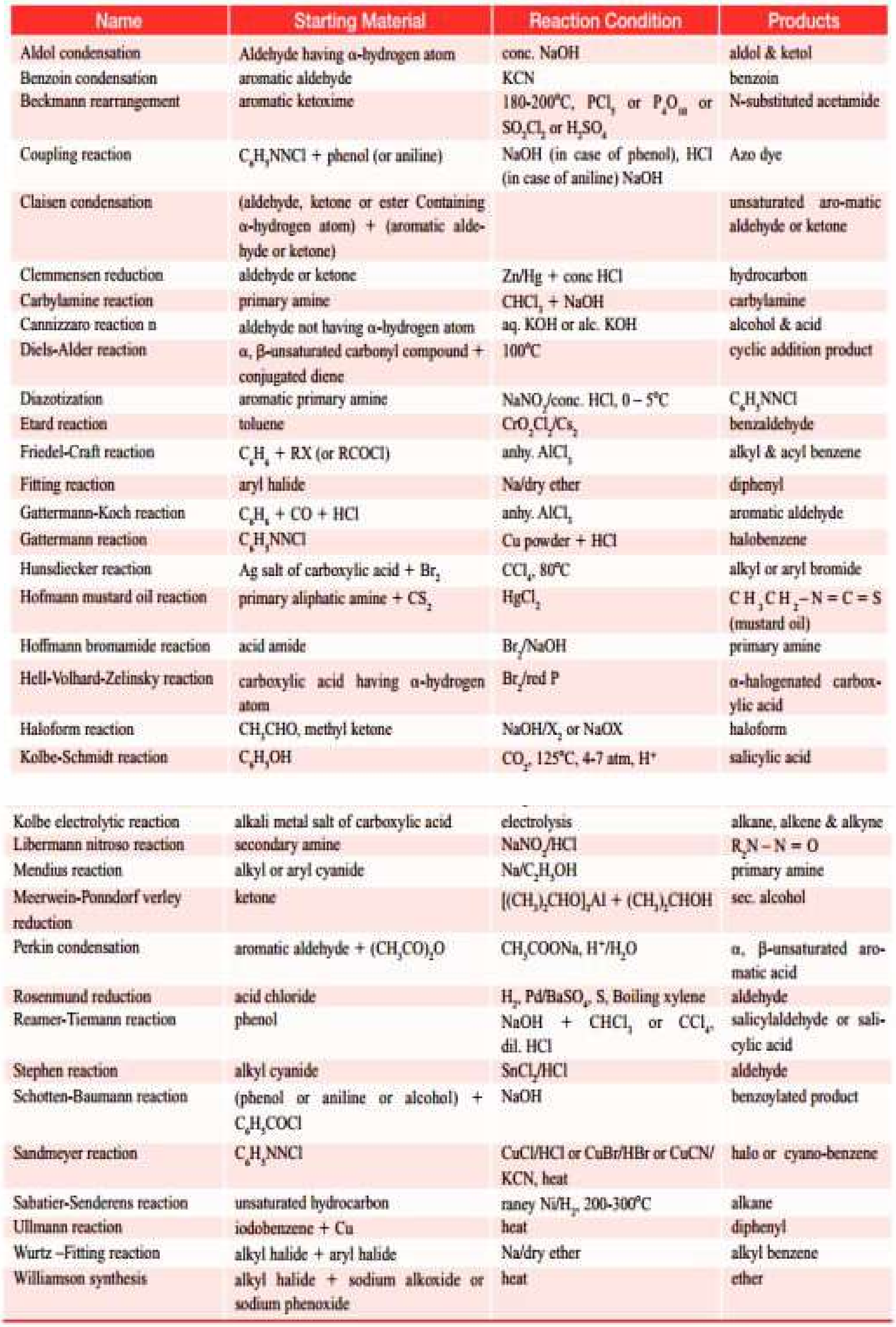
Reaction of MnO_4^-



IMPORTANT REAGENTS AND MIXTURES

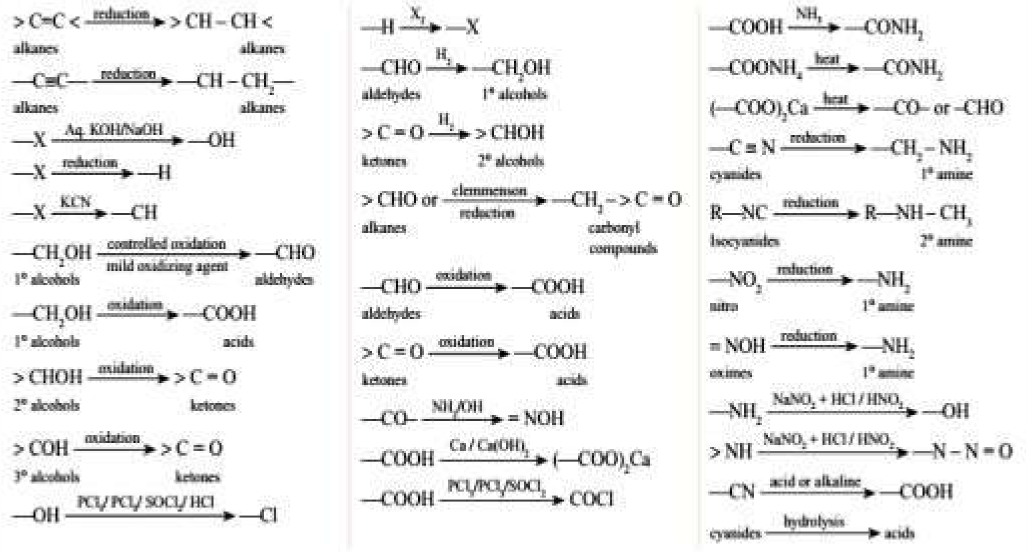
Ammonal	Al powder + NH_4NO_3 [used as an explosive]
Amatol	NH_4NO_3 (80%) + trinitrotoluene (20%) [used as an explosive]
Aqua regia	Conc. HNO_3 + conc. HCl (1 : 3) [used as a laboratory reagent]
Bordeaux mixture	A solution of $CuSO_4$ + lime [used to kill moulds and fungi on plants]
Black ash	Na_2CO_3 + CaS [impure Na_2CO_3 obtained in Leblanc process]
Benedict solution	A solution of $CuSO_4.5H_2O$ 1 NaOH + sodium citrate [used for detecting aldehydes]
Baeyer reagent	Alkaline $KMnO_4$ solution [used for detecting ethylene and acetylene linkages]
Baking powder	$NaHCO_3$ + sodium potassium tartarate
Carbon oil	Vegetable oil + lime water [used for treatment of burns]
Carbogen	O_2 (90-95%) + CO_2 (5-10%) [used for artificial respiration]
Coal gas	H_2 (47%) + CH_4 (32%) + CO (7%) + N_2 (4%) + C_2H_4 (3%) + C_2H_2 (2%) + CO_2 (1%) + other gases (4%) [used to produce reducing atmosphere in metallurgical operations]
Euchlorine	Cl_2 + ClO_2
Fusion mixture	Na_2CO_3 + K_2CO_3 [used as a laboratory reagent]
Freezing mixture	NaCl + ice [used for lowering temperature]
Fehling solution	$CuSO_4.5H_2O$ + NaOH + sodium potassium tartarate [used for detecting aldehydes]
Fenton reagent	H_2O_2 + few drops of $FeCl_3$
Gun powder	KNO_3 (75%) + S (12%) + charcoal (13%) [used as an explosive]
Granite	Mica + rock + clay + sand
Gobar gas	CH_4 + CO + H_2 [used as
Milk of magnesia	An aqueous suspension of $Mg(OH)_2$ [used as a antacid]
Methylated spirit	Rectified spirit (85-90%) + CH_3OH (10-15%) + pyridine + acetone [used as a solvent]
Matte	Cu_2S + FeS
Nitrophos	$Ca(H_2PO_4)_2$ + $Ca(NO_3)_2$ [used as a fertilizer]
Nitrolim	$CaCN_2$ + graphite [used as a fertilizer]
Nitro chalk	NH_4NO_3 + $CaCO_3$
Rectified spirit	C_2H_5OH (95.87%) + H_2O (4.13%) [used as a solvent]
Super phosphate of lime	$Ca(H_2PO_4)_2$ + $CaSO_4$ [used as a fertilizer]
Sublimated white lead	PbO + $PbSO_4$ + ZnO [used as a white paint]
Sorel's cement	MgO + $MgCl_2$ [used as a substitute for tiles]
Sodalime	NaOH + $Ca(OH)_2$ [used in decarboxylation of carboxylic acids]
Soda bleach	Na_2O_2 + HCl [used for bleaching of fabrics]

Named reactions in Organic chemistry



Name	Starting Material	Reaction Condition	Products
Aldol condensation	Aldehyde having α-hydrogen atom	conc. NaOH	aldol & ketol
Benzoin condensation	aromatic aldehyde	KCN	benzoin
Beckmann rearrangement	aromatic ketoxime	180-200°C, PCl_5 or P_4O_{10} or SO_2Cl_2 or H_2SO_4	N-substituted acetamide
Coupling reaction	C_6H_5NNCl + phenol (or aniline)	NaOH (in case of phenol), HCl (in case of aniline) NaOH	Azo dye
Claisen condensation	(aldehyde, ketone or ester Containing α-hydrogen atom) + (aromatic aldehyde or ketone)		unsaturated aromatic aldehyde or ketone
Clemmensen reduction	aldehyde or ketone	Zn/Hg + conc HCl	hydrocarbon
Carbylamine reaction	primary amine	$CHCl_3$ + NaOH	carbylamine
Cannizzaro reaction n	aldehyde not having α-hydrogen atom	aq. KOH or alc. KOH	alcohol & acid
Diels-Alder reaction	α, β-unsaturated carbonyl compound + conjugated diene	100°C	cyclic addition product
Diazotization	aromatic primary amine	$NaNO_2$/conc. HCl, 0 – 5°C	C_6H_5NNCl
Etard reaction	toluene	CrO_2Cl_2/Cs_2	benzaldehyde
Friedel-Craft reaction	C_6H_6 + RX (or RCOCl)	anhy. $AlCl_3$	alkyl & acyl benzene
Fitting reaction	aryl halide	Na/dry ether	diphenyl
Gattermann-Koch reaction	C_6H_6 + CO + HCl	anhy. $AlCl_3$	aromatic aldehyde
Gattermann reaction	C_6H_5NNCl	Cu powder + HCl	halobenzene
Hunsdiecker reaction	Ag salt of carboxylic acid + Br_2	CCl_4, 80°C	alkyl or aryl bromide
Hofmann mustard oil reaction	primary aliphatic amine + CS_2	$HgCl_2$	$CH_3CH_2-N=C=S$ (mustard oil)
Hoffmann bromamide reaction	acid amide	Br_2/NaOH	primary amine
Hell-Volhard-Zelinsky reaction	carboxylic acid having α-hydrogen atom	Br_2/red P	α-halogenated carboxylic acid
Haloform reaction	CH_3CHO, methyl ketone	NaOH/X_2 or NaOX	haloform
Kolbe-Schmidt reaction	C_6H_5OH	CO_2, 125°C, 4-7 atm, H^+	salicylic acid
Kolbe electrolytic reaction	alkali metal salt of carboxylic acid	electrolysis	alkane, alkene & alkyne
Libermann nitroso reaction	secondary amine	$NaNO_2$/HCl	$R_2N-N=O$
Mendius reaction	alkyl or aryl cyanide	Na/C_2H_5OH	primary amine
Meerwein-Ponndorf verley reduction	ketone	$[(CH_3)_2CHO]_3Al + (CH_3)_2CHOH$	sec. alcohol
Perkin condensation	aromatic aldehyde + $(CH_3CO)_2O$	CH_3COONa, H^+/H_2O	α, β-unsaturated aromatic acid
Rosenmund reduction	acid chloride	H_2, Pd/$BaSO_4$, S, Boiling xylene	aldehyde
Reamer-Tiemann reaction	phenol	NaOH + $CHCl_3$ or CCl_4, dil. HCl	salicylaldehyde or salicylic acid
Stephen reaction	alkyl cyanide	$SnCl_2$/HCl	aldehyde
Schotten-Baumann reaction	(phenol or aniline or alcohol) + C_6H_5COCl	NaOH	benzoylated product
Sandmeyer reaction	C_6H_5NNCl	CuCl/HCl or CuBr/HBr or CuCN/KCN, heat	halo or cyano-benzene
Sabatier-Senderens reaction	unsaturated hydrocarbon	raney Ni/H_2, 200-300°C	alkane
Ullmann reaction	iodobenzene + Cu	heat	diphenyl
Wurtz –Fitting reaction	alkyl halide + aryl halide	Na/dry ether	alkyl benzene
Williamson synthesis	alkyl halide + sodium alkoxide or sodium phenoxide	heat	ether

IMPORTANT FORMULAE OF REPLACEMENT OF GROUPS



$$\underset{\text{alkanes}}{>C=C<} \xrightarrow{\text{reduction}} \underset{\text{alkanes}}{>CH-CH<}$$

$$\underset{\text{alkanes}}{-C\equiv C-} \xrightarrow{\text{reduction}} \underset{\text{alkanes}}{-CH-CH_2-}$$

$$-X \xrightarrow{\text{Aq. KOH/NaOH}} -OH$$

$$-X \xrightarrow{\text{reduction}} -H$$

$$-X \xrightarrow{KCN} -CH$$

$$\underset{1^\circ\text{ alcohols}}{-CH_2OH} \xrightarrow[\text{mild oxidizing agent}]{\text{controlled oxidation}} \underset{\text{aldehydes}}{-CHO}$$

$$\underset{1^\circ\text{ alcohols}}{-CH_2OH} \xrightarrow{\text{oxidation}} \underset{\text{acids}}{-COOH}$$

$$\underset{2^\circ\text{ alcohols}}{>CHOH} \xrightarrow{\text{oxidation}} \underset{\text{ketones}}{>C=O}$$

$$\underset{3^\circ\text{ alcohols}}{>COH} \xrightarrow{\text{oxidation}} \underset{\text{ketones}}{>C=O}$$

$$-OH \xrightarrow{PCl_5/PCl_3/SOCl_2/HCl} -Cl$$

$$-H \xrightarrow{X_2} -X$$

$$\underset{\text{aldehydes}}{-CHO} \xrightarrow{H_2} \underset{1^\circ\text{ alcohols}}{-CH_2OH}$$

$$\underset{\text{ketones}}{>C=O} \xrightarrow{H_2} \underset{2^\circ\text{ alcohols}}{>CHOH}$$

$$\underset{\text{alkanes}}{>CHO \text{ or}} \xrightarrow[\text{reduction}]{\text{clemmenson}} \underset{\text{carbonyl compounds}}{-CH_2->C=O}$$

$$\underset{\text{aldehydes}}{-CHO} \xrightarrow{\text{oxidation}} \underset{\text{acids}}{-COOH}$$

$$\underset{\text{ketones}}{>C=O} \xrightarrow{\text{oxidation}} \underset{\text{acids}}{-COOH}$$

$$-CO- \xrightarrow{NH_2OH} =NOH$$

$$-COOH \xrightarrow{Ca/Ca(OH)_2} (-COO)_2Ca$$

$$-COOH \xrightarrow{PCl_5/PCl_3/SOCl_2} COCl$$

$$-COOH \xrightarrow{NH_3} -CONH_2$$

$$-COONH_4 \xrightarrow{\text{heat}} -CONH_2$$

$$(-COO)_2Ca \xrightarrow{\text{heat}} -CO- \text{ or } -CHO$$

$$\underset{\text{cyanides}}{-C\equiv N} \xrightarrow{\text{reduction}} \underset{1^\circ\text{ amine}}{-CH_2-NH_2}$$

$$\underset{\text{Isocyanides}}{R-NC} \xrightarrow{\text{reduction}} \underset{2^\circ\text{ amine}}{R-NH-CH_3}$$

$$\underset{\text{nitro}}{-NO_2} \xrightarrow{\text{reduction}} \underset{1^\circ\text{ amine}}{-NH_2}$$

$$\underset{\text{oximes}}{=NOH} \xrightarrow{\text{reduction}} \underset{1^\circ\text{ amine}}{-NH_2}$$

$$-NH_2 \xrightarrow{NaNO_2 + HCl/HNO_2} -OH$$

$$>NH \xrightarrow{NaNO_2 + HCl/HNO_2} -N-N=O$$

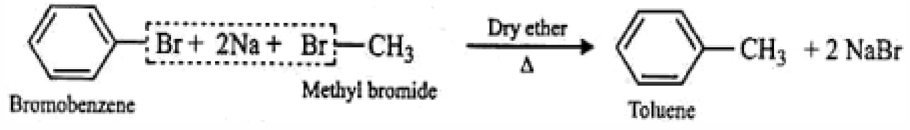
$$-CN \xrightarrow{\text{acid or alkaline}} -COOH$$

$$\text{cyanides} \xrightarrow{\text{hydrolysis}} \text{acids}$$

1. **Acetylation**

$$\underset{\text{Benzoyl chloride}}{C_6H_5COCl} + \underset{\text{Ethyl alcohol}}{HOCH_2CH_3} \xrightarrow{\text{Aq.NaOH}} \underset{\text{Ethyl benzoate}}{C_6H_5COOCH_2CH_3} + HCl$$

2. **Wurtz FittigReaction**



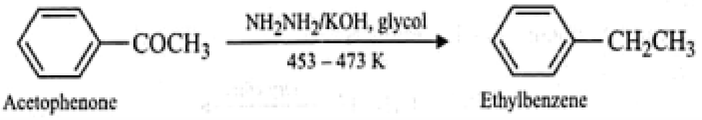
3. **Wurtz Reaction**

$$\underset{\text{Methyl bromide}}{CH_3-\boxed{Br + 2\,Na + Br}-CH_3} \xrightarrow{\text{Dry ether}} \underset{\text{Ethane}}{CH_3-CH_3} + 2\,NaBr$$

4. **Wolff-Kishner Reduction**

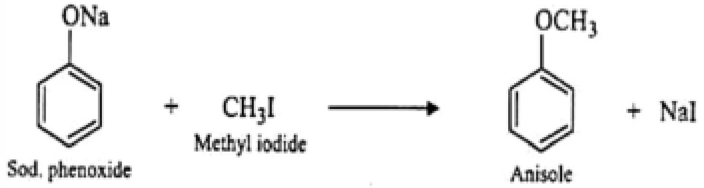
$$\underset{\text{Aldehyde}}{R-CH=O} \xrightarrow[-H_2O]{NH_2NH_2} \underset{\text{Hydrazone}}{[R-CH=NNH_2]} \xrightarrow[453-473\,K]{\text{KOH, glycol}} R-CH_3 + N_2$$

$$\underset{\text{Acetone}}{CH_3COCH_3} \xrightarrow[453-473\,K]{NH_2NH_2/\text{KOH, glycol}} \underset{\text{Propane}}{CH_3CH_2CH_3}$$



5. Wiliamsons Reaction

$$\underset{\text{Ethyl iodide}}{CH_3CH_2I} + \underset{\text{Sod. ethoxide}}{CH_3CH_2ONa} \longrightarrow \underset{\text{Diethyl ether}}{CH_3CH_2{-}O{-}CH_2CH_3} + NaI$$



6. Stephen Reaction

$$SnCl_2 + 2\,HCl \longrightarrow SnCl_4 + 2\,[H]$$

$$\underset{\text{Acetonitrile}}{CH_3C \equiv N} + 2\,[H] + HCl \xrightarrow[290-295\,K]{\text{Dry ether}} \underset{\text{Acetaldimine hydrochloride}}{CH_3CH = NH.HCl}$$

$$\downarrow \text{Boiling } H_2O$$

$$\underset{\text{Acetaldehyde}}{CH_3CH = O} + NH_4Cl$$

7. Swarts Reaction

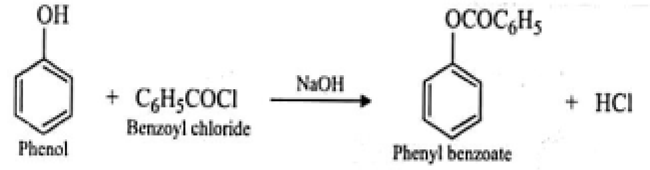
$$\underset{\text{Bromomethane}}{CH_3Br} + AgF \xrightarrow{\Delta} \underset{\text{Fluoromethane}}{CH_3F} + AgBr$$

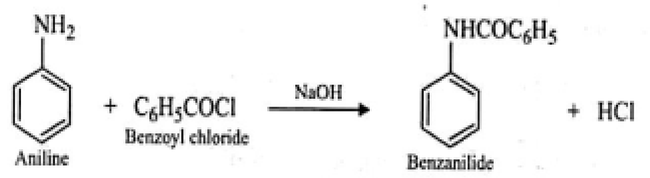
$$\underset{\text{Chloroethane}}{2\,CH_3CH_2Cl} + Hg_2F_2 \xrightarrow{\Delta} \underset{\text{Fluoroethane}}{2\,CH_3CH_2F} + Hg_2Cl_2$$

8. Schmidt Reaction

$$\underset{\text{Benzoic acid}}{C_6H_5COOH} \xrightarrow[+\text{conc.}H_2SO_4]{N_3H} \underset{\text{Aniline}}{C_6H_5{-}NH_2} + CO_2 + N_2$$

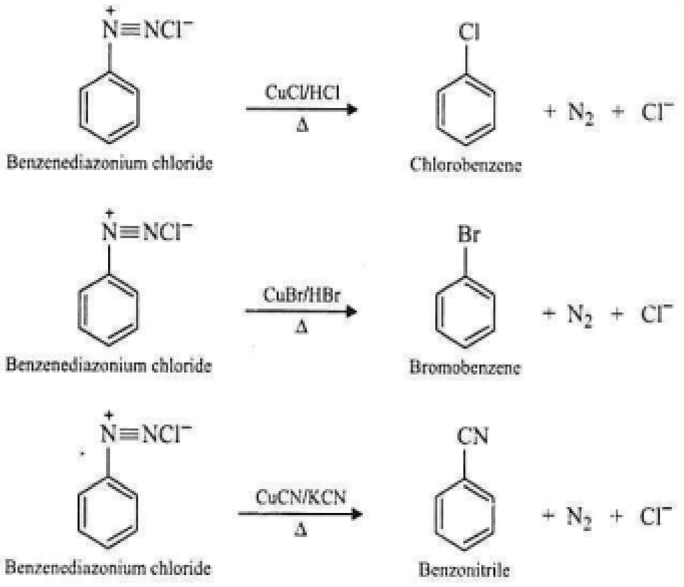
9. Schotten Baumann Reaction





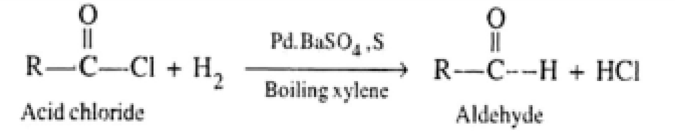
$$\underset{\text{Ethyl alcohol}}{CH_3CH_2OH} + \underset{\text{Benzoyl chloride}}{C_6H_5COCl} \xrightarrow{NaOH} \underset{\text{Ethyl benzoate}}{CH_3CH_2OCOC_6H_5} + HCl$$

10. Sandmeyer’s Reaction



v

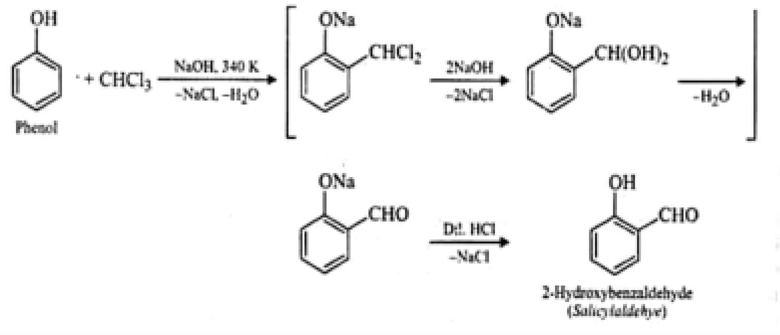
11. Rosenmund Reaction



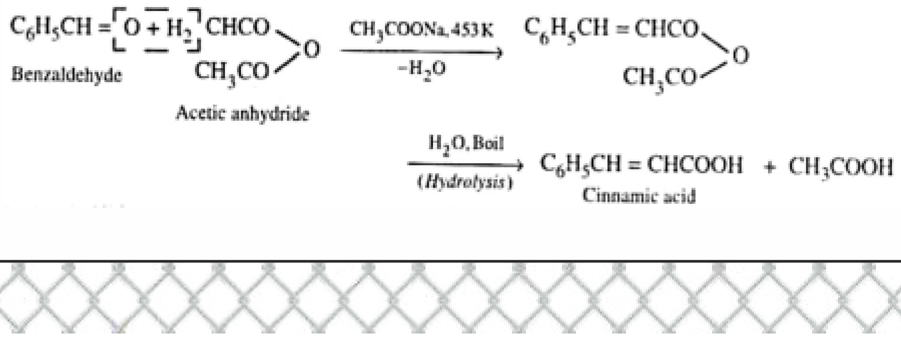
$$R-\overset{\overset{O}{\|}}{C}-Cl + H_2 \xrightarrow[\text{Boiling xylene}]{Pd.BaSO_4,S} R-\overset{\overset{O}{\|}}{C}-H + HCl$$

$$CH_3-\overset{\overset{O}{\|}}{C}-Cl + H_2 \xrightarrow[\text{Boiling xylene}]{Pd.BaSO_4,S} CH_3-\overset{\overset{O}{\|}}{C}-H + HCl$$

12. Reimer-Tiemann Reaction



13. Perkin Reaction



$$C_6H_5CH=\boxed{O+H_2}CHCO \diagdown O / CH_3CO \xrightarrow[-H_2O]{CH_3COONa,\,453\,K} C_6H_5CH=CHCO \diagdown O / CH_3CO$$

$$\xrightarrow[(Hydrolysis)]{H_2O,\,Boil} C_6H_5CH=CHCOOH + CH_3COOH$$

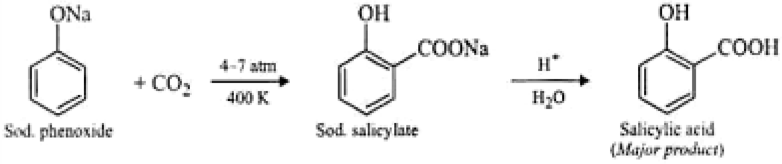
14. Liebermann's nitroso Reaction

$$\underset{\text{2° amine}}{R_2NH} + \underset{\text{Nitrous acid}}{HO{-}N=O} \longrightarrow \underset{\text{N-Nitrosodialkylamine}}{R_2N{-}N=O} + H_2O$$

15. Mendius Reaction

$$\underset{\text{Acetonitrile}}{CH_3C\equiv N} + 4\,[H] \xrightarrow{Na/C_2H_5OH} \underset{\text{Ethylamine}}{CH_3CH_2NH_2}$$

16. Colbe-Schmitt Reaction



17. Hunsdicker Reaction

$$\underset{\text{Silver propionate}}{CH_3CH_2COOAg} + Br_2 \xrightarrow[\text{Reflux}]{CCl_4,\,350\,K} \underset{\text{Ethyl bromide}}{CH_3CH_2{-}Br} + CO_2 + AgBr$$

18. Hoffmann bromamide Reaction

$$\underset{\text{Acetamide}}{CH_3CONH_2} + Br_2 + 4\,NaOH \xrightarrow{\Delta} \underset{\text{Methylamine}}{CH_3NH_2} + 2\,NaBr + Na_2CO_3 + 2\,H_2O$$

19. Hoffmann Ammonolysis

$$(i)\quad \underset{\text{Ammonia}}{H_3N:} + \underset{\text{Alkyl halide}}{R{-}X} \xrightarrow{373\,K} \underset{\text{1° Amine salt}}{R\overset{+}{N}H_3X^-} \overset{NH_3}{\rightleftharpoons} \underset{\text{1° Amine}}{R{-}NH_2} + NH_4^+X^-$$

20. Hell-Volhard Zelinsky Reaction

$$\underset{\text{Acetic acid}}{\overset{\alpha}{C}H_3COOH} \xrightarrow[-HCl]{Cl_2,P} \underset{\text{Monochloro-acetic acid}}{Cl\overset{\alpha}{C}H_2COOH} \xrightarrow[-HCl]{Cl_2,P} \underset{\text{Dichloro-acetic acid}}{Cl_2\overset{\alpha}{C}HCOOH} \xrightarrow[-HCl]{Cl_2,P} \underset{\text{Trichloro-acetic acid}}{Cl_3CCOOH}$$

21. Iodoform Reaction

$$\underset{\text{Ethanol}}{CH_3CH_2OH} + 4\,I_2 + 6\,NaOH \longrightarrow \underset{\text{Iodoform}}{CHI_3} + HCOONa + 5\,NaI + 5\,H_2O$$

$$\underset{\text{2-Propanol}}{CH_3CHOHCH_3} + 4\,I_2 + 6\,NaOH \longrightarrow \underset{\text{Iodoform}}{CHI_3} + CH_3COONa + 5\,NaI + 5\,H_2O$$

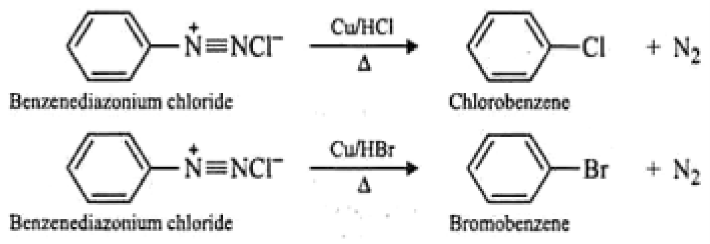
$$\underset{\text{Propanone}}{CH_3COCH_3} + 3\,I_2 + 4\,NaOH \longrightarrow \underset{\text{Iodoform}}{CHI_3} + CH_3COONa + 3\,NaI + 3\,H_2O$$

22. Gattermann-Koch Reaction

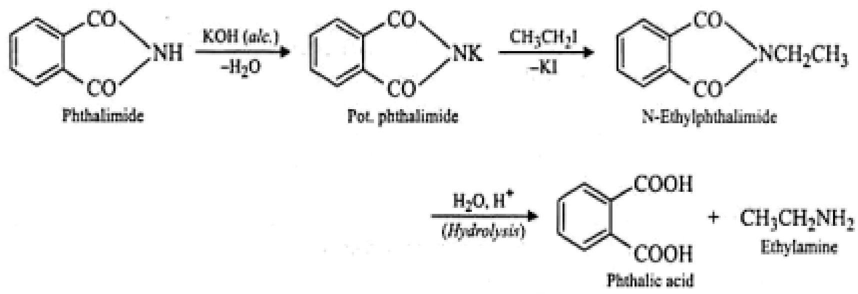
$$CO + HCl \longrightarrow \underset{\text{Formyl chloride (unstable)}}{HCOCl}$$

$$C_6H_6 + HCOCl \xrightarrow{AlCl_3+CuCl} \underset{\text{Benzaldehyde}}{C_6H_5CHO} + HCl$$

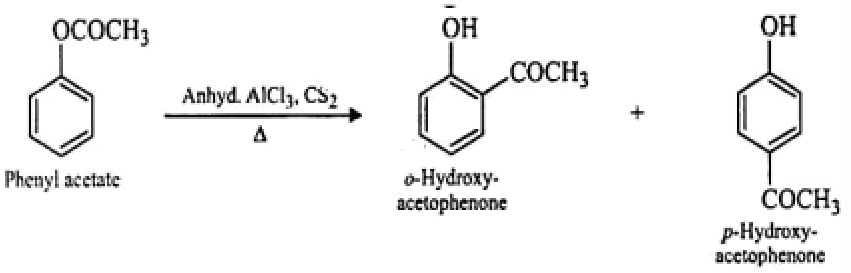
23. Gattermann Reaction



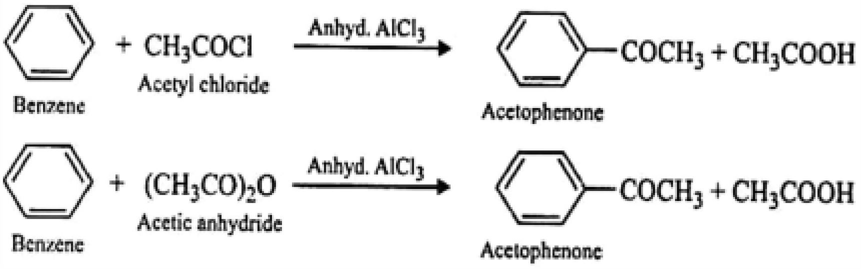
24. Gabriel Phthalimide Reaction



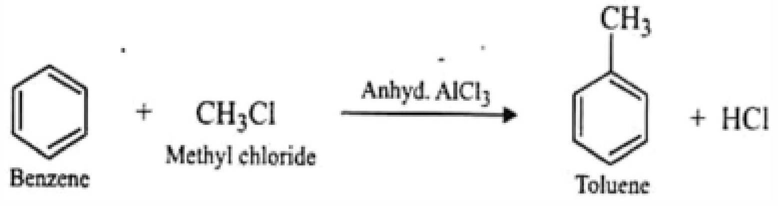
25. Fries rearrangement



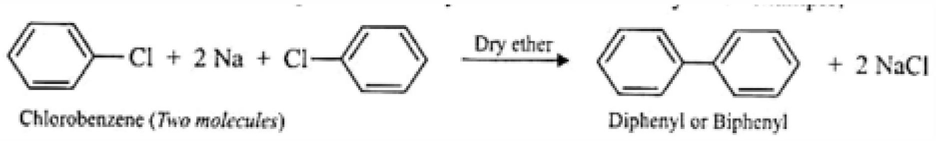
26. Friedel-CraftsAcylation



27. Friedel-Craft Reaction



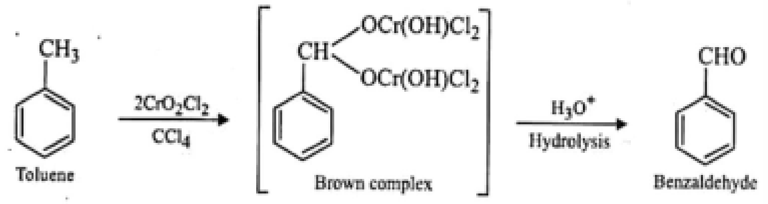
28. Fittig Reaction



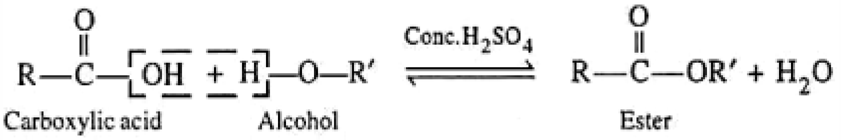
29. Finkelstein Reaction

$$\underset{\text{Bromoethane}}{CH_3CH_2—Br} + NaI \xrightarrow[\Delta]{\text{Acetone or methanol}} \underset{\text{Iodoethane}}{CH_3CH_2—I} + NaBr$$

30. Etard Reaction



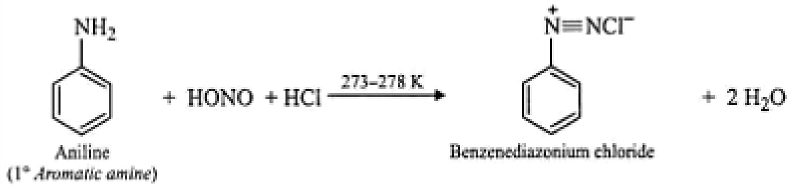
31. Esterification Reaction



$$\underset{\text{Carboxylic acid}}{R—\overset{\overset{\displaystyle O}{\|}}{C}—\boxed{OH + H}}\underset{\text{Alcohol}}{—O—R'} \underset{}{\overset{\text{Conc.}H_2SO_4}{\rightleftharpoons}} \underset{\text{Ester}}{R—\overset{\overset{\displaystyle O}{\|}}{C}—OR'} + H_2O$$

32. Diazotization Reaction

$$NaNO_2 + HCl \longrightarrow \underset{\text{Nitrous acid}}{HONO} + NaCl$$

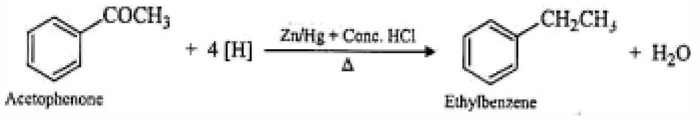


33. Decarboxylation Reaction

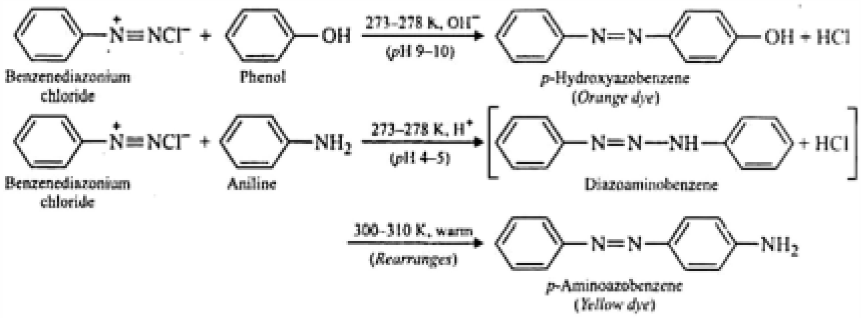
$$\underset{\text{Sod. propanoate}}{CH_3CH_2COONa} + NaOH \xrightarrow{\text{CaO, 630 K}} \underset{\text{Ethane}}{CH_3—CH_3} + Na_2CO_3$$

34. Clemmensen Reduction

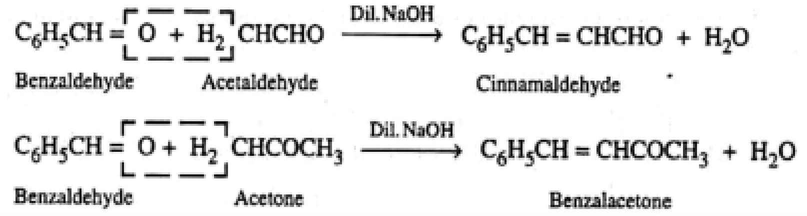
$$\underset{\text{Acetone}}{CH_3COCH_3} + 4\,[H] \xrightarrow[\Delta]{\text{Zn/Hg + Conc. HCl}} \underset{\text{Propane}}{CH_3CH_2CH_3} + H_2O$$



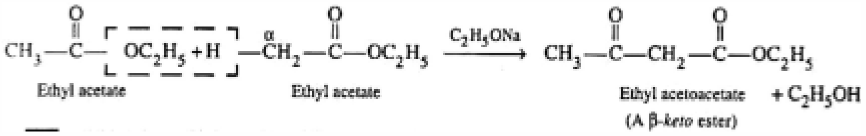
35. Coupling Reaction



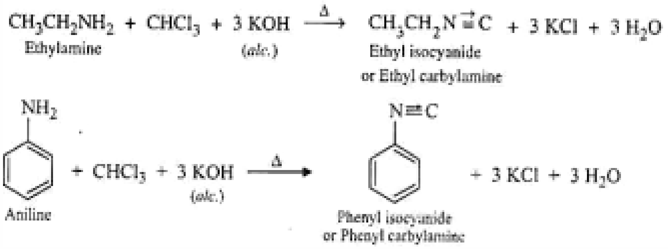
36. Claisen Schmidt Reaction



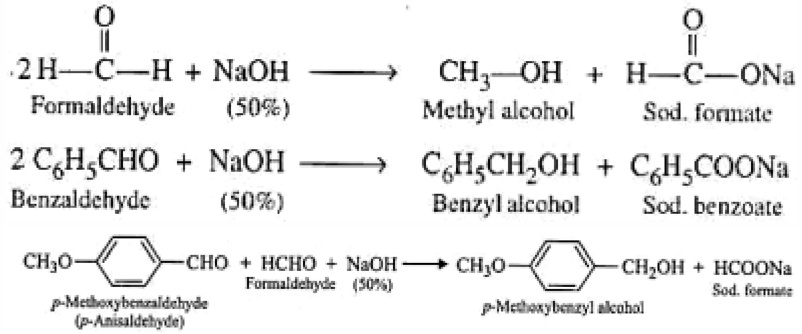
37. Claisen Condensation



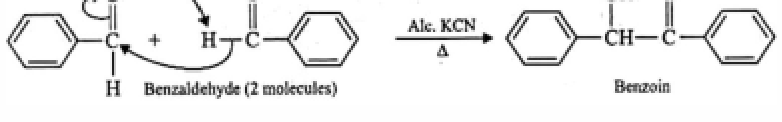
38. Carbylamine Reaction



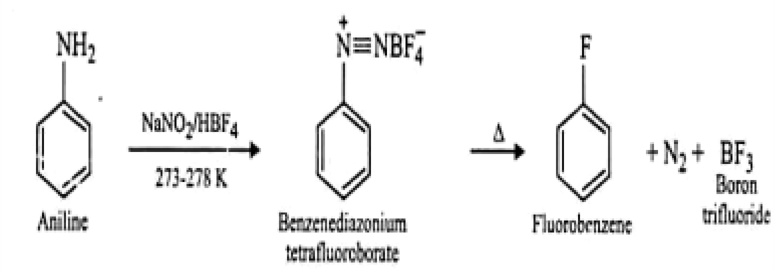
39. Cannizzaro Reaction



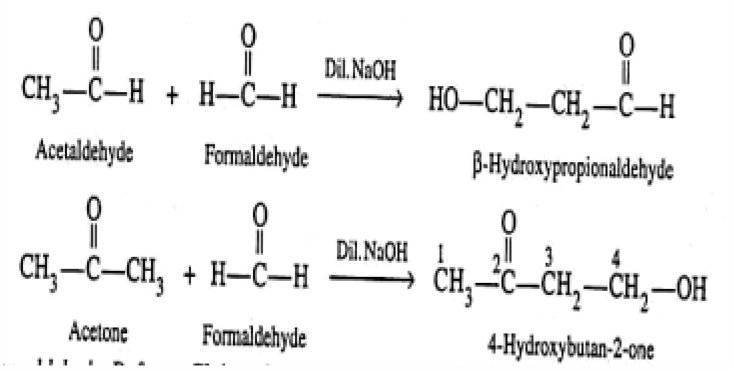
40. Benzoin Condensation



41. Balz-SchiemannReaction



42. Cross Aldol Condensation



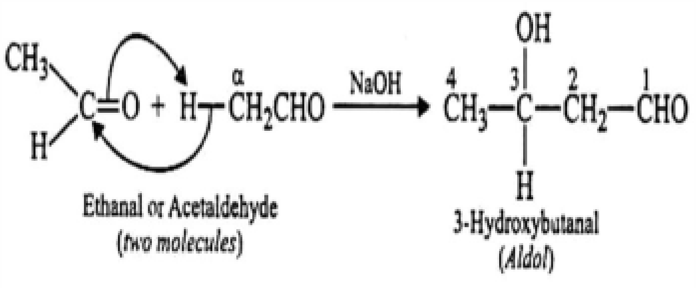
$$CH_3-\overset{O}{\overset{\|}{C}}-H + H-\overset{O}{\overset{\|}{C}}-H \xrightarrow{Dil.NaOH} HO-CH_2-CH_2-\overset{O}{\overset{\|}{C}}-H$$

Acetaldehyde   Formaldehyde   β-Hydroxypropionaldehyde

$$CH_3-\overset{O}{\overset{\|}{C}}-CH_3 + H-\overset{O}{\overset{\|}{C}}-H \xrightarrow{Dil.NaOH} \overset{1}{C}H_3-\overset{O}{\overset{2\|}{C}}-\overset{3}{C}H_2-\overset{4}{C}H_2-OH$$

Acetone   Formaldehyde   4-Hydroxybutan-2-one

43. Aldol Condensation



Ethanal or Acetaldehyde (*two molecules*)

3-Hydroxybutanal (*Aldol*)

44. Benzoylation Reaction

$$C_6H_5COCl + CH_3CH_2NH_2 \xrightarrow{Aq.NaOH} C_6H_5CONHCH_2CH_3 + HCl$$

Benzoyl chloride   Ethylamine   N-Ethylbenzamide

***

Mathematics

Important FORMULAE

Basic Algebra (Upto class IX & X)

1	$(a+b)^2 = a^2 + 2ab + b^2$	2	$(a-b)^2 = a^2 - 2ab + b^2$
3	$(a+b)(a-b) = a^2 - b^2$	4	$(a+b)^2 + (a-b)^2 = 2\,(a^2 + b^2)$
5	$(a+b)^2 - (a-b)^2 = 4ab$	**6**	$a^2 + b^2 = (a+b)^2 - 2ab = (a-b)^2 + 2ab$
7	$\left(x+\frac{1}{x}\right)^2 = x^2 + \frac{1}{x^2} + 2$	**8**	$\left(x-\frac{1}{x}\right)^2 = x^2 + \frac{1}{x^2} - 2$
9	$(x+a)(x+b) = x^2 + (a+b)x + ab$		
10	$(x-a)(x+b) = x^2 - (a-b)x - ab$		
11	$(x+a)(x-b) = x^2 + (a-b)x - ab$		
12	$(x-a)(x-b) = x^2 - (a+b)x + ab$		
13	$(a+b)^3 = a^3 + 3ab(a+b) + b^3 = a^3 + 3a^2b + 3ab^2 + b^3$		
14	$(a-b)^3 = a^3 - 3ab(a-b) - b^3 = a^3 - 3a^2b + 3ab^2 - b^3$		
15	$(a+b)^3 + (a-b)^3 = 2\,a^3 + 6\,ab^2$		
16	$(a+b)^3 - (a-b)^3 = 2\,b^3 + 6\,a^2b$		
17	$a^3 + b^3 = (a+b)(a^2 - ab + b^2) = (a+b)^3 - 3ab(a+b)$		
18	$a^3 - b^3 = (a-b)(a^2 + ab + b^2) = (a-b)^3 + 3ab(a-b)$		
19	$\left(x+\frac{1}{x}\right)^3 = x^3 + \frac{1}{x^3} + 3\left(x+\frac{1}{x}\right)$		
20	$\left(x-\frac{1}{x}\right)^3 = x^3 - \frac{1}{x^3} - 3\left(x-\frac{1}{x}\right)$		
21	$x^3 + \frac{1}{x^3} = \left(x+\frac{1}{x}\right)^3 - 3\left(x+\frac{1}{x}\right) = \left(x+\frac{1}{x}\right)\left(x^2 + \frac{1}{x^2} - 1\right)$		
22	$x^3 - \frac{1}{x^3} = \left(x-\frac{1}{x}\right)^3 + 3\left(x-\frac{1}{x}\right) = \left(x-\frac{1}{x}\right)\left(x^2 + \frac{1}{x^2} + 1\right)$		
23	$(a+b+c)^2 = a^2 + b^2 + c^2 + 2ab + 2bc + 2ca$		
28	$(a+b+c)^3 = a^3 + b^3 + c^3 + 3(a+b)(b+c)(c+a)$ $= a^3 + b^3 + c^3 + 3ab(a+b) + 3bc(b+c) + 3ca(c+a) + 6abc$		
29	$a^3 + b^3 + c^3 - 3abc = (a+b+c)(a^2 + b^2 + c^2 - ab - bc - ca)$ $= \frac{1}{2}(a+b+c)[(a-b)^2 + (b-c)^2 + (c-a)^2]$		
30	$a^4 - b^4 = (a^2 + b^2)(a+b)(a-b)$		
	Indices and Logarithms		
1	$a^m \times a^n = a^{m+n}$	**2**	$a^m \div a^n = a^{m-n}$
3	$(a^m)^n = a^{mn}$	**4**	$a^0 = 1$
5	$a^m \times b^m = (a \times b)^m$	**6**	$a^m \div b^m = (a \div b)^m$
7	$a^{-m} = \frac{1}{a^m}$	**8**	$\sqrt[m]{a} = a^{1/m}$
9	$\log_a m + \log_a n = \log_a (m \times n)$	**10**	$\log_a m - \log_a n = \log_a (m \div n)$
11	$\log_a b^n = n\log_a b$	**12**	$\log_{a^m} b^n = \frac{n}{m}\log_a b$
13	$\log_a a = 1$	**14**	$\log_b a = \frac{1}{\log_a b} = \frac{\log_e a}{\log_e b}$
	Remainder Theorem - If $p(x)$ is any polynomial of degree greater than or equal to 1 and $p(x)$ is divided by the linear polynomial $x-a$, then the remainder is $p(a)$. ***Factor Theorem***– $(x-a)$ is a factor of the polynomial $p(x)$, if $p(a) = 0$. Also, if $x-a$ is a factor of $p(x)$, then $p(a) = 0$.		

	Quadratic Formula $x = \frac{-b\pm\sqrt{b^2-4ac}}{2a}$,where the values of x are the roots of the quadratic equation $ax^2+bx+c=0$ $and\ D(=b^2-4ac)\ is\ the$ Discriminant. (a) If D < 0, then the roots are non-real. (b) If D = 0, then the roots are real and equal. (c) If D > 0, then the roots are real and unequal. $If\ the\ roots\ of\ the\ quadratic\ equation\ ax^2+bx+c=0\ are\ \alpha\ and\ \beta, then$ $sum\ of\ roots = \alpha+\beta = -\frac{b}{a} = -\frac{Coefficient\ of\ x}{Coefficient\ of\ x^2}$and $product\ of\ roots = \alpha.\beta = \frac{c}{a} = \frac{Constant\ term}{Coefficient\ of\ x^2}$
	Arithmetic Progression
	The nth term of an AP (from beginning) = a+(n-1)d Where first term is$a$ and common differenceis d. The nth term of an AP (from end) = l -(n-1)d Where last term is l and common differenceis d. The sum S_n of n terms of an A.P. with first term a and common difference d is given by $S_n = \frac{n}{2}[2a+(n-1)d]$ or $S_n = \frac{n}{2}[a+l]$, where l = last term = $a+(n-1)d$
	If the sum S_n of n terms of a sequence is given, then n^{th} term a_n of the sequence can be determined by using the formula $a_n = S_n - S_{n-1}$

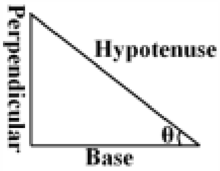
Mensuration (2-D plane figures & 3-D Solids)(Upto class IX & X)

1	$Perimeter\ of\ Polygon = Sum\ of\ all\ the\ sides\ of\ the\ polygon$
2	$Perimeter\ of\ Rectangle = 2(length + breadth) = 2(l+b)$
3	$Perimeter\ of\ Square = 4\times side = 4a$
4	$Circumference\ of\ a\ Circle = C = 2\pi r, \quad where\ \boldsymbol{r}\ is\ the\ radius\ of\ the\ circle$
5	$Perimeter\ of\ a\ Semicircle = \pi r + 2r = (\pi+2)r$
6	$Area\ of\ Circle = \pi r^2$
7	$Area\ of\ a\ Semicircle = \frac{1}{2}\pi r^2$
8	$Length\ of\ an\ Arc = \frac{\theta}{360°}\times 2\pi r$
9	$Area\ of\ a\ Sector = \frac{\theta}{360°}\times \pi r^2$
10	$Heron's\ Formula - Area\ of\ a\ Scalene\ Triangle = \sqrt{s(s-a)(s-b)(s-c)},$ $where\ \boldsymbol{s}\ is\ the\ semi-perimeter\ of\ the\ Scalene\ Triangle, \quad \boldsymbol{s} = \frac{\boldsymbol{1}}{\boldsymbol{2}}(\boldsymbol{a}+\boldsymbol{b}+\boldsymbol{c})$ $and\ \boldsymbol{a}, \boldsymbol{b}\&\boldsymbol{c}\ are\ the\ sides\ of\ the\ Scalene\ Triangle.$
11	$Area\ of\ a\ Right\ Angled\ Triangle = \frac{1}{2}\times base\times heht = \frac{1}{2}\times b\times h$
12	$Area\ of\ an\ Isosceles\ Triangle = \frac{1}{2}\times \mathrm{b}\times\sqrt{\mathrm{a}^2-\left(\frac{\mathrm{b}}{2}\right)^2}$ Where '**b**' is the base and '**a**' is one of the equal sides of the Isosceles Triangle

13	Area of an Equilateral Triangle $= \frac{\sqrt{3}}{4} \times side \times side = \frac{\sqrt{3}}{4} a^2$
14	Area of Rhombus $= \frac{1}{2} \times d_1 \times d_2$, where $\boldsymbol{d_1}$&$\boldsymbol{d_2}$ are the diagonals of the Rhombus
15	Area of Parallelogram = base × height $= b \times h$
16	Area of Rectangle = Length × breadth $= l \times b$
17	Area of Square = side × side $= a^2$
18	Area of Trapezium or Trapezoid $= \frac{1}{2} \times$ sum of parallel sides × height $= \frac{1}{2} \times (a+b) \times h$
19	Euler's Formula $\boldsymbol{F + V - E = 2}$, where '$\boldsymbol{F}$' stands for number of faces, '$\boldsymbol{V}$' stands for number of vertices and '$\boldsymbol{E}$' stands for number of edges
20	Area of four walls of a recangular box or Curved Surace Area of Cuboid $= 2(l+b) \times h$
21	Total Surface Area of a Cuboid $= 2\,(lb + bh + hl)$
22	Volume of a Cuboid $= l \times b \times h$
23	Curved or Lateral Surface Area of a Cube $= 4\,l^2$
24	Total Surface Area of a Cube $= 6\,l^2$
25	Volume of a Cube $= l^3$
26	Curved or Lateral Surface Area of a Cylinder $= 2\pi rh$
27	Total Surface Area of a Cylinder $= 2\pi r(r+h)$
28	Volume of a Cylinder $= \pi r^2 h$
29	Curved or Lateral Surface Area of a Cone $= \pi rl$, where $\boldsymbol{l}\left(= \sqrt{r^2 + h^2}\right)$ is slant height of cone
30	Total Surface Area of Cone $= \pi r(r+l)$
31	Volume of a Cone $= \frac{1}{3}\pi r^2 h$
32	Curved or Lateral Surface Area of a Prism = height × Perimeter of the base $= h \times P$
33	Total Surface Area of a Prism = 2 × Area of the base + h × Perimeter of the base $= 2A + hP$
34	Volume of a Prism = Area of base × height $= Ah$
35	Curved or Lateral Surface Area of a Pyriamid = Number of sides at the base × Area of a triangle $= n \times \frac{1}{2} \times b \times h$
36	TotalSurfaceAreaofaPyramid = Area of base + Combined Area of the lateral faces $= A + n \times \frac{1}{2} \times b \times h$
37	Volume of a Pyramid $= \frac{1}{3} \times$ Area of Base × height $= \frac{1}{3} \times A \times h$
38	Surface Area of a Sphere $= 4\pi r^2$
39	Volume of a Sphere $= \frac{4}{3}\pi r^3$
40	Surface Area of a Hemisphere $= 3\pi r^2$
41	Volume of a Hemisphere $= \frac{2}{3}\pi r^3$
42	TotalSurfaceAreaofaHollowCylinder $= 2\pi rh + 2\pi Rh + 2\pi(R^2 - r^2)$
43	Volume of a Hollow Cylinder $= \pi(R^2 - r^2)h$
44	Curved Surface Area of Frustum of a Cone or Truncated Cone $= \pi l(r_1 + r_2)$, where $\boldsymbol{l}\left(= \sqrt{h^2 + (r_1 - r_2)^2}\right)$ is slant height of the frustum

45	$Total\ Surface\ Area\ of\ Frustum\ of\ a\ Cone\ or\ Truncated\ Cone$ $= \pi l(r_1 + r_2) + \pi({r_1}^2 + {r_2}^2)$
46	$Volume\ of\ Frustum\ of\ a\ Cone\ or\ Truncated\ Cone$ $= \frac{1}{3}\pi h({r_1}^2 + {r_2}^2 + r_1 r_2),\ \ where\ \boldsymbol{h}\ is\ vertical\ height\ of\ the\ frustum,$ $\boldsymbol{r_1}\&\boldsymbol{r_2}\ are\ radii\ of\ the\ two\ bases\ (ends) of\ the\ frustm$

Trigonometry (Level upto class X)

$\sin\theta = \frac{Perpendicular}{Hypotenuse}$	$\mathrm{cosec}\theta = \frac{Hypotenuse}{Perpendicular}$	
$\cos\theta = \frac{Base}{Hypotenuse}$	$\sec\theta = \frac{Hypotenuse}{Base}$	
$\tan\theta = \frac{Perpendicular}{Base}$	$\cot\theta = \frac{Base}{Perpendicular}$	
$\sin\theta = \frac{1}{cosec\theta}$	$\mathrm{cosec}\theta = \frac{1}{sin\theta}$	
$\cos\theta = \frac{1}{sec\theta}$	$\sec\theta = \frac{1}{cos\theta}$	$\tan\theta = \frac{1}{cot\theta}$
$\cot\theta = \frac{1}{tan\theta}$	$\tan\theta = \frac{sin\theta}{cos\theta}$	$\cot\theta = \frac{cos\theta}{sin\theta}$
$\sin^2\theta + \cos^2\theta = 1$ **Or** $\sin^2\theta = 1 - \cos^2\theta$ **Or** $\cos^2\theta = 1 - \sin^2\theta$	$1 + \tan^2\theta = \sec^2\theta$ **Or** $\tan^2\theta = \sec^2\theta - 1$ **Or** $\sec^2\theta - \tan^2\theta = 1$ **Or** $\mathrm{Sec}\theta - \tan\theta = \frac{1}{sec\theta + \tan\theta}$	$1 + \cot^2\theta = \mathrm{cosec}^2\theta$ **Or** $\cot^2\theta = \mathrm{cosec}^2\theta - 1$ **Or** $\mathrm{cosec}^2\theta - \cot^2\theta = 1$ **Or** $\mathrm{cosec}\theta - \cot\theta = \frac{1}{cosec\theta + \cot\theta}$

	0°	30°	45°	60°	90°
sin	0	1/√2	1/√2	√3/2	1
cos	1	√3/2	1/√2	1/2	0
tan	0	1/√3	1	√3	∞
cosec	∞	2	√2	2/√3	1
sec	1	2/√3	√2	2	∞
cot	∞	√3	1	1/√3	0

T Ratios of Complementary angles

sin(90°-θ)=cosθ	cosec(90°-θ)=secθ
cos(90°-θ)=sinθ	sec(90°-θ)=cosecθ
tan(90°-θ)=cotθ	cot(90°-θ)=tanθ

Coordinate Geometry (Level upto class X)

1	The Distance Formula – The Distance between the points $P(x_1, y_1)$ & $Q(x_2, y_2)$ $= PQ = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$
2	The Section Formula – The coordinates of point $P(x, y)$, which divides the line segment joining the points $A(x_1, y_1)$ and $B(x_2, y_2)$, in the ratio $m_1 : m_2$ are $\left(\frac{m_1x_2 + m_2x_1}{m_1 + m_2}, \frac{m_1y_2 + m_2y_1}{m_1 + m_2}\right)$, internally and $\left(\frac{m_1x_2 - m_2x_1}{m_1 - m_2}, \frac{m_1y_2 - m_2y_1}{m_1 - m_2}\right)$, externally.
3	The Mid point Formula – The coordinates of the midpoint P of the $A(x_1, y_1)$ and $B(x_2, y_2)$ are $\left(\frac{x_1+x_2}{2}, \frac{y_1+y_2}{2}\right)$. Centroid of a $\Delta\, ABC$ = $\left(\frac{x_1+x_2+x_3}{2}, \frac{y_1+y_2+y_3}{2}\right)$ where $A(x_1, y_1), B(x_2, y_2)$ and $C(x_3, y_3)$ are the vertices of the $\Delta\, ABC$.
4	Area of a $\Delta\, ABC = \frac{1}{2}[x_1(y_2 - y_3) + x_2(y_3 - y_1) + x_3(y_1 - y_2)]$, where $A(x_1, y_1), B(x_2, y_2)$ and $C(x_3, y_3)$ are the vertices of the $\Delta\, ABC$

Statistics (Level upto class X)

1	Mean (for ungrouped data) $= \frac{\text{Sum of all the observations}}{\text{Total number of observations}}$
2	Mean(for grouped data – The Direct Method) $\overline{x} = \frac{\sum f_i x_i}{\sum f_i}$, where x_i are the class marks
3	Mean (for grouped data – The Assumed Mean Method) $\overline{x} = A + \frac{\sum f_i d_i}{\sum f_i}$, where $\boldsymbol{A}$ is the assumed mean, $\boldsymbol{d_i}$ is the deviation from the class mark nd $\boldsymbol{d_i = x_i - A}$
4	Mean (for grouped data – The Step Deviation Method) $\overline{x} = a + \left(\frac{\sum f_i u_i}{\sum f_i}\right) h$, where $\boldsymbol{h}$ is class size of each class interval and $\boldsymbol{u_i} = \frac{x_i - a}{h}$
5	Median (for ungrouped data & Odd number of observations) $= \left(\frac{N+1}{2}\right)^{th}$ observation, where $\boldsymbol{N}$ is the total number of observations
6	Median (for ungrouped data & Even number of observations) $=$ Mean of $\left(\frac{N}{2}\right)^{th}$ & $\left(\frac{N}{2} + 1\right)^{th}$ observations
7	Median(for grouped data) $= l + \left(\frac{\frac{N}{2} - cf}{f}\right) \times h$, where $\boldsymbol{l}$ is lower limit of median class, $\boldsymbol{N}$ is total number of observations, $\boldsymbol{cf}$ is cumulative frequency of class preceding the median class, $\boldsymbol{f}$ is frequency of median class, $\boldsymbol{h}$ is class size (assuming class size to be equal)
8	Mode(for ungrouped data) = The observation which occurs most number of times
9	Mode(for grouped data) $= l + \left(\frac{f_1 - f_0}{2f_1 - f_0 - f_2}\right) \times h$, where $\boldsymbol{l}$ is lower limit of the modal class, $\boldsymbol{h}$ is size of the class interval (assuming all class sizes to be equal), $\boldsymbol{f_1}$ is frequency of the modal class $\boldsymbol{f_0}$ is frequency of the class preceding the modal class, $\boldsymbol{f_2}$ is frequency of the class succeeding the modal class.

Algebra (Level Class XI & XII)

Set Theory

For any three sets A, B & C and Universal set $\xi\ (or)\ U$, we have		
$A \times (B \cup C) = (A \times B) \cup (A \times C)$		$A \times (B \cap C) = (A \times B) \cap (A \times C)$
$A \times (B - C) = (A \times B) - (A \times C)$		$A \times B = B \times A \Leftrightarrow A = B$
$(A \times B) \cap (B \times A) = (A \cap B) \times (B \cap A)$		$A \times B = A \times C \Rightarrow B = C$
Some Important Laws (on Sets)		
Idempotent laws $A \cup A = A$ *and* $A \cap A = A$ *Identity laws* $A \cup \phi = A$ *and* $A \cap \xi = A$ Dominance laws $A \cup \xi = \xi$ *and* $A \cap \phi = \phi$ *Complementary laws* $A \cup A' = \xi$ *and* $A \cap A' = \phi$		
Commutative laws $A \cup B = B \cup A$ *and* $A \cap B = B \cap A$		
Associative laws $(A \cup B) \cup C = A \cup (B \cup C)$ *and* $(A \cap B) \cap C = A \cap (B \cap C)$		
Distributive laws $A \cup (B \cap C) = (A \cup B) \cap (A \cup C)$ *and* $A \cap (B \cup C) = (A \cap B) \cup (A \cap C)$		
De' Morgan's laws $(A \cup B)' = A' \cap B'$ *and* $(A \cap B)' = A' \cup B'$		
n(AUB)= n(A)+n(B)- n$(A \cap B)$		
n(AUBUC)= n(A)+n(B)+n(C) -n$(A \cap B)$-n$(B \cap C) - n(C \cap A)$+n $(A \cap B \cap C)$		

Permutations - Combinations & Binomial Theorem		
If n is a natural number and r is a non-negative integer such that 0 ≤ r ≤ n, then		
$^{n}C_{r} = \dfrac{n!}{(n-r)!\,r!}$		$^{n}C_{r} \times r! = {}^{n}P_{r}$
$^{n}C_{r} = {}^{n}C_{n-r}$		$^{n}C_{r} + {}^{n}C_{r-1} = {}^{n+1}C_{r}$
$^{n}C_{r} = \dfrac{n}{r}.{}^{n-1}C_{r-1} = \dfrac{n}{r} \times \dfrac{(n-1)}{(r-1)}.{}^{n-2}C_{r-2} = \ldots\ldots\ldots = \dfrac{n}{r} \times \dfrac{(n-1)}{(r-1)} \times \dfrac{(n-2)}{(r-2)} \times \ldots. \times \dfrac{n-(r-1)}{1}$		
$^{n}C_{x} = {}^{n}C_{y} \Rightarrow x = y$ **OR** $x + y = n$		
If n is an even natural number, then the greatest among $^{n}C_{0}, {}^{n}C_{1}, {}^{n}C_{2}, \ldots.., {}^{n}C_{n}$ is $^{n}C_{\frac{n}{2}}$		
If n is an odd natural number, then the greatest among $^{n}C_{0}, {}^{n}C_{1}, {}^{n}C_{2}, \ldots.., {}^{n}C_{n}$ is $^{n}C_{\frac{n-1}{2}}$ or $^{n}C_{\frac{n+1}{2}}$		
The number of ways of selecting **r** items or objects from a group of ***n*** distinct items or objects is $\dfrac{n!}{(n-r)!\,r!} = {}^{n}C_{r}$		
Binomial Theorem: - If x and a are real numbers, then for all n ∈ N, we have $(x+a)^{n} = {}^{n}C_{0}x^{n}a^{0} + {}^{n}C_{1}x^{n-1}a^{1} + {}^{n}C_{2}x^{n-2}a^{2} + \ldots.. + {}^{n}C_{r}x^{n-r}a^{r} + \ldots.. + {}^{n}C_{n-1}x^{1}a^{n-1} + {}^{n}C_{n}x^{0}a^{n}$ i.e., $(x+a)^{n} = \sum_{r=0}^{n} {}^{n}C_{r}x^{n-r}a^{r}$		

Sequence & Series (AP & GP)

The nth term of an AP (from beginning) = a+(n-1)d
Where first term is a and common difference is d.
The nth term of an AP (from end) = l -(n-1)d
Where last term is$l$ and common difference is d.

The sum S_n of n terms of an A.P. with first term a and common difference d is given by $S_n = \frac{n}{2}[2a + (n-1)d]$ or $S_n = \frac{n}{2}[a + l]$, where l = last term = $a + (n-1)d$

If the sum S_n of n terms of a sequence is given, then n^{th} term a_n of the sequence can be determined by using the formula $a_n = S_n - S_{n-1}$

If n numbers A_1, A_2, ….., A_n are inserted between two given numbers a and b such that $a, A_1, A_2, \ldots\ldots, A_n, b$ is an arithmetic progression, then $A_1, A_2, \ldots\ldots, A_n$ are known as narithmetic means between a and b and the common difference of the A. P. is $d = \frac{b-a}{n+1}$.

Also, $A_1 + A_2 + \ldots\ldots\ldots\ldots + A_n = n\left(\frac{a+b}{2}\right)$ where Arithmetic Mean of a and b is $\frac{a+b}{2}$

Three numbers a, b, c are in A. P. iff (if and only if) $2b = a + c$.

The n^{th} term of a Geometric Progression with first term a and common ratio r is given by
$a_n = ar^{n-1}$

If the sum of n terms of a G. P. with first term a and common ratio is given by

$$S_n = a\left(\frac{r^n - 1}{r - 1}\right) \quad for\ \boldsymbol{r} > 1$$

$$S_n = a\left(\frac{1 - r^n}{1 - r}\right) \quad for\ \boldsymbol{r} < 1$$

$S_n = n$, if $r = 1$

Also, $S_n = \frac{a - lr}{1 - r}$ or $S_n = \frac{lr - a}{r - 1}$, where l is the last term.

Let a and b be two given numbers. If n numbers $G_1, G_2, G_3, \ldots\ldots, G_n$ are inserted between a and b such that the sequence $a, G_1, G_2, \ldots\ldots, G_n, b$ is a G. P., then the numbers $G_1, G_2, G_3, \ldots\ldots, G_n$ are known as n geometric means between a and b. The common ratio of the G.P. is given by $r = \left(\frac{b}{a}\right)^{\frac{1}{n+1}}$ and G_1 G_2G_3 ……… G_n = G^n where G is the single Geometric Mean of a and b given by $\sqrt{ab}$.

If A and G are respectively Arithmetic and Geometric Means between two positive numbers a and b, then

(i) A > G.

(ii) The quadratic equation having a and b as its roots is $x^2 - 2Ax + G^2 = 0$.

(iii) a : b = $\left(A + \sqrt{A^2 - G^2}\right) : \left(A - \sqrt{A^2 - G^2}\right)$.

If AM and GM between two numbers are in the ratio m : n, then the numbers are in the ratio $m + \sqrt{m^2 - n^2} : m - \sqrt{m^2 - n^2}$.

Three numbers a, b, c are in G. P. iff (if and only if) $b^2 = ac$.

$$\sum_{k=1}^{n} k = 1 + 2 + 3 + \ldots\ldots + n = \frac{n(n+1)}{2} = \Sigma n$$

$$\sum_{k=1}^{n} k^2 = 1^2 + 2^2 + 3^2 + \dots\dots\dots + n^2 = \frac{n(n+1)(2n+1)}{6} = \Sigma n^2$$

$$\sum_{k=1}^{n} k^3 = 1^3 + 2^3 + 3^3 + \dots\dots\dots\dots + n^3 = \left[\frac{n(n+1)}{2}\right]^2 = \Sigma n^3$$

$$\sum_{k=1}^{n} k^4 = 1^4 + 2^4 + 3^4 + \dots\dots\dots\dots + n^4 = \frac{n(n+1)(2n+1)(3n^2+3n-1)}{30} = \Sigma n^4$$

Statistics (Level Class XI)

Mean deviation is the arithmetic mean of the absolute values of deviations about some point (mean or median or mode).

(i) For individual observation, we have

$$M.D. = \frac{1}{n}\sum_{i=1}^{n} |x_i - a|,$$

where a = mean, median, mode

Also, $M.D. = a + h\left\{\frac{1}{N}\sum_{i=1}^{n}|u_i|\right\}$, where $u_i = \dfrac{x_i - a}{h}$.

(ii) For a discrete frequency distribution, we have

$M.D. = \frac{1}{N}\sum_{i=1}^{n} f_i|x_i - a|$, a = mean, median, mode

$M.D. = a + h\left\{\frac{1}{N}\sum_{i=1}^{n} f_i u_i\right\}$, where $u_i = \frac{x_i - a}{h}$.

Variance is the arithmetic mean of the squares of deviations about mean $\overline{x}$

(i) For individual observations, we have

$$Variance = \frac{1}{n}\sum_{i=1}^{n}\left(x_i - \overline{X}\right)^2$$

Also, $Var\ (X) = \frac{1}{n}\sum_{i=1}^{n} {x_i}^2 - \left(\frac{1}{n}\sum_{i=1}^{n} x_i\right)^2$

$Var\ (X) = h^2\left[\frac{1}{n}\sum_{i=1}^{n} {u_i}^2 - \left(\frac{1}{n}\sum_{i=1}^{n} u_i\right)^2\right]$, where $u_i = \dfrac{x_i - a}{h}$.

(ii) For a discrete frequency distribution, we have

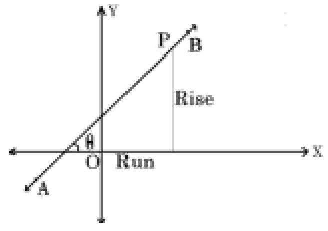
$$Var\ (X) = \frac{1}{N}\sum_{i=1}^{n} f_i\left(x_i - \overline{X}\right)^2$$

$$\Rightarrow Var\ (X) = \frac{1}{N}\sum_{i=1}^{n} f_i {x_i}^2 - \left(\frac{1}{N}\sum_{i=1}^{n} f_i x_i\right)^2$$

$$\Rightarrow Var\ (X) = h^2\left[\frac{1}{N}\sum_{i=1}^{n} f_i {u_i}^2 - \left(\frac{1}{N}\sum_{i=1}^{n} f_i u_i\right)^2\right]$$

The coefficient of variation = C. V. = $\frac{\sigma}{\overline{X}} \times 100$

Coordinate Geometry (Level Class XI)

1	$TheDistanceFormula - TheDistancebetweenthepointsP(x_1, y_1)\&Q(x_2, y_2)$ $= PQ = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$
2	$The\ Section\ Formula$ – $The\ coordinates\ of\ point\ P(x, y), which\ divides\ the$ $line\ segment\ oining\ the\ points\ A(x_1, y_1)\ and\ B(x_2, y_2), in\ the\ ratio\ m_1 : m_2\ are$ $\left(\frac{m_1x_2 + m_2x_1}{m_1 + m_2}, \frac{m_1y_2 + m_2y_1}{m_1 + m_2}\right), internally\ and\ \left(\frac{m_1x_2 - m_2x_1}{m_1 - m_2}, \frac{m_1y_2 - m_2y_1}{m_1 - m_2}\right),$ externally.
3	$The\ Mid\ point\ Formula$ – The coordinates of the midpoint P of the $A(x_1, y_1)$ and $B(x_2, y_2)$ are $\left(\frac{x_1+x_2}{2}, \frac{y_1+y_2}{2}\right)$. Centroid of a $\Delta\ ABC$ = $\left(\frac{x_1+x_2+x_3}{2}, \frac{y_1+y_2+y_3}{2}\right)$ $where\ A(x_1, y_1), B(x_2, y_2)\ and\ C(x_3, y_3)\ are\ the\ vertices\ of\ the\ \Delta\ ABC.$
4	$Area\ of\ a\ \Delta\ ABC = \frac{1}{2}[x_1(y_2 - y_3) + x_2(y_3 - y_1) + x_3(y_1 - y_2)],$ $where\ A(x_1, y_1), B(x_2, y_2)\ and\ C(x_3, y_3)\ are\ the\ vertices\ of\ the\ \Delta\ ABC.$
5	$The\ Slope\ of\ a\ ne\ AB\ = m == tan\theta = \frac{Rise}{Run}$ $= \frac{Diference\ of\ Ordinates}{Difference\ of\ abscissae} = \frac{y_2 - y_1}{x_2 - x_1},$ $Where\ (x_1, y_1)\ and\ (x_2, y_2)\ are\ the\ two\ on\ line\ AB.$ 
6	An acute angle θ between the lines having slopes m_1 and m_2 is given by tan θ= $\left\lvert\frac{m_1 - m_2}{1 + m_1m_2}\right\rvert$, where 1 + $m_1m_2 \neq 0$.
7	The distance between two points $P(x_1, y_1)$ and $Q(x_2, y_2)$ is given by $PQ = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$ i.e. $PQ = \sqrt{(Differenceofabscissae)^2 + (Differenceofordinates)^2}$
8	The distance of a point $\boldsymbol{P(x, y)}$ from the origin **O (0, 0)** is given by $OP = \sqrt{x^2 + y^2}$.

9	The area of the triangle, the coordinates of whose vertices are $A(x_1, y_1)$, $B(x_2, y_2)$and $C(x_3, y_3)$, is the absolute value of $\frac{1}{2}[x_1(y_2 - y_3) + x_2(y_3 - y_1) + x_3(y_1 - y_2)]$ or $\frac{1}{2}\begin{vmatrix} x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \\ x_3 & y_3 & 1 \end{vmatrix}$
10	If the points $(x_1, y_1), (x_2, y_2)$and(x_3, y_3) are collinear, then $\begin{vmatrix} x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \\ x_3 & y_3 & 1 \end{vmatrix} = 0$
11	The coordinates of the mid-point of the line segment joining (x_1, y_1) and (x_2, y_2) are$\left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right)$.
12	The coordinates of the centroid of the triangle whose vertices are $(x_1, y_1), (x_2, y_2)$and(x_3, y_3) are$\left(\frac{x_1 + x_2 + x_3}{3}, \frac{y_1 + y_2 + y_3}{3}\right)$.
13	The equation of a line with slope m and making an intercept c on y-axis is $y = mx + c$.
14	The equation of the line which passes through the point (x_1, y_1) and has slope m is $y - y_1 = m(x - x_1)$
15	The equation of the line which passes through the point (x_1, y_1) and (x_2, y_2) is $y - y_1 = \frac{y_2 - y_1}{x_2 - x_1}(x - x_1)$
16	The equation of the line making intercepts a and b on x and y-axis respectively is $\frac{x}{a} + \frac{y}{b}$=1. (Intercept Form) If perpendicular to the line drawn from origin makes an angle α with x-axis and the length of perpendicular is p then equation of the line is xcosα+ysinα = p (Normal form)
17	General Equation of Circle – > $(x - h)^2 + (y - k)^2 = r^2$ Where *(h, k)* is the centre of the circle and *r* is radius of the circle.
18	Standard Equation of circle – $x^2 + y^2 + 2gx + 2fy + c = 0$ Where $(-g, -f)$ is the centre of the circle and $r \left(= \sqrt{g^2 + f^2 - c}\right)$ is the radius of the circle.
19	If (α, β) is the focus and $ax + by + c = 0$ is the equation of the directrix of a parabola, then its equation is $(x - \alpha)^2 + (y - \beta)^2 = \frac{(ax + by + c)^2}{a^2 + b^2}$. This equation is of the form $ax^2 + 2hxy + by^2 + 2gx + 2fy + c = 0$ satisfying the conditions $abc + 2fgh - af^2 - bg^2 - ch^2 \neq 0$ and $h^2 - ab = 0$.

20 Following are four standard forms of parabola:

	$y^2 = 4ax$	$y^2 = -4ax$	$x^2 = 4ay$	$x^2 = -4ay$
Coordinates of vertex	$(0,0)$	$(0,0)$	$(0,0)$	$(0,0)$
Coordinates of focus	$(a,0)$	$(-a,0)$	$(0,a)$	$(0,-a)$
Equation of the directrix	$x = -a$	$x = a$	$y = -a$	$y = a$
Equation of the axis	$y = 0$	$y = 0$	$x = 0$	$x = 0$
Length of the Latus – rectum	$4a$	$4a$	$4a$	$4a$
Focal distance of a point P (x,y)	$\lvert a + x \rvert$	$\lvert a - x \rvert$	$\lvert a + y \rvert$	$\lvert a - y \rvert$

21 If S is the focus and ZZ′ is the directrix and P is any point on the ellipse such that M is the foot of perpendicular from P on ZZ′ then SP = e . PM

The equation $ax^2 + 2hxy + by^2 + 2gx + 2fy + c = 0$ represents an ellipse, if

$$\Delta = abc + 2fgh - af^2 - bg^2 - ch^2 \neq 0 \text{ and } h^2 < ab.$$

22 The equation of the ellipse whose axes are parallel to the coordinate axes and whose centre is at the origin, is $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$ with the following properties

	$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1, a > b$	$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1, a < b$
Coordinates of the centre	(0, 0)	(0, 0)
Coordinates of the vertices	$(a,0)$ and $(-a,0)$	$(0,b)$ and $(0,-b)$
Coordinates of foci	$(ae,0)$ and $(-ae,0)$	$(0,be)$ and $(0,-be)$
Length of the major axis	$2a$	$2b$
Length of the minor axis	$2b$	$2a$
Equation of the major axis	$y = 0$	$x = 0$
Equation of the minor axis	$x = 0$	$y = 0$
Equations of the directices	$x = \frac{a}{e}$ and $x = -\frac{a}{e}$	$y = \frac{b}{e}$ and $y = -\frac{b}{e}$
Eccentricity	$e = \sqrt{1 - \frac{b^2}{a^2}}$	$e = \sqrt{1 - \frac{a^2}{b^2}}$
Length of the latus-rectum	$\frac{2b^2}{a}$	$\frac{2a^2}{b}$
Focal distances of a point (x,y)	$\lvert a \pm e x \rvert$	$\lvert b \pm e y \rvert$

23 If the centre of the ellipse is at the point (h,k) and the directions of the axes are parallel to the coordinate axes, then its equation is $\frac{(x-h)^2}{a^2} + \frac{(y-k)^2}{b^2} = 1$

The equation of the hyperbola having its centre at the origin and axes along the coordinate axes is $\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$ with the following properties:

	Hyperbola $\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$	Conjugate hyperbola $-\frac{x^2}{a^2} - \frac{y^2}{b^2} = -1$

	Coordinates of the centre	(0, 0)	(0, 0)
	Coordinates of the vertices	$(a,0)$ and $(-\ a,0)$	$(0,b)$ and $(0,-\ b)$
	Coordinates of foci	$(\pm\ ae,0)$	$(0,\pm\ be)$
	Length of the transverse axis	$2a$	$2b$
	Length of the conjugate axis	$2b$	$2a$
	Equation of the transverse axis	$y = 0$	$x = 0$
	Equation of the conjugate axis	$x = 0$	$y = 0$
	Equations of the direectices	$x = \pm\ \frac{a}{e}$	$y = \pm\ \frac{b}{e}$
	Eccentricity	$e = \sqrt{1+\frac{b^2}{a^2}}$ or $b^2\ = a^2(e^2-1)$	$e = \sqrt{1+\frac{a^2}{b^2}}$ or $a^2\ = b^2(e^2-1)$
	Length of the latus-rectum	$\frac{2b^2}{a}$	$\frac{2a^2}{b}$

24 If the centre of the hyperbola is at the point $(h,k)$and the directions of the axes are parallel to the coordinate axes, then its equation is $\frac{(x-h)^2}{a^2}-\frac{(y-k)^2}{b^2} = 1$

25 Distance between two points $P(x_1,y_1,z_1)$ and $Q(x_2,y_2,z_2)$ is

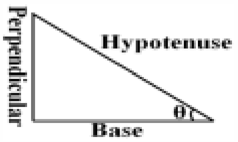
$$d = \sqrt{(x_2-x_1)^2+(y_2-y_1)^2+(z_2-z_1)^2}$$

26 Section Formula: If R divides PQ in the ratio $m{:}n$, then

$$R_x = \frac{mQ_x \pm nP_x}{m \pm n}, \qquad R_y = \frac{mQ\ \ \pm nP_y}{m \pm n}, \qquad R_z = \frac{mQ_z \pm nP_z}{m \pm n}$$

Note:- "+" sign for internal division & "-" sign for external division.

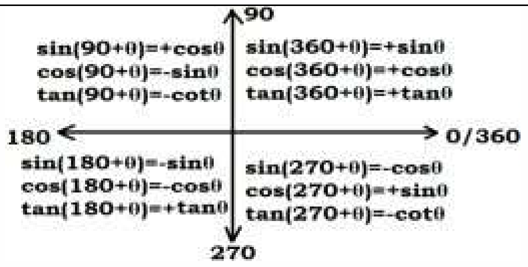
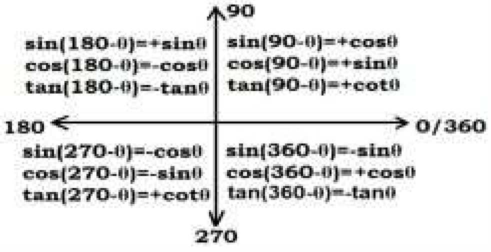
Trigonometry and Inverse Trigonometry (Level Class X-XI-XII)

	$\sin\theta = \frac{Perpendicular}{Hypotenuse}$		$\text{cosec}\theta = \frac{Hypotenuse}{Perpendicular}$		
	$\cos\theta = \frac{Base}{Hypotenuse}$		$\sec\theta = \frac{Hypotenuse}{Base}$		
	$\tan\theta = \frac{Perpendicular}{Base}$		$\cot\theta = \frac{Base}{Perpendicular}$		
	$\sin\theta = \frac{1}{cosec\theta}$		$\text{cosec}\theta = \frac{1}{sin\theta}$		
	$\cos\theta = \frac{1}{sec\theta}$		$\sec\theta = \frac{1}{cos\theta}$		$\tan\theta = \frac{1}{cot\theta}$
	$\cot\theta = \frac{1}{tan\theta}$		$\tan\theta = \frac{sin\theta}{cos\theta}$		$\cot\theta = \frac{cos\theta}{sin\theta}$
	$\sin^2\theta + \cos^2\theta = 1$ **Or** $\sin^2\theta = 1 - \cos^2\theta$ **Or** $\cos^2\theta = 1 - \sin^2\theta$		$1 + \tan^2\theta = \sec^2\theta$ **Or** $\tan^2\theta = \sec^2\theta - 1$ **Or** $\sec^2\theta - \tan^2\theta = 1$		$1 + \cot^2\theta = \text{cosec}^2\theta$ **Or** $\cot^2\theta = \text{cosec}^2\theta - 1$ **Or** $\text{cosec}^2\theta - \cot^2\theta = 1$

			Or $\text{Sec}\theta - \tan\theta = \frac{1}{sec\theta + \tan\theta}$		**Or** $\text{cosec}\theta - \cot\theta = \frac{1}{cosec\theta + \cot\theta}$

	0°	30°	45°	60°	90°
sin	0	1/√2	1/√2	√3/2	1
cos	1	√3/2	1/√2	1/2	0
tan	0	1/√3	1	√3	∞
cosec	∞	2	√2	2/√3	1
sec	1	2/√3	√2	2	∞
cot	∞	√3	1	1/√3	0

T Ratios of Complementary angles	
sin(90°-θ)=cosθ	cosec(90°-θ)=secθ
cos(90°-θ)=sinθ	sec(90°-θ)=cosecθ
tan(90°-θ)=cotθ	cot(90°-θ)=tanθ

			
	$\sin(-\theta) = -\sin\theta$		$\cos(-\theta) = \cos\theta$
	$\tan(-\theta) = -\tan\theta$		$\text{cosec}(-\theta) = -\text{cosec}\theta$
	$\sec(-\theta) = \sec\theta$		$\cot(-\theta) = -\cot\theta$
	Sin(A + B)= sinAcosB + cosAsinB		Sin(A – B)= sinAcosB -cosAsinB
	cos(A + B)= cosAcosB – sinAsinB		cos(A – B)= cosAcosB + sinAsinB
	$\tan(A + B) = \frac{tanA + tanB}{1 - tanAtanB}$		$\tan(A - B) = \frac{tan\ A - \tan B}{1 + \tan A \tan B}$
	Sin(A + B) + sin(A – B) = 2sinAcosB		Sin(A + B) – sin(A – B) = 2cosAsinB
	cos(A + B) + cos(A – B) =2cosAcosB		cos(A – B) – cos(A + B) = 2sinAsinB
	$\sin(A + B)\sin(A - B) = \sin^2 A - \sin^2 B$		$\cos(A + B)\cos(A - B) = \cos^2 A - \sin^2 B$
	$\sin C + \sin D = 2\sin\left(\frac{C+D}{2}\right)\cos\left(\frac{C-D}{2}\right)$		$\sin C - \sin D = 2\cos\left(\frac{C+D}{2}\right)\sin\left(\frac{C-D}{2}\right)$
	$\cos C + \cos D = 2\cos\left(\frac{C+D}{2}\right)\cos\left(\frac{C-D}{2}\right)$		$\cos C - \cos D = 2\sin\left(\frac{C+D}{2}\right)\sin\left(\frac{D-C}{2}\right)$
	$\sin 2\theta = 2\sin\theta\cos\theta = \frac{2tan\theta}{1+tan^2\theta}$		$\cos 2\theta = \cos^2\theta - \sin^2\theta = 2\cos^2\theta - 1$

			$= 1-2\sin^2\theta = \frac{1-tan^2\theta}{1+tan^2\theta}$
	$\tan 2\theta = \frac{2tan\theta}{1-tan^2\theta}$		$\sin 3\theta = 3\sin\theta - 4\sin^3\theta$
	$\cos 3\theta = 4\cos^3\theta - 3\cos\theta$		$\tan 3\theta = \frac{3tan\theta - \tan^3\theta}{1-3\,tan^2\theta}$
	$1 + \cos 2\theta = 2\cos^2\theta$ **OR** $\cos\theta = \sqrt{\frac{1+cos2\theta}{2}}$		$1 - \cos 2\theta = 2\sin^2\theta$ **OR** $\sin\theta = \sqrt{\frac{1-cos2\theta}{2}}$
	$\sin 18^\circ = \frac{\sqrt{5}-1}{4}$		$\cos 36^\circ = \frac{\sqrt{5}+1}{4}$
	sin(A + B + C) = sinAcosBcosC + cosAsinBcosC + cosAcosBsinC − sinAsinBsinC		
	cos(A + B + C) = cosAcosBcosC − cosAsinBsinC − sinAcosBsinC − sinAsinBcosC		
	$tan(A+B+C) = \frac{\tan A + \tan B + \tan C - tanAtanBtanC}{1 - tanAtanB - tanBtanC - tanCtanA}$		
	The relation between three systems of measurement of an angle is $\frac{D}{90^\circ} = \frac{G}{100} = \frac{2R}{\pi}$ Where the three systems of measuring angles are: i) Sexagesimalsystem, in which we have 1right angle = 90 degrees, (= 90°), $1^\circ = 60\ minutes (= 60'), 1' = 60\ seconds\ (= 60'')$ ii) Centesimal system, in which we have 1 right angle = 100 grades, 1grade = 100 minutes, 1 minute = 100 seconds iii) Circular system, in which the unit of measurement is radian. One radian is the measure of an angle subtended at the centre of a circle by an arc of length equal to the radius of the circle.Π radians = 180°		

Trigonometric Equations and their General Solutions

Trigonometric Equations	General solutions
$\sin\theta = 0$	$\theta = n\pi$
$\cos\theta = 0$	$\theta = (2n+1)\pi/2$
$\tan\theta = 0$	$\theta = n\pi$
$\sin\theta = \sin\alpha$	$\theta = n\pi + (-1)^n\alpha$
$\cos\theta = \cos\alpha$	$\theta = 2n\pi \pm \alpha$
$\tan\theta = \tan\alpha$	$\theta = n\pi + \alpha$
$\sin^2\theta = \sin^2\alpha$	$\theta = n\pi \pm \alpha$
$\cos^2\theta = \cos^2\alpha$	$\theta = n\pi \pm \alpha$
$\tan^2\theta = \tan^2\alpha$	$\theta = n\pi \pm \alpha$

Solutions of Triangle Formulas

In a ΔABC

- a, b, and c are the lengths of the sides of the triangle (opposite to angles A,B,C respectively)
- A, B, and C are the angles of the triangle.
- R is the radius of the circumcircle of the triangle.

Sine Rule or Sine Law a/sin A = b/sin B = c/sin C=2R

Where circumradius of ΔABC $R = \frac{abc}{4\Delta}$

$$\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c} = \frac{2\Delta}{abc}$$

$$R = \frac{a}{2\sin A} = \frac{b}{2\sin B} = \frac{c}{2\sin C} = \frac{abc}{4\Delta S}$$ Where Δ is area of triangle and $s = \frac{a+b+c}{2}$.

Cosine Formula: In any triangle ABC,

(i) cos A = $(b^2+c^2-a^2)/2bc$ (ii) cos B = $(c^2+a^2-b^2)/2ca$ (iii) cos C = $(a^2+b^2-c^2)/2ab$

Projection Formula: In any triangle ABC,

(i) a = b cos C + c cos B(ii) b = c cos A + a cos C(iii) c = a cos B + b cos A

Napier's Analogy- Tangent rule:

In any triangle ABC, with sides a = BC, b = CA and c = BA, then prove that

(i) $\tan\frac{B-C}{2} = \frac{b-c}{b+c}\cot\frac{A}{2}$

(ii) $\tan\frac{C-A}{2} = \frac{c-a}{c+a}\cot\frac{B}{2}$

(iii) $\tan\frac{A-B}{2} = \frac{a-b}{a+b}\cot\frac{C}{2}$

In ΔABC, $\angle A + \angle B + \angle C = \pi$

(a) $\sin(B+C) = \sin(\pi - A) = \sin A$

(b) $\cos(C+A) = \cos(\pi - B) = -\cos B$

(c) $\sin\frac{A+B}{2} = \sin\left(\frac{\pi}{2} - \frac{C}{2}\right) = \cos\frac{C}{2}$

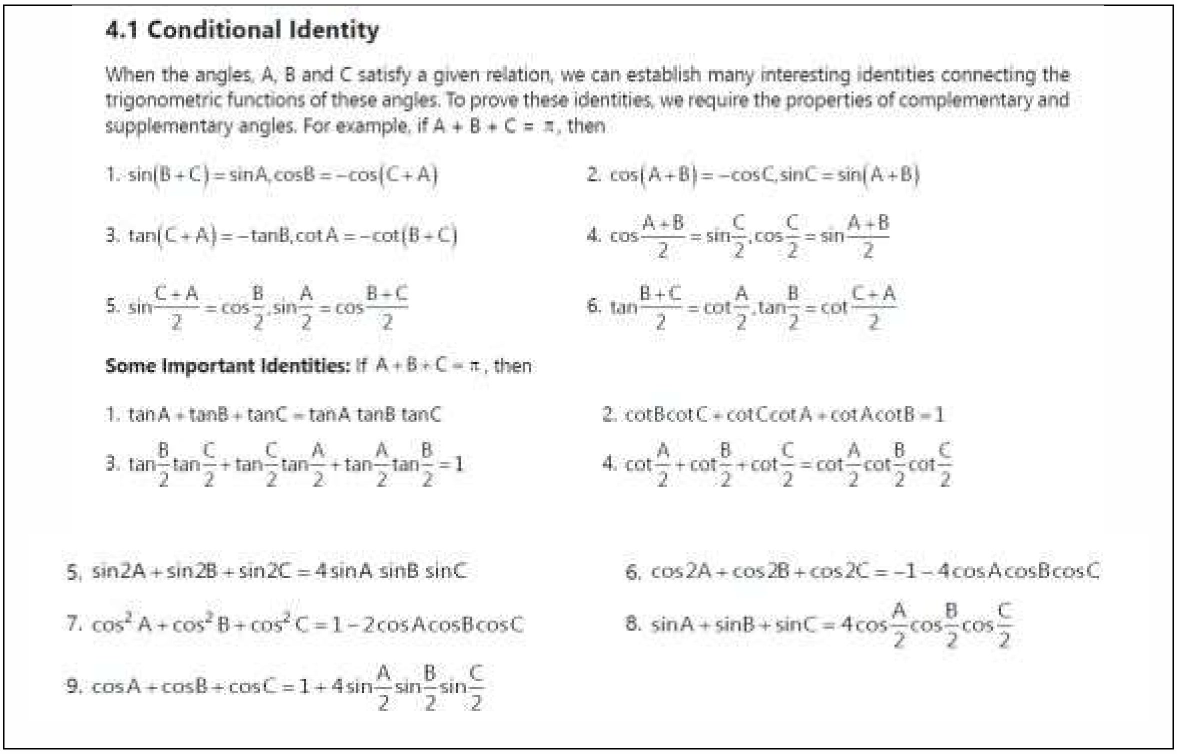
(d) $\cos\frac{B+C}{2} = \cos\left(\frac{\pi}{2} - \frac{A}{2}\right) = \sin\frac{A}{2}$

Sine rule: In, $\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C} = 2R$ Where R = Circumradius and a, b, c are sides of triangle.

Cosine rule: $\cos A = \frac{b^2+c^2-a^2}{2bc}$, $\cos B = \frac{a^2+c^2-b^2}{2ac}$, $\cos C = \frac{a^2+b^2-c^2}{2ab}$

Trigonometric ratios of half – angles:

(a) $\sin\frac{A}{2} = \sqrt{\frac{(s-b)(s-c)}{bc}}$ where 2s = a + b + c; **(b)** $\cos\frac{A}{2} = \sqrt{\frac{s(s-a)}{bc}}$; **(c)** $\tan\frac{A}{2} = \sqrt{\frac{(s-b)(s-c)}{s(s-a)}}$



4.1 Conditional Identity

When the angles, A, B and C satisfy a given relation, we can establish many interesting identities connecting the trigonometric functions of these angles. To prove these identities, we require the properties of complementary and supplementary angles. For example, if $A + B + C = \pi$, then

1. $\sin(B+C) = \sin A, \cos B = -\cos(C+A)$
2. $\cos(A+B) = -\cos C, \sin C = \sin(A+B)$
3. $\tan(C+A) = -\tan B, \cot A = -\cot(B+C)$
4. $\cos\frac{A+B}{2} = \sin\frac{C}{2}, \cos\frac{C}{2} = \sin\frac{A+B}{2}$
5. $\sin\frac{C+A}{2} = \cos\frac{B}{2}, \sin\frac{A}{2} = \cos\frac{B+C}{2}$
6. $\tan\frac{B+C}{2} = \cot\frac{A}{2}, \tan\frac{B}{2} = \cot\frac{C+A}{2}$

Some Important Identities: If $A + B + C = \pi$, then

1. $\tan A + \tan B + \tan C = \tan A \tan B \tan C$
2. $\cot B \cot C + \cot C \cot A + \cot A \cot B = 1$
3. $\tan\frac{B}{2}\tan\frac{C}{2} + \tan\frac{C}{2}\tan\frac{A}{2} + \tan\frac{A}{2}\tan\frac{B}{2} = 1$
4. $\cot\frac{A}{2} + \cot\frac{B}{2} + \cot\frac{C}{2} = \cot\frac{A}{2}\cot\frac{B}{2}\cot\frac{C}{2}$
5. $\sin 2A + \sin 2B + \sin 2C = 4\sin A \sin B \sin C$
6. $\cos 2A + \cos 2B + \cos 2C = -1 - 4\cos A \cos B \cos C$
7. $\cos^2 A + \cos^2 B + \cos^2 C = 1 - 2\cos A \cos B \cos C$
8. $\sin A + \sin B + \sin C = 4\cos\frac{A}{2}\cos\frac{B}{2}\cos\frac{C}{2}$
9. $\cos A + \cos B + \cos C = 1 + 4\sin\frac{A}{2}\sin\frac{B}{2}\sin\frac{C}{2}$

Inverse Trigonometric Functions

	$\sin^{-1}(sin\,\theta) = \theta$, for all $\theta \in [-\frac{\pi}{2}, \frac{\pi}{2}]$		$\cos^{-1}(\cos\theta) = \theta$, for all $\theta \in [0, \pi]$
	$\tan^{-1}(\tan\theta) = \theta$, for all $\theta \in (-\frac{\pi}{2}, \frac{\pi}{2})$		$cosec^{-1}(cosec\,\theta) = \theta$, for all $\theta \in [-\frac{\pi}{2}, \frac{\pi}{2}]$, $\theta \neq 0$
	$sec^{-1}(\sec\theta) = \theta$, for all $\theta \in [0, \pi]$, $\theta \neq \frac{\pi}{2}$		$cot^{-1}(\cot\theta) = \theta$, for all $\theta \in (0, \pi)$
	$sin(sin^{-1} x) = x$, for all $x \in [-1, 1]$		$\cos(\cos^{-1} x) = x$, for all $x \in [-1, 1]$
	$\tan(\tan^{-1} x) = x$, for all $x \in$ R		cosec $(cosec^{-1} x) = x$, for all $x \in (-\infty, -1] \cup [1, \infty)$
	sec$(sec^{-1} x) = x$, for all $x \in (-\infty, -1] \cup [1, \infty)$		$\cot(\cot^{-1} x) = x$, for all $x \in$ R
	$\sin^{-1}(-x) = -\sin^{-1} x$, for all $x \in [-1, 1]$		$\cos^{-1}(-x) = \pi - \cos^{-1} x$, for all $x \in [-1, 1]$
	$\tan^{-1}(-x) = -\tan^{-1} x$, for all $x \in$ R		$cosec^{-1}(-x) = -cosec^{-1} x$, for all $x \in (-\infty, -1] \cup [1, \infty)$
	$\sec^{-1}(-x) = \pi - \sec^{-1} x$, for all $x \in (-\infty, -1] \cup [1, \infty)$		
	$\cot^{-1}(-x) = \pi - \cot^{-1} x$, for all $x \in$ R		
	$\sin^{-1}\left(\frac{1}{x}\right) = cosec^{-1}x$, for all $x \in (-\infty, -1] \cup [1, \infty)$		
	$\cos^{-1}\left(\frac{1}{x}\right) = sec^{-1}x$, for all $x \in (-\infty, -1] \cup [1, \infty)$		
	$tan^{-1}\left(\frac{1}{x}\right) = \begin{cases} cot^{-1}x, & for\ x > 0 \\ -\pi + \cot^{-1} x, & for\ x < 0 \end{cases}$		
	$\sin^{-1} x + \cos^{-1} x = \frac{\pi}{2}$, for all $x \in [-1, 1]$		

In ΔABC, $\angle A + \angle B + \angle C = \pi$

(a) $\sin(B+C) = \sin(\pi - A) = \sin A$

(b) $\cos(C+A) = \cos(\pi - B) = -\cos B$

(c) $\sin\frac{A+B}{2} = \sin\left(\frac{\pi}{2} - \frac{C}{2}\right) = \cos\frac{C}{2}$

(d) $\cos\frac{B+C}{2} = \cos\left(\frac{\pi}{2} - \frac{A}{2}\right) = \sin\frac{A}{2}$

Sine rule: In, $\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C} = 2R$ Where R = Circumradius and a, b, c are sides of triangle.

Cosine rule: $\cos A = \frac{b^2+c^2-a^2}{2bc}$, $\cos B = \frac{a^2+c^2-b^2}{2ac}$, $\cos C = \frac{a^2+b^2-c^2}{2ab}$

Trigonometric ratios of half – angles:

(a) $\sin\frac{A}{2} = \sqrt{\frac{(s-b)(s-c)}{bc}}$ where $2s = a + b + c$; **(b)** $\cos\frac{A}{2} = \sqrt{\frac{s(s-a)}{bc}}$; **(c)** $\tan\frac{A}{2} = \sqrt{\frac{(s-b)(s-c)}{s(s-a)}}$

Area of a triangle : $\Delta = \frac{1}{2}bc\sin A = \frac{1}{2}ca\sin B = \frac{1}{2}ab\sin C$

Heron's formula : $\Delta = \sqrt{s(s-a)(s-b)(s-c)}$, where $s = \frac{a+b+c}{2}$.

Circumcircle Radius : $R = \frac{a}{2\sin A} = \frac{b}{2\sin B} = \frac{c}{2\sin C} = \frac{abc}{4\Delta}$

Incircle Radius : **(a)** $r = \frac{\Delta}{s}$; **(b)** $r = (s-a)\tan\left(\frac{A}{2}\right)$, $r = (s-b)\tan\left(\frac{B}{2}\right)$ and $r = (s-c)\tan\left(\frac{C}{2}\right)$

Radius of the Escribed Circle :

(a) $r_1 = \frac{\Delta}{s-a}$, $r_2 = \frac{\Delta}{s-b}$, $r_3 = \frac{\Delta}{s-c}$

(b) $r_1 = s\tan\frac{A}{2}$, $r_2 = s\tan\frac{B}{2}$, $r_3 = s\tan\frac{C}{2}$

(c) $r_1 = a\frac{\cos\frac{B}{2}\cos\frac{C}{2}}{\cos\frac{A}{2}}$, $r_2 = b\frac{\cos\frac{C}{2}\cos\frac{A}{2}}{\cos\frac{B}{2}}$, $r_3 = c\frac{\cos\frac{A}{2}\cos\frac{B}{2}}{\cos\frac{C}{2}}$

(d) $r_1 = 4R\sin\frac{A}{2}\cos\frac{B}{2}\cos\frac{C}{2}$, $r_2 = 4R\cos\frac{A}{2}\sin\frac{B}{2}\cos\frac{C}{2}$, $r_3 = 4R\cos\frac{A}{2}\cos\frac{B}{2}\sin\frac{C}{2}$

Length of Angle bisector and Median:

$m_a = \frac{1}{2}\sqrt{2b^2+2c^2-a^2}$ and $\beta_a = \frac{2bc\cos\frac{A}{2}}{b+c} \Rightarrow m_a$ - length of median, β_a - length of bisector.

The circle which can be inscribed within the triangle so as to touch all the three sides of the triangle is called the incircle of the triangle. The centre of the incircle is called the incentre of the triangle and it is the point of intersection of the internal bisectors of the angles of the triangle. The radius of the circle is called the inradius of the triangle and is usually denoted by rin-Radius: The radius r of the inscribed circle of a triangle ABC is given by

(a) $r = \frac{\Delta}{s}$ (ii) $r = (s-a)\tan\left(\frac{A}{2}\right)$, $r = (s-b)\tan\left(\frac{B}{2}\right)$ and $r = (s-c)\tan\left(\frac{C}{2}\right)$

(b) $r = \frac{a\sin\left(\frac{B}{2}\right)\sin\left(\frac{C}{2}\right)}{\cos\left(\frac{A}{2}\right)}$, $r = \frac{b\sin\left(\frac{A}{2}\right)\sin\left(\frac{C}{2}\right)}{\cos\left(\frac{B}{2}\right)}$ and $r = \frac{c\sin\left(\frac{B}{2}\right)\sin\left(\frac{A}{2}\right)}{\cos\left(\frac{C}{2}\right)}$

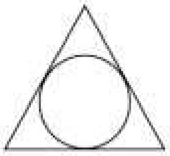


Figure 19.11

	$2\cos^{-1}x = \begin{cases} \cos^{-1}(2x^2-1), & if\ 0 \le x \le 1 \\ 2\pi - \cos^{-1}(2x^2-1), & if\ -1 \le x \le 0 \end{cases}$
	$3\cos^{-1}x = \begin{cases} \cos^{-1}(4x^3-3x), & if\ \frac{1}{2} \le x \le 1 \\ 2\pi - \cos^{-1}(4x^3-3x), & if\ -\frac{1}{2} \le x \le \frac{1}{2} \\ 2\pi + \cos^{-1}(4x^3-3x), & if\ -1 \le x \le -\frac{1}{2} \end{cases}$
	$2\tan^{-1}x = \begin{cases} \tan^{-1}\left(\frac{2x}{1-x^2}\right), & if\ -1 < x < 1 \\ \pi + \tan^{-1}\left(\frac{2x}{1-x^2}\right), & if\ x > 1 \\ -\pi + \tan^{-1}\left(\frac{2x}{1-x^2}\right), & if\ x < -1 \end{cases}$
	$3\tan^{-1}x = \begin{cases} \tan^{-1}\left(\frac{3x-x^3}{1-3x^2}\right), & if\ -\frac{1}{\sqrt{3}} < x < \frac{1}{\sqrt{3}} \\ \pi + \tan^{-1}\left(\frac{3x-x^3}{1-3x^2}\right), & if\ x > \frac{1}{\sqrt{3}} \\ -\pi + \tan^{-1}\left(\frac{3x-x^3}{1-3x^2}\right), & if\ x < -\frac{1}{\sqrt{3}} \end{cases}$
	$2\tan^{-1}x = \begin{cases} \sin^{-1}\left(\frac{2x}{1+x^2}\right), & if\ -1 \le x \le 1 \\ \pi - sin^{-1}\left(\frac{2x}{1+x^2}\right), & if\ x > 1 \\ -\pi - \sin^{-1}\left(\frac{2x}{1+x^2}\right), & if\ x < -1 \end{cases}$
	$2\tan^{-1}x = \begin{cases} \cos^{-1}\left(\frac{1-x^2}{1+x^2}\right), & if\ 0 \le x < \infty \\ -\cos^{-1}\left(\frac{1-x^2}{1+x^2}\right), & if\ -\infty < x \le 0 \end{cases}$
	$\sin^{-1}x = \cos^{-1}\left(\sqrt{1-x^2}\right) = \tan^{-1}\left(\frac{x}{\sqrt{1-x^2}}\right) = \cot^{-1}\left(\frac{\sqrt{1-x^2}}{x}\right) = \sec^{-1}\left(\frac{1}{\sqrt{1-x^2}}\right) = \text{cosec}^{-1}\left(\frac{1}{x}\right)$
	$\cos^{-1}x = \sin^{-1}\left(\sqrt{1-x^2}\right) = \tan^{-1}\left(\frac{\sqrt{1-x^2}}{x}\right) = \cot^{-1}\left(\frac{x}{\sqrt{1-x^2}}\right) = \sec^{-1}\left(\frac{1}{x}\right) = \text{cosec}^{-1}\left(\frac{1}{\sqrt{1-x^2}}\right)$
	$\tan^{-1}x = \sin^{-1}\left(\frac{x}{\sqrt{1+x^2}}\right) = \cos^{-1}\left(\frac{1}{\sqrt{1+x^2}}\right) = \cot^{-1}\left(\frac{1}{x}\right) = \sec^{-1}\left(\sqrt{1+x^2}\right) = \text{cosec}^{-1}\left(\frac{\sqrt{1+x^2}}{x}\right)$

	Calculus (Limits, derivatives and Integrals)		
	Limits		
1	$\lim_{x\to a} f(x)$ exists $\Leftrightarrow \lim_{x\to a^-} f(x) = \lim_{x\to a^+} f(x)$		
2	Let $\lim_{x\to a} f(x) = l$ and $\lim_{x\to a} g(x) = m$. If l and m both exist, then (i) $\lim_{x\to a} kf(x) = k \lim_{x\to a} f(x)$ (ii) $\lim_{x\to a}(f \pm g)(x) = \lim_{x\to a} f(x) \pm \lim_{x\to a} g(x) = l + m$ (iii) $\lim_{x\to a}(fg)(x) = \lim_{x\to a} f(x) \lim_{x\to a} g(x) = lm$ (iv) $\lim_{x\to a}\left(\frac{f}{g}\right)(x) = \frac{\lim_{x\to a} f(x)}{\lim_{x\to a} g(x)} = \frac{l}{m}$ (v) $\lim_{x\to a}\{f(a)\}^{g(x)} = l^m$		
3	$\lim_{x\to a}\frac{x^n - a^n}{x - a} = n\,a^{n-1}$	**4**	$\lim_{x\to 0}\frac{sinx}{x} = 1$
5	$\lim_{x\to 0}\frac{tanx}{x} = 1$	**6**	$\lim_{x\to a}\frac{\sin(x-a)}{x-a} = 1$
7	$\lim_{x\to a}\frac{\tan(x-a)}{x-a} = 1$	**8**	$\lim_{x\to 0}\frac{\log(1+x)}{x} = 1$

	$\tan^{-1}x+\cot^{-1}x=\frac{\pi}{2}$, for all $x\in$ R
	$\sec^{-1}x+\operatorname{cosec}^{-1}x=\frac{\pi}{2}$, for all $x\in(-\infty,-1]\cup[1,\infty)$
	$\tan^{-1}x+\tan^{-1}y=\begin{cases}\tan^{-1}\left(\frac{x+y}{1-xy}\right), & if\ xy<1\\ \pi+\tan^{-1}\left(\frac{x+y}{1-xy}\right), & if\ x>0,\quad y>0\ and\ xy>1\\ -\pi+\tan^{-1}\left(\frac{x+y}{1-xy}\right), & if\ x<0,\quad y<0\ and\ xy>1\end{cases}$
	$\tan^{-1}x-\tan^{-1}y=\begin{cases}\tan^{-1}\left(\frac{x-y}{1+xy}\right), & if\ xy>-1\\ \pi+\tan^{-1}\left(\frac{x-y}{1+xy}\right), & if\ x>0,\quad y<0\ and\ xy<-1\\ -\pi+\tan^{-1}\left(\frac{x-y}{1+xy}\right), & if\ x<0,\quad y>0\ and\ xy<-1\end{cases}$
	If $x_1,x_2,x_3,\dots\dots\dots,x_n\in$ R, then $\tan^{-1}x_1+\tan^{-1}x_2+\ \dots\dots+\tan^{-1}x_n=\left(\frac{S_1-S_3+S_5-S_7+\cdots\dots}{1-S_2+S_4-S_6+S_8+\cdots\dots}\right)$, where S_k denotes the sum of the products of $x_1,x_2,x_3,\dots\dots\dots,x_n$ taken k at a time.
	$\sin^{-1}x+\sin^{-1}y$ $=\begin{cases}\sin^{-1}\left(x\sqrt{1-y^2}+y\sqrt{1-x^2}\right), & if\ -1\le x,y\le 1\ and\ x^2+y^2\le 1\\ & or\\ & if\ xy<0\ and\ x^2+y^2>1\\ \pi-\sin^{-1}(x\sqrt{1-y^2}+y\sqrt{1-x^2}), & if\ 0<x,y\le 1 and\ x^2+y^2>1\\ -\pi-\sin^{-1}(x\sqrt{1-y^2}+y\sqrt{1-x^2}), & if\ -1\le x,y<0\ and\ x^2+y^2>1\end{cases}$
	$\sin^{-1}x-\sin^{-1}y$ $=\begin{cases}\sin^{-1}\left(x\sqrt{1-y^2}-y\sqrt{1-x^2}\right), & if\ -1\le x,y\le 1\ and\ x^2+y^2\le 1\\ & or\\ & if\ xy>0\ and\ x^2+y^2>1\\ \pi-\sin^{-1}(x\sqrt{1-y^2}-y\sqrt{1-x^2}), & if\ 0<x\le 1,-1\le y\le 0\ and\ x^2+y^2>1\\ -\pi-\sin^{-1}(x\sqrt{1-y^2}+y\sqrt{1-x^2}), & if\ -1\le x<0,0<y\le 1\ and\ x^2+y^2>1\end{cases}$
	$\cos^{-1}x+\cos^{-1}y$ $=\begin{cases}\cos^{-1}\left(xy-\sqrt{1-x^2}\sqrt{1-y^2}\right), & if\ -1\le x,y\le 1\ and\ x+y\ge 0\\ 2\pi-\cos^{-1}\left(xy-\sqrt{1-x^2}\sqrt{1-y^2}\right), & if\ -1\le x,y\le 1\ and\ x+y\le 0\end{cases}$
	$\cos^{-1}x-\cos^{-1}y$ $=\begin{cases}\cos^{-1}\left(xy+\sqrt{1-x^2}\sqrt{1-y^2}\right), & if\ -1\le x,y\le 1\ and\ x\le y\\ -\cos^{-1}\left(xy+\sqrt{1-x^2}\sqrt{1-y^2}\right), & if\ \ 0\le x\le 1,-1\le y\le 0\ and\ x\ge y\end{cases}$
	$2\sin^{-1}x=\begin{cases}\sin^{-1}\left(2x\sqrt{1-x^2}\right), & if\ -\frac{1}{\sqrt{2}}\le x\le\frac{1}{\sqrt{2}}\\ \pi-\sin^{-1}\left(2x\sqrt{1-x^2}\right), & if\ \frac{1}{\sqrt{2}}\le x\le 1\\ -\pi-\sin^{-1}\left(2x\sqrt{1-x^2}\right), & if\ -1\le x\le-\frac{1}{\sqrt{2}}\end{cases}$
	$3\sin^{-1}x=\begin{cases}\sin^{-1}(3x-4x^3), & if\ -\frac{1}{2}\le x\le\frac{1}{2}\\ \pi-\sin^{-1}(3x-4x^3), & if\ \frac{1}{2}<x\le 1\\ -\pi-\sin^{-1}(3x-4x^3), & if\ -1\le x<-\frac{1}{2}\end{cases}$

9	$\lim\limits_{x\to 0}\frac{a^x-1}{x}=\log_e a, \qquad a>0$	**10**	$\lim\limits_{x\to 0}\frac{e^x-1}{x}=1$
Differentiation (Derivatives, Tangents & Normals)			
1	$\frac{d}{dx}(x^n)=nx^{n-1}$	**2**	$\frac{d}{dx}(x)=1$
3	$\frac{d}{dx}(c)=0 \quad (c\ i\ a\ constant)$	**4**	$\frac{d}{dx}(\sqrt{x})=\frac{1}{2\sqrt{x}}$
5	$\frac{d}{dx}(\log_e x)=\frac{1}{x}$	**6**	$\frac{d}{dx}\left(\frac{1}{x}\right)=\frac{-1}{x^2}$
7	$\frac{d}{dx}(e^x)=e^x$	**8**	$\frac{d}{dx}(a^x)=a^x\log_e a, a>0\ a\neq 1$
9	$\frac{d}{dx}(x^x)=x^x(1+\log_e x)$	**10**	$\frac{d}{dx}(a^n)=0$
11	$\frac{d}{dx}(sin\ x)=\cos x$	**12**	$\frac{d}{dx}(cos\ x)=-\sin x$
13	$\frac{d}{dx}(tan\ x)=\sec^2 x$	**14**	$\frac{d}{dx}(cot\ x)=-cosec^2 x$
15	$\frac{d}{dx}(sec\ x)=\sec x\tan x$	**16**	$\frac{d}{dx}(cosec\ x)=-\operatorname{cosec} x\cot x$
17	$\frac{d}{dx}(\sin^{-1}x)=\left(\frac{1}{\sqrt{1-x^2}}\right)$, $\frac{d}{dx}(\tan^{-1}x)=\frac{1}{1+x^2}$, $\frac{d}{dx}(\sec^{-1}x)=\frac{1}{\lvert x\rvert\sqrt{x^2-1}}$ $\frac{d}{dx}(\cos^{-1}x)=\left(\frac{-1}{\sqrt{1-x^2}}\right)$, $\frac{d}{dx}(\cot^{-1}x)=\frac{-1}{1+x^2}$, $\frac{d}{dx}(\sec^{-1}x)=\frac{-1}{\lvert x\rvert\sqrt{x^2-1}}$		
18	$\frac{d}{dx}\{C\pm f(x)\}=0\pm\frac{d}{dx}f(x)$		
19	$\frac{d}{dx}\{C.f(x)\}=C.\frac{d}{dx}f(x)$		
20	$\frac{d}{dx}\left\{\frac{f(x)}{C}\right\}=\frac{\frac{d}{dx}f(x)}{C}$		
21	$\frac{d}{dx}\{f(x)\pm g(x)\}=\frac{d}{dx}f(x)\pm\frac{d}{dx}g(x)$		
22	$\frac{d}{dx}\{f(x)\times g(x)\}=f(x)\frac{d}{dx}g(x)+g(x)\frac{d}{dx}f(x)$		
23	$\frac{d}{dx}\left\{\frac{f(x)}{g(x)}\right\}=\frac{g(x)\frac{d}{dx}f(x)-f(x)\frac{d}{dx}g(x)}{\{g(x)\}^2}$		
24	$\frac{d}{dx}\{f(x)g(x)h(x)\}=f'(x)g(x)h(x)+f(x)g'(x)h(x)+f(x)g(x)h'(x)=$ $\frac{d}{dx}f(x)\,Xg(x)h(x)+\frac{d}{dx}g(x)\,Xh(x)f(x)+\frac{d}{dx}h(x)\,Xf(x)g(x)$		
25	$\frac{d}{dx}(f_1\,f_2\,f_3\,f_4)=f_1'\,f_2\,f_3\,f_4+f_1\,f_2'\,f_3\,f_4+f_1\,f_2\,f_3'\,f_4+f_1\,f_2\,f_3\,f_4'$		

26.	A real valued function $f(x)$ defined on (a, b) is said to be differentiable at $x = c \in (a, b)$, iff $\lim\limits_{x \to c} \frac{f(x)-f(c)}{x-c}$ $exists\ finitely$ $\Leftrightarrow \lim\limits_{x \to c^-} \frac{f(x)-f(c)}{x-c} = \lim\limits_{x \to c^+} \frac{f(x)-f(c)}{x-c}$ $\Leftrightarrow \lim\limits_{h \to 0} \frac{f(c-h)-f(c)}{-h} = \lim\limits_{h \to 0} \frac{f(c+h)-f(c)}{h}$ $\Leftrightarrow (LHD\ at\ x = c) = (RHD\ at\ x = c)$		
27.	If $P(x_1, y_1)$ is a point on the curve $y = f(x)$, then $y - y_1 = \left(\frac{dy}{dx}\right)_P (x - x_1)$ is the equation of tangent at P. $y - y_1 = -\frac{1}{\left(\frac{dy}{dx}\right)_P}(x - x_1)$is the equation of the normal at P.		
28.	The angle between the tangents to two given curves at their point of intersection is defined as the angle of intersection of two curves. If C_1 and C_2 are two curves having equations $y = f(x)$ and $y = g(x)$ respectively such that they intersect at point P. The angle θ of intersection of these two curves is given by $\tan\theta = \frac{\left(\frac{dy}{dx}\right)_{C_1} - \left(\frac{dy}{dx}\right)_{C_2}}{1 + \left(\frac{dy}{dx}\right)_{C_1}\left(\frac{dy}{dx}\right)_{C_2}}$ If the angle of intersection of two curves is a right angle, then the curves are said to intersect orthogonally. The condition for orthogonally of two curves C_1 and C_2 is $\left(\frac{dy}{dx}\right)_{C_1} \times \left(\frac{dy}{dx}\right)_{C_2} = -1$		
29.	Two curves $ax^2 + by^2 = 1$ and $a'x^2 + b'y^2 = 1$ will intersect orthogonally, if $\frac{1}{a} - \frac{1}{b} = \frac{1}{a'} - \frac{1}{b'}$		
	Integrals (Indefinite & Definite)		
1	$\int x^n\,dx = \frac{x^{n+1}}{n+1} + C, \quad n \neq -1$	**2**	$\int 0\,dx = C$
3	$\int 1\,dx = x + C$	**4**	$\int \frac{1}{x}\,dx = log_e x + C$
5	$\int -\frac{1}{x^2}\,dx = \frac{1}{x} + C$	**6**	$\int e^x\,dx = e^x + C$
7	$\int e^{mx}\,dx = \frac{e^{mx}}{m} + C$	**8**	$\int a^x\,dx = \frac{a^x}{log_e a} + C, \quad a \neq -1, a > 0$
9	$\int \sin x\,dx = -\cos x + C$	**10**	$\int \cos x\,dx = \sin x + C$
11	$\int \sec^2 x\,dx = \tan x + C$	**12**	$\int \text{cosec}^2 x\,dx = -\cot x + C$
13	$\int \sec x \tan x\,dx = \sec x + C$	**14**	$\int \text{cosec}\,x \cot x\,dx = -\text{cosec}\,x + C$
15	$\int tan\,x\,dx = log\|sec\,x\| + C$	**16**	$\int cot\,x\,dx = log\|sin\,x\| + C$
17	$\int sec\,x\,dx = log\|sec\,x + tan\,x\| + C = log\left\|tan\left(\frac{\pi}{4} + \frac{x}{2}\right)\right\| + C$		

40	$\int_0^{\pi/2} \log sinx\, dx$ = - π/2 $\log_e 2$
41	Area bounded between two curves y=f(x) & y=g(x) is A=$\int_a^b (y_2 - y_{1)}$ dx or A= $\int_a^b f(x)$-g(x) dx , where a & b are abscissas of intersecting points.
42	In a differential equation is expressible in the form$\frac{dy}{dx} + Py = Q$, where P and Q are either constants or functions of x, then it is called a linear differential equation. Here Integration Factor IF= $e^{\int P\,dx}$& the solution of this equation is given by $y.IF = \int Q.IF\,dx + C$ or $y\left(e^{\int P\,dx}\right) = \int\left(Q\,e^{\int P\,dx}\right)dx + C$ Sometimes a linear differential equation is in the form$\frac{dx}{dy} + Rx = S$, where R and S are either constants or functions of y. Here IF= $e^{\int R\,dy}$& The solution of this equation is given by $x.IF = \int S.IF\,dy + C$ or $x\left(e^{\int R\,dy}\right) = \int\left(S\,e^{\int R\,dy}\right)dy + C$

Matrices
Let $A = [a_{ij}]$ be an $m \times n$ matrix. Then, the transpose of A, denoted by A^T, is an $n \times m$ Matrix such that $(A^T)_{ij} = a_{ji}$for all i = 1, 2, m; j= 1, 2, …., n. Following are the properties of transpose of a matrix: **(i)**$(A^T)^T = A$**(ii)**$(A+B)^T = A^T + B^T$**(iii)**$(kA)^T = kA^T$**(iv)**$(AB)^T = B^T A^T$**(v)**$(ABC)^T = C^T B^T A^T$
If A is a non-singular matrix, then $A^{-1} = \frac{1}{\lvert A\rvert}(adj\ A)$
If A and $B$are two invertible matrices of the same order, then $(AB)^{-1} = B^{-1}A^{-1}$
A system $AX = B$ of n linear equations in n equations has a unique solution given by $X = A^{-1}B$, if $\lvert A\rvert \neq 0$. If $\lvert A\rvert = 0$ and $(adj\ A)B = 0$, then the system is consistent and hasinfinitely many solutions. If $\lvert A\rvert = 0$ and$(adj\ A)B \neq 0$, then the system is inconsistent.
A homogeneous system of n linear equations in n unknowns is expressible in the form AX =O. If $\lvert A\rvert \neq 0$, then AX =O has unique solution X = 0, i.e. $x_1 = x_2 = \cdots = x_n = 0$. This solution is called the Trivial solution. If $\lvert A\rvert = 0$, then AX =O has infinitely many solutions.
$\lvert kA\rvert = k^n \lvert A\rvert$ $\lvert adj\ A\rvert = \lvert A\rvert^{n-1}$ $adj(adjA) = \lvert A\rvert^{n-2}A$ $[adjA]^{-1} = adj(A^{-1})$ $[A^T]^{-1} = (A^{-1})^T$
$(A^{-1})^{-1} = A$ $A\,(adj\,A) = (adj\,A)\,A = I\lvert A\rvert$

18	$\int cosec\,x\;dx = log\lvert cosec\,x - cot\,x\rvert + C = log\left\lvert tan\frac{x}{2}\right\rvert + C$		
19	$\int \frac{1}{\sqrt{1-x^2}}dx = \sin^{-1}x + C,\ \int \frac{1}{1+x^2}\,dx = \tan^{-1}x + C,\ \int \frac{1}{\lvert x\rvert\sqrt{x^2-1}} = \sec^{-1}x + \mathrm{C}$		
20	$\int \frac{1}{ax+b}\;dx = \frac{1}{a}log_e\lvert ax+b\rvert + C$		
21	$\int \frac{1}{x^2+a^2}\;dx = \frac{1}{a}\tan^{-1}\frac{x}{a} + C$		
22	$\int \frac{1}{x^2-a^2}\;dx = \frac{1}{2a}log\left\lvert\frac{x-a}{x+a}\right\rvert + C$		
23	$\int \frac{1}{a^2-x^2}\;dx = \frac{1}{2a}log\left\lvert\frac{a+x}{a-x}\right\rvert + C$		
24	$\int \frac{1}{\sqrt{x^2+a^2}}\;dx = log\left\lvert x + \sqrt{x^2+a^2}\right\rvert + C$		
25	$\int \frac{1}{\sqrt{x^2-a^2}}\;dx = log\left\lvert x + \sqrt{x^2-a^2}\right\rvert + C$		
26	$\int \frac{1}{\sqrt{a^2-x^2}}\;dx = \sin^{-1}\frac{\mathrm{x}}{a} + C$		
27	$\int \sqrt{x^2+a^2}\;dx = \frac{x}{2}\sqrt{x^2+a^2} + \frac{1}{2}a^2\,log\left\lvert x + \sqrt{x^2+a^2}\right\rvert + C$		
28	$\int \sqrt{x^2-a^2}\;dx = \frac{x}{2}\sqrt{x^2-a^2} - \frac{1}{2}a^2\,log\left\lvert x + \sqrt{x^2-a^2}\right\rvert + C$		
29	$\int \sqrt{a^2-x^2}\;dx = \frac{x}{2}\sqrt{a^2-x^2} + \frac{1}{2}a^2\sin^{-1}\frac{\mathrm{x}}{a} + C$		
30	If u and v are two functions of x, then $\int uv\;dx = u\left(\int v\,dx\right) - \int\left\{\frac{du}{dx}\int v\,dx\right\}dx$		
31	$\int e^x\{f(x) + f'(x)\}\,dx = e^x f(x) + C$		
32	$\int e^{ax}\sin bx\;dx = \frac{e^{ax}}{a^2+b^2}\{a\sin bx - b\cos bx\} + C$		
33	$\int e^{ax}\cos bx\;dx = \frac{e^{ax}}{a^2+b^2}\{a\cos bx + b\sin bx\} + C$		
34	$\int_a^b f(x)dx = -\int_b^a f(x)dx$, i.e. if the limits of a definite integral are interchanged, then its value changes by minus sign only.		
35	$\int_a^c f(x)dx = \int_a^b f(x)dx + \int_b^c f(x)dx$, where $a < b < c$. The above property can be generalized into the following form $\int_a^b f(x)dx = \int_a^{c_1} f(x)dx + \int_{c_1}^{c_2} f(x)dx + \ldots\ldots.. + \int_{c_n}^{b} f(x)dx$ Where $a < c_1 < c_2 < c_3 \ldots\ldots < c_{n-1} < c_n < b$.		
36	$\int_a^b f(x)dx = \int_a^b f(t)dt$, i.e. integration is independent of the change of variable. $\int_a^b f(x)dx = \int_a^b f(y)dy = \int_a^b f(z)dz = \int_a^b f(t)dt$		
37	$\int_a^b f(x)dx = \int_a^b f(a+b-x)dx$		
38	$\int_{-a}^{a} f(x)dx = \begin{cases} 2\int_0^a f(x)dx\,, & if\ f(x)\ is\ an\ even\ function\quad i.e.\ f(-x) = f(x) \\ 0\,, & if\ f(x)\ is\ an\ odd\ function\quad i.e.\ f(-x) = -f(x) \end{cases}$		

Vectors and 3-D Geometry

If $\vec{a}$ and $\vec{b}$ are two non-zero vectors inclined at an angle θ, then

Scalar Product or Dot Product of two vectors – Let $\vec{a}$ and $\vec{b}$ be two vectors and let θ be the angle between them. Then, the scalar product or dot product of $\vec{a}$ and $\vec{b}$, denoted by $\vec{a}.\vec{b}$, is defined as

$\vec{a}.\vec{b} = |\vec{a}||\vec{b}|\cos\theta = ab\ \cos\theta$.

Therefore $\cos\theta = \frac{\vec{a}.\vec{b}}{|\vec{a}||\vec{b}|} \Longrightarrow \theta = \cos^{-1}\left(\frac{\vec{a}.\vec{b}}{|\vec{a}||\vec{b}|}\right)$

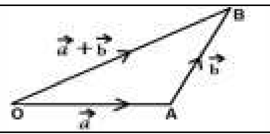
Projection of $\vec{a}$ on $\vec{b} = \frac{\vec{a}.\vec{b}}{\lvert\vec{b}\rvert} = \vec{a}.\ \hat{b}$		Projection of $\vec{b}$ on $\vec{a} = \frac{\vec{a}.\vec{b}}{\lvert\vec{a}\rvert} = \vec{b}.\ \hat{a}$
$\vec{a}.\vec{b} = 0 \Leftrightarrow \vec{a}$ is perpendicular to $\vec{b}$		$\vec{a}.\vec{b} = \vec{b}.\vec{a}$
$\vec{a}.\vec{a} = \lvert\vec{a}\rvert^2$		$m\vec{a}.\vec{b} = m(\vec{a}.\vec{b}) = \vec{a}.m\vec{b}$, for any scalar m
$m\vec{a}.n\vec{b} = mn(\vec{a}.\vec{b}) = \vec{a}.mn\vec{b}$, for scalars $m\ ,n$		$\lvert\vec{a}+\vec{b}\rvert \leq \lvert\vec{a}\rvert + \lvert\vec{b}\rvert$
$\lvert\vec{a}-\vec{b}\rvert \geq \lvert\vec{a}\rvert - \lvert\vec{b}\rvert$		$\lvert\vec{a}\pm\vec{b}\rvert^2 = \lvert\vec{a}\rvert^2 + \lvert\vec{b}\rvert^2 \pm 2(\vec{a}.\vec{b})$
$(\vec{a}+\vec{b})(\vec{a}-\vec{b}) = \lvert\vec{a}\rvert^2 - \lvert\vec{b}\rvert^2$		$\vec{a}.\vec{b} > 0$, iff θ is acute.
$\vec{a}.\vec{b} < 0$, iff θ is obtuse.		

If $\vec{a}$, $\vec{b}$ and $\vec{c}$ are three vectors, then

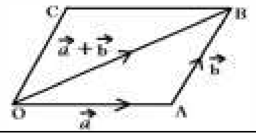
$|\vec{a}+\vec{b}+\vec{c}|^2 = |\vec{a}|^2 + |\vec{b}|^2 + |\vec{c}|^2 + 2(\vec{a}.\vec{b} + \vec{b}.\vec{c} + \vec{c}.\vec{a})$

If $\vec{a} = a_1\hat{i} + a_2\hat{j} + a_3\hat{k}$ and $\vec{b} = b_1\hat{i} + b_2\hat{j} + b_3\hat{k}$, then $\vec{a}.\vec{b} = a_1b_1 + a_2b_2 + a_3b_3$.

Triangle law of Addition for Vectors – In a ΔOAB, if $\overline{OA}$ and $\overline{AB}$ represent $\vec{a}$ and $\vec{b}$ respectively, then $\overline{OB}$ represents$(\vec{a}+\vec{b})$.



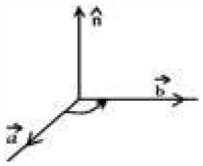
Parallelogram Law of addition for vectors – In a parallelogram OABC, if $\overline{OA}$ and $\overline{AB}$ represent $\vec{a}$ and $\vec{b}$ respectively, then $\overline{OB}$ represents$(\vec{a}+\vec{b})$.



Vector Product of two vectors – Let $\vec{a}$ and $\vec{b}$ be two nonzero, nonparallel vectors and let θ be the angle between them such that $0 < \theta < \pi$. Then, the vector product of $\vec{a}$ and $\vec{b}$ is defined as

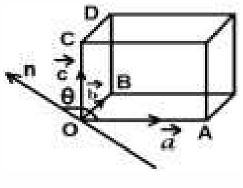
$\vec{a} \times \vec{b} = (|\vec{a}||\vec{b}|\sin\theta)\,\hat{n} \Rightarrow \theta = \sin^{-1}\left\{\frac{|\vec{a}\times\vec{b}|}{|\vec{a}||\vec{b}|}\right\}$,

Where $\hat{n}$ is a unit vector perpendicular to both $\vec{a}$and $\vec{b}$, such that $\vec{a}$,$\vec{b}$, $\hat{n}$ form a right-handed system.



Volume of Parallelopiped – If $\vec{a}$, $\vec{b}$, $\vec{c}$ be three vectors then the scalar product of $\vec{a}$ with the vector product of $\vec{b}$ and $\vec{c}$ is called the scalar triple product of the vectors $\vec{a}$, $\vec{b}$, $\vec{c}$. It is written as

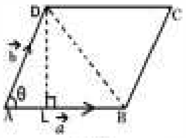
$$V = \vec{a}.(\vec{b}\times\vec{c}) = [\vec{a}\vec{b}\vec{c}] = [\vec{b}\vec{c}\vec{a}] = [\vec{c}\vec{a}\vec{b}] = \begin{vmatrix} a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \\ c_1 & c_2 & c_3 \end{vmatrix}$$



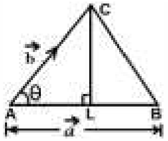
Vector Triple Product – If $\vec{a}$, $\vec{b}$, $\vec{c}$ be three vectors then the vector product of $\vec{a}$ with $(\vec{b}\times\vec{c})$, is called the vector triple product and is written as

$$\vec{a} \times (\vec{b} \times \vec{c}) = (\vec{a}.\vec{c})\vec{b} - (\vec{a}.\vec{b})\vec{c} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ a_1 & a_2 & a_3 \\ b_2c_3 - b_3c_2 & b_3c_1 - b_1 \quad {}_3 & b_1c_2 - b_2c_1 \end{vmatrix}$$

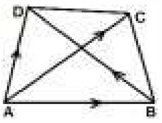
(a) $ar\,(\parallel gm\ ABCD) = |\vec{a} \times \vec{b}|$, where $\overrightarrow{AB} = \vec{a}$ and $\overrightarrow{AD} = \vec{b}$.



(b) $ar\,(\Delta\, ABC) = \frac{1}{2}|\vec{a} \times \vec{b}|$, where $\overrightarrow{AB} = \vec{a}$ and $\overrightarrow{AC} = \vec{b}$.



(c) $ar(quad.ABCD) = \frac{1}{2}|\overrightarrow{AC} \times \overrightarrow{BD}|$, where AC and BD are its diagonals.



Co-linearity – The points A, B, C with position vectors $\vec{a}$, $\vec{b}$, $\vec{c}$ are collinear if and only if

$$(\vec{b} \times \vec{c}) + (\vec{c} \times \vec{a}) + (\vec{a} \times \vec{b}) = \vec{0}$$

Area of Triangle – If $\vec{a}$, $\vec{b}$, $\vec{c}$ are the position vectors of the points A, B, C, then

The area of triangle = $\Delta = \frac{1}{2}\left[(\vec{b} \times \vec{c}) + (\vec{c} \times \vec{a}) + (\vec{a} \times \vec{b})\right]$

Equation of a line passing through two given points –

Vector Form – The vector equation of a line L, passing through two given points A and B with position vectors $\vec{r_1}$ and $\vec{r_2}$, is given by

$$\vec{r} = \vec{r_1} + \lambda\,(\vec{r_2} - \vec{r_1})$$

Cartesian Form – The equations of a line passing through two given points A (x_1, y_1, z_1) and B (x_2, y_2, z_2) is given by

$$\frac{x-x_1}{a} = \frac{y-y_1}{b} = \frac{z-z_1}{c} \quad \text{OR} \quad \frac{x-x_1}{x_2-x_1} = \frac{y-y_1}{y_2-y_1} = \frac{z-z_1}{z_2-z_1}$$

Where a,b,c are the direction ratios of the line

(i) The vector equation of a line through a point with position vector $\vec{r_1}$ and parallel to $\vec{m}$ is

$$\vec{r} = \vec{r_1} + \lambda\,\vec{m}$$

(ii) The vector equation of a line through a point with position vectors $\vec{r_1}$ and $\vec{r_2}$ is

$$\vec{r} = \vec{r_1} + \lambda\,(\vec{r_2} - \vec{r_1})$$

Cartesian Form – Three given points A (x_1, y_1, z_1), B $(x_2, y_2, 2)$ and C (x_3, y_3, z_3) will be collinear if

$$\frac{x_3 - x_1}{x_2 - x_1} = \frac{y_3 - y_1}{y_2 - y_1} = \frac{z_3 - z_1}{z_2 - z_1}$$

Vector Form – Three given points A, B, C with position vectors $\vec{a}$, $\vec{b}$, $\vec{c}$ respectively are collinear if $\vec{c} = (1-\lambda)\vec{a} + \lambda\,\vec{b}$

The vector equation of a plane passing through a point having position vector $\vec{a}$ and parallel to vectors $\vec{b}$ and $\vec{c}$ is
$\vec{r} = \vec{a} + m\vec{b} + n\vec{c}$, where m and n are parameters.

$$\text{or} \qquad \vec{r}\,.(\vec{b} \times \vec{c}) = \vec{a}\,.(\vec{b} \times \vec{c})$$

If a plane makes intercepts of lengths a, b, c with the x-axis, y-axis and z-axis respectively, the equation of the plane is $\frac{x}{a} + \frac{y}{b} + \frac{z}{c} = 1$

Vector Form – The equation of a plane through the intersection of two planes $\vec{r}.\vec{n_1} = d_1$ and $\vec{r}.\vec{n_2} = d_2$ is given by
$\vec{r}.(\vec{n_1} + \lambda\,\vec{n_2}) = d_1 + \lambda\, d_2$
Cartesian Form – The equation of a plane through the intersection of two planes $a_1x + b_1y + c_1z + d_1 = 0$ and $a_2x + b_2y + c_2z + d_2 = 0$ is given by $(a_1x + b_1y + c_1z + d_1) + \lambda\,(a_2x + b_2y + c_2z + d_2) = 0$

The Cartesian equation of a plane passing through points (x_1, y_1, z_1), (x_2, y_2, z_2) and (x_3, y_3, z_3) is

$$\begin{vmatrix} x - x_1 & y - y_1 & z - z_1 \\ x_2 - x_1 & y_2 - y_1 & z_2 - z_1 \\ x_3 - x_1 & y_3 - y_1 & z_3 - z_1 \end{vmatrix} = 0$$

The equation of a plane parallel to the plane
(a) $\vec{r}\,.\vec{n} = d$ is $\vec{r}\,.\vec{n} = d_1$
(b) $ax + by + cz + d = 0$ is $ax + by + cz + \lambda = 0$

The length of perpendicular from the point (x_1, y_1, z_1) to the plane $ax + by + cz + d = 0$ is

$$\frac{|ax_1 + by_1 + cz_1 + d|}{\sqrt{a^2 + b^2 + c^2}}$$

The distance between the parallel planes $ax + by + cz + d_1 = 0$ and $ax + by + cz + d_2 = 0$ is given by

$$\frac{|d_2 - d_1|}{\sqrt{a^2 + b^2 + c^2}}$$

The equation of the family of planes containing the lines
$a_1x + b_1y + c_1z + d_1 = 0$ and $a_2x + b_2y + c_2z + d_2 = 0$ is

$$a_1x + b_1y + c_1z + d_1 + \lambda(a_2x + b_2y + c_2z + d_2) = 0,$$

where λ is a parameter.

The equations of the planes bisecting the angles between the planes $a_1x + b_1y + c_1z + d_1 = 0$ and $a_2x + b_2y + c_2z + d_2 = 0$ are given by

$$\frac{a_1x + b_1y + c_1z + d_1}{\sqrt{a^2 + b^2 + c^2}} = \pm\frac{a_2x + b_2y + c_2z + d_2}{\sqrt{a^2 + b^2 + c^2}}$$

The angle θ between a line $\frac{x - x_1}{l} = \frac{y - y_1}{m} = \frac{z - z_1}{n}$ and a plane
$ax + by + cz + d = 0$ is the complement of the angle between the line and normal to the plane and is given by
$\sin\theta = \frac{al + bm + cn}{\sqrt{a^2 + b^2 + c^2}\sqrt{l^2 + m^2 + n^2}}$ The angle θ between the line $\vec{r} = \vec{a} + \lambda\vec{b}$ and the plane $\vec{r}.\vec{n} = d$ is given by $\sin\theta = \frac{\vec{b}.\vec{n}}{|\vec{b}||\vec{n}|}$

Two lines $\frac{x - x_1}{l_1} = \frac{y - y_1}{m_1} = \frac{z - z_1}{n_1}$ and $\frac{x - x_2}{l_2} = \frac{y - y_2}{m_2} = \frac{z - z_2}{n_2}$ are coplanar, if

$$\begin{vmatrix} x_2 - x_1 & y_2 - y_1 & z_2 - z_1 \\ l_1 & m_1 & n_1 \\ l_2 & m_2 & n_2 \end{vmatrix} = 0$$

and the equation of the plane containing them is

$$\begin{vmatrix} x - x_1 & y - y_1 & z - z_1 \\ l_1 & m_1 & n_1 \\ l_2 & m_2 & n_2 \end{vmatrix} = 0 \quad \text{or} \quad \begin{vmatrix} x - x_2 & y - y_2 & z - z_2 \\ l_1 & m_1 & n_1 \\ l_2 & m_2 & n_2 \end{vmatrix} = 0$$

Vector Form – Let the vector equations of two given lines be $\vec{r} = \overrightarrow{r_1} + \lambda \overrightarrow{n_1}$ and $\vec{r} = \overrightarrow{r_2} + \overrightarrow{n_2}$, where λ and μ are scalars. Let θ be the angle between these lines. Since the given lines are parallel to $\overrightarrow{n_1}$ and $\overrightarrow{n_2}$ respectively, the angle between the given lines must be equal to the angle between $\overrightarrow{n_1}$ and $\overrightarrow{n_2}$.

$$\cos\theta = \frac{\overrightarrow{n_1}.\ \overrightarrow{n_2}}{|\overrightarrow{n_1}||\overrightarrow{n_2}|}$$

These planes are parallel, if $\overrightarrow{n_1}$ is parallel to $\overrightarrow{n_2}$.

These planes are perpendicular, if $\overrightarrow{n_1}\ .\ \overrightarrow{n_2} = 0$.

Cartesian Form – Let the Cartesian equations of two given lines be

$$\frac{x-x_1}{a_1} = \frac{y-y_1}{b_1} = \frac{-z_1}{c_1} \text{and} \frac{x-x_2}{a_2} = \frac{y-y_2}{b_2} = \frac{z-z_2}{c_2}.$$

Then, the direction ratios of these lines are a_1, b_1, c_1 and a_2, b_2, c_2 respectively. Let θ be angle between these lines. Then

$$\cos\theta = \frac{a_1a_2 + b_1b_2 + c_1c_2}{\left(\sqrt{{a_1}^2 + {b_1}^2 + {c_1}^2}\right)\left(\sqrt{{a_2}^2 + {b_2}^2 + {c_2}^2}\right)}$$

These planes are parallel, if $\frac{a_1}{a_2} = \frac{b_1}{b_2} = \frac{c_1}{c_2}$

These planes are perpendicular, if $a_1a_2 + b_1b_2 + c_1c_2 = 0$

Vector Form – (i) The shortest distance between two skew lines $\vec{r} = \overrightarrow{a_1} + \lambda \overrightarrow{b_1}$ and $\vec{r} = \overrightarrow{a_2} + \mu \overrightarrow{b_2}$ is given by $d = \left|\frac{(\overrightarrow{b_1} \times \overrightarrow{b_2}).(\overrightarrow{a_2} - \overrightarrow{a_1})}{|\overrightarrow{b_1} \times \overrightarrow{b_2}|}\right|$

(ii) Let $L_1(\vec{r} = \overrightarrow{a_1} + \lambda \overrightarrow{b_1})$ and $L_2(\vec{r} = \overrightarrow{a_2} + \mu \overrightarrow{b_2})$ be two parallel lines. Then these lines are coplanar if

$$\overrightarrow{a_1}.(\overrightarrow{b_1} \times \overrightarrow{b_2}) = \overrightarrow{a_2}.(\overrightarrow{b_1} \times \overrightarrow{b_2})$$

Distance between Parallel Lines = $|\overrightarrow{BM}| = \left|\frac{\vec{b} \times (\overrightarrow{a_2} - \overrightarrow{a_1})}{|\vec{b}|}\right|$

Condition for two given lines to intersect – Suppose that the lines $\vec{r} = \overrightarrow{a_1} + \lambda \overrightarrow{b_1}$ and $\vec{r} = \overrightarrow{a_2} + \mu \overrightarrow{b_2}$ intersect. Then the shortest distance between them is zero, i.e.

$$[(\overrightarrow{a_2} - \overrightarrow{a_1})\overrightarrow{b_1}\overrightarrow{b_2}] = 0.$$

Cartesian Form - The shortest distance between two skew lines $\frac{x-x_1}{a_1} = \frac{y-y_1}{b_1} = \frac{z-z_1}{c_1}$ and $\frac{x-x_2}{a_2} = \frac{y-y_2}{b_2} = \frac{z-z_2}{c_2}$ is given by

$$d = \frac{\begin{vmatrix} x_2-x_1 & y_2-y_1 & z_2-z_1 \\ a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \end{vmatrix}}{\sqrt{D}}$$

where D = $\{(a_1b_2 - a_2b_1)^2 + (b_1c_2 - b_2c_1)^2 + (c_1a_2 - c_2a_1)^2\}$

Vector Form – If $\hat{n}$ is a unit vector normal to a given plane, directed from the origin to the plane and p is the length of the perpendicular drawn from the origin to the plane then the vector equation of the plane is $\vec{r}\ .\ \hat{n} = p$.

A vector normal to the plane $ax + by + cz + d = 0$ is $\vec{n} = a\hat{i} + b\hat{j} + c\hat{k}$.

Cartesian Form – If a, b, c are the direction ratios of the normal to a plane, then the equation of the plane is $ax + by + cz + d = 0$

Vector Form – The vector equation of a plane passing through a point having position vector $\vec{a}$ and normal to $\vec{n}$ is

$(\vec{r} - \vec{a}).\vec{n} = 0$ or $\vec{r}.\vec{n} = \vec{a}.\vec{n}$

Cartesian Form – The equation of a plane passing through a point P(x_1, y_1, z_1) is $a(x - x_1) + b(y - y_1) + c(z - z_1) = 0$, where a, b, c are constants.

Probability & Conditional Probability (XI-XII)

Probability

Probability of an event: - If there are n elementary events associated with a random experiment and m of them are favourable to an event A, then the probability of occurrence of A is defined as:

$$P\ (A) = \frac{m}{n} = \frac{Favourable\ number\ of\ elementary\ events}{Total\ number\ of\ elementary\ events}$$

The odds in favour of occurrence of the event A are defined by: $m : (n - m)$

The odds against the occurrence of A are defined by : $(n - m) : m.$

The probability of non-occurrence of A is given by $P\ (\bar{A}\,) = 1 - P\ (A)$

If A and B are two events associated with a random experiment, then

$$P\ (A\ \cup B) = P\ (A) +\ P\ (B) -\ P\ (A \cap B).$$

If A and B are mutually exclusive events, then

$$P\ (A \cup B) =\ P\ (A) +\ P(B).$$

If A, B, C are three events associated with a random experiment, then

$$P\ (A \cup B \cup C) =\ P\ (A) + P\ (B) +\ P\ (C) -\ P\ (A \cap B) -\ P\ (B \cap C) -\ P\ (C \cap A) + P\ (A \cap B \cap C)$$

If A and B are two events associated with a random experiment, then

(i) $P\ \left(\bar{A} \cap B\right) = P\ (B) -\ P\ (A \cap B)$, i.e. probability of occurrence of B only

(ii) $P\ \left(A \cap \bar{B}\right) = P\ (A) -\ P\ (A \cap B)$, i.e. probability of occurrence of A only

(iii) Probability of occurrence of exactly one of A and B $= P\ (A) + P\ (B) - 2\ P\ (A \cap B) = P(A \cup B) -\ P(A \cap B)$

Theoretical Probability = $\frac{Number\ of\ favourable\ outcomes}{Total\ number\ of\ outcomes}$

Experimental Probability = $\frac{Number\ of\ favourable\ trials}{Total\ number\ of\ trials}$

Theorem of Total Probability: - Let $E_1, E_2, \ldots\ldots\ldots, E_n$ be mutually exclusive and exhaustive events associated with a random experiment and let E be an event occurs with some E_i, then

$$P(E) = \sum_{i=1}^{n} P\left(\frac{E}{E_i}\right).P(E_i)$$

Bayes' Theorem – Let$E_1, E_2, \ldots\ldots\ldots, E_n$ be mutually exclusive & exhaustive events, associated with a random experiment and let E be any event that occurs with some E_i then

$$P\left(\frac{E_i}{E}\right) = \frac{P\left(\frac{E}{E_i}\right).P(E_i)}{\sum_{i=1}^{n} P\left(\frac{E}{E_i}\right)P(E_i)}$$

Probability distribution of X is given by

X	x_1	x_2	………………………	x_n
P(X)	P_1	P_2	………………………	P_n

$Where\ each\ P_i \geq 0\ \ \& \sum_{i=1}^{n} P_i = 1$

$Mean\ \ \mu\ = E(X) = \sum_{i=1}^{n} x_i P_i\ Variance\ \sigma^2 = \left(\sum x_i{}^2 P_i - \mu^2\right)$

$Standard\ Deviation\ \ \sigma = \sqrt{Variance}$

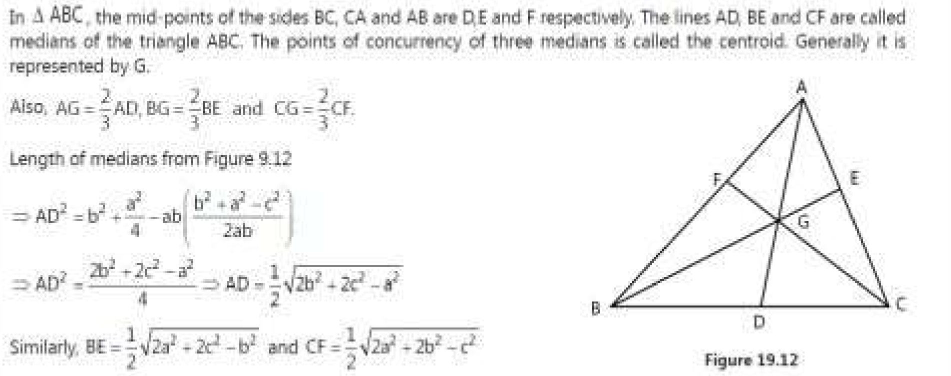
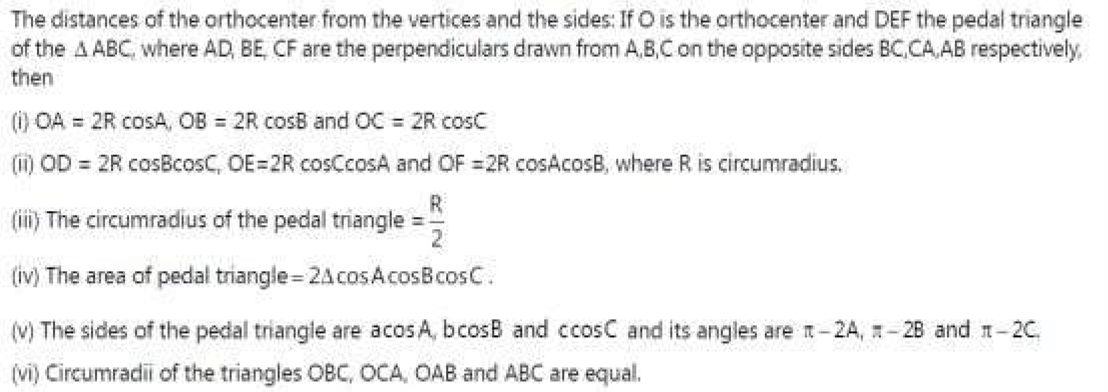
Binomial Distribution: $P(X = r) =\ {}^{n}c_r\, p^r q^r$, where $p\&q$ are probability of success & failure and $p + q = 1$.

$Mean\ \ \mu = \sum_{i=1}^{n} x_i P_i = np$

$Variance\ \sigma^2 = \left(\sum x_i{}^2 P_i - \mu^2\right) = npq$

$Standard\ Deviation\ \ \sigma = \sqrt{Variance} = \sqrt{npq}$

Some other important and useful facts & statements

1	$Sum~of~all~the~interior~angles~of~a~polygon = (n-2) \times 180^\circ$, $where~'n'~is~the~number~of~sides~of~the~polygon$
2	$Measure~of~each~Exterior~Angle = \frac{360^\circ}{n}$
3	$Measure~of~each~Interior~Angle = 180^\circ - \frac{360^\circ}{n} = \frac{(n-2) \times 180^\circ}{n}$
4	Rational Number (between two given rational numbers ‘$\boldsymbol{a}$’ and ‘$\boldsymbol{b}$’) $= a + \frac{n(b-a)}{N}$, where $\boldsymbol{n}$ is the sequence of the rational number and $\boldsymbol{N}$ is the total number of rational numbers which we need to find.
5	**Euclid’s Division Lemma** $a = bq + r$, where a is dividend, b is divisor, q is quotient and r is remainder.
6	The Fundamental Theorem of Arithmetic $LCM \times HCF = Product~of~the~numbers$
7	The Result of the Fundamental Theorem of Arithmetic $LCM~(p,q,r) = \frac{p.q.r.HCF(p,q,r)}{HCF(p,q).HCF(q,r).HCF(p,r)}$ $HCF~(p,q,r) = \frac{p.q.r.LCM(p,q,r)}{LCM(p,q).LCM(q,r).LCM(p,r)}$
	 In Δ ABC, the mid-points of the sides BC, CA and AB are D,E and F respectively. The lines AD, BE and CF are called medians of the triangle ABC. The points of concurrency of three medians is called the centroid. Generally it is represented by G. Also, $AG = \frac{2}{3}AD$, $BG = \frac{2}{3}BE$ and $CG = \frac{2}{3}CF$. Length of medians from Figure 9.12 $\Rightarrow AD^2 = b^2 + \frac{a^2}{4} - ab\left(\frac{b^2 + a^2 - c^2}{2ab}\right)$ $\Rightarrow AD^2 = \frac{2b^2 + 2c^2 - a^2}{4} \Rightarrow AD = \frac{1}{2}\sqrt{2b^2 + 2c^2 - a^2}$ Similarly, $BE = \frac{1}{2}\sqrt{2a^2 + 2c^2 - b^2}$ and $CF = \frac{1}{2}\sqrt{2a^2 + 2b^2 - c^2}$ Figure 19.12
	Apollonius's theorem - "the sum of the squares of any two sides of any triangle equals twice the square of half the third side, together with twice the square on the median bisecting the third side". For a triangle ABC with M be the midpoint of its side BC, $AB^2 + AC^2 = 2\{AM^2 + (BC/2)^2\}$
	 The distances of the orthocenter from the vertices and the sides: If O is the orthocenter and DEF the pedal triangle of the Δ ABC, where AD, BE, CF are the perpendiculars drawn from A,B,C on the opposite sides BC,CA,AB respectively, then (i) OA = 2R cosA, OB = 2R cosB and OC = 2R cosC (ii) OD = 2R cosBcosC, OE=2R cosCcosA and OF =2R cosAcosB, where R is circumradius. (iii) The circumradius of the pedal triangle $= \frac{R}{2}$ (iv) The area of pedal triangle $= 2\Delta \cos A \cos B \cos C$. (v) The sides of the pedal triangle are $a\cos A$, $b\cos B$ and $c\cos C$ and its angles are $\pi - 2A$, $\pi - 2B$ and $\pi - 2C$. (vi) Circumradii of the triangles OBC, OCA, OAB and ABC are equal.

The circumcentre, centroid and orthocentre are collinear.

In any right angled triangle, the orthocentre coincides with the vertex containing the right angle.

The mid-point of the hypotenuse of a right angled triangle is equidistant from the three vertices of a triangle.

The mid-point of the hypotenuse of a right angled triangle is the circumcentreof the triangle.

The centroid of the triangle lies on the line joining the circumcentre to the orthocentre and divides it in the ratio 1:2

In an acute angled triangle, orthocentre of ΔABC is the in-centre of the pedal triangle DEF.

Orthocentre and Pedal Triangle:

The triangle formed by joining the feet of the altitudes is called the Pedal Triangle.

(i) Its angles are $\pi - 2A$, $\pi - 2B$ and $\pi - 2C$.

(ii) The sides are $a \cos A = R \sin 2A$

$a \cos B = R \sin 2B$

$a \cos C = R \sin 2C$

(iii) Circum radii of the triangle PBC, PCA, PAB and ABC are equal.

Excentral Triangle:

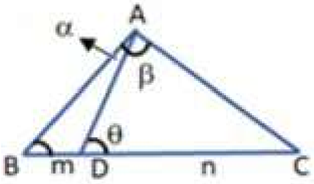
The triangle formed by joining the three excentres I_1, I_2 and I_3 of ΔABC is called the excentral triangle.

In geometry, the nine-point circle is a circle that can be constructed for any given triangle. It is so named because it passes through nine significant concyclic points defined from the triangle.
These nine points are:
The midpoint of each side of the triangle
The foot of each altitude
The midpoint of the line segment from each vertex of the triangle to the orthocenter (where the three altitudes meet; these line segments lie on their respective altitudes).
The nine-point circle is also known as Feuerbach's circle (after Karl Wilhelm Feuerbach), Euler's circle (after Leonhard Euler), Terquem's circle (after Olry Terquem), the six-points circle, the twelve-points circle, the n-point circle, the medioscribed circle, the mid circle or the circum-midcircle. Its center is the nine-point center of the triangle.

distance between the circumcenter and the orthocentre of triangle ABC is $R\sqrt{1 - 8cosAcosBcosC}$

the centroid divides the orthocenter and the circumcenter internally in the ratio 2:1

m – n Theorem:



If D be the point on the side BC of a triangle ABC which divides the side BC in the ratio m: n,
BD:DC = m:n, ∠ BAD = α, ∠ CAD = β, ∠ CDA = θ, then
$(m+n) \cot \theta = m \cot \alpha - n \cot \beta = n \cot B - m \cot C$

Commercial & Financial Mathematics

1	$Cost\ Price\ =\ Buying\ Price\ +\ Overhead\ Expenses$		
2	$Profit\ =\ Sale\ Price - Cost\ Price$	3	$Loss\ =\ Cost\ Price - Sale\ Price$
4	$Profit\ \%\ =\ \frac{Profit}{Cost\ Price} \times 100\%$	5	$Loss\ \%\ =\ \frac{Loss}{Cost\ Price} \times 100\%$
6	$SP = CP(1 + P\%)$		
7	$SP = CP(1 - L\%)$		
8	$Discount\ =\ Marked\ Price - Sale\ Price$ $SP = MP(1 - D\%),\quad SP = MP(1 + T\%)$ Where D stands for Discount and T stands for Tax		
9	$Sales\ Tax\ =\ Tax\ \%\ of\ Bill\ Amount$	10	$Simple\ Interest\ = \frac{PRT}{100}$
11	$Amount\ =\ Principal\ +\ Simple\ Interest$		
12	$If\ the\ Interest\ is\ compounded\ annually, then$ $A = P\left(1 + \frac{R}{100}\right)^{n},$ $where\ \boldsymbol{A}\ is\ Amount, \boldsymbol{P}\ is\ Principal, \boldsymbol{R}\ is\ Rate\ of\ Interest\ and\ \boldsymbol{n}\ is\ time\ period.$		
13	$If\ the\ Interest\ is\ compounded\ half\ yearly, then$ $A = P\left(1 + \frac{R}{200}\right)^{2n},$		
14	$If\ the\ Interest\ is\ compounded\ quarterly, then$ $A = P\left(1 + \frac{R}{400}\right)^{4n},$		
15	$Compund\ Interest = P\left[\left(1 + \frac{R}{100}\right)^{n} - 1\right]$		

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OUR ASSOCIATIONS

O.P. JINDAL SCHOOL
RAIGARH (CG)

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