PHYSICS

MIND MAPS

&

MNEMONICS

Physical & Measurements

The digits of a number that are used to express it to the required degree of accuracy:

- All non-zero digits
- All zero between two non-zero digits
- If the number is less than 1, the zero(s) on the right of decimal point but to the left of the non-digit zero are not significant.
- Terminal or trailing zero (s) in a number without a decimal point are not significant
  e.g →In 020342.010
  Here 20342.01 has significant figure 7

ignificant figures

Expression which shows how and which of the base quantities represent the dimensions of a physical quantity is called dimension formula.
e.g:- Force = $[MLT^{-2}]$

imensions of Physical Quantities

Unit

- Comparison with a certain internationally accepted reference standard is called unit
- Reference standard use to measure physical quantities.

Types

Fundamental Units

Mass, length, time, temperature, electric current, luminous intensity and amount of substance have fundamental units. kilogram, metre, second, Kelvin, ampere, candela and mol respectively.

Derived units

. The units which are derived from fundamental units are called derived units.
. Physical quantities like speed acceleration are derived units like m/s, m/s^2

upplementary Units

Quantities plane angle and solid angle have radian and steradian as units

Properties

Universal acceptance
Non-perishable
Well defined
Does not change with time

System of units

Set of fundamental and derived units

CGS – Centimeter, Gram, Second

FPS – Foot, Pound, Second

MKS– Metre, Kilogram, Second

S.I - System International

(Internationally accepted)

Measurement

recision

Limit of resolution of quantity measured.

accuracy

Closeness of the measured value to the true value

Types

Error = True Value – Measured Value

Absolute Errror

$\Delta a_n = a_n - a_{mean}$

$a_{mean} = \frac{a_1 + a_2 + ... + a_n}{n}$

Relative Errror

$= \frac{\Delta a_{mean}}{a_{mean}}$

$\Delta a_{mean} = \frac{(|\Delta a_1| + |\Delta a_2| + ... + |\Delta a_n|)}{n}$

Percentage Errror

$\delta a = \frac{\Delta a_{mean}}{a_{mean}} \cdot 100$

Combination of Errors in

um or Difference

$\pm\Delta Z = \pm\Delta A \pm \Delta B$

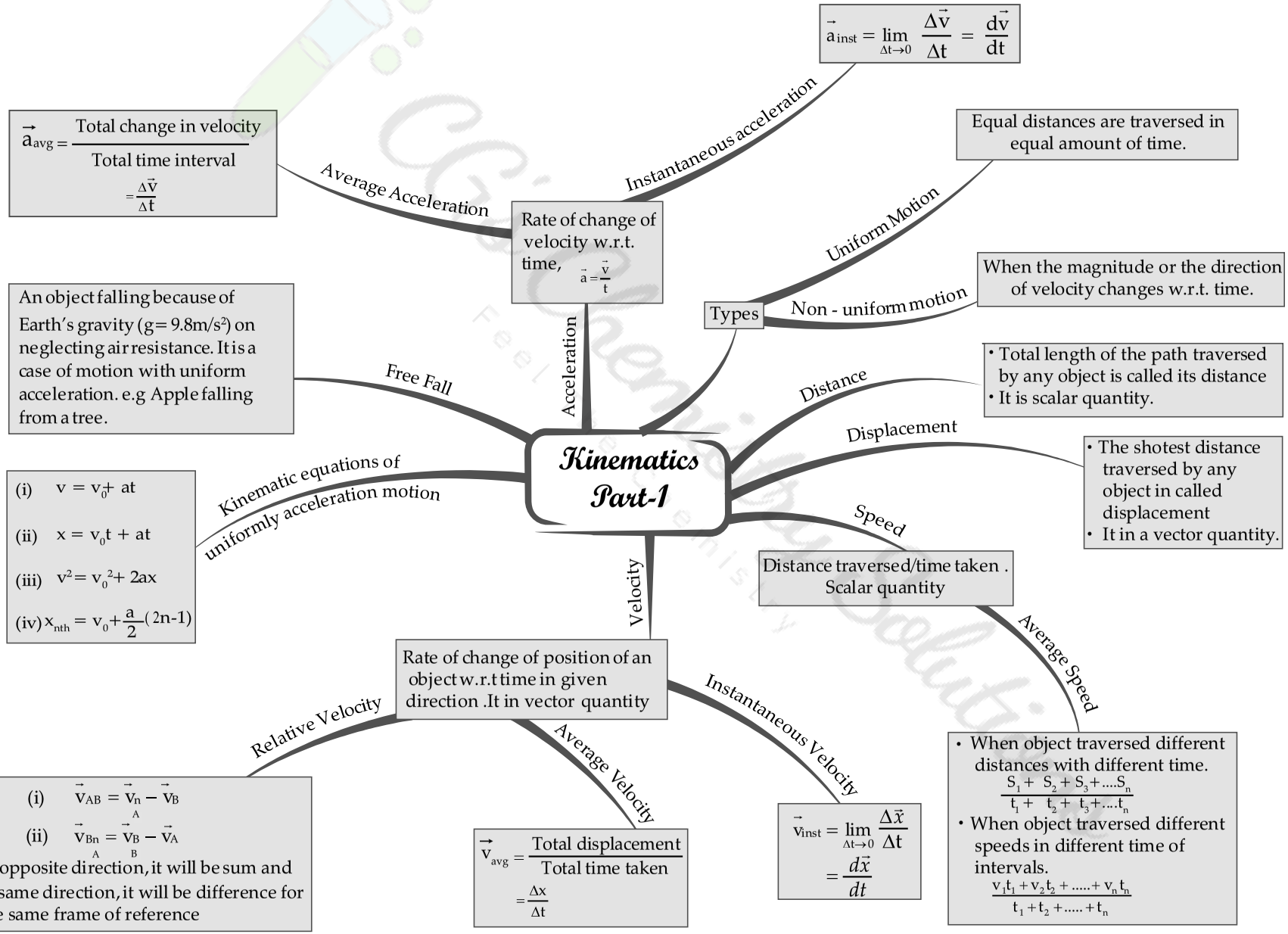
If $Z = A/B$

$\frac{\Delta Z}{Z} = \left(\frac{\Delta A}{A}\right) + \left(\frac{\Delta B}{B}\right)$

Measured quantity raised to the power

If $Z = A^p \cdot B^q / C^r$

$\frac{\Delta Z}{Z} = p\left(\frac{\Delta A}{A}\right) + q\left(\frac{\Delta B}{B}\right) + r\left(\frac{\Delta C}{C}\right)$



Kinematics Part-2

Vector

Types

- **Zero or Null vector** — It has zero magnitude and orbitary direction
- **Unit Vector** — It has magnitude as one or unity $\hat{A} = \frac{\vec{A}}{|\vec{A}|}$
- **Equal Vectors** — Vectors having same direction and magnitude
- **Negative Vector** — Vectors having same magnitude but opposite direction. eg. $\vec{A}$ is a negative of $\vec{B}$. If, $\vec{A} = -\vec{B}$
- **Co-initial Vectors** — Vectors having common starting point.

Addition of Vectors

Law of Triangle: $\vec{R} = \vec{P} + \vec{Q}$

Law of Parallelogram

Subtraction of two vectors

$\vec{A} - \vec{B} = \vec{A} + (-\vec{B})$

Multiplication of a vector by a real number λ

$\lambda \times \vec{A} = \lambda \vec{A}$

Position of displacement vector

Position vector, $\vec{r} = x\hat{i} + y\hat{j}$

Displacement vector, $\Delta\vec{r} = \Delta x\hat{i} + \Delta y\hat{j}$

Velocity vector

$\vec{v} = v_x\hat{i} + v_y\hat{j}$,

magnitude $|\vec{v}| = \sqrt{v_x^2 + v_y^2}$

Relative velocity

$\vec{V}_{AB} = \vec{V}_A - \vec{V}_B$

$\vec{V}_{BA} = \vec{V}_B - \vec{V}_A$

$\vec{V}_{AB} = -\vec{V}_{BA}$

$|\vec{V}_{AB}| = |\vec{V}_{BA}|$

Acceleration vector

$\vec{a} = a_x i + a_y\hat{j}$; $a_x = dv_x/dt$ & $a_y = dv_y/dt$

$|\vec{a}| = \sqrt{a_x^2 + a_y^2}$

Motion in a Plane

Motion of Body under two dimensional frame.

Uniform circular motion

When an object follows a circular path at a constant speed, the motion of the object is called uniform circular motion.

Angular velocity, $\omega = \theta/t$

Angular acceleration, $d = \Delta\omega/\Delta t$

eg- merry go around.

Centripetal Acceleration

A body in a circular motion acted upon by an acceleration directed towards centre of the circular motion.

$a_c = v^2/r = r\omega^2 = 4\pi^2 r\upsilon^2$

Projectile motion

Motion of an object that is in flight after being thrown or projected.

Components of velocity (initial velocity)

$u_x = u\cos\theta$, $u_y = u\sin\theta$

Components of acceleration

at any instant $a_x = 0$, $a_y = g$

Position after time t

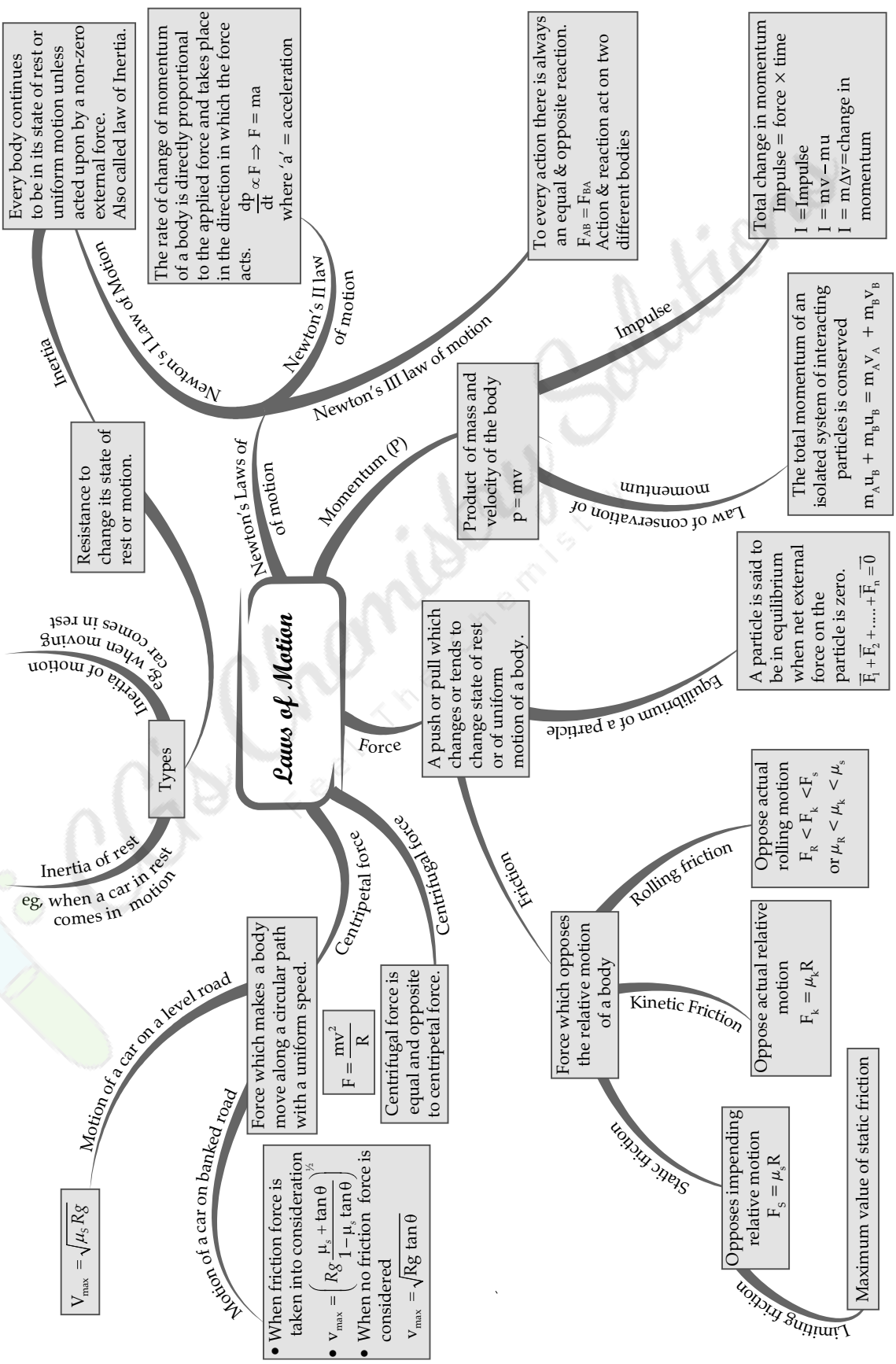
$x = (u\cos\theta)t$;

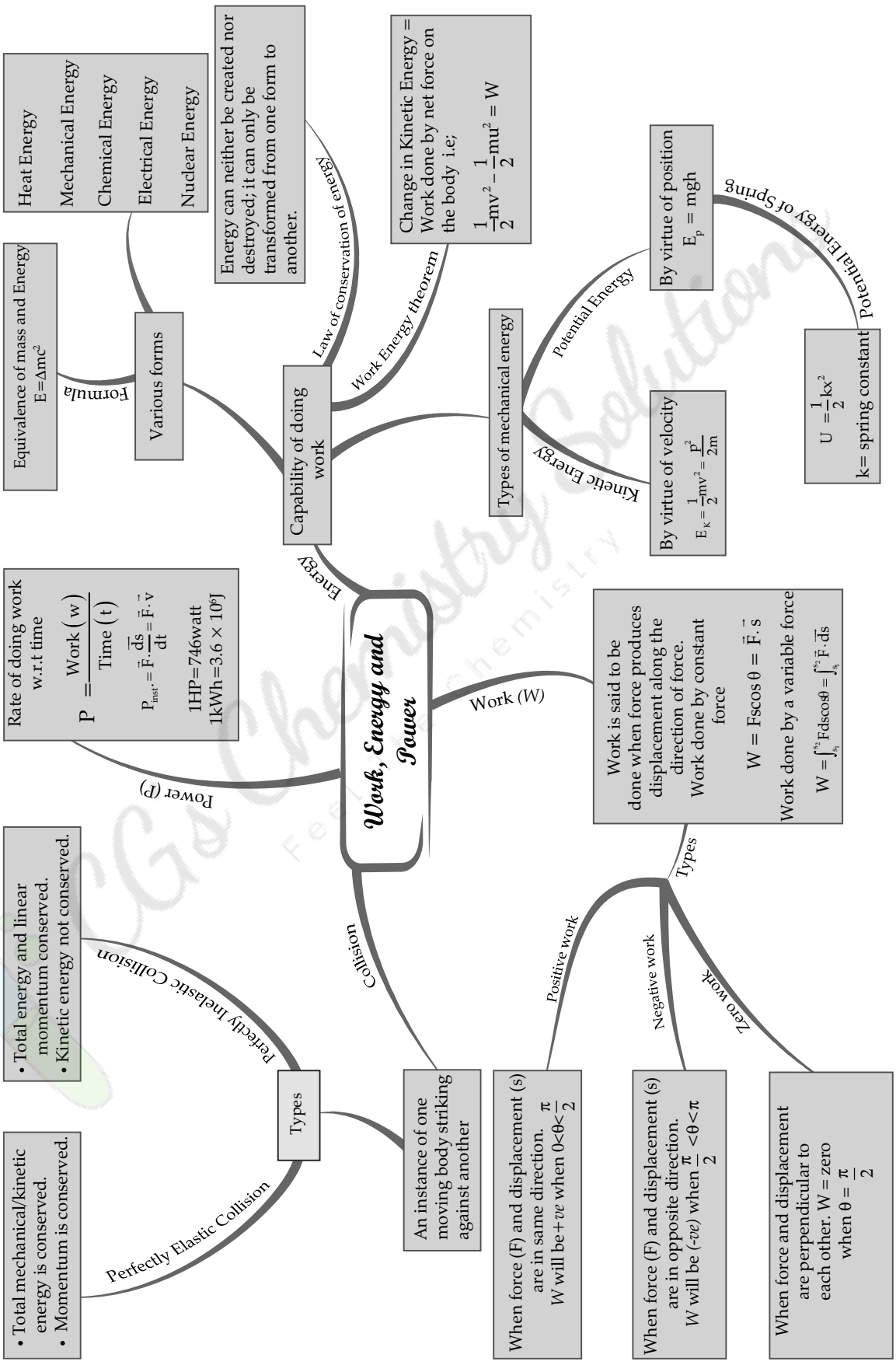
$y = (u\sin\theta)\,t - \frac{1}{2}gt^2$

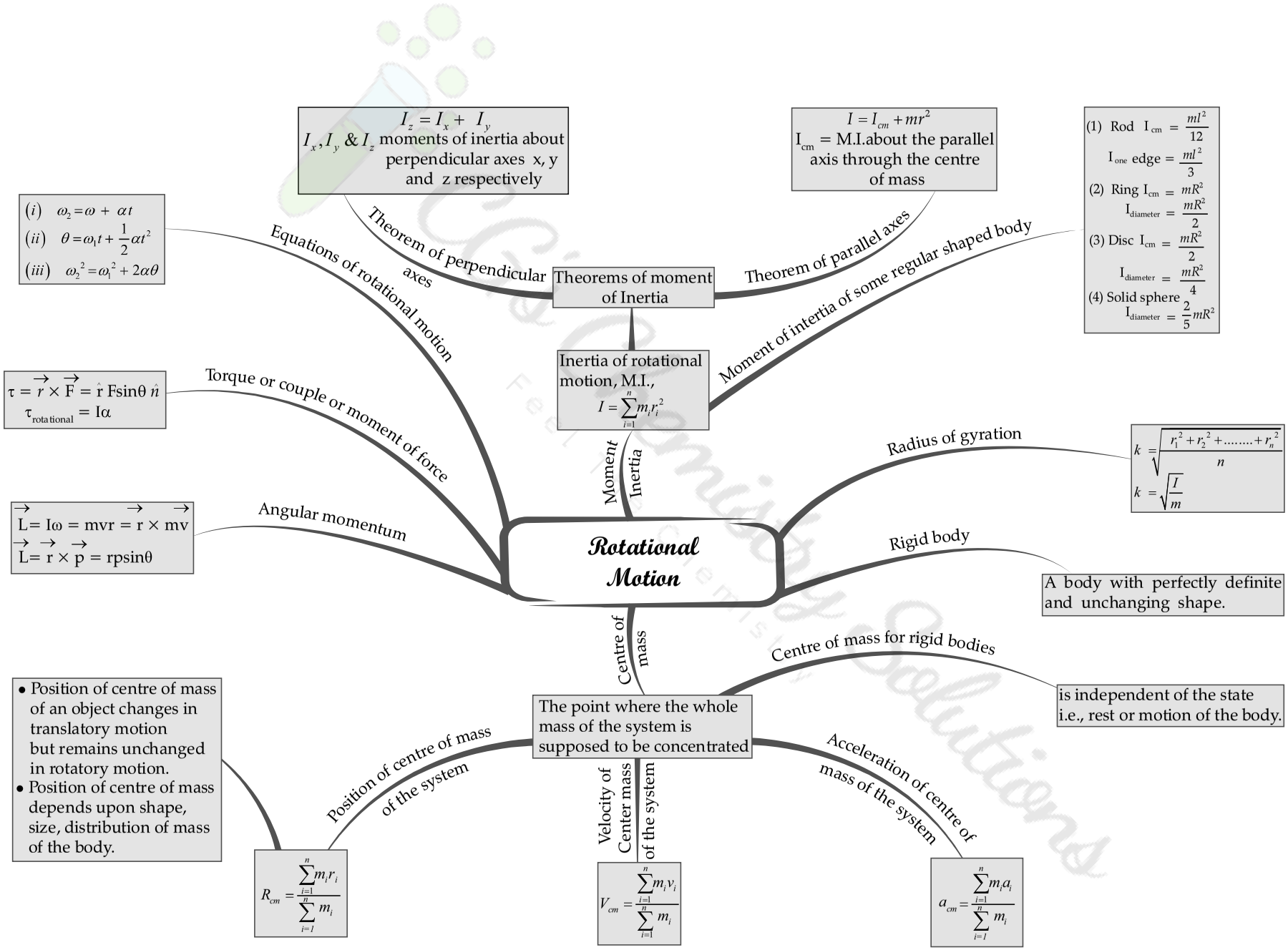
Equation of path of projectile

$y = x\tan\theta - \frac{g}{2u^2\cos^2\theta}x^2$

- Total time of flight, $T_f = \frac{2u\sin\theta}{g}$
- Maximum height, $H_{max} = \frac{u^2\sin^2\theta}{2g}$
- Horizontal range, $R = \frac{u^2\sin 2\theta}{g}$


Laws of Motion
Newton's Laws of motion
Inertia
Every body continues to be in its state of rest or uniform motion unless acted upon by a non-zero external force. Also called law of Inertia.
Newton's I Law of Motion
Newton's II law of motion
The rate of change of momentum of a body is directly proportional to the applied force and takes place in the direction in which the force acts. $\frac{dp}{dt} \propto F \Rightarrow F = ma$ where 'a' = acceleration
Newton's III law of motion
To every action there is always an equal & opposite reaction. $F_{AB} = F_{BA}$ Action & reaction act on two different bodies
Momentum (P)
Product of mass and velocity of the body p = mv
Impulse
Total change in momentum Impulse = force × time
I =Impulse
I = mv – mu
I = mΔv=change in momentum
Law of conservation of momentum
The total momentum of an isolated system of interacting particles is conserved $m_A u_B + m_B u_B = m_A v_A + m_B v_B$
Force
A push or pull which changes or tends to change state of rest or of uniform motion of a body.
Equilibrium of a particle
A particle is said to be in equilibrium when net external force on the particle is zero. $\vec{F}_1 + \vec{F}_2 + ... + \vec{F}_n = \vec{0}$
Types
Resistance to change its state of rest or motion.
Inertia of motion eg, when moving car comes in rest
Inertia of rest eg, when a car in rest comes in motion
Centripetal force
Force which makes a body move along a circular path with a uniform speed.
$F = \frac{mv^2}{R}$
Centrifugal force
Centrifugal force is equal and opposite to centripetal force.
Friction
Force which opposes the relative motion of a body
Rolling friction
Oppose actual rolling motion $F_R < F_k < F_s$ or $\mu_R < \mu_k < \mu_s$
Kinetic Friction
Oppose actual relative motion $F_k = \mu_k R$
Static friction
Opposes impending relative motion $F_S = \mu_s R$
Limiting friction
Maximum value of static friction
Motion of a car on a level road
$V_{max} = \sqrt{\mu_S R g}$
Motion of a car on banked road
• When friction force is taken into consideration $v_{max} = \left(Rg \frac{\mu_s + \tan\theta}{1 - \mu_s \tan\theta} \right)^{1/2}$
• When no friction force is considered $v_{max} = \sqrt{Rg \tan\theta}$


Work, Energy and Power
Energy
Capability of doing work
Various forms
Heat Energy
Mechanical Energy
Chemical Energy
Electrical Energy
Nuclear Energy
Formula
Equivalence of mass and Energy
$E=\Delta mc^2$
Law of conservation of energy
Energy can neither be created nor destroyed; it can only be transformed from one form to another.
Work Energy theorem
Change in Kinetic Energy = Work done by net force on the body i.e;
$\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = W$
Types of mechanical energy
Potential Energy
By virtue of position
$E_p = mgh$
Potential Energy of Spring
$U = \frac{1}{2}kx^2$
k= spring constant
Kinetic Energy
By virtue of velocity
$E_K = \frac{1}{2}mv^2 = \frac{p^2}{2m}$
Power (P)
Rate of doing work w.r.t time
$P = \frac{\text{Work}(w)}{\text{Time}(t)}$
$P_{inst} = \vec{F}.\frac{\vec{ds}}{dt} = \vec{F}.\vec{v}$
1HP=746watt
1kWh=3.6×10^6J
Work (W)
Work is said to be done when force produces displacement along the direction of force.
Work done by constant force
$W = Fs\cos\theta = \vec{F}.\vec{s}$
Work done by a variable force
$W = \int_{s_1}^{s_2} Fds\cos\theta = \int_{s_1}^{s_2} \vec{F}.\vec{ds}$
Types
Positive work
When force (F) and displacement (s) are in same direction. $\frac{\pi}{2}$
W will be+ve when $0<\theta<\frac{\pi}{2}$
Negative work
When force (F) and displacement (s) are in opposite direction.
W will be (-ve) when $\frac{\pi}{2}<\theta<\pi$
Zero work
When force and displacement are perpendicular to each other. W = zero when $\theta = \frac{\pi}{2}$
Collision
An instance of one moving body striking against another
Types
Perfectly Inelastic Collision
• Total energy and linear momentum conserved.
• Kinetic energy not conserved.
Perfectly Elastic Collision
• Total mechanical/kinetic energy is conserved.
• Momentum is conserved.



Gravitation

Satellite

Heavenly object that revolves around a planet

Polar satellite

Height from earth's surface = 880km
Time period = 84min
Orbital velocity = 7.92km/s

Geostationary satellite

Height from surface of earth =36000km
Radius of orbit = 42,400km
Time periods = 24 hours
Orbital velocity = 3.1km/s

Escape speed $v_{esc} = \sqrt{2GM/R}$
$= \sqrt{2gR} = \sqrt{2}\,\upsilon_o$

Earth 's v_{esc} = 11.2km/s

Orbitals speed $v_{orb} = \sqrt{gR} = \frac{v_e}{\sqrt{2}}$

Total Energy of a satellite

E = K.E + P.E

$= \left(\frac{GMm}{2r}\right) + \left(\frac{-GMm}{r}\right) = -\frac{1}{2}G\frac{Mm}{r}$

Weightlessness

During free fall under gravity inside a spacecraft or satellite a body is weightless i.e., effective weight becomes zero.

Kepler's Law-of planetary motion

(i) **Law of Orbit:** Every planet revolves around the Sun in an elliptical orbit and Sun is at its one focus.

(ii) **Law of Area:** The radius vector drawn from the Sun to a planet sweeps out equal areas in equal intervals of time.

$\frac{dA}{dt} = \frac{L}{2m} = \text{Constant}$

(iii) **Law of Periods:** $T^2 \propto a^3$
where, a = length of semi-major axis

Acceleration due to gravity (g)

Acceleration possessed by an object during free fall due to earth's gravitational pull,

$g = \frac{G\,M_e}{R_e^2}$

Variation in acceleration due to gravity (g)

(i) with height $g' = g\left(1 - \frac{2h}{R_E}\right)$,
i.e. g′ decreases with height

(ii) with depth $g' = g\left(1 - \frac{d}{R_E}\right)$,
i.e. g′ decreases with depth

(iii) with rotation of earth about its own axis
$g' = g - R\omega^2 \cos^2\lambda$,
At poles, $\lambda = 90^0$, g maximum
At equator, $\lambda = 0^0$, g minimum

Gravitational Field and potential

•Gravitational field Intensity

$I = \frac{Gm}{r^2}$

•Gravitational potential

$V_g = \frac{work\ done}{mass} = \frac{-Gm}{r}$

•Gravitational Potential Energy

$U = \frac{-GMm}{r}$

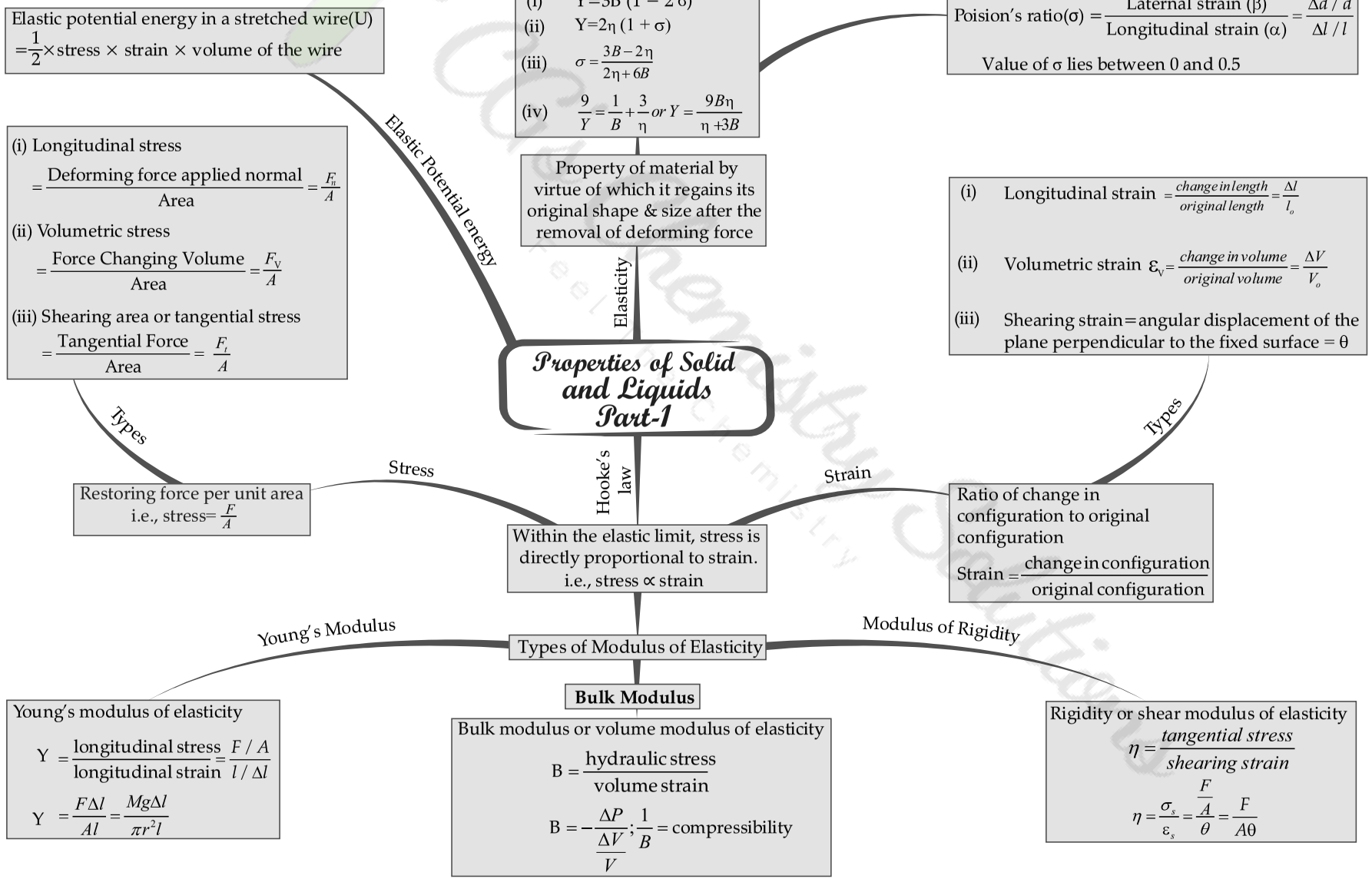
Newton's universal law of Gravitation

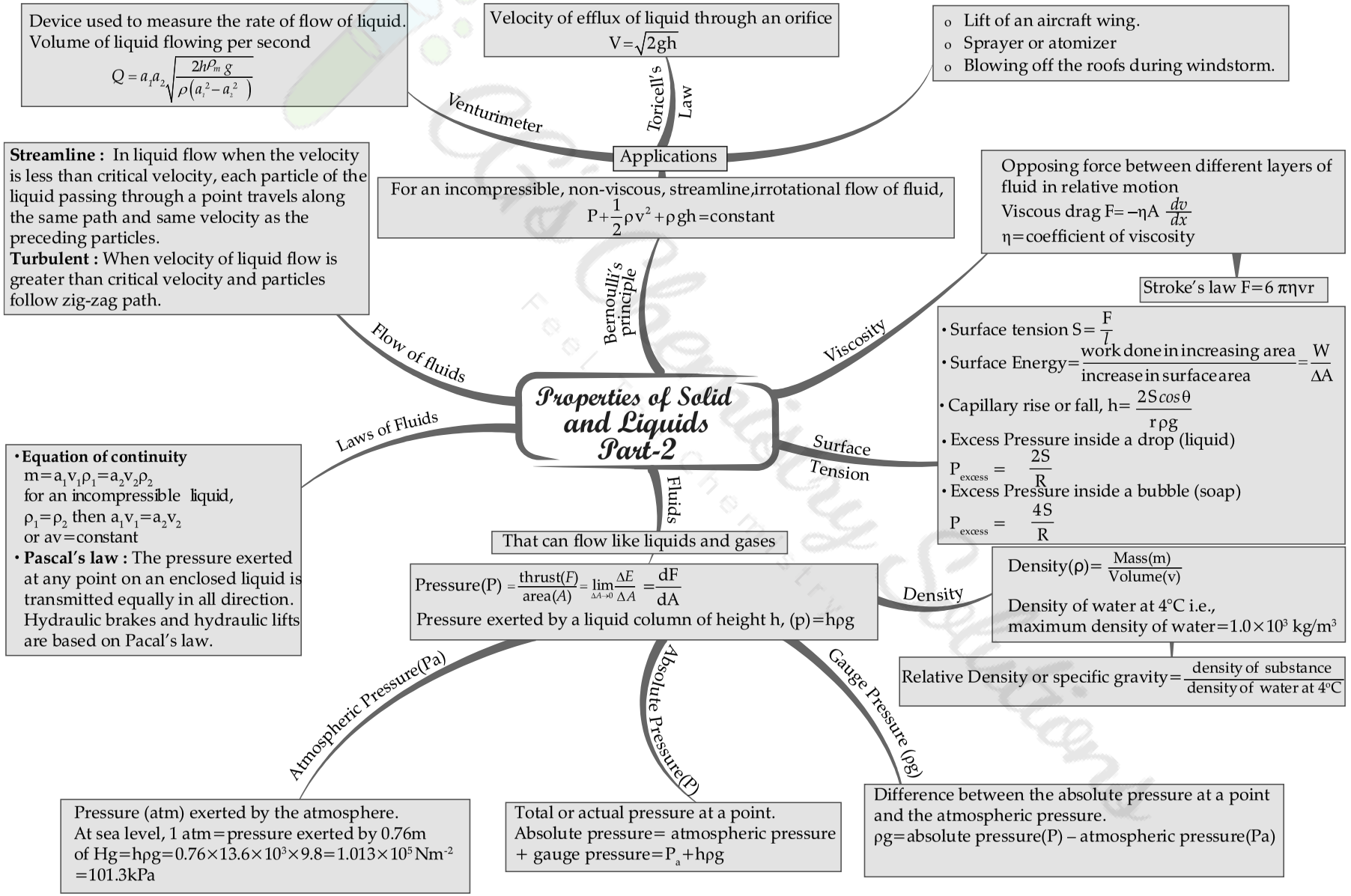
When two mass bodies are separted by a distance, they experience an attractive force which is directly proportional to the product of their masses and inversaly proportional to the square of their separation.

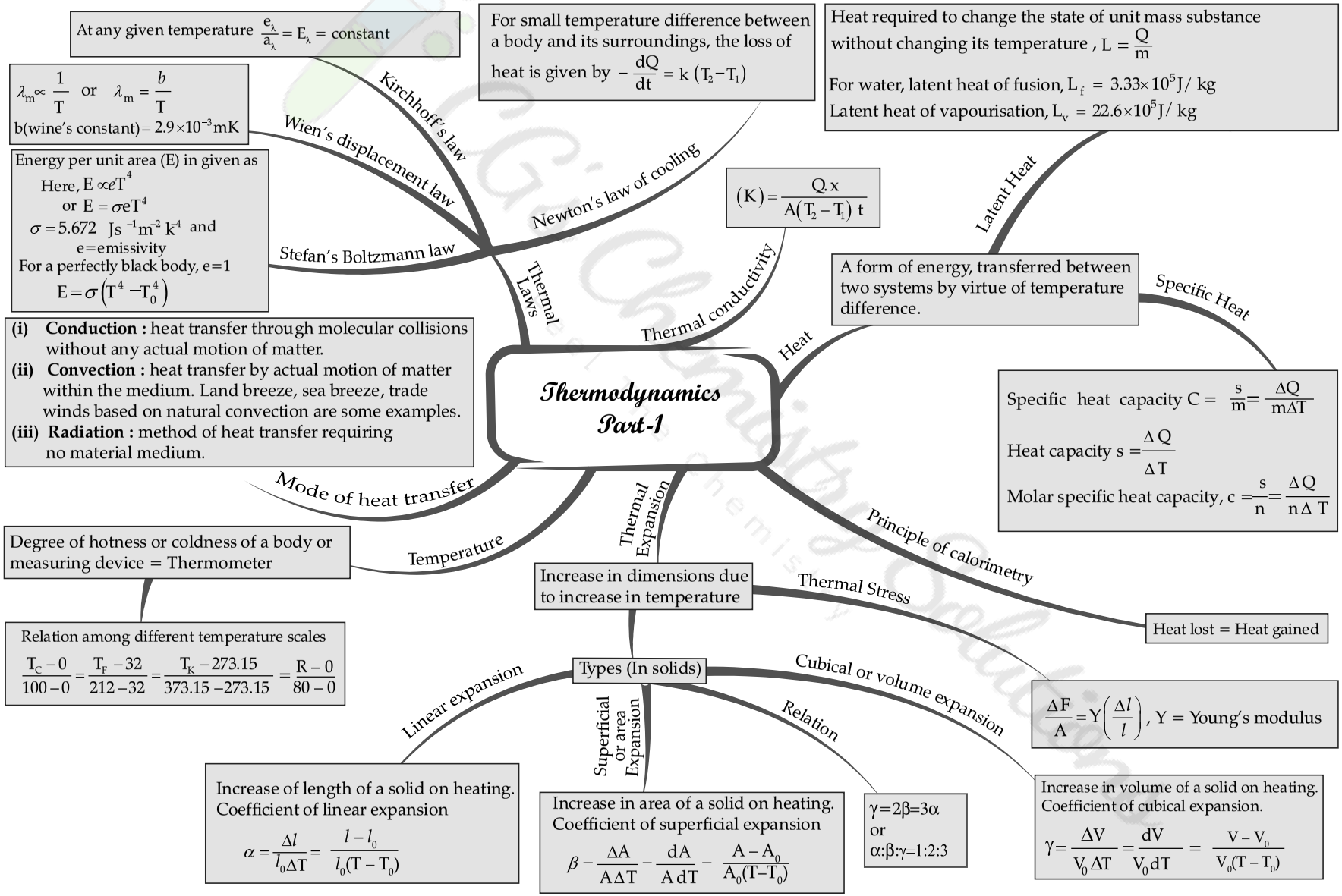
$F = \frac{Gm_1m_2}{r^2},\ G = 6.67 \times 10^{-11} Nm^2kg^{-2}$

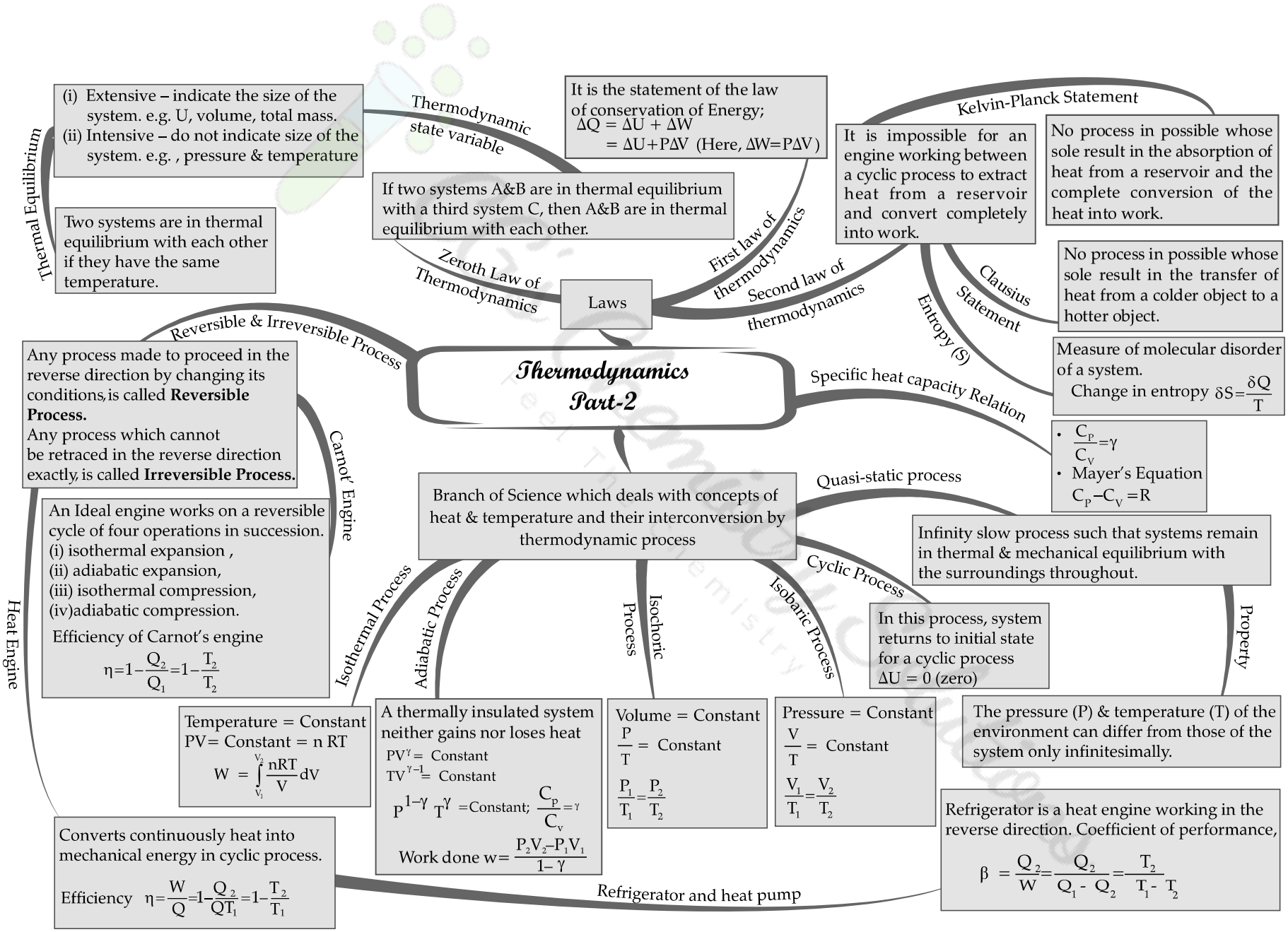
Characteristics of gravitational force

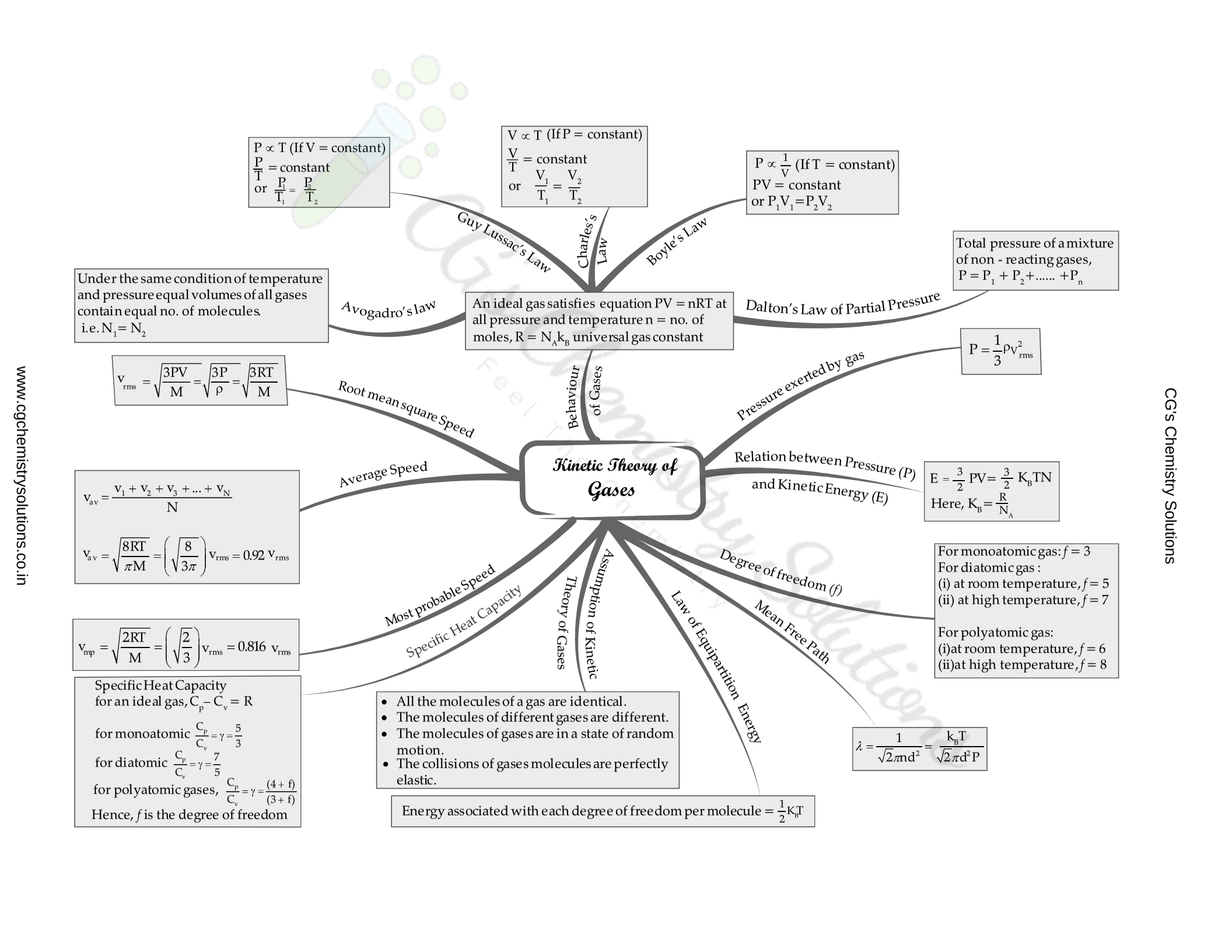
(i) Weakest force in Nature.
(ii) Central as well as conservative.
(iii) Always attractive in nature.
(iv) Applicable for all bodies irrespective of their shape, size and position.











Oscillations & Wave Part-1

Simple Harmonic Motion is the simplest form of oscillatory motion

Displacement in SHM

$x(t) = A\cos(\omega t + \phi)$

A = Amplitude i.e., maximum displacement of particles.

Phase

Time varying quantity $(\omega t + \phi)$

Phase constant or Phase angle (ϕ)

- It depends upon velocity (v) and displacement of particle at t = 0

Time period (T)

The smallest interval of time after which the motion is repeated

Frequency

The number of oscillations per second

i.e., $f = \frac{1}{T} = \frac{\omega}{2\pi}$

Velocity in SHM

$v = \frac{dx(t)}{d(t)} = -\omega A\sin(\omega t + \varphi)$

$v_{max} = \omega A$

Acceleration in SHM

$a = \frac{dv}{dt} = -\omega^2 A\cos(\omega t + \varphi)$

$a_{max} = \omega^2 A$

Energy in SHM

Kinetic Energy

K.E = $m\omega^2 A^2 \sin^2(\omega t + \varphi)$

Potential Energy

P.E = $\frac{1}{2} m\omega^2 A^2 \cos^2(\omega t + \varphi)$

Total energy, T.E. = K.E. + P.E.

$= \frac{1}{2} kA^2\left[\cos^2(\omega t + \varphi) + \sin^2(\omega t + \varphi)\right] = \frac{1}{2} KA^2$

Force law equation for SHM

$F = -k(x), k = m\omega^2$

$\therefore \omega = \sqrt{\frac{k}{m}}$

SHM

Simple pendulum

Time period $T = 2\pi\sqrt{\frac{I}{mgl}} = 2\pi\sqrt{\frac{l}{g}}$

Oscillations due to a spring

Time period $T = 2\pi\sqrt{\frac{m}{k}}$

Here, $k = \frac{F}{x}$ = *spring constant*

- Every oscillatory motion is periodic, but every periodic motion need not be oscillatory.
- To and fro motion repeatedly about a fixed point in a definite interval of time.

Damped Oscillations

Oscillation of a body whose amplitude goes on decreasing with time.

Damping force $F_d = -bv$, b = damping constant

Displacement of damped oscillator

$x = x_m e^{-bt/2m}\sin(\omega' t + \varphi)$, here, $\omega' = \sqrt{\frac{m}{k} - \frac{b^2}{4m^2}}$

Amplitude decreases with time as

$x = x_m e^{-(b/2m)t}$

Forced Oscillations

Driving force, $F(t) = F_o\cos\omega_d t$

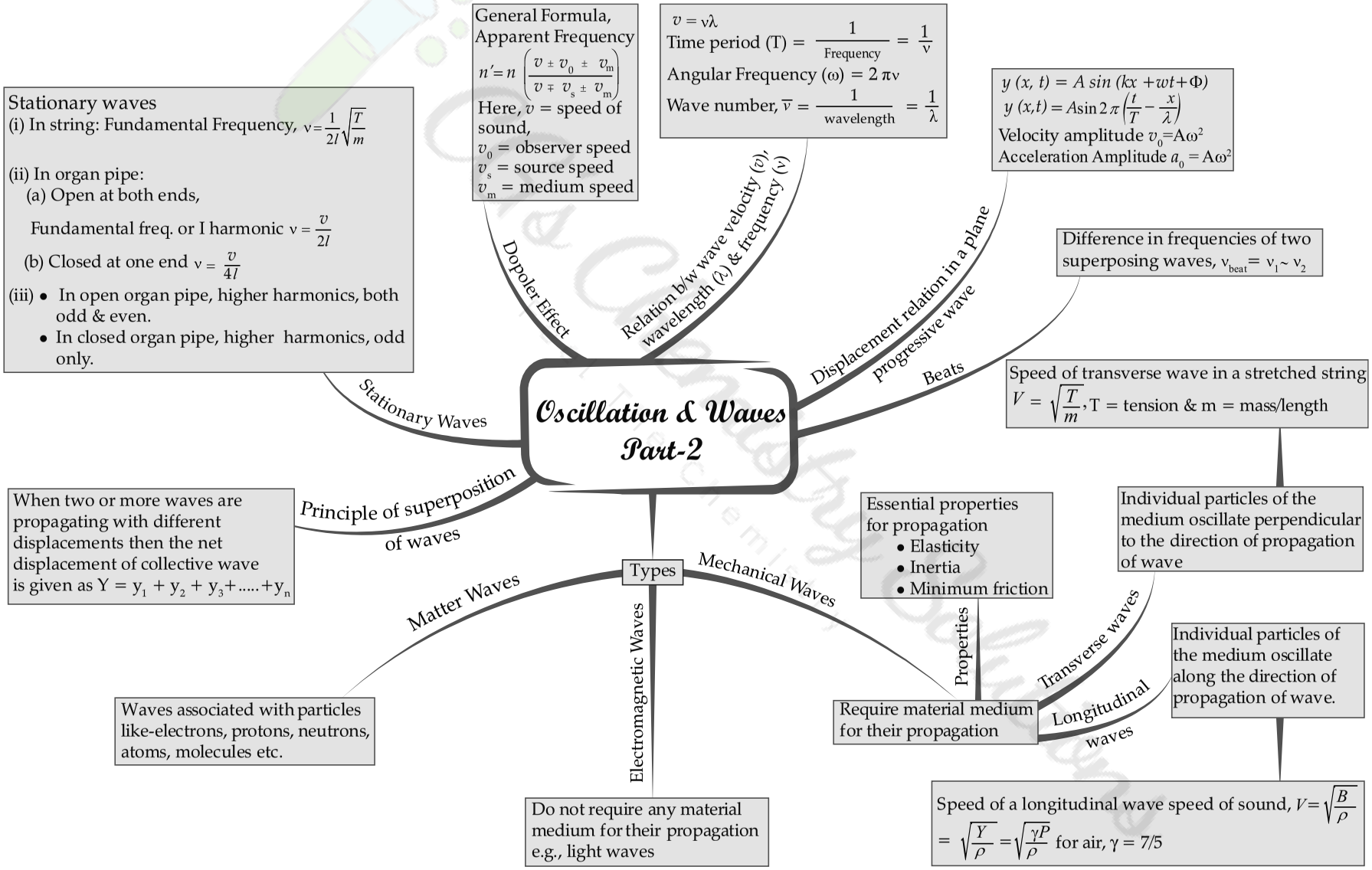
Displacement, $x(t) = A\cos(\omega_d t + \varphi)$

Amplitude, $A = \frac{F_o}{\left\{m^2\left(\omega^2 - \omega_d^2\right)^2 + \omega_d^2 b^2\right\}^{\frac{1}{2}}}$

$\tan\varphi = \frac{-v_o}{\omega_d x_o}$

Resonance

When frequency of external force is equal to natural frequency of oscillator.



Electrostatics

Electric Potential

Electric potential due to a point charge: $V_P = Q/4\pi\varepsilon_0 r$

Potential due to a system of charges: $V = \frac{1}{4\pi\varepsilon_0}\sum\frac{Q_i}{r_i}$

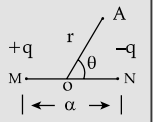
- Work done per unit test charge by an external agent in moving the test charge from reference point to the desired point S.I. unit J/C
- V_0 = Work done/charge

Potential due to a dipole:

$V = \frac{1}{4\pi\varepsilon_0}\frac{p\,\cos\theta}{r^2}$

Where $p = qd$

$\theta = \angle AON$



At $\theta = 0$, $V = \frac{1}{4\pi\varepsilon_0}\frac{p}{r^2}$ [axial position]

At, $\theta = 90°$, $V = 0$ [equitorial position]

Conductors & Insulators

Conductors	Insulators
Such a material Which when placed in an electric field, the free electrons move in a direction opposite to the field.	Such a material in which electrons are tightly bound, & when exposed in an electric field, electrons do not move *i.e.* having no free electrons

- Electric field inside a conductor is zero
- Electric field is always perpendicular to the charged surface
- In static state, there will be no additional charge in a conductor

Equipotential Surface

- Potential is same at all the points of the surface
- Component of electric field parallel to an equipotential surface is zero.

Dielectric

- $F = \frac{q_1 q_2}{4\pi K\varepsilon_0 r^2}$, K = dielectric constant of medium
- A dielectric is an electrical insulator that can be polarized by an applied electric field.

Capacitance, $C = \frac{Q}{V}$

Capacitance of a parallel plate capacitor

$C = K\,\varepsilon_0 A/d$, K = dielectric constant

Capacitance when material slab inserted between the plates

$C = K\varepsilon_0 A/[Kd - x(K-1)]$

where x = thickness of the slab inserted

Capacitance of a spherical capacitor

$C = 4\pi\varepsilon_0/\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

For isolated sphere

$C = 4\pi\varepsilon_0 R$

Energy stored in a capacitor

$U = \frac{1}{2}CV^2 = \frac{Q^2}{2C}$

Series grouping of capacitors

$\frac{1}{C} = \frac{1}{C_1}+\frac{1}{C_2}+\frac{1}{C_3}+----+\frac{1}{C_n}$

For two, $C = \frac{C_1 C_2}{C_1 + C_2}$

Parallel grouping of capacitors

$C = C_1 + C_2 + C_3 + ---- + C_n$

for two, $C = C_1 + C_2$

Electric Potential Energy

- It is negative of work done by the electric force as the configuration of the system changes.
- $Ur_2 - Ur_1 = -W = \frac{q_1 \cdot q_2}{4\pi\varepsilon_0}\left(\frac{1}{r_2}-\frac{1}{r_1}\right)$
- If the separation between charges is 'r' then $U_{(r)} = \frac{q_1 \cdot q_2}{4\pi\varepsilon r}$
- Potential Difference, $V_B - V_A = \frac{U_B - U_A}{q}$

  $U_B - U_A$ = change in Potential Energy

  q = test charge

Potential Energy of a dipole

$dU = pE\sin\theta d\theta$

If we choose P.E. of dipole to be zero when $\theta = 90°$ then

$U_\theta - U_{90°} = \int_{90°}^{\theta} pE\sin\theta\,d\theta$

$U_\theta = -pE\cos\theta = -\vec{p}\times\vec{E}$

If it is rotated through angle θ against the torque

Current Electricity

Electric Current

Rate of flow of charge through an area.

$i = \frac{Q}{t}$

$i = \int \vec{J}.\vec{ds}$

Current density

$\vec{J} = \frac{\Delta i}{\Delta s \cos\theta} = \sigma E$

Δs = area of cross-section

θ = angle between Area vector & current flow

σ = conductivity

Drift velocity

$V_d = \frac{i}{neA} = \frac{J}{ne}$

Mobility

$\mu = \frac{V_d}{E} = \frac{e\tau}{m}$

τ = average collision time

Ohm's Law

$J = \sigma E$ or $V = IR$

Resistance

$R = \rho \frac{l}{A} \tau$

Resistivity

$\rho = \frac{1}{\sigma} \Omega m$

Conductivity

$\sigma = J/E$

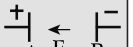
Electric cell

It is a device which maintains a potential difference between its two terminals.

E MF

emf = $E = \frac{W}{q} = \frac{F_b}{d}$

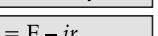
It is equal to the potential difference between the terminals when the terminals are not connected externally.



Internal Resistance

$V_A - V_B = E - ir$

r = internal resistance of the cell



Grouping of Cell

Parallel grouping

$E_{eq} = \frac{E_1 r_2 + E_2 r_1}{r_1 + r_2}$, $i = \frac{E_{eq}}{R + \frac{r_1 r_2}{r_1 + r_2}}$

Series grouping

$i = \frac{E_1 + E_2}{R + (r_1 + r_2)} = \frac{E_0}{R_1 + R_2}$

$E_0 = E_1 + E_2$, $R_2 = r_1 + r_2$

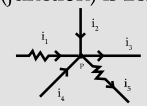
Kirchhoff's Law

Junction Law

$i_1 + i_2 + i_4 = i_3 + i_5$

algebraic sum of all the currents directed towards a point (junction) is zero.

$\Sigma I_p = 0$



Loop Law

The algebraic sum of all the potential difference along a closed loop is zero.

$\Sigma E = 0$

Potentiometer

$P = \frac{V_A - V_B}{l} = \frac{\text{potential difference}}{\text{length of wire}}$

Comparison of emf, $\frac{E_1}{E_2} = \frac{l_1}{l_2}$

Internal Resistance (r) = $R\left(\frac{l_1}{l_2} - 1\right)$

l_1 l_2 are lengths of null point

Meter Bridge

Unknown resistance

$S = \frac{R(100-l)}{l}$

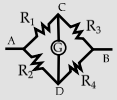
l = balancing length

R = known resistance

Wheatstone Bridge

- is balanced

If $\frac{R_1}{R_2} = \frac{R_3}{R_4}$



- $V_c = V_D$

No current through G

Temperature Dependence of Resistance

$R = R_0 [1 + \alpha (T - T_0)]$

$\rho = \rho_0 [1 + \alpha (T - T_0)]$

R = resistance at temperature T

R_0 = resistance at temperature T_0

α = coefficient of resistivity

Grouping of Resistance

Parallel grouping

$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + - - - + \frac{1}{R_n}$

For two resistors

$R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$

Series grouping

$R = R_1 + R_2 + R_3 + - - - + R_n$

For two resistors

$R = R_1 + R_2$

Magnetic effect of current & Magnetism Part-1

- It is a region around a magnet or current carrying conductor or a moving charge in which its magnetic effect can be felt
- SI unit is Tesla(T) = weber/m^2
- 1 Gauss = 10^{-4} Tesla

Magnetic Field $(\vec{B})$

Oersted Law

In April, 1820, Hans Christian Oersted discovered that flow of current in a wire can deflect a nearby magnetic compass needle.

Ampere's Law

$\oint \vec{B}.\vec{dl} = \mu_0 i$

where i = total current crossing the area bounded by closed curve.

Solenoid

- Magnetic filed at a point inside due to a long solenoid $B = \mu_0 ni$
- And at point on one end $B = \frac{\mu_0 ni}{2}$

where n = no. of turns per unit length along the length of solenoid.

Magnetic field due to Toroid

$B = \frac{\mu_0 N i}{2\pi r}$, N = total no. of turns

i = current in toroid

Force on a current carrying conductor

$d\vec{F} = i\, d\vec{l} \times \vec{B}$, $F = ilB$

Force between parallel currents

$F = \frac{\mu_0 i_1 i_2}{2\pi d}$

Torque experienced by a loop in uniform magnetic field

$\vec{\tau} = MB \sin\theta\, \hat{n} = \vec{M} \times \vec{B}$

Definition of Ampere

If two parallel wire kept 1 m apart, if $F = 2 \times 10^{-7}$, then current = 1A in each.

Sensitivity

Sensitivity of moving coil galvanometer is nBA/k

Gal.to ammeter

$S = \frac{Ig}{I\ I_g} G$

Gal.to voltameter

$R = \frac{V}{I_g} - G$

Magnetic Force on moving charge

$\vec{F} = q\vec{v} \times \vec{B}$

$= qvB \sin\theta$

- For $\theta = 0$, $\vec{F} = 0$ along the magnetic field
- For $\theta = 90°$, i.e. if charge's velocity is perpendicular to field direction, Force is perpendicular to both field & velocity

$F = qvB = \frac{mv^2}{r}$

$r = \frac{mv}{qB}$ = radius of the circle in which charge rotates

Time period $(T) = \frac{2\pi m}{qB}$

ν(frequency) $= \frac{1}{T} = \frac{qB}{2\pi m}$

If $\theta \neq 0, 180°, 90°$

Then, $F = qvB \sin\theta$

And the charge particle will follow helical path whose

$r = \frac{m v_1}{q B}$ and pitch $= V_{\parallel} \times T = V_{\parallel} \times \frac{2\pi m}{qB}$

Biot-Savart Law

$d\vec{B} = \frac{1}{4\pi\varepsilon_0 c^2} \frac{i d\vec{l} \times \vec{r}}{r^3}$

$d\vec{B} = \frac{\mu_0}{4\pi} \frac{i d\vec{l} \times \vec{r}}{r^3}$ [θ = angle between $d\vec{l}$ and $\vec{r}$]

$dB = \frac{\mu_0}{4\pi} \frac{i dl \sin\theta}{r^2}$ [Direction of field will be perpendicular to plane containing current element and the point of observation]

where $\mu_0 = \frac{1}{\varepsilon_0 c^2}$

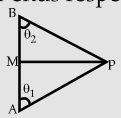
$= 4\pi \times 10^{-7}\ TmA^{-1}$

Magnetic field due to straight wire current

Field due to a long straight wire current

$B = \frac{\mu_0 i}{4\pi d} (\cos\theta_1 - \cos\theta_2)$

where θ_1 and θ_2 are the angle corresponding to the lower and upper ends respectively



i.e $\theta_1 = 0$

$\theta_2 = \pi$

$B = \frac{\mu_0 i}{2\pi d}$

Field due to a current carrying circular ring

Field at the centre

$B = \frac{\mu_0 i}{2a}$

Field at an axial point

$B = \frac{\mu_0 i a^2}{2(a^2 + d^2)^{3/2}}$

Field at a point far away from the centre

i.e. for d>>>a

$B = \frac{\mu_0 i a^2}{2 d^3}$

Magnetic Effects of Current & Magnetism Part-2

Dipole moment

- Current loop of area $A = \pi r^2$ carrying current i may be replaced by a magnetic dipole of dipole moment $\mu = md = iA$
- Circular Loop
- Revolving Electron
  - $|\vec{\mu}| = iA = \frac{ev}{2\pi r} \times \pi r^2$
  - $= evr/2$
  - $\vec{\mu} = \frac{-e}{2m_e}\vec{L}$
  - $\mu = md$
  - m = magnetic charge or pole strength
  - d = separation between poles
  - r = radius of circular orbit
  - e = charge on electron
  - v = speed of electron;
  - L = angular momentum
  - m_e = mass of electron
- Solenoid
  - $\mu = NIA$,
  - N = no. of turns
  - I = current
  - A = area

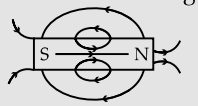
Earth's Magnetic field

Earth is a natural source of magnetic field having geometric north and geometric south pole

- Declination
  - Angle b/w magnetic meridian and geographical meridian.
- Inclination or dip (δ)
  - Angle made by earth's magnetic field with horizontal in the magnetic direction
  - $\delta_{equator} = 0, \delta_{pole} = 90°$
- Horizontal component
  - $B_H = B\cos\theta$
  - B_H (at pole) = 0
  - B_H(at equator) is maximum

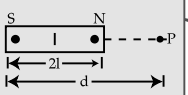
Magnetic field Lines

Continuous imaginary lines which represent the direction of magnetic field.

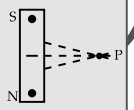


Bar Magnet

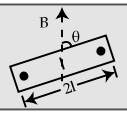
- End–on–position
  - $= \frac{\mu_0}{4\pi}\frac{2M}{d^3}$
  - $M = 2ml$
  - $d >>> l$



- Broadside Position
  - $B = \frac{\mu_0}{4\pi}\frac{M}{(d^2+l^2)^{3/2}}$
  - For $d >>> l$
  - $B = \mu_0 M/4\pi d^3$



- Magnetic field Intensity
- Potential Energy of a Field–Magnet System
  - $U_\theta = U_\theta - U_{90°} = -MB\cos\theta = -\vec{M}.\vec{B}$
  - we take P.E. at θ = 90° to be zero
- Torque
  - $\vec{\tau} = \vec{M} \times \vec{B} = MB\sin\theta$
  - M = 2ml
  - B = Magnetic field



Megenetic Terms

- Magnetic Intensity
  - $H = \frac{B_0}{\mu}$
- Magnetic permeability
  - $\mu = \mu_0(1+\chi_m)$
- Magnetic susceptibility
  - $\chi = \frac{I}{H}$
- Intensity of magnetization
  - $I = \frac{M}{V}$
- Time period oscillating bar magnet
  - $(T) = 2\pi\sqrt{\frac{I}{MB}}$

Magnetic Substance

- Para-magnetism
  - Tendency to increase the magnetic field due to magnetization,
  - e.g. Al, Mn (x_m, $\mu_r > 1$)
- Ferromagnetism
  - Tendency of strong magnetization in the direction of magnetic field.
  - e.g. Fe, Co, Ni,(μ_r, $x_m >>1$)
- Diamagnetism
  - Tendency to magnetise in a direction opposite to direction of magnetic field
  - e.g. Bi, Cu, Hg, Ni.
  - (μ_r, $x_m < 1$)

Electromagnets

Magnet in which the magnetic field is produced by an electric current. Magnetic field disappears when current is turned off.

Electromagnetic Induction & Alternating Currents Part-1

Faraday's Law of Electromagnetic Induction

1- Whenever magnetic flux through an area bounded by a closed conducting loop changes, an emf is produced in the loop

2- The emf is given by $E = -d\phi/dt$ where $\phi = \int \vec{B}.\vec{ds}$ is the magnetic flux through the area.

In 1831, Michael Faraday discovered electromagnetic induction and James Clerk Maxwell mathematically described it.

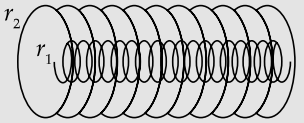
Mutual Inductance

$\phi = Mi$

$\frac{d\phi}{dt} = -M\frac{di}{dt}$

$M_{12} = \mu_0 n_1 n_2 \pi r_1^2 l$

$M_{21} = \mu_0 n_1 n_2 \pi r_2^2 l$



Emf induced in an AC generator, $E = NBA\omega \sin \omega t$

Lenz's Law

The direction of the induced current is such that it opposes the change that has induced it.

Self Induction

If a solenoid of N turns, the flux through each each turn = $\phi = \int \vec{B}.\vec{ds}$

emf induced between the ends of coil = $E = -N\frac{d}{dt}\int \vec{B}.\vec{ds}$

Self Inductance of long Solenoid

$L = \mu_0 n^2 \pi r^2 l$

n = no. of turns per unit length

ϕ = flux = $(\mu_0 ni)\ \pi r^2$

r = radius of each loop of solenoid

- **Growth of current in LR Circuit**

  $i = \frac{E}{R}(1 - e^{tR/L}) = i_0(1 - e^{-t/r})$

- **Decay of current**

  $i = i_0 e^{-t/r}$

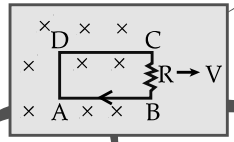
- **Energy stored in an Inductor**

  $U = \frac{1}{2}Li^2$

Eddy Current

It is induced when magnetic flux linked with the conductor changes

Rectangular loop



emf induced

$E = vBl$

$i = \frac{vBl}{R}$

Magnetic force on the loop

$F = B^2 l^2 v/R$

= force required to move the loop with constant velocity (v)

Thermal power developed in the loop is

$P = \frac{v^2 B^2 l^2}{R}$

Induced EMF

$E = \frac{d\phi}{dt}$

Induced current

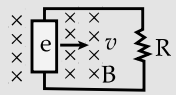
$I = \frac{E}{R} = -\frac{1}{R}\frac{d\phi}{dt}$

Motional EMF

$E = \left|\frac{d\phi}{dt}\right| = \left|Bl\frac{dx}{dt}\right|$

$= Blv$

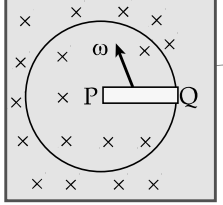
$i = vbl/(R+r)$



r = resistance of rod moving with velocity v in uniform magnetic field $\vec{B}$

EMF induced in a rotating conductor

$E = \frac{1}{2}B\omega l^2$



Electromagnetic Induction & Alternating Currents Part-2

AC Current

Direction of current changes alternatively
$i = i_0 \sin\omega t$
$v = v_0 \sin\omega t$

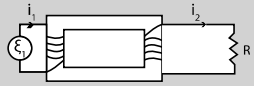
- RMS value or root mean square value
  - $i_{rms} = i_0/\sqrt{2}$
  - $v_{rms} = v_0/\sqrt{2}$
- Mean value or Average value
  - $i_{mean} = 2i_0/\pi$
  - $v_{rms} = 2v_0/\pi$
- Peak value or Max^m value
  - $i_0 = \sqrt{2}\, i_{rms}$
  - $v_0 = \sqrt{2}\, v_{rms}$

A C Generator

A device generating alternating current having elements magnet, Armature and graphite Brushes emf induced through coil

$E = NBA\,\omega \sin\omega t$

$i = E/R = NBA\,\omega \sin\omega t/R$



$E_2 = -N_2E_1/N_1$

$i_2 = -N_1E_1/N_2$

If $N_2 > N_1$ it is called step–up Transfomer

If $N_1 > N_2$, it is called step–down

Transformer

It is used to obtain a high AC voltage from a Low–voltage AC source or vice–versa

Efficiency of a transformer

- η = output power/Input power
- 99% efficiency can easily achieved

Power in AC Circuit

$P = E_{rms}\, i_{rms} \cos\phi = \frac{E_0}{\sqrt{2}} \times \frac{i_0}{\sqrt{2}} \cos\phi = \frac{1}{2} E_0 i_0 \cos\phi$

Impedance

The ratio of emf applied and the current produced in an AC circuit
$Z = E_0/i_0$ Ohm

Reactance

The hindrance offered by inductor or capacitor or both to the flow of AC (χ)

A C Circuits

Inductive (L) circuit

$i = i_0 \sin\left(\omega t - \frac{\pi}{2}\right)$

Phase difference b/w V& I, $\phi = \pi/2$

Power factor $\cos(\phi) = 0$

Voltage leads current by $\pi/2$

$P = 0$

Capacitive (C) circuit

$i = i_0 \sin\left(\omega t + \frac{\pi}{2}\right)$

$\phi = \pi/2$ or $-\pi/2$

$\cos\phi = 0$

Power(P) $= 0$

Current leads the voltage by $\pi/2$

Resistive (R) circuit

$i = i_0 \sin(\omega t)$

$\phi = 0°$

$\cos\phi = 1$

$P = V_0\ _0/2$

Current & voltage both are in same phase

R–C circuit

$i = i_0 \sin(\omega t + \phi)$

$Z = \sqrt{R^2 + X_c^2}$

$X_c = 1/\omega C$

$\tan\phi = 1/\omega CR$

$i_0 = E_0/Z$

- Power factor $\cos\phi = \frac{R^2}{\sqrt{R^2 + X_c^2}}$
- current leading.

L–C circuit

$i = i_0 \sin\left(\omega t \pm \frac{\pi}{2}\right)$

$X = X_L - X_C$

$\phi = \pi/2$

- Power factor = 0, Either voltage or current leading

L–R circuit

$i = i_0 \sin(\omega t + \phi)$

$Z = \sqrt{R^2 + X_L^2}$

$X_L = \omega L$

$\tan\phi = \omega L/R$

$i_0 = E_0/Z$

- power factor = R/Z
- voltage is leading

L–C–R circuit

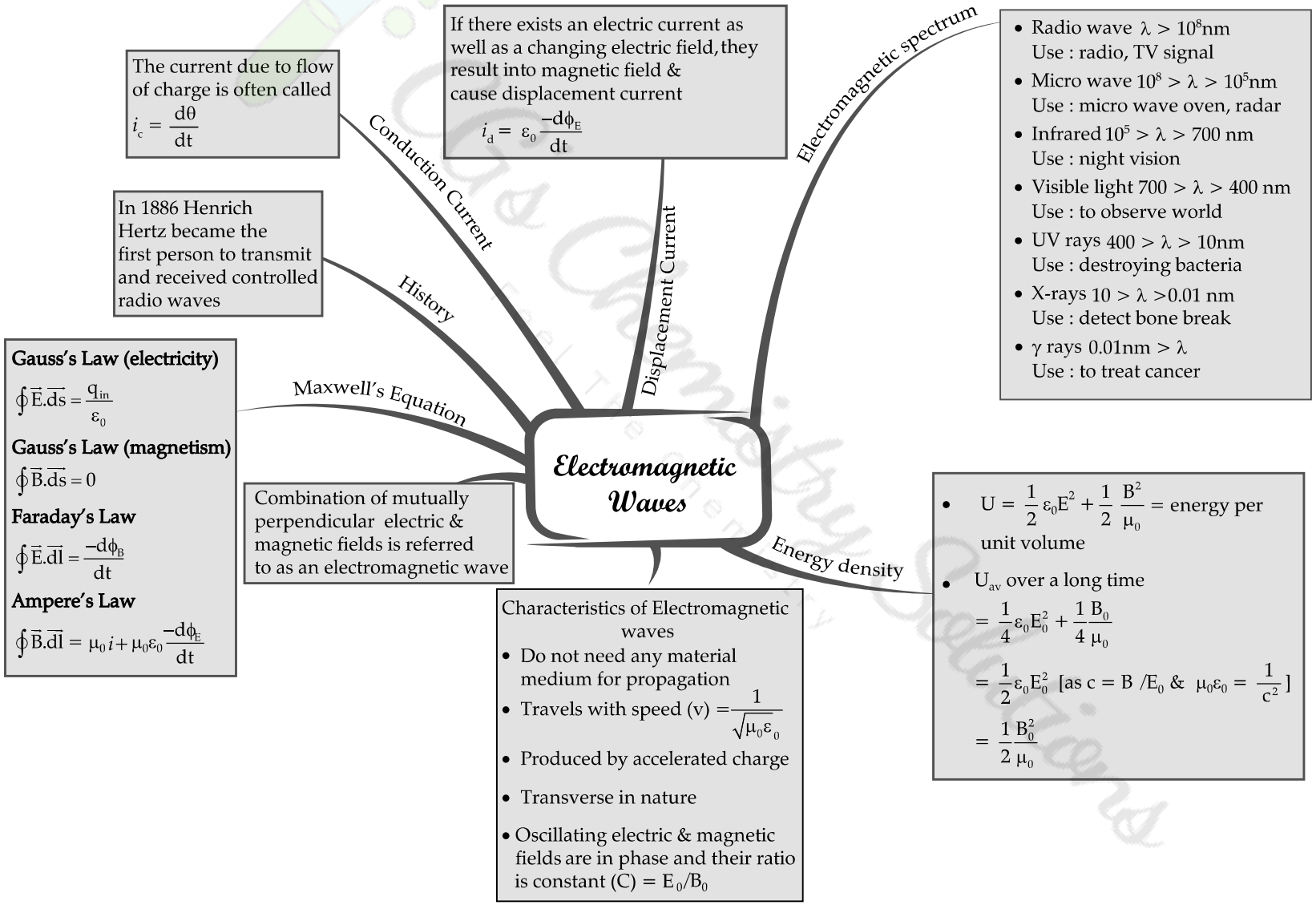
$i = i_0 \sin(\omega t \pm \phi)$

$Z = \sqrt{R^2 + (X_c - X_L)^2}$

$X = X_c - X_L$

$= \left(\frac{1}{\omega c} - \omega L\right)$

$\tan\phi = \left(\frac{1}{\omega c} - \omega L\right)/R$, $i_0 = \frac{E_0}{Z}$



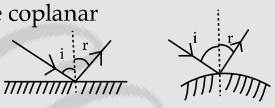
Optics Part-1

Sign Conversion

- Pole is taken as origin
- Principle axis as the X-axis
- All distance are measured from origin (or pole)
- All distance measured in the direction of incident ray are taken + ve.
- All distance measured in the direction opposite to the incident ray are taken - ve.

Reflection of Light

- $\angle i = \angle r$
- Incident ray reflected ray and normal to the reflecting surface are coplanar

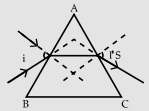


Prism

Angle of deviation $\delta = i - i' - A$

$\delta_{minimum} = 2i - A \quad [i = i']$

$\delta_{minimum} = (\mu - 1)A$, if A is small



Scattering of Light

Light scattered i.e. redirected in different paths when interacts with particle
e.g. sunset, sunrise, colours, blue colour of sky

Spherical Mirror

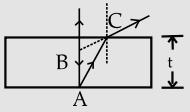
$$\frac{1}{u}+\frac{1}{v}=\frac{2}{R}=\frac{1}{f}$$

Lateral Magnification $= \frac{h_2}{h_1} = -\frac{v}{u}$

Refraction of light

$$\frac{\sin i}{\sin r} = \frac{v_1}{v_2} = \frac{\mu_2}{\mu_1}$$

$$\mu = \frac{real\ depth}{apparent\ depth}$$



$\Delta t = \left(1 - \frac{1}{\mu}\right)t$ = image shift

Microscope

$M = 1 + \frac{D}{f}$ [image at near point]

$M = D / f$ [image at infinite]

Compound Microscope

$M = \frac{v}{u}\left[\frac{D}{f_e}\right]$ [normal adjustment]

$M = \frac{v}{u}\left(1 + \frac{D}{f_e}\right) = -\frac{1}{f_o}\left(1 + \frac{D}{f_e}\right)$

For final image at least distance

Telescope

$M = \frac{f_o}{f_e}\left(1 + \frac{f_e}{D}\right)$ [image at near point]

$M = -\frac{f_o}{f_e}$ [image at infinite]

Total internal refection

When ray passes from optically denser to rarer medium, if incident angle (i) further increased till $(\theta)_C$ critical angle, entire light is then reflected back to the denser medium again, this process is called T.I.R. It is used in optical fibre.

Critical Angle

- Incident angle (θ_c) for which angle of refraction is 90°

i.e. $\sin\theta_c = 1/\mu$

$\theta_c = \sin^{-1}\left(\frac{1}{\mu}\right)$

When ray passes from optically denser to rarer medium.

Refraction on Spherical surface

$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$

Lateral Magnification

$$m = \frac{h_2}{h_1} = \frac{\mu_1 v}{\mu_2 u} = \frac{R - v}{R - u}$$

Lens Maker's Formula

$$\frac{1}{v} - \frac{1}{u} = \frac{\mu_2 - \mu_1}{\mu_1}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f} = \left(\frac{\mu_2}{\mu_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad [If\ \mu_2 = \mu, \mu_1 = 1\ (air)]$$

$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$ (lens formula)

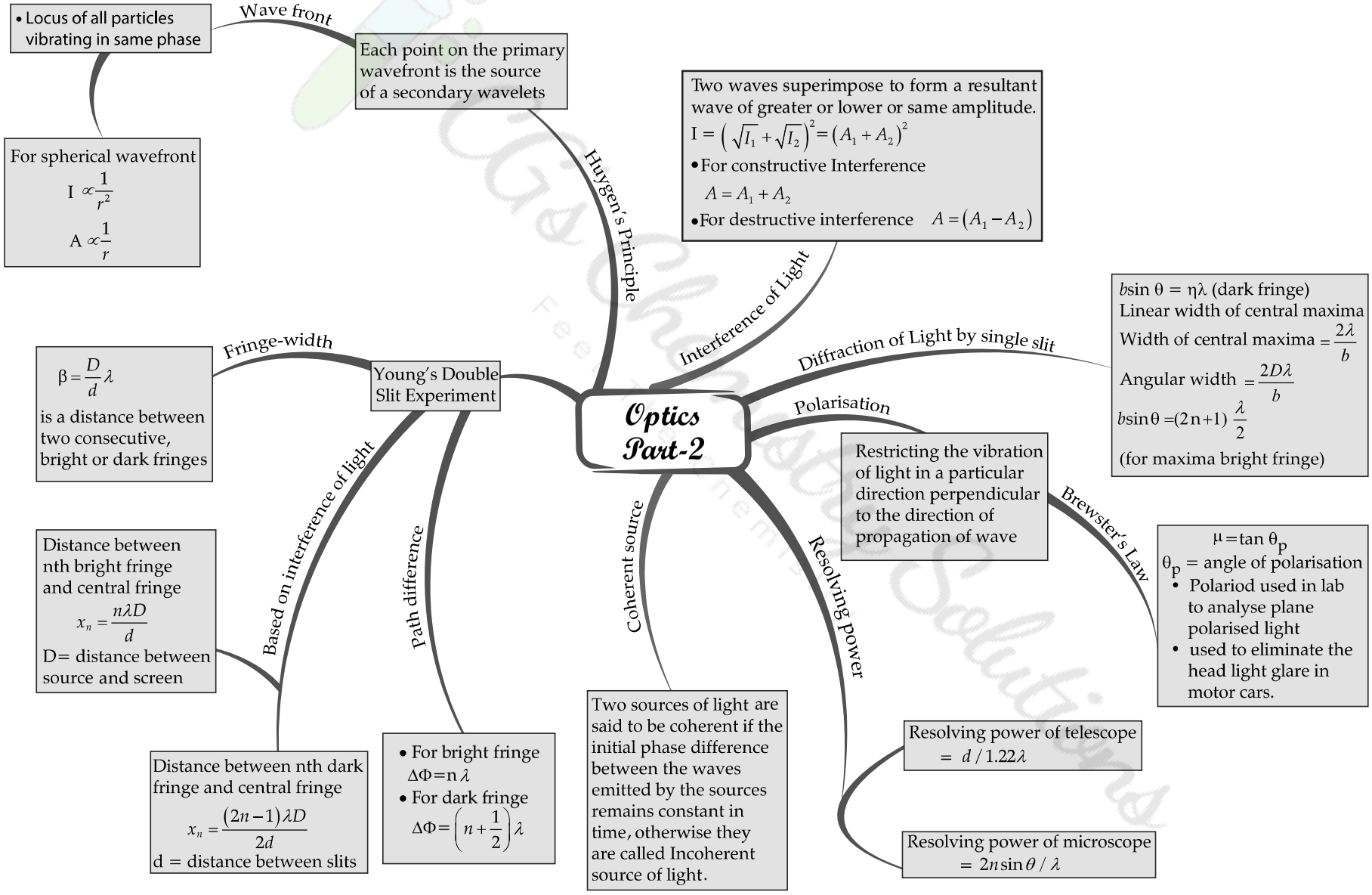
Lateral Magnification $= \frac{h_2}{h_1} = \frac{v}{u}$

Power of a lens

$$P = \frac{1}{f}$$

[For Combination of lens in Contact]

$$P = \frac{1}{f_1} + \frac{1}{f_2}$$



Dual Nature of Matter & Radiation

Dual Nature of Radiation

- Light has both wave character as well as particle
- Interference can be explained by wave nature
- When light is of sufficiently low wavelength, it behaves as particle
- Light particles having definite energy and definite linear momentum are called "photons"
  Energy of each photon = $h\nu = hc/\lambda$
  Momentum of each photon = $h/\lambda = E/c$

Contribution

Einstein, after an average academic career put forward quantum theory of light in 1905 while working as a grade III technical officer in a patent office.

Matter waves

All matter can exhibit wave–like behaviour e.g. beam of electrons can be diffracted like a water wave

de - Broglie relation

$\lambda = h/p$

λ = wavelength associated with particle or de-Broglie wavelength

p = momentum

$$\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2\,m\,K_{max}}}$$

Davisson–Germer Experiment

A beam of electrons emitted by electron gun is made to fall on nickel crystal cut along cubical axis at a particular angle .Scattered beam of electrons is received by detector.

Results : λ = de Broglie's wavelength
$= h/p$
$= 1227/\sqrt{v}$ nm
$= 1227/\sqrt{54}$ nm
$= 0.167$ nm $= 1.67$ Å

This experiment verifies the wave nature of electrons & relation with de-Broglie wavelength.

Photoelectric Effect

- When light of sufficient small wavelength is incident on metal surface, electrons are ejected from the metal, the phenomenon is called photoelectric effect.
- Ejected electrons are called photoelectrons
- Minimum energy equal to work function (ϕ) must be given to an electron so as to bring it out of the metal

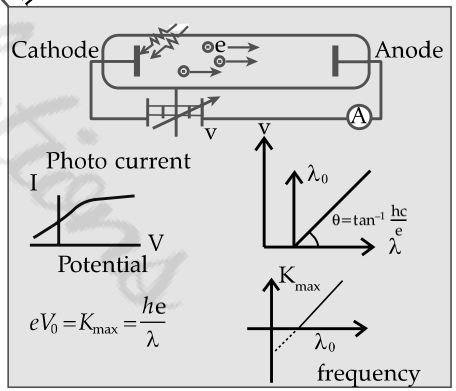
Einstein's Photoelectric equation

- $K_{max} = E - \phi = eV_0$
  $= \frac{hc}{\lambda} - \phi$, V_0 = stopping potential
  K_{max} = maximum kinetic energy of elected electrons

Hore, $\lambda_0 = hc/\phi$
λ_0 = Threshold Wavelength
$\lambda_0 = c/\lambda_0 = \phi/h$
λ_0 = Threshold frequency
$K_{max} = \lambda(\nu - \nu_0)$

- If $\lambda = \lambda_0 = hc/\phi$
  $K_{max} = 0$, *i.e.*
  Electron may just come out.
- If $\lambda > \lambda_0$
  i.e. $E < \phi$
  no electron will come out
- If $\lambda \le \lambda_0$.
  Photoelectric effect takes place this λ_0
- λ_0 = depends on metal used

Hertz and Lenard's Observation



Atoms & Nuclei Part-1

Contribution

- α- particle bombarded on thin gold foil
- Most of α– particle passed undeviated or with a small angle
- 1 out of 8000 α particles were deflected by scattering angle

α – particle scattering experiment

Impact parameter

$$b = \frac{Ze^2 \cot \theta/2}{4\pi\varepsilon_0\left(\frac{1}{2}mv^2\right)}$$

In 1898 J.J Thomson proposed the first model of atom also known as plum-pudding model

Energy of electron in each stationary orbits is

Given by $E_n = -13.6\ \frac{Z^2}{n^2}$ eV

Where n = 1,2,3….

Z = atomic number of atom

- These stationary energy orbits are also called energy levels.
- When electron jumps from higher energy level to lower energy level it releases energy.

$$\Delta E = E_f - E_i = 13.6\left[\frac{1}{n_i^2} - \frac{1}{n_f^2}\right]Z^2 eV$$

Energy Level

Hydrogen Spectrum

- Hydrogen gas heated in a sealed tube emits radiation which passes through prism components of different wavelengths appear
- Wavelength in each series given by

$$\bar{\nu} = \frac{1}{\lambda} = R\left[\frac{1}{n_i^2} - \frac{1}{n_f^2}\right]$$

$n_f > n_i$

- Lyman series [U.V. region]
  $n_i = 1$, $n_f = 2,3,4….$
  $\lambda_{min} = 912$ Å , $\lambda_{max} = 1216$ Å
- Balmer series [visible region]
  $n_i = 2$ $n_f = 3, 4, 5…..$
  $\lambda_{min} = 3648$ Å , $\lambda_{max} = 6563$ Å
- Paschan series [I–R region]
  $n_i = 3$ $n_f = 4, 5, 6…..$
  $\lambda_{min} = 8208$ Å , $\lambda_{max} = 18761$ Å
- Brackett series [I R region]
  $n_i = 4$ $n_f = 5, 6, 7…$
  $\lambda_{min} = 14592$ Å $\lambda_{max} = 40533$ Å
- P –fund [I R region]
  $n_i = 5$ $n_f = 6, 7, 8……$
  $\lambda_{min} = 23850$ Å $\lambda_{max} = 74618$ Å

Rutherford's Model

Postulates

- Atoms have a central, massive, positively charged core called nucleus around which electron revolves.
- Size of nucleus ≈ 1 fermi = 10^{-15}m

Drawbacks

- Doesn't explain the stability of atom
- Doesn't explain the atomic spectra

Bohr Model

Postulates

- Electron revolves around the nucleus in stationary orbits
- Angular momentum of electron

$$mvr_n = n \times \frac{h}{2\pi}$$

n = Integers. It is also known as principle Quantum Number

- It explains spectrums of hydrogen or hydrogen like [He^+, Li^{++}] atoms.

Limitations

- Fails to explain spectrum of complex atoms/ions of multi electron system
- Doesn't explain Zeeman's and Stark's effect

Radius of nth Bohr's orbit

$$R_n = \frac{\varepsilon_0 h^2}{\pi me^2}\left(\frac{n^2}{Z}\right) = 0.53\ \frac{n^2}{Z}\text{ Å}$$

Velocity of electron in nth Bohr's orbit

$$v_n = \frac{e^2}{2\varepsilon_0 h}\left(\frac{Z}{n}\right) = 2.2 \times 10^6\ \frac{Z}{n}\text{ m/s}$$

Total Energy

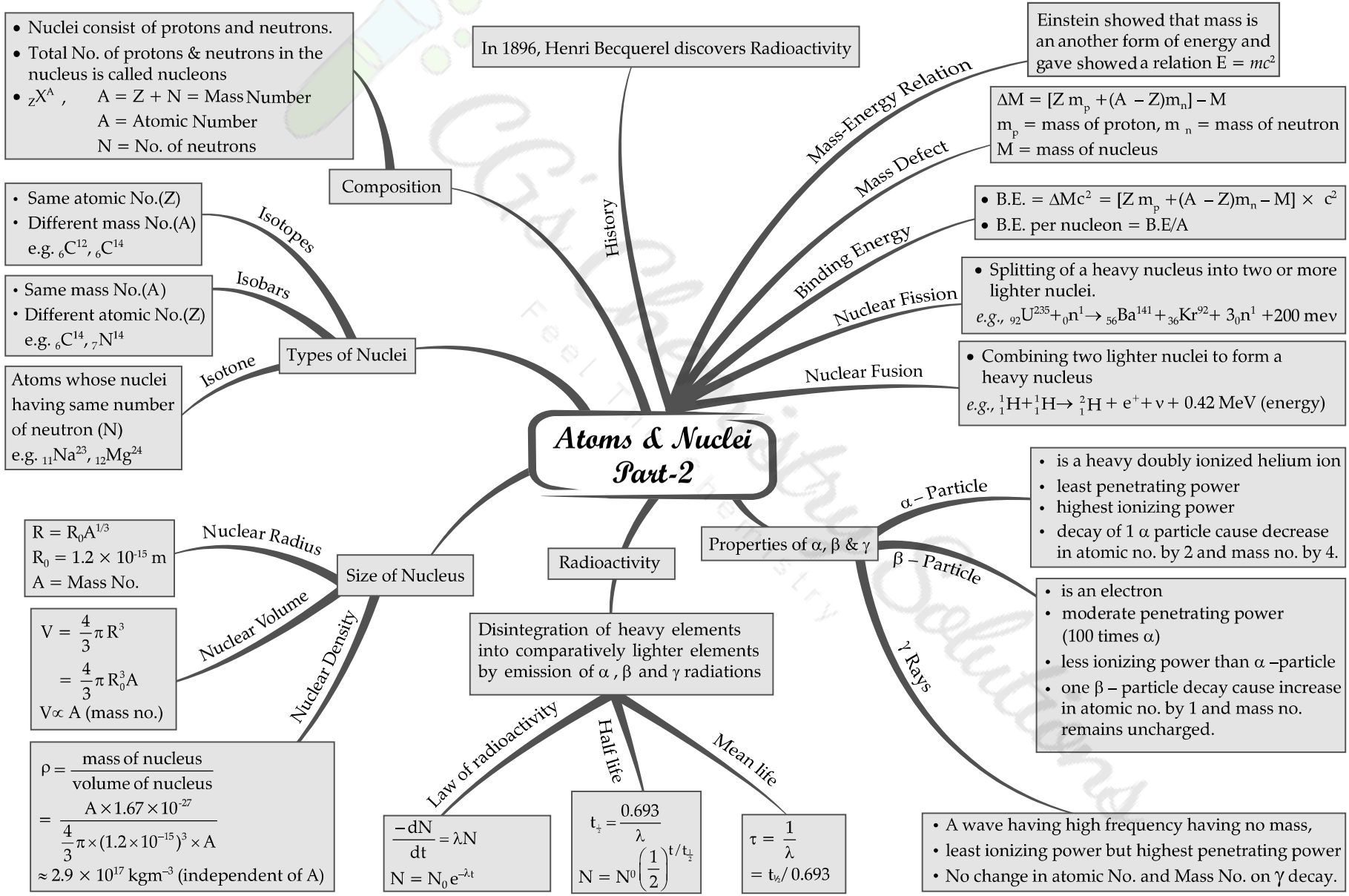
Potential Energy

$$U_n = -\frac{KZe^2}{r_n} = \frac{-me^4}{4\varepsilon_0^2 h^2}\left(\frac{Z^2}{n^2}\right) = \frac{-27.2\,Z^2}{n^2}\text{ eV}$$

Kinetic Energy

$$E_k = \frac{KZe^2}{2r_n} = \frac{me^4}{8\varepsilon_0^2 h^2}\frac{Z^2}{n^2} = \frac{13.6^2}{n^2}Z^2\text{ eV}$$

$$E = U_n + E_k = -\frac{KZe^2}{2r_n} = \frac{-13.6\,Z^2}{n^2}\text{ eV} = \frac{U_n}{2} = -E_K$$



Electronic Devices

Energy Band

- Valence Band: The energy band which are completely filled with electron at Zero kelvin (0K)
- Conduction Band: The bands with higher energy above the valence band (C.B., E_g = Band gap, V.B.)
- Band Gap or Forbidden Gap: The difference between the highest energy in a valence band and lowest energy in the next higher band.

A range of energies associated with the quantum states of electrons in a crystalline solid.

History

In 1927, Walter Heitler and Fritz London discover bands

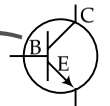
Semiconductor Diode

- P N junction Diode: Device made by a close contact of N– type and P–type semiconductors
  - Forward Biased
    - +ve terminal to P-side
    - –ve to N–side
    - diffusion current increases
    - depletion layer reduced
  - Reverse Biased
    - –ve terminal to P– side
    - +ve terminal to N–Side
    - diffusion current decreases
    - depletion layer increases
- Zener Diode: used as a voltage regulator
- Light Emitting Diode/LED: used in T.V. or electronic gadgets.
- Photo Diode: is a P.N. junction whose function is controlled by the light allowed to fall on it.

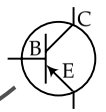
Transistor

Types

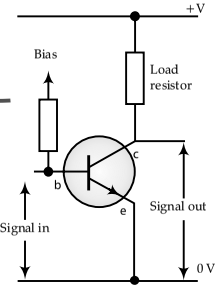
- NPN F_1



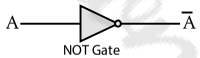
- PNP F_2

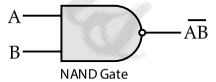


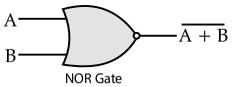
Amplifier (CEC)



Logic gates







Classification of metals, Semiconductor & Insulator on the basis of band theory

- Conductors
  - → Eg = 0 or least
  - → Density of charge carriers is very high (For electrons e)
  - $= 9 \times 10^{23}\ m^{-3}$ for For Hole (h)
  - $= 0\ m^{-3}$ (in case of copper)
- Semiconductors
  - E_g = 0.72 eV for Ge ≈ 1.1ev for Si
  - $0 < E_g <$ Insulator
  - → very low (e)
  - For– n–type $= 7 \times 10^{15} m^{-3}$ for *Si* doped with P (C.B, E_g, V.B)
  - For– p–type $= 1 \times 10^{9} m^{-3}$ for Si doped with Al
- Insulators
  - E_g = very high ≈ 7eV for diamond negligible ≈ 0 (C.B, E_g >>, V.B)

Intrinsic Semiconductor

- Pure semiconductor
- Charge carrier concentration $n_i = n_e = n_h$
- $I = n_e + n_h$
- e.g. Si (Silicon)

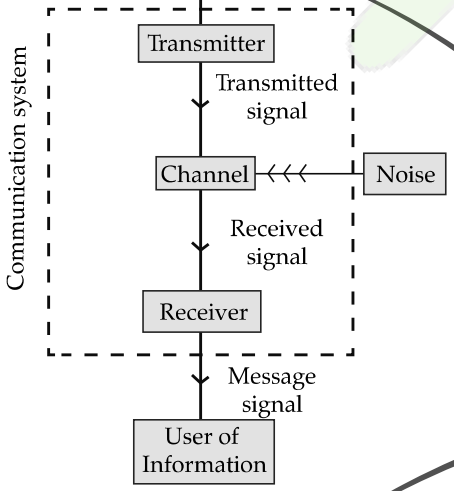
Extrinsic Semiconductor

Impure or doped semiconductor

- P–Type Semiconductor
  - Si or Ge doped with pentavalent (P,As, Sb) elements
  - Electrons are majority carriers
  - Holes are minority carriers
- N–Type Semiconductor
  - Si or Ge doped with trivalent (B, Al) elements
  - Electrons are minority carriers
  - Holes are majority carriers

Communication Systems

Block diagram

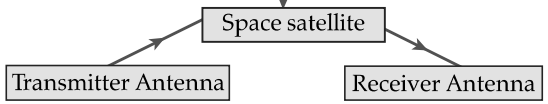


Contribution

Sir Tim Burners–Lee invented the world–wide web (www) in 1989

Propagation of Electromagnetic waves in Atmosphere

Transmitter antenna radiates E.M. waves, these waves travel through space & reach receiving antenna at other end.



Sky waves

- Ionosphere plays major role in sky wave propagation.
- In ionosphere ionization occurs due to the absorption of UV rays coming from the sun by the air molecule.
- In this layer bending of E.M. wave occurs so that they are diverted towards the earth which is helpful in sky wave propagation.
- Radio waves (1710 K HZ to 40 MHZ) are propagated in sky wave propagation.

Space Wave

- Space waves travel in straight line from transmitter antenna to receiver antenna.
- It is used for line of sight communication as TV broadcast or satellite communication.
- The maximum line of sight (LOS) distance $d_m = \sqrt{2Rh_T} + \sqrt{2Rh_r}$
  h_T = height of transmitter antenna
  h_r = height of receiver antenna.

Modulation

To transmit the information signal of low frequency, it is super imposed on high frequency wave as a carrier wave called modulation.

Demodulation

The process of retrieval of information from the carrier wave at the receiver is termed as demodulation. It is reverse of modulation

Band width of Transmission Medium

Signal	Band width
Mobile phone	896 – 901 M Hz 840 – 935 M Hz
Satellite Communication	5.9 – 6.4 G Hz 3.7 – 4.2 G Hz
AM	540 – 1600 kHz
FM	88 – 108 M Hz
TV (V HF)	54 – 72 M Hz
(V HF)	76 – 216 M Hz 420 – 890 M Hz

Band Width

It refers to the data carrying capacity of a channel or medium

Signal	Band width
speech/voice	300 Hz – 3100 Hz
Music signals	20 Hz – 20 K Hz
Video signal	4.2 M Hz
TV signals (both voice & video)	6 M Hz

PHYSICS

Class - 11, Unit-I

Physical World

Good **W**orkers **w**ork **f**or **E**xtended **S**ession.

Strength wise arrangement of fundamental forces in ascending order : **G**ravitation < **W**eak Nuclear force < **E**lectromagnetism < **S**trong Nuclear force

Class - 11, Unit-II

Motion In A Straight Line

Delhi **t**o **V**adodara **v**ia **T**undla **A**gra.

Displacement/**t**ime = **V**elocity

Velocity / **t**ime = **a**cceleration

Class - 11, Unit-III

1.(a) Newton's Laws of Motion

Newton, Newton don't kick cow
She may move ahead little bit now*
Newton hears her MAAA sound**
Cow gives Newton a kick rebound***

* Newton's 1st law. A body continues its state of rest or state of motion unless it is acted upon by an unbalanced force.

** Newton's 2nd law F = ma

*** Newton's 3rd law : Every action has its equal and opposite reaction

Interpretation :

1st two lines of the rhyme depicts the 1st law of motion

3rd line depicts the 2nd law of motion

i.e. F = m × l

Lat the depicts the 3rd law of motion

1.(b) Motion In A Straight Line

A will be **I**, when 0 is close to **T**

Replace the "Δ" simply with "d"

Average Velocity = ΔD/ΔT

$\lim_{\Delta T \to 0} \frac{\Delta D}{\Delta T}$ = **I**nstantaneous velocity = dD/dT

Average Acceleration = ΔV/ΔT

$\lim_{\Delta T \to 0} \frac{\Delta V}{\Delta T}$ = Instantaneous velocity = dV/dT

Class - 11, Unit-IV

Work, Energy And Power

Fernandez **d**'souza **o**rdered **n**oodles, **b**ut **w**as **s**erved **p**izza **a**nd **p**izza **w**as **a** **z**est.

If **f**orce and **D**isplacement are in **o**pposite direction, then work done is **n**egative.

If **f**orce and **D**isplacement are in **s**ame direction, then work done is **p**ositive.

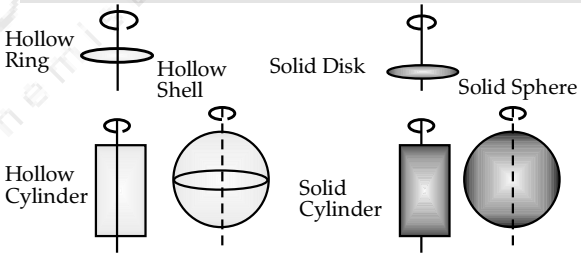
If force and Displacement are **p**erpendicular to each other, then **w**ork done is **z**ero.

Class - 11, Unit-V

Motion Of System Of Particles & Rigid Body

How **r**hino **c**ame **s**wift? **S**ince **d**ino **c**ame **s**low.

Write $2MR^2$ under each figure and then divide by 2, 3, 4, 5 respectively.



Class - 11, Unit-VI

Kelper's Laws of Planetary motion :

Take **E**ssential **F**oods **E**veryday **2/3 T**imes

1st Law: Planets move in **elliptical** orbits

Sun is at one of **foci** of the orbit

2nd Law: A planet covers the **equal** area of space in **equal** interval of time no matter where it is in its orbit

3rd Law: Square of the **Time-period** of the planet is proportional to the cube of the semi major axes of the orbit. $T^2 \propto R^3$

Interpretation:

Letter E and F of Essential Food represents ''Elliptical'' and ''Foci".

1st Law : Planets move in **elliptical** orbits with Sun at one of the foci.

Letter E of the word Everyday represents "Equal":

2nd Law : A planet covers the equal area space in equal interval of time no matter where it is in its orbit.

2/3 and T of the last two words represents the "power of Time Period" and "power of semi-major axis:

3rd Law :

Square of the Time-period of the planet is proportional to the cube of the semi major axes of the orbit.

$T^2 \alpha R^3$.

Class - 11, Unit-VII

1. Mechanical Properties Of Solid

Young **R**avi **b**ought **a** **p**en.

(1) Relation between **Y**, **B** and σ : (write Y and B(1+ σ) with coefficients and an equal sign in between. 1Y = 3B (1 + σ)

To find the coefficient of σ, refer the anti-clock circle, subtract the coefficients of B from

coefficient of Y i.e. 1 – 3 = -2

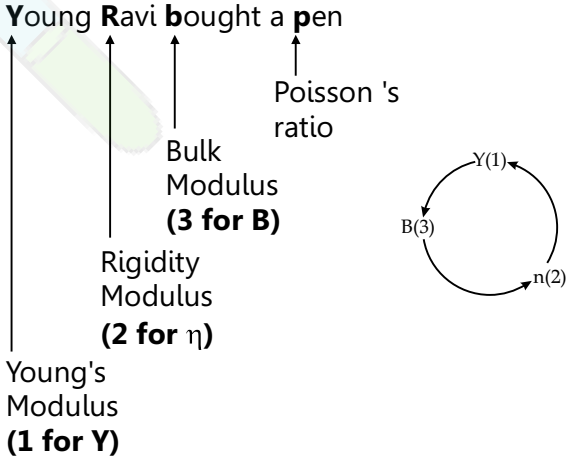
So, the relation is 1**Y** = 3**B** (1 - 2σ) or, **Y** = 3**B** (1 - 2σ)

(2) Relation between **Y**, η and σ : (write **Y** and η(1+ σ) with coefficients and an equal sign in between.

1**Y** = 2η (1 + σ)

To find the coefficient of σ, subtract the coefficient of **Y** from coefficient of η i.e. 2 – 1 = 1

So, the relation is 1**Y** = 2η (1 + σ) or, **Y** = 2η (1 + σ)



2. Thermal Properties of Matter

Fingers **w**e **h**ave **f**ive
Cats **h**ave **n**ine **l**ives.
With **160** **m**ore
Cat **w**ill **h**elp **y**ou **s**ure!

Fingers we have five → 5F

Cats have nine lives. → 9C

With 160 more → 9C + 160

Cat will help you sure! → 5F = 9C + 160

Class - 11, Unit-VIII

Thermodynamics

Temperature, **V**olume, **P**ressure **N**o **H**eat **i**s **t**ransferred

Constant **t**emperature → Isothermal process

Constant **v**olume → Isochoric process

Constant **p**ressure → Isobaric process

No **h**eat **t**ransferred → Adiabatic process

Class - 11, Unit-IX

Behaviour of Perfect Gas & Kinetic Theory

Degrees of freedom :
Baa Baa Black Sheep
Have you any wool?
Yes sir, **M**om has **3** bags full.
Dadi needs **5** bags **n**ormally cool
Papa keeps **6** bags **n**ormal rule.
Papa, **D**adi each needs **2** bags more
High **c**old whenever, be very sure.

Mom has **3** bags full → Degrees of freedom of Monoatomic gas is 3.

Dadi needs **5** bags **n**ormally cool

Degrees of freedom of diatomic gas at normal → (room) temperature is 5.

Papa keeps **6** bags **n**ormal rule → Degrees of freedom of Polyatomic gas at normal (room) temperature is 6.

Papa, **D**adi each needs **2** bags more → Degrees of freedom of Polyatomic gas at high temperature is 6+2=8.

High cold whenever, be very sure → Degrees of freedom of Diatomic gas at high temperature is 5+2=7.

Class - 11, Unit-X

Waves

Teacher **P**unished **L**azy **D**og.

Particle oscillation in **T**ransverse wave → **P**erpendicular to the direction of propagation of wave

Particle oscillation in **L**ongitudinal wave → In the **d**irection of propagation of wave

Class - 12, Unit-I

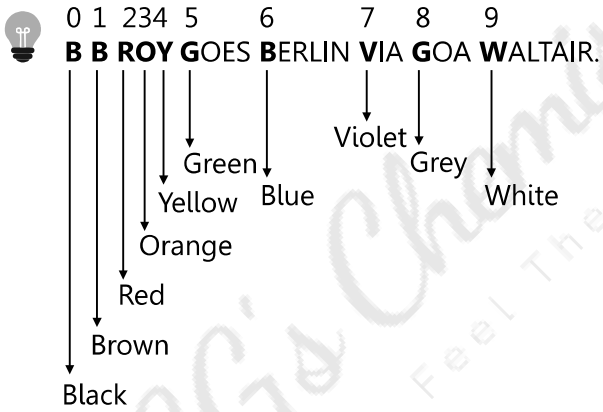
Electric Charge & Field

Equally **d**ivide **c**ost **p**er **a**nnum.

To find **e**lectric field, **d**ivide the **c**harge (enclosed) by the free space **p**ermittivity and **a**rea of the Gaussian

Class - 12, Unit-II

Resistor colour code :



Interpretation :

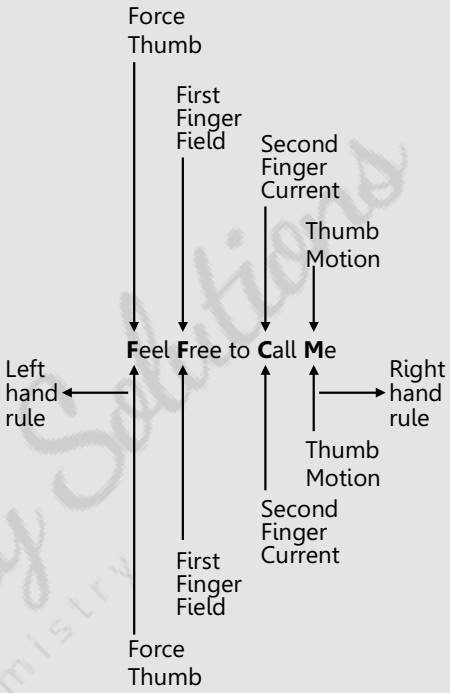
Colour codes of carbon resistors :

Colour	Corresponding number
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Berlin	6
Violet	7
Grey	8
White	9

Class - 12, Unit-III

Moving Charge And Magnetism

Fleming's left and right hand rule:



In Fleming's left hand rule, Thumb indicates FORCE.

In Fleming's left hand rule, Thumb indicates MOTION.

In both rules, first finger indicates FIELD and second finger indicates CURRENT

Class - 12, Unit-IV

Alternating Current

Calcutta **C**ity **V**ery **L**ovely **a**nd **V**ery **C**ongested

For **c**apacitive circuit → **C**urrent leads **V**oltage

For **i**nductive circuit → **v**oltage leads **c**urrent

Class - 12, Unit-V

Electromagnetic Waves

Russian **M**agician **s**howed **a**n **I**nteresting **V**ery **U**nusual **X**-ray **e**ye **G**ame

Electromagnetic waves with increasing frequency (decreasing wavelength) is in the order of:

(a) **R**adio wave

(b) **M**icrowave

(c) **I**nfrared

(d) **V**isible light

(e) **U**ltraviolet

(f) **X**-Rays

(g) **G**amma Rays

Class - 12, Unit-VI

(a). Ray Optics & Optical Instruments

M means **M**ORE **i.e**

Mirror Formula

↓

M means **MORE** i.e+

So, $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$

Magnification will be of opposite sign :

So, $m=-\frac{v}{u}$

Particle oscillation in Transverse wave → Perpendicular to the direction of propagation of wave

Particle oscillation in Longitudinal wave → In the direction of propagation of wave

(b). Ray Optics & Optical Instruments

L means **M**ORE **i.e**

Lens Formula

↓

L means **LESS** i.e–

So, $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$

Magnification will be of opposite sign :

So, $m=+\frac{v}{u}$

Particle oscillation in Transverse wave → Perpendicular to the direction of propagation of wave

Particle oscillation in Longitudinal wave → In the direction of propagation of wave

Class - 12, Unit-VII

Einstein's equation of Photoelectric effect :

W E Unite to form **P**eople

↓ Photon energy

Add

Energy of electron emitted

Work Function

Energy of emitted electron + Work function = Energy of incident Photon

Interpretation :

$E + \varphi = hf$

Or, $E = hf = \varphi$

Class - 12, Unit-VIII

(a). Atom : Hydrogen Spectra

Papa **b**rings **P**astry **f**or **B**abu **a**nd **L**al

When ni = 1, the series is **L**yman

When ni = 2, the series is **B**almer

When ni = 3, the series is **P**aschen

When ni = 4, the series is **B**rackett

When ni = 5, the series is **p**-fund

(b). Atom : Hydrogen Spectra

1 is **U**nimportant, **2 i**s **V**ery **i**mportant **a**nd **r**est **a**re **I**mportant

If ni = 1, i.e. Lyman series is in **UV** range.

If ni = 2, i.e. Balmer series is in **VIS**IBLE range.

If ni = 3, 4 and 5, i.e. Paschen series, Brackett series and p-fund series are in **IR** range

(c). Isotope, Isobar, Isotone

ISO **T**ope **B**ar **T**one

- TOPE — Ⓟi.e numbers of PROTONs are same and numbers of NEUTRONs different
- ISO—BAR — NoⓅNoⓃi.e. both PROTONs and NEUTRONs differ in number (Total remains same.)
- TONE — Ⓝi.e. numbers of NEUTRONs are same and numbers of PROTONs different

In isotopes, numbers of protons are same. Numbers of neutrons are different.

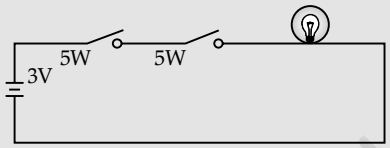
In isotones, numbers of neutrons are same. Numbers of protons are different.

In isobars, numbers of neutrons are different. Numbers of protons are also different. But the total nucleons remain same.

Class - 12, Unit-IX

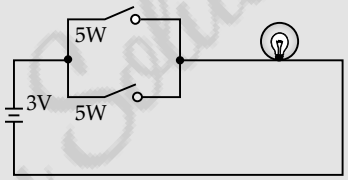
Electronic Devices

Truth **t**able of **A**ND and **OR g**ate



For AND gate, when both the switches are ON, then only the bulb is ON.

i.e. When both the inputs are 1, then only output is 1. Otherwise the output is 0.



For OR gate, when both the switches are OFF, then only the bulb is OFF.

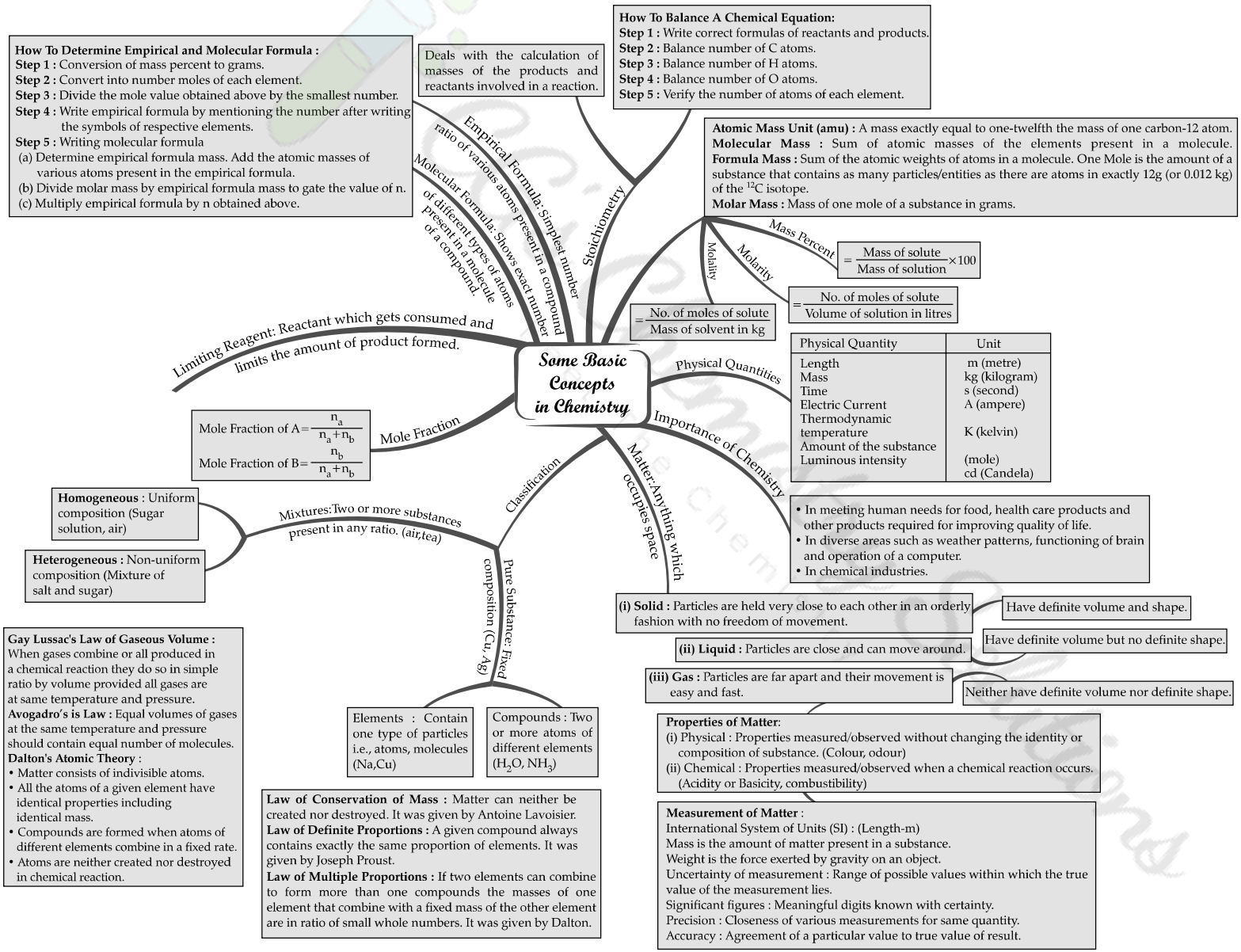
i.e. When both the inputs are 0, then only output is 0. Otherwise the output is 1

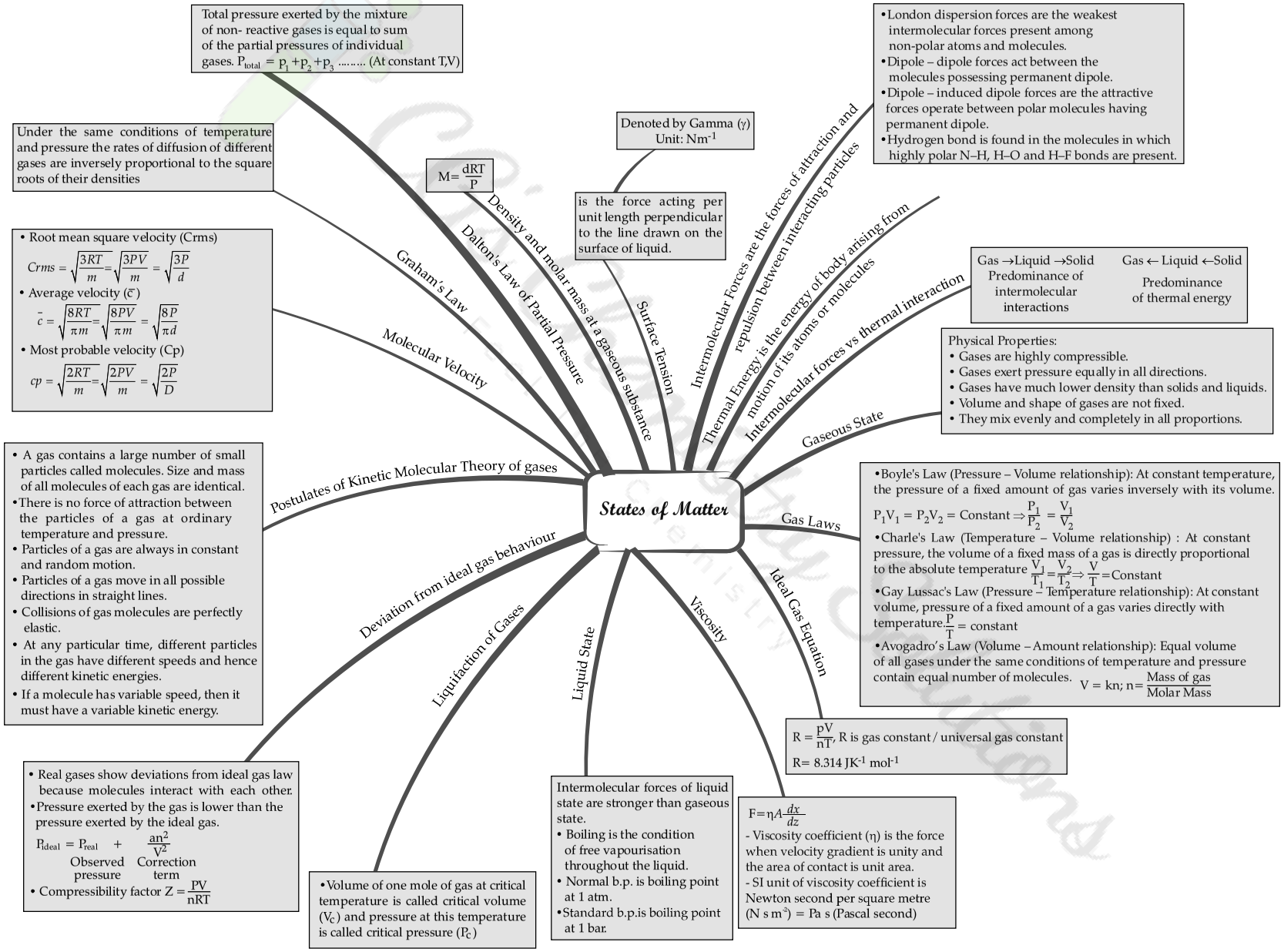
CHEMISTRY

MIND MAPS

&

MNEMONICS





Atomic Structure

Atomic Number (Z)

Number of protons in nucleus of an atom or Number of electrons in a neutral atom

Mass Number (A)

Number of protons (Z) + number of neutrons (*n*)

Isotopes

Atoms of same element having same atomic number but different mass number. (Isotopes of hydrogen: Protium $^{1}_{1}H$, Deuterium $^{2}_{1}D$ and Tritium $^{3}_{1}T$).

Isobars

Atoms of different elements with different atomic number but same mass number. ($^{40}_{20}Ca$ and $^{40}_{18}Ar$)

Discovery of Electron

By J.J.Thomson Charge to mass ratio of electron
$= 1.758820 \times 10^{11}\ C\ kg^{-1}$
Charge electron $= 1.6022 \times 10^{-19} C$
Mass of electron $= 9.1094 \times 10^{-31} Kg$

Discovery of Proton

By Ernest Rutherford
Charge on proton $= +1.6022 \times 10^{-19} C$
Mass of Proton $= 1.672 \times 10^{-27}$ Kg

Discovery of Neutron

By James Chadwick
Charge on neutron = 0
Mass of neutron $= 1.675 \times 10^{-27}$ Kg

Thomson Model of Atom: (Watermelon Model)

Atom possesses a spherical shape in which the positive charge is uniformly distributed.

Rutherford's Nuclear Model of Atom

Postulates:
- Positive charge and most of the mass of atoms was densely concentrated in extremely small region i.e. nucleus.
- Nucleus is surrounded by electrons that move around the nucleus with high speed in circular path called orbits.
- Electrons and nucleus are held together by electrostatic forces of attraction.

Drawbacks:
- It cannot explain the stability of an atom.
- It does not say anything about the electronic structure of atoms.

Developments Leading To Bohr's Model of Atom

Photoelectric Effect: It was found By H.Hertz

It is the phenomenon of ejection of electrons from the surface of a metal when light of suitable frequency strikes on it.

KE of ejected electron $h\nu = h\nu_0 + 1/2\ m_e v^2$

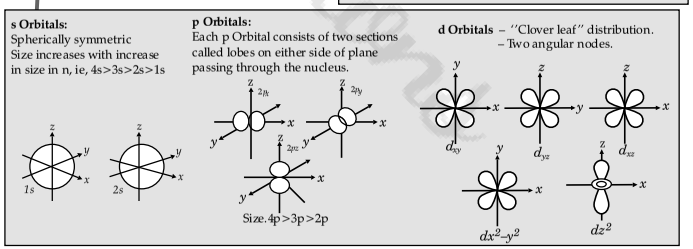
Shapes of orbitals

s Orbitals:
Spherically symmetric
Size increases in size in n, ie, 4s>3s>2s>1s

p Orbitals:
Each p Orbital consists of two sections called lobes on either side of plane passing through the nucleus.

Size. 4p>3p>2p

d Orbitals – "Clover leaf" distribution.
– Two angular nodes.

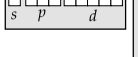


Energy of orbitals

Lower the value of $(n+l)$ for an orbital, lower is its energy.

Electronic Configuration of atoms

(i) $s^a p^b d^c$..... notation
(ii) Orbital diagram



Filling of electrons in orbitals

- **Aufbau Principle :** In the ground state of atoms, the orbitals are filled according to increasing energies.
- **Pauli Exclusion Principle :** No two electrons in an atom can have same set of four quantum numbers.
- **Hund's rule :** Pairing of electrons in the orbitals belonging to same subshell does not take place until each electron belonging to the subshell is singly occupied.

Quantum Numbers

(i) Principal quantum number (n) :n = 1,2,3,4…….. Shell = K, L, M, N.....
(ii) Azimuthal quantum number (l) : For given value of n, l = 0 to n-1
(iii) Magnetic quantum number (m) : for subshell with 'l' value $m_l = 2l+1$
(iv) Spin quantum Number (m_s): $+1/2$ (↑), $-1/2$ (↓)

Quantum Mechanical Model of Atom:

Schrodinger Equation

Fundamental Equation was developed by Schrodinger as $\hat{H}\psi = E\psi$ where $\hat{H}$ = Hamiltonian

- Dual behaviour of atom i.e., particle and wavelike. De Broglie equation: $\lambda = \frac{h}{mv} = \frac{h}{p}$
- Heisenberg's Uncertainty Principle: It is impossible to determine simultaneously, the exact position and momentum of an electron.
  $\Delta x.\ \Delta p_x \geq \frac{h}{4\pi}$
  $\Rightarrow \Delta v.\ \Delta x = \frac{h}{4\pi m}$

Bohr's Model for Hydrogen Atom

Postulates:
- Electron in H atom can move around the nucleus in a circular path of fixed radius and energy called as orbits. These orbits are arranged concentrically around the nucleus.
- Each of these orbits has a definite energy known as energy levels or stationary states.
- When an electron jumps from a lower energy level to higher one, some energy is absorbed.
- $\nu = \frac{\Delta E}{n} = \frac{E_2 - E_1}{n}$ Bohr's frequency rule.

Angular momentum of electron: $m_e v_r = n\frac{h}{2\pi}$ n=1,2,3.....

Limitations:
- Unable to account for finer details of H atom. Spectrum observed by sophisticated spectroscopic techniques.
- Could not explain the ability of atoms to form molecules by chemical bonds.

Atomic Spectra

- **Emission Spectra :** Spectrum of radiation emitted by a substance that has absorbed energy.
- **Absorption Spectra :** It is like photographic negative of an emission spectra.
- **Line / Atomic Spectra :** Emission spectra which do not show a continuous spread of wavelength from red to violet, rather they emit light only at specific wavelength with dark space between them.

Types:

$\bar{\nu} = 109677\ (\frac{1}{n_1^2} - \frac{1}{n_2^2})\ cm^{-1}$ where

n_1=1,2……$n_2 = n_1+1, n_1+2$……

Series	n_1	n_2	Spectral Region
Lyman	1	2,3.....	Ultraviolet
Balmer	2	3,4.....	Visible
Paschen	3	4,5.....	Infrared
Brackett	4	5,6.....	Infrared
Pfund	5	6,7.....	Infrared

Dual nature i.e. wave like and particle like of the electromagnetic radiation.
- Experimental results regarding atomic spectra.
- Wave nature of electromagnetic radiation.

It was given by James Maxwell.

Frequency (ν): Number of waves that pass a given point in one second. Unit – Hertz (Hz),
Velocity of light = Frequency × Wavelength

Wave number ($\bar{\nu}$): Number of wavelengths per unit length. Unit – m^{-1}

- **Particle nature of electromagnetic radiation:**
  Planck's quantum theory: E= hν
  Planck's constant (h) $= 6.626 \times 10^{-34}$ Js

Chemical Bonding and Molecular Structure

Chemical Bonding

Kossel Lewis approach to chemical bonding :

* Lewis pictured the atom as a positively charged 'kernel' and the outer shell accommodates a maximum of eight electrons.
• Lewis postulated that atoms achieve the stable octet when linked by chemical bonds.
• Kossel gave following facts:
* In the periodic table, highly electronegative halogens and highly electropositive alkali separated by noble gases.
* Formation of a negative ion from a halogen atom and a positive ion from an alkali metal atom is associated with gain and loss of electron by respective atoms.
* Negative and positive ions formed attain noble gas electronic configuration.
• Negative and positive ions are stabilized by electrostatic attraction.

Octet Rule : Atoms can combine either by transfer of valence electrons from one atom to another or by sharing of valence electrons to complete octet in their valence shells.

Lewis dot Structure provides a picture of bonding in molecules and ions in terms of the shared pairs of electrons and the octet rule.

How To Write A Lewis Dot Structure:

Step 1 : Add the valence electrons of the combining atoms to obtain total number of electrons.

Step 2 : For anions, each negative charge means addition of one electron. For cations, each positive charge means subtraction of one electron from total number of valence electrons.

Step 3 : Write chemical symbols of combining atoms.

Step 4 : Least electronegative atom occupies central position.

Step 5 : After accounting for shared pairs of electrons, remaining are either utilized for multiple bonding or remain as lone pairs.

Formal Charge= (Total number of valence electrons in free atom) – [(Total number of non-bonding electrons) + 1/2(Total number of bonding electrons)]

Limitations Of Octet Rule :

• Shows three types of exceptions i.e. incomplete octet of central atom, odd-electron molecules and expanded octet.
• Does not account for the shape of molecules.
• Fails to explain stability of molecules.

Hydrogen Bond: Formed when the negative end of one molecule attracts the positive end of other.

Types:

(i) Intermolecular : Between two different molecules of same or different substances.
(ii) Intramolecular : Between two highly electronegative atoms in the same molecule.

Molecular orbital theory

Postulates :

• Electrons in a molecule are present in various molecular orbitals as electrons are present in atomic orbitals.
• Atomic orbitals of comparable energies and proper symmetry combine.
•Atomic orbitals is monocentric while a molecular orbital is polycentric.
• Number of molecular orbitals formed is equal to number of combining atomic orbitals.
• Bonding molecular orbitals has low energy and high stability.

Types of MO : σ(Sigma), ⍻ (Pi), δ (Delta)

Chemical Bond:Attractive forces which hold the various chemical constituents together in different chemical species.

Types :

(i) Covalent Bond : A chemical bond formed between two atoms by mutual sharing of electrons between them to complete their octet.
(ii) Ionic Bond : A chemical bond formed by complete transfer of electrons from one atom to another acquire the stable nearest noble gas configuration.
(iii) Coordinate bond : A chemical bond formed by donation of two electrons from one atom to another to complete their octct.

Lattice Enthalpy

Energy required to completely separate one mole of a solid ionic compound into gaseous constituent ions.

Valence Shell Electron Pair Repulsion (VSEPR)

Postulates :

• Shape of molecule depends upon the number of valence shell electron pairs around central atom.
• Pairs of electrons in the valence shell repel one another.
• These pairs of electrons tend to occupy such positions in space that minimize repulsion.
• The valence shell is taken as a sphere with electron pairs localising on spherical surface at maximum distance from one another.
• A multiple bond is treated as if it is a single electron pair and the two or three electron pairs of a multiple bond are treated as a single super pair.
• When one or more resonance structures can represent a molecule, VSEPR model is applicable.
• **Decreasing order of repulsive interaction :**
lp – lp > lp – bp > bp – bp

Valence Bond Theory : Given by L Pauling. It explains that a covalent bond is formed between two atoms by overlap of their half-filled valance orbitals, each of which contains one unpaired electron.

Orbital Overlap Concept : Formation of a covalent bond results by pairing of electrons in valence shell with opposite spins.

Types of Overlapping : (i) Sigma (σ) bond – end to end.
(ii) Pi (π) bond – axis remain parallel to each other.

Hybridisation : Process of intermixing of orbitals of different energies resulting in formation of new set of orbitals of equivalent energies and shape.

Types of Hybridisation –(i) sp (ii) sp^2 (iii) sp^3

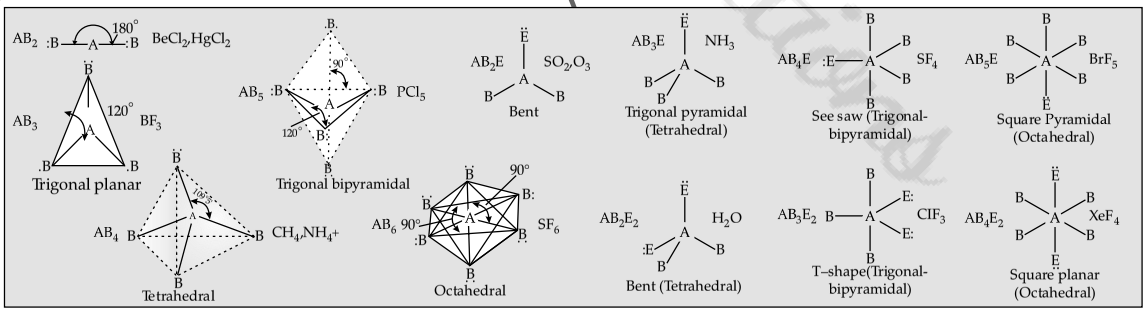
Bonding Molecular Orbitals : Addition of atomic orbitals.

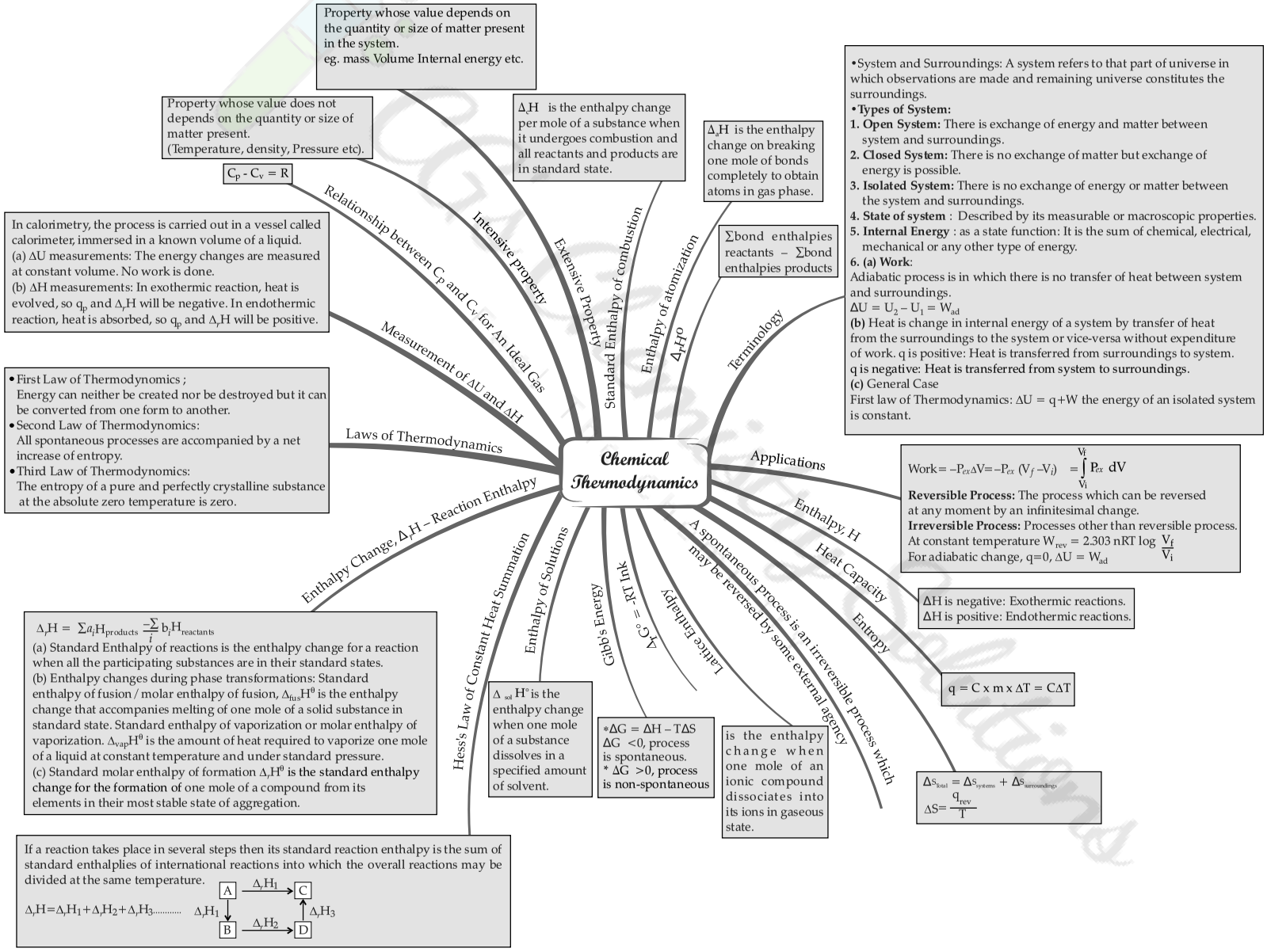
Antibonding Molecular Orbitals : Subtraction of atomic orbitals.

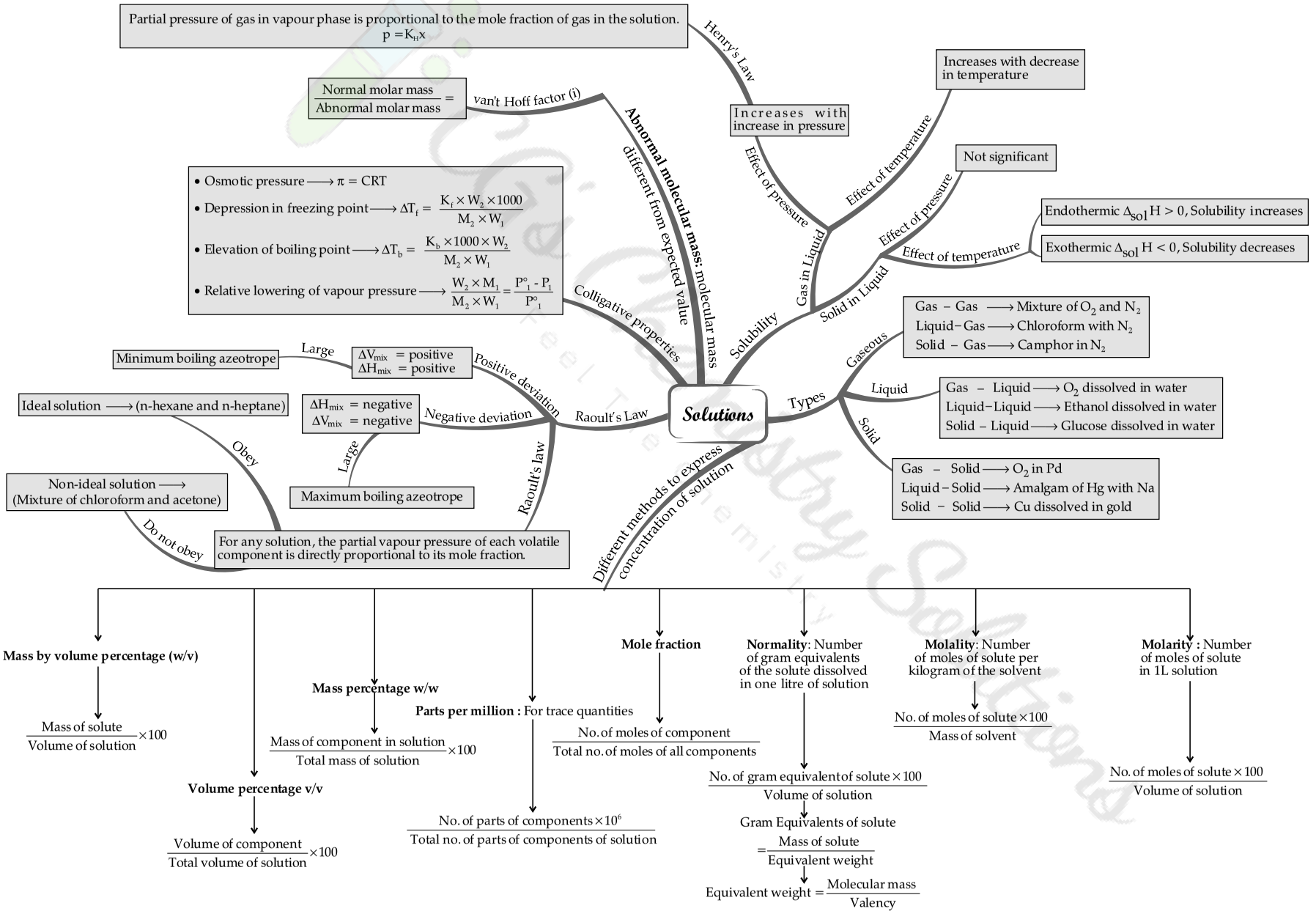
Bond Parameters

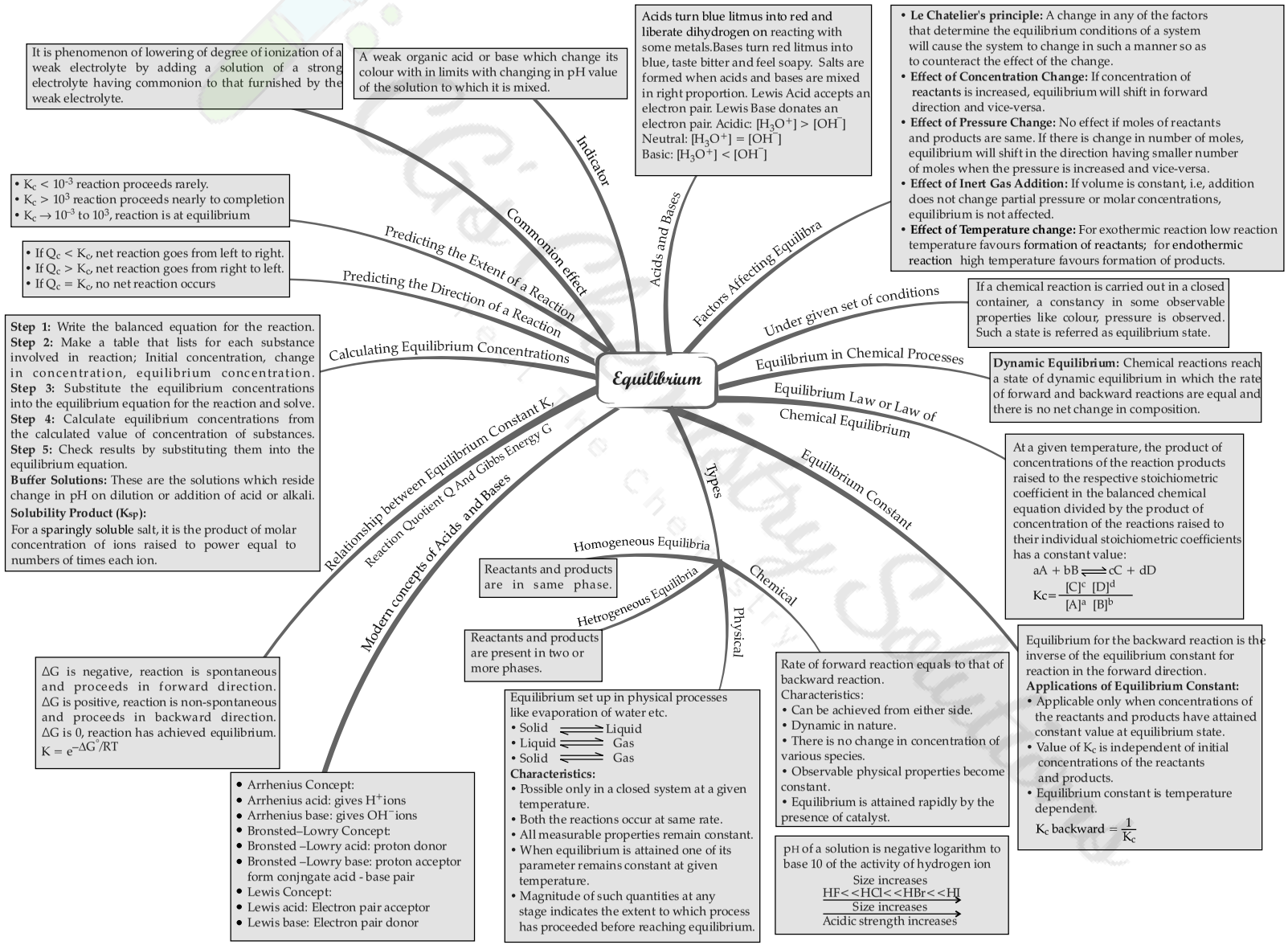
(i) Bond Length : Equilibrium distance between the nuclei of two bonded atoms in molecule.
(ii) Bond Angle : Angle between the orbitals containing bonding electron pairs around central atom in a molecule complex ion.
(iii) Bond Enthalpy : Amount of energy required to break one mole of bonds of particular type between two atoms.
(iv) Bond Order : Number of bonds between the two atoms of a molecule.
(v) Resonance Structures : A set of two or more Lewis structures that collectively describe the electronic bonding a single polyatomic species.
(vi) Dipole Moment : Product of the magnitude of the charge and distance between centres of positive and negative charge. μ = Q x r

Hybridization









Redox Reactions

Oxidation Number

Oxidation state of an element in a compound ascertained according to a set of rules formulated on the basis that pair in a covalent bond belongs to electronegative element.

Rules for O.N.

1. In elements, each atom bears an oxidation number of zero.
2. For ions with only one atom, O.N. is equal to the charge on ion.
3. O.N. of oxygen in most compounds is -2.
4. O.N. of hydrogen is +1, except when it is bonded to metals in binary compound.
5. Halogens have on O.N. of -1, when they occur as halide ions in their compound.
6. Algebraic sum of O.N. of all the atoms in a compound must be zero.

Balancing of Redox Reactions

Two Methods

O.N. Method

Step 1 : Write the correct formula for each reactant and product.
Step 2 : Identify atoms undergoing change in O.N.
Step 3 : Calculate increase / decrease in O.N per atom and for entire ion or molecule. If unequal, multiply by suitable number to make equal.
Step 4 : Add H^+/OH^- ion to make total ionic charges of reactants and products equal.
Step 5 : Equalize H^+ on two sides by adding water.

Half-Reaction Method

Step 1 : Produce, unbalanced equation for the reaction in ionic form.
Step 2 : Separate equation into two half-reactions.
Step 3 : Individually balance atoms other than O and H.
Step 4 : For reactions occurring in acidic medium, add H_2O to balance O atoms and H^+ to balance H atoms.
Step 5 : Balance charges by adding electrons to one side of the half reaction.
Step 6 : Add two half reactions and cancel the electrons on each side.
Step 7 : Verify if equation has same type and number of atoms and same charges on both sides of the equation.

Competitive Electron Transfer Reactions

Loss of $2e^-$

$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$

Gain of $2e^-$

Oxidation:Addition of oxygen to an element/compound or removal of hydrogen from a substance

Loss of electrons → Reducing agent: Donor of electron(s) → Lowers O.N.

Reduction: Removal of oxygen from a substance or addition of hydrogen to a substance

Gain of electrons → Oxidising agent: Acceptor of electron(s) → Increases O.N.

Types of Redox Reactions

1. Combination reactions : A+ B → C; Either A and B or both A and B must be in elemental form.
2. Decomposition reactions : Lead to the breakdown of a compound into two or more components at least one of which must be in the elemental state. $CaCO_3(s) \xrightarrow{\Delta} CaO(s) + CO_2(g)$
3. Displacement reactions : An ion/ atom in a compound, is replaced by an ion/atom of another element, $X + YZ \rightarrow XZ + Y$
   (a) Metal displacement : $CuSO_4(aq) + Zn(s) \rightarrow Cu(s) + ZnSO_4(aq)$
   (b) Non-Metal displacement : Includes hydrogen displacement.
4. Disproportionation reaction : An element in one oxidation state is simultaneously oxidised and reduced.

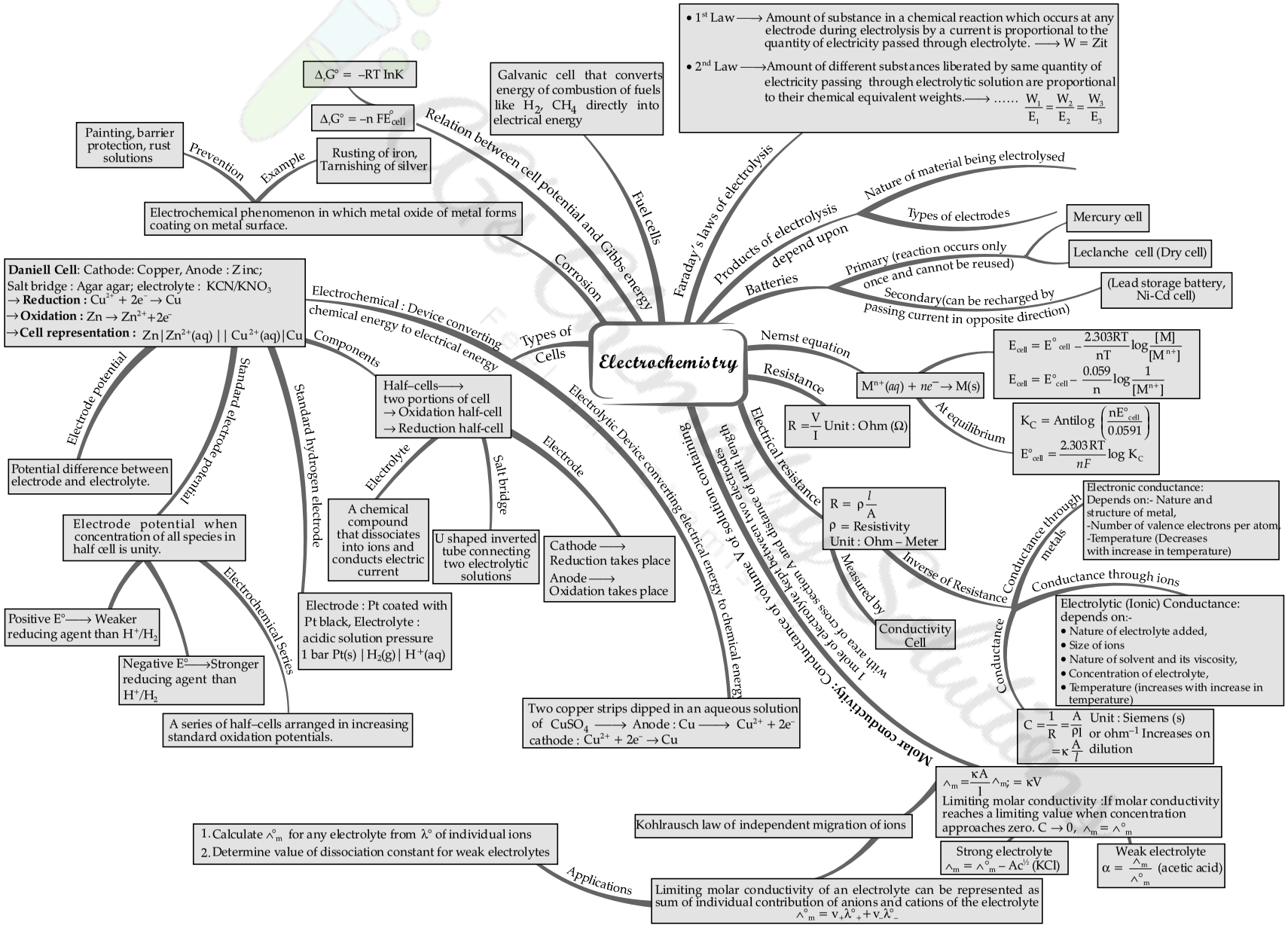
Application

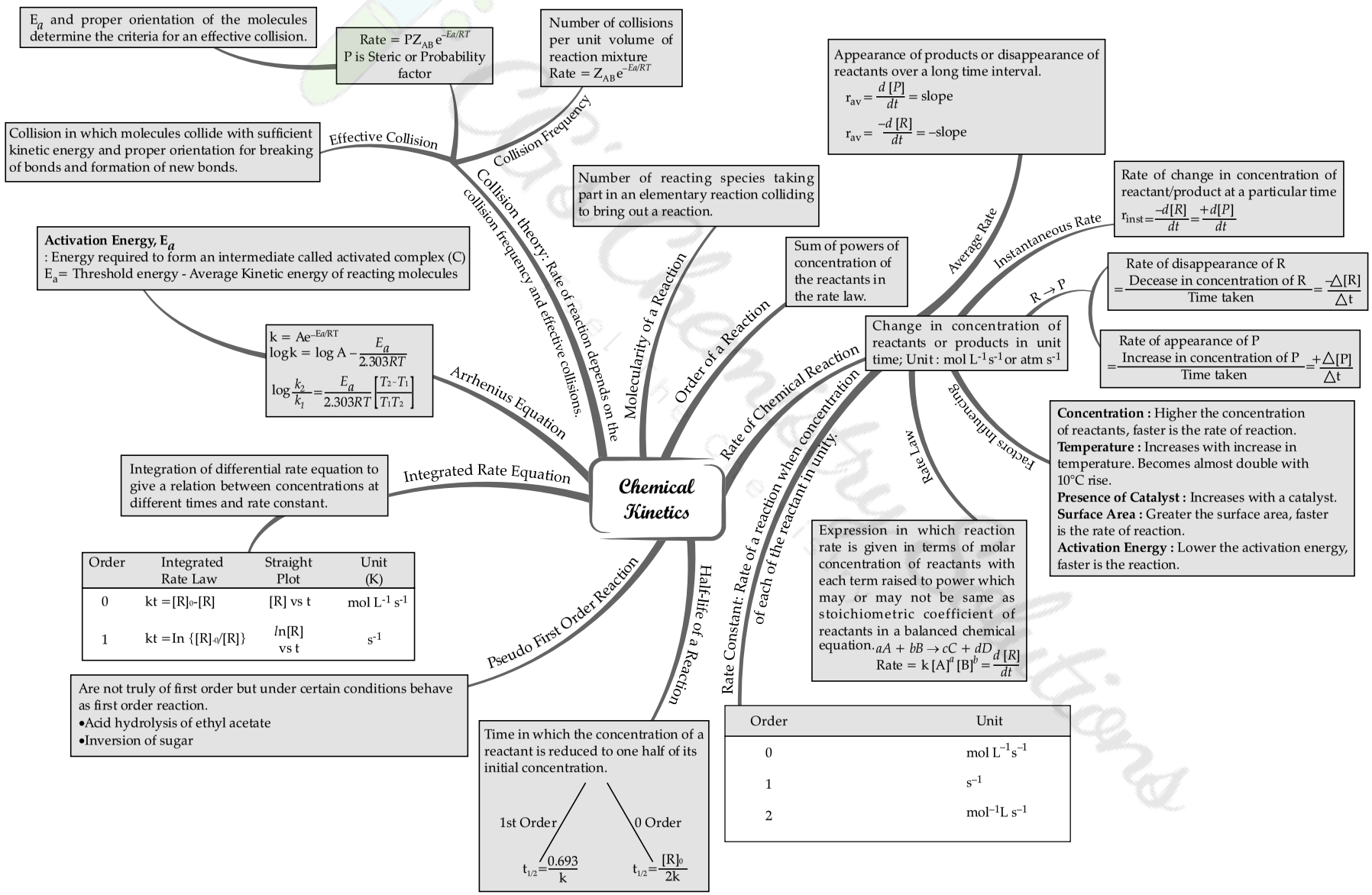
Study of electrode processes and cells.

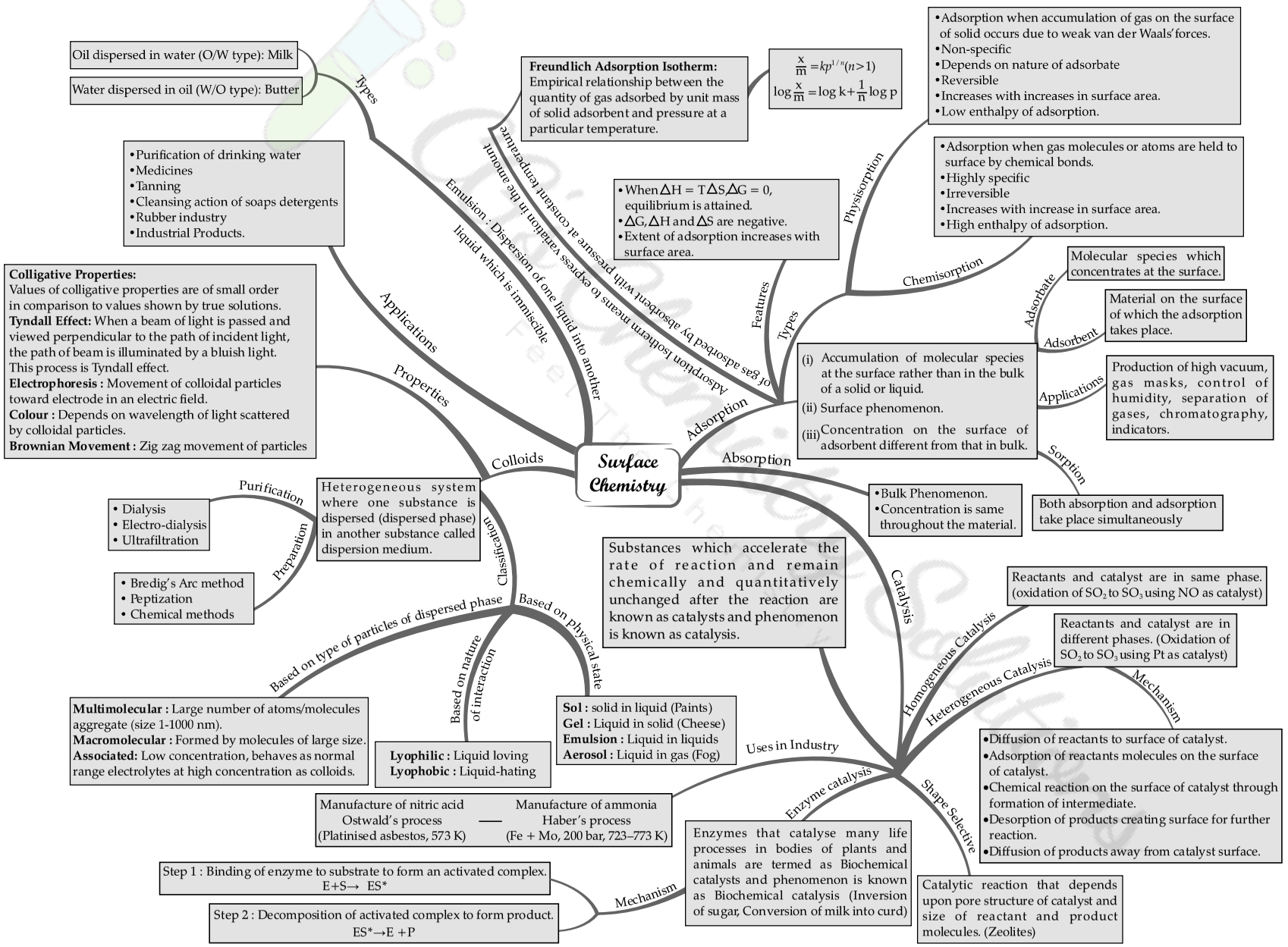
Redox Reactions and Electrode Processes

- **Redox Couple :** Having together oxidised and reduced forms of a substance involved in oxidation/reduction half reaction.
- **Electrode Potential :** Potential associated with each electrode.
- **Standard Electrode Potential :** Electrode potential of concentration of each species is unity and carried out at 298K.

Negative E°: Stronger reducing agent than H^+/H_2 couple.
Positive E°: Weaker reducing agent than H^+/H_2 couple.







Classification of Elements and Periodicity in Properties

Periodic Trends in Properties of Elements

Properties	Group	Period
(a) Atomic Radius : Distance from the centre of the nucleus to the outermost shell containing electrons.	Increases	Decreases
(b) Electron Gain Enthalpy : Energy released when a neutral isolated gaseous atom accepts an electron from anion.	Becomes less negative	Becomes more negative
(c) Ionization Energy: The minimum amount of energy required to remove an electron from the outermost orbit of an isolated atom in gaseous state.	Decreases	Increases
(d) Electronegativity : Tendency of an atom to attract the shared pair of electrons towards itself.	Decreases	Increases
(e) Electron Affinity	Decreases	Increases
(f) Valency: Number of univalent atoms which combine with an atom of given element.	No Change	Increases from 1 to 4 and then decreases from 4 to 0.
(g) Metallic Character	Increases	Decreases
(h) Non–Metallic Character	Decreases	Increases

Purpose

To ease out difficulty in studying individually the chemistry of all the elements and their compounds.

Genesis of Periodic Classification

- Law of Triads: Johann Dobereiner (1829)
- Law of Octaves: John Alexander Newlands (1865)
- Periodic Law: Dimitri Mendeleev and Lothar Meyer. It states that the physical and chemistry properties of the elements are periodic function of their atomic weights.
- Modern Periodic Law: Henry Moseley (1913) It states that the physical and chemical properties of the elements are periodic functions of their atomic numbers.

Horizontal rows – Periods (Numbered from 1 to 7)
Vertical columns – Groups (Numbered from 1 to 18)

IUPAC Nomenclature of Elements with Atomic number > 100

Derived from the atomic number of element using numerical roots for 0 and numbers 1-9 and "ium" is added at the end.

Diagonal relationship

It exists between certain pairs of diagonally adjacent elements in the 2nd and 3rd periods

eg: Li ↘↙ Be ↘↙ B ↘↙ C ↘↙ N ↘↙ O ↘↙ F
Ne ↘↙ Mg ↘↙ Al ↘↙ Si ↘↙ P ↘↙ S ↘↙ Cl

Properties of Elements based on Electronic Configuration

- Electronic Configuration is the distribution of electrons into orbitals of an atom.
- In periods: Number of elements in each period is twice the number ofatomic orbitals available in the energy level that is being filled.
- Group wise: Elements in same group have similar valence shell electronic configurations, same number of electrons in outer orbitals and similar properties. These are classified into four blocks i.e., s-block, p-block, d-block and f-block.

Periodic Table Classification based on Types of Elements

f -Block Elements

- Also called as Inner Transition Elements.
- Contain of Lanthanoids and Actinoids.
- Outer elatronic configuration is $(n-2)\ f^{1-14}\ (n-1)\ d^{1-10} ns^{0-2}$
- All are metals.
- Actinoids are radioactive.

d- Block Elements

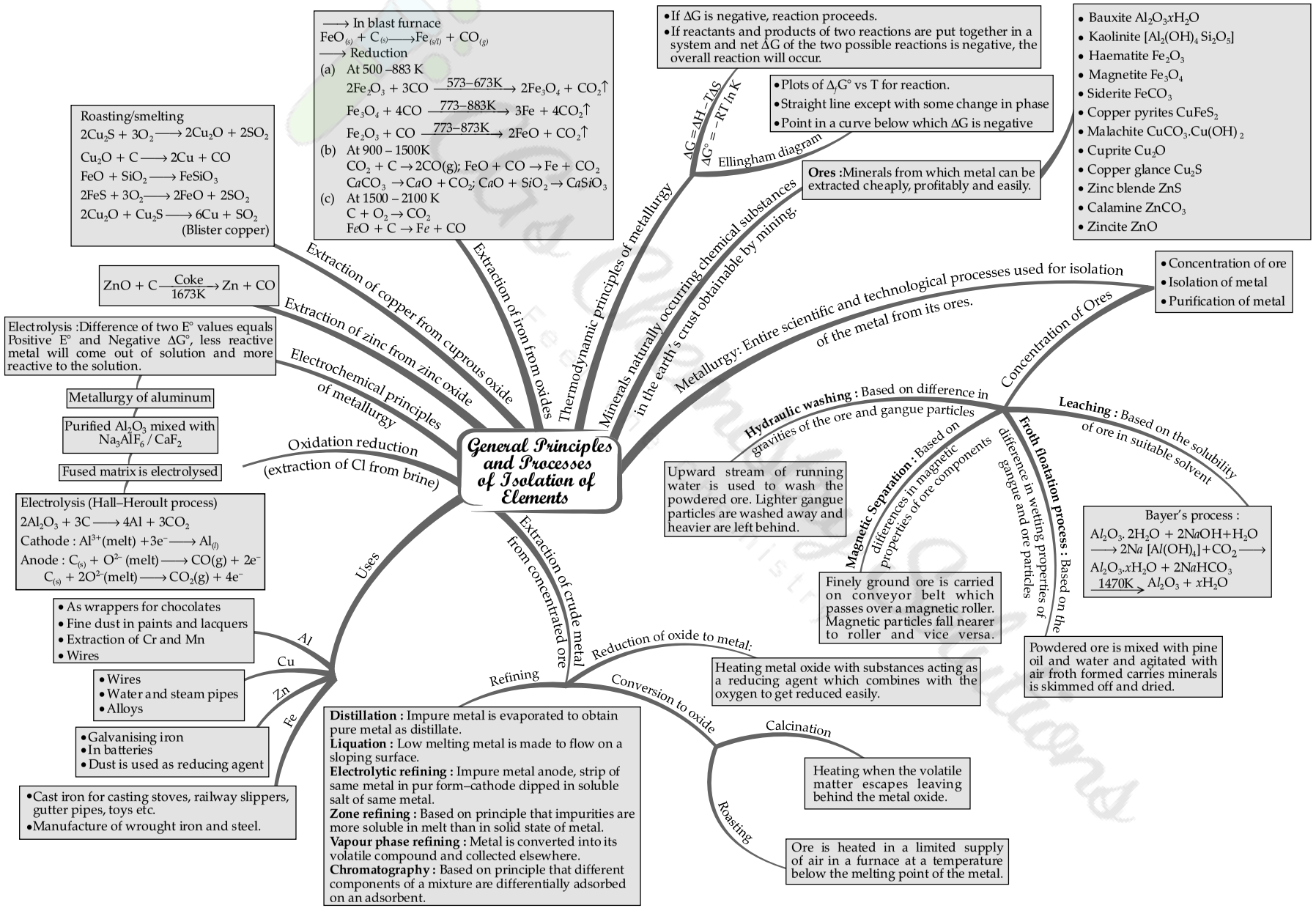
- Group 3-12
- Outer elatronic configuration is $(n-1)\ d^{1-10}\ ns^{1-2}$
- Forms coloured ions.
- Exhibit variable valencies, paramagnetism.
- Also called as Transition elements.
- Some are used as catalysts.

p- Block elements

- Group 13 to 18.
- Also called as representatives or main group elements
- Outermost configuration varies from $ns^2\ np^1$ to $ns^2\ np^6$
- At the end of period are low reactive noble gases.
- Halogens and Chalcogens have high negative electron gain enthalpies.
- Metallic character increases down the group.

s-Block Elements

- Group 1 (alkali metals) and Group 2 (alkaline earth metals)
- Outermost configuration is ns^1 or ns^2
- Reactive with low IE.
- Metallic character and reactivity increases down the group.



Hydrogen

Dihydrogen (H_2)

Occurrence: Most abundant in universe.

Preparation:

– Laboratory Method:

- $Zn+2H^+ \rightarrow Zn^{2+}+H_2$
- $Zn+2NaOH \rightarrow Na_2ZnO_2+H_2$

–Commercial Method:

- $2H_2O(l) \xrightarrow[\text{Traces of acid/base}]{\text{Electrolysis}} 2H_2(g)+O_2(g)$
- By electrolysing warm aqueous barium hydroxide solution between Ni electrodes.
- $C_nH_{2n+2}+nH_2O \xrightarrow[\text{Ni}]{1270\ K} nCO+(2n+1)H_2$

➢ $CO+H_2$ is called water gas

- Coal Gasification : $C(s)+H2O(g) \xrightarrow{1270\ K} CO_{(g)}+H_{2(g)}$
- Water-gas shift reaction : $CO_{(g)}+H_2O_{(g)} \xrightarrow[\text{Catalyst}]{673\ K} CO_{2(g)}+H_{2(g)}$

Physical Properties:

- Colourlers, odourless, tasteless and combustible.
- Lighter than air, insoluble in water.

Chemical Properties:

$H_{2(g)}+X_{2(g)} \longrightarrow 2HX_{(g)}$ $(X=F, Cl, Br, I)$

$2H_{2(g)}+O_{2(g)} \xrightarrow[\text{Heating}]{\text{Catalyst or}} 2H_2O(l)\ \Delta H^\circ = -285.9\ kJmol^{-1}$

$3H_{2(g)}+N_{2(g)} \xrightarrow[\text{Fe}]{673\ K,\ 200\ atm} 2NH_{3(g)}\ \Delta H^\circ = -92.6\ kJmol^{-1}$

$H_{2(g)}+2M_{(g)} \longrightarrow 2MH_{3(s)}$ Where M = alkali metal

$H_{2(g)}+Pd^{2+}_{(aq)} \longrightarrow Pd_{(s)}+2H^+_{(aq)}$

$H_2+CO+RCH=CH_2 \longrightarrow RCH_2CH_2CHO$

$H_2+RCH_2CH_2CHO \longrightarrow RCH_2CH_2CH_2OH$

Uses:

- Synthesis of ammonia.
- In manufacture of vanaspati fat.
- In manufacture of bulk organic chemicals.
- For manufacture of metal hydrides
- Preparation of HCl.
- In metallurgical processes.
- As a rocket fuel
- In fuel cells

Heavy Water (D_2O)

Preparation: By exhaustive electrolysis of water.

Uses:

- As a moderator in nuclear reactors.
- In exchange reactions for the study of reaction mechanisms.

Different forms

- Atomic Hydrogen :- Obtained from thermal decomposition of H_2.
- Nascent Hydrogen :- Freshly prepared hydrogen, more reactive than ordinary hydrogen.
- Adsorbed Hydrogen :- Adsorption of hydrogen at the metal surface is called occlusion.

➢ Ortho and Para Hydrogen :-

- In ortho hydrogen, nuclear spins are in the same direction.
- In para hydrogen, nuclear spins are in opposite direction.

Isotopes

Protium: Predominant form. (^1_1H)

Deuterium: (^2_1H)

Tritium : Radioactive (^3_1H)

Properties

- Resembles alkali metals (lose one e^- to form unipositive ions).
- Resembles halogens (gain one e^- to form uninegative ion).
- Forms oxides, halides and sulphides.
- Very high ionization enthalpy.
- Does not possess metallic character under normal conditions.
- Forms diatomic molecules.

Hydrides

Types:

(i) **Ionic/saline/salt like:** Stoichiometric compounds of dihydrogen formed with s-block elements.

(ii) **Covalent/molecular:** Formation of molecular compounds from dihydrogen and p-block elements.

(iii) **Metallic/non-stoichiometric/interstitial:** Formed by d-block and f-block elements.

Electronic Configuration $1S^1$

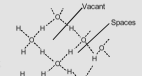
Water

(Human body: 65%, Plants: 95%)

Physical Properties:

- Colourless and tasteless
- Presence of extensive H bonding.
- High freezing point, high B.P, high heat of vaporization, high heat of fusion

Structure:



Chemical Properties:

$H_2O_{(l)}+NH_{3(aq)} \rightleftharpoons OH^-_{(aq)}+NH_4^+{}_{(aq)}$

$2H_2O_{(l)}+2Na_{(s)} \longrightarrow 2NaOH_{(aq)}+H_{2(g)}$

$6CO_{2(g)}+12H_2O_{(l)} \longrightarrow C_6H_{12}O_{6(aq)}+6H_2O_{(l)}+6O_{2(g)}$

$P_4O_{10(s)}+6H_2O_{(l)} \longrightarrow 4H_3PO_{4(aq)}$

Difference: Hard water does not give lather with soap whereas soft water gives lather easily.

Temporary hardness: Removed by boiling,Clark's method. (Due to presence of magnesium and calcium hydrogen carbonates)

Permanent hardness: Removed by treatment with washing soda, Calgon's method, Ion exchange method, synthetic resins methods. (Due to presence of soluble salts of Mg and Ca in the form of chlorides and sulphates)

Hydrogen Peroxide (H_2O_2)

Preparation

- $BaO_2.8H_2O_{(s)}+H_2SO_{4(aq)} \rightarrow BaSO_{4(s)}+H_2O_{2(aq)}+8H_2O_{(l)}$
- $2HSO^-_{4(aq)} \xrightarrow{\text{Electrolysis}} HO_3SOOSO_3H_{(aq)} \longrightarrow 2HSO^-_{4(aq)}+2H^+{}_{(aq)}+H_2O_{2(aq)}$
- 2– ethylanthraquinol $\underset{H_2/Pd}{\overset{O_2(air)}{\rightleftharpoons}}$ H_2O_2 + Oxidised Product

Physical Properties

- Colourless, miscible with water.

Structure: Non-Planar

Chemical Properties:

$PbS+4H_2O_{2(aq)} \rightarrow PbSO_{4(s)}+4H_2O_{(l)}$

$HOCl+H_2O_2 \rightarrow H_3O^+ + Cl + O_2$

$Mn^{2+}+H_2O_2 \rightarrow Mn^{4+}+2OH^-$

$I_2+H_2O_2+2OH^- \rightarrow 2I^-+2H_2O+O_2$

Decomposes on exposure

Uses

- As hair bleach, disinfectant.
- Manufacture chemicals used in detergents.
- In industries of as bleaching agent.
- In environmental chemistry.

s- Block Elements (Alkali and Alkaline earth metals)

Group 2 Elements (Alkaline Earth Metals)

- **Atomic and Ionic Radii:** Smaller than corresponding alkali in group,increase with increase in atomic number.
- **I.E:** IE_1 higher than corresponding Group 1 metals. IE_2 smaller than corresponding alkali metals.
- **Hydration Enthalpies:** Decrease with increase in ionic size down the group.

Physical properties:

- Slivery white, lustrous and relatively soft but harder than alkali metals.
- M.p. and b.p. higher than corresponding alkali metals.
- Electropositive character increases down the group.

Chemical properties:

- Be and Mg are kinetically inert to O_2 and H_2O.
- Mg is more electropositive and burns in air.
- Ca, Sr and Ba with air form oxide and nitride.

$M + X_2 \longrightarrow MX_2 \ (X = F, Cl, Br, I)$

$2BeCl_2 + LiAlH_4 \longrightarrow 2BeH_2 + LiCl + AlCl_3$

$M + 2HCl \longrightarrow MCl_2 + H_2$

$M + (x+y)NH_3 \longrightarrow [M(NH_3)_x]^{2+} + 2[e(NH_3)_y]^-$

Uses:

- Be is used in the manufacture of alloys.
- Metallic Be is used for making windows of X–rays tubes.
- Mg-Al alloys are used in air craft construction.
- Ca is used in extraction of metals.
- Ra is used in radiotherapy.

Characteristics of Compounds of Alkaline Earth Metals:

Oxides and Hydroxides

- Alkaline earth metals burn with oxygen to form MO.
- All oxides except BeO are basic in nature.

$MO + H_2O \longrightarrow M(OH)_2$

$Be(OH)_2$ is amphoteric in nature.

Halides:

- Except for Be halides, all other halides are ionic.
- Tendency to form halide hydrates decreases gradually.
- Salts of oxoacids: Form carbonates, sulphates and nitrates.
- Anomalous behavior of Be: Small atomic and ionic size, does not exhibit C.N. more than four, its oxide and hydroxide are amphoteric.
- Be shows diagonal relationship with Al.

Biological importance of Mg and Ca:

- All enzymes that utilise ATP in PO_4 transfer requires Mg as cofactor. Chlorophyll contains Mg. Ca is present in bones and teeth. Important in neuromuscular function, intraneuronal transmission and blood coagulation.

Important Compounds of Calcium

(i) CaO, Quick Lime

Preparations $CaCO_3 \xrightarrow{heat} CaO + CO_2$

Properties : White amorphous solid with m.p. 2870 K

$CaO + H_2O \longrightarrow Ca(OH)_2$, $CaO + CO_2 \longrightarrow CaCO_3$

(ii) $Ca(OH)_2$ Calcium hydroxide :

Preparation: Addition of water to CaO. $CaO + H_2O \longrightarrow Ca(OH)_2$

Properties: White amorphous powder .

$Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O$

(iii) $CaSO_4 \cdot \frac{1}{2}H_2O$ (Plaster of Paris)

$2(CaSO_4 \cdot 2H_2O) \longrightarrow 2(CaSO_4) \cdot H_2O + 3H_2O$

Group 1 Elements (Alkali Metals)

- **Atomic and Ionic Radii:** Increase with increase in atomic number down the group.
- **I.E.:** Decreases down the group.
- **Hydration Enthalpy:** Decreases with increase in ionic sizes.
- **Physical properties**:
- Silvery white, soft and light metals.
- Low m.p. and b.p.
- Alkali metals and their salts impart colour to an oxidizing flame.

Chemical Properties:

$4Li + O_2 \rightarrow 2Li_2O$; $2Na + O_2 \rightarrow Na_2O_2$; $M + O_2 \rightarrow MO_2$ (M=K, Rb, Cs)

$2M + 2H_2O \rightarrow 2M^+ + 2OH^- + H_2$

$2M + H_2 \rightarrow 2M^+H^-$

React vigorously with halogens to form ionic halides

$M + (x+y)NH_3 \rightarrow [M(NH_3)_x]^+ + [e(NH_3)_y]^-$

Uses:

- Li is used to make useful alloys.
- Li is used in thermonuclear reactions and making electrochemical cells.
- Na is used to make Na/Pb alloy.
- Liquid Na metal is used as coolant in nuclear reactors.
- KCl is used as fertilizer.
- Cs is used in devising photoelectric cells.

Characteristics of Compounds of Alkali Metals:

– Oxides and Hydroxides

Combustion in excess of air $\xrightarrow{+Li} Li_2O$; $\xrightarrow{+Na} Na_2O_2$; $\xrightarrow{+K/Rb/Cs} MO_2$

– Halides

- Alkali metal halides (MX) have high melting points, and they are colourless crystalline solids.
- Preparation: Reaction of oxide, hydroxide or carbonate with aq HX.
- High negative enthalpies of formation.
- Melting and boiling points: F >Cl> Br > I
- Soluble in water.

Salts of Oxo-Acids:

- Alkali metals form salts with all oxo-acids.
- Soluble in water and thermally stable.
- Stability of carbonates and hydrogen carbonates increases

Anomalous properties of Li: Due to

(i) exceptionally small size of its atom and ion.

(ii) High polarising power.

Biological importance of Na and K:

Na^+ ions participate in nuclear signals transmission, regulator of flow of water across cell membranes. K ions activate many enzymes and oxidation of glucose to produce ATP.

Electronic Configuration

ns^1 : Alkali metals; ns^2 : Alkaline earth metals

Important Compounds of Sodium:

(*i*)Sodium Carbonate (Washing Soda):

Preparation: By Solvay process $2NH_3 + H_2O + CO_2 \rightarrow (NH_4)_2CO_3$

$(NH_4)_2CO_3 + H_2O + CO_2 \rightarrow 2NH_4HCO_3$

$NH_4HCO_3 + NaCl \rightarrow NH_4Cl + NaHCO_3$

$2NaHCO_3 \rightarrow Na_2CO_3 + CO_2 + H_2O$

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

Properties: (a)White, crystalline solid. (b)Readily soluble in water

$Na_2CO_3 \cdot 10H_2O \xrightarrow{375K} Na_2CO_3 \cdot H_2O + 9H_2O$

$Na_2CO_3 \cdot H_2O \xrightarrow{>373K} Na_2CO_3 + H_2O$

Uses: Water softening, laundering, cleaning, manufacturing, as laboratory reagent.

(*ii*)Sodium Chloride (NaCl)

Preparation: Crude NaCl by crystallization of brine solution.

-Pure NaCl is obtained by dissolving crude salt in minimum water and filtered to remove insoluble impurities. Solution is saturated with HCl gas. Uses: As common salt.

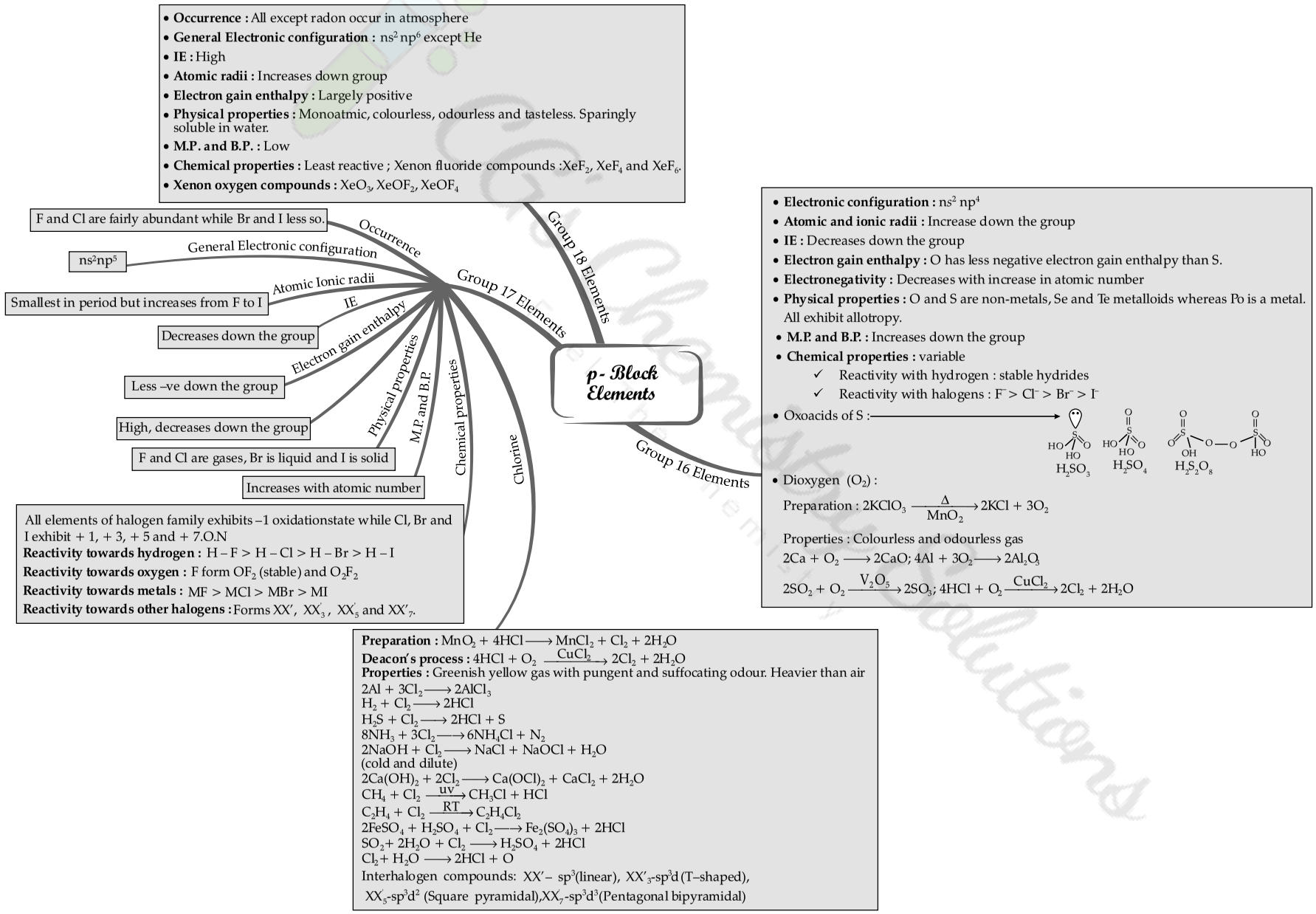
(*iii*)Sodium Hydroxide (NaOH)

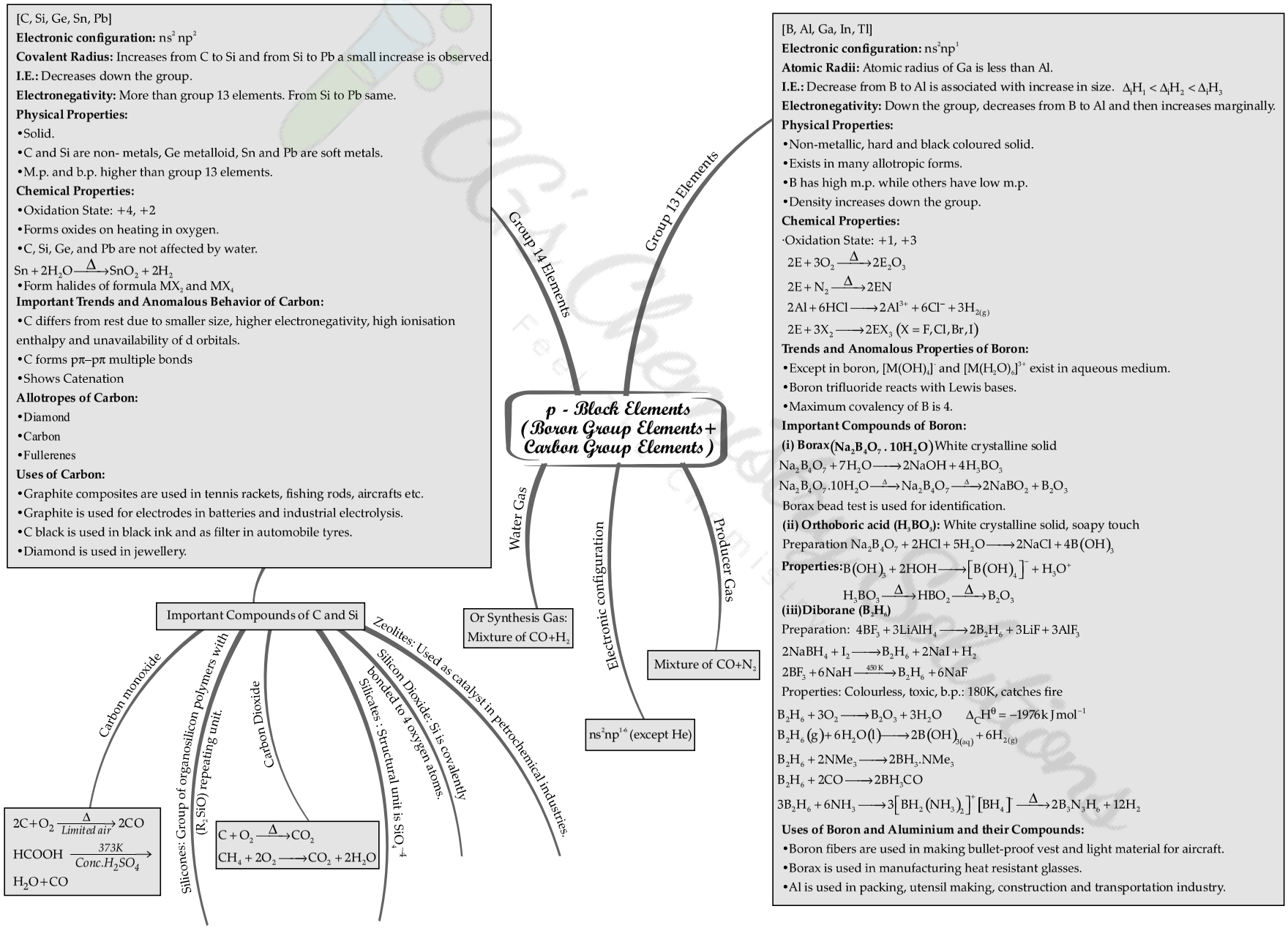
Preparation: By electrolysis of NaCl in Castner-Kellner cell.

Uses: In manufacture of soap, paper, petroleum refining.

(*iv*)Sodium hydrogencarbonate ($NaHCO_3$)

Preparation: $Na_2CO_3 + H_2O + CO_2 \rightarrow 2NaHCO_3$





The d– And F– Block Elements

d– Block transition elements groups 3–12

- Position : Between s- and p–blocks.
- General Electronic configuration : $(n-1)d^{1-10}ns^{1-2}$
- Physical properties : Show typical metallic properties, melting and boiling point are high; High enthalpies of atomization.
- Decrease in radius with increasing atomic number. Lanthanoid contraction is due to imperfect shielding of one e^- by another in same set of orbitals.
- Ionisation enthalpies : Increases from left to right.
- Oxidation states : Variable; higher ON stable.
- Trends in M^{3+}/M^{2+} : E° for Mn, Ni and Zn are more negative than expected.
- Trends in M^{3+}/M^{2+} E° : Variable.
- Chemical reactivity and E° values : Variable; Ti^{2+}, V^{2+} and Cr^{2+} are strong reducing agents.
- Magnetic properties : Diamagnetism and paramagnetism. Magnetic moment increases with increasing atomic number.
- Formation of coloured ions : Form coloured compounds due to d-d transitions.
- Formation of complex compounds : Form a large number of complex compounds.
- Catalytic properties : Due to variable oxidation states and ability to form complexes.
- Form interstitial compounds : Non - stoichiometric and are neither ionic nor covalent.
- Alloy formation : Due to similar atomic sizes.

Uses

- Helps in production of iron and steels.
- TiO in pigment industry.
- MnO_2 in dry battery cells.
- As catalysts in industry.
- Ni complexes useful in the polymerization of alkynes and other organic compounds such as benzene.
- AgBr in photographic industry.

Oxides and oxoanions of metals

- **Potassium dichromate $K_2Cr_2O_7$**

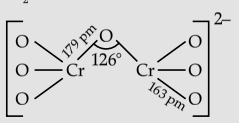
Preparation : $4FeCr_2O_4 + 8Na_2CO_3 + 7O_2 \rightarrow 8Na_2CrO_4 + 2Fe_2O_3 + 8CO_2$

$2Na_2CrO_4 + 2H^+ \rightarrow Na_2Cr_2O_7 + 2Na^+ + H_2O$

$Na_2Cr_2O_7 + 2KCl \rightarrow K_2Cr_2O_7 + 2NaCl$

Properties : $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$

Oxidises iodide to iodine, H_2S to S, SO_3^{2-} to SO_4^{2-}, NO_2^- to NO_3^-



- **Potassium permanganate $KMnO_4$**

Preparation : $2MnO_2 + 4KOH + O_2 \rightarrow 2KMnO_4 + 2H_2O$

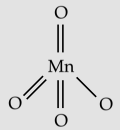
$3MnO_4^{2-} + 4H^+ \rightarrow 2MnO_4^- + MnO_2 + 2H_2O$

$2Mn^{2+} + 5S_2O_8^{2-} + 8H_2O \rightarrow 2MnO_4^- + 10SO_4^{2-} + 16H^+$

Properties : Intense colour, weak temperature dependent paramagnetism

$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$

Oxidizes I^- to I_2, Fe^{2+} to Fe^{3+}, $C_2O_4^{2-}$ to CO_2, S^{2-} to S, SO_3^{2-} to SO_4^{2-}, NO_2^- to NO_3^-



f– Block inner-transition Elements

Lanthanoid contraction is progressive decrease in atomic/ionic radii from La^{3+} to Lu^{3+}

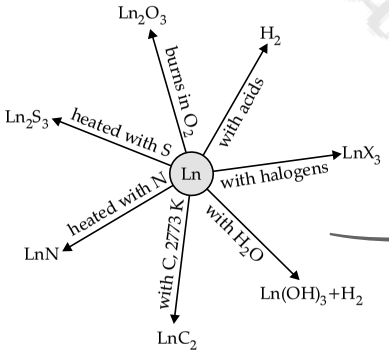
Actinoids

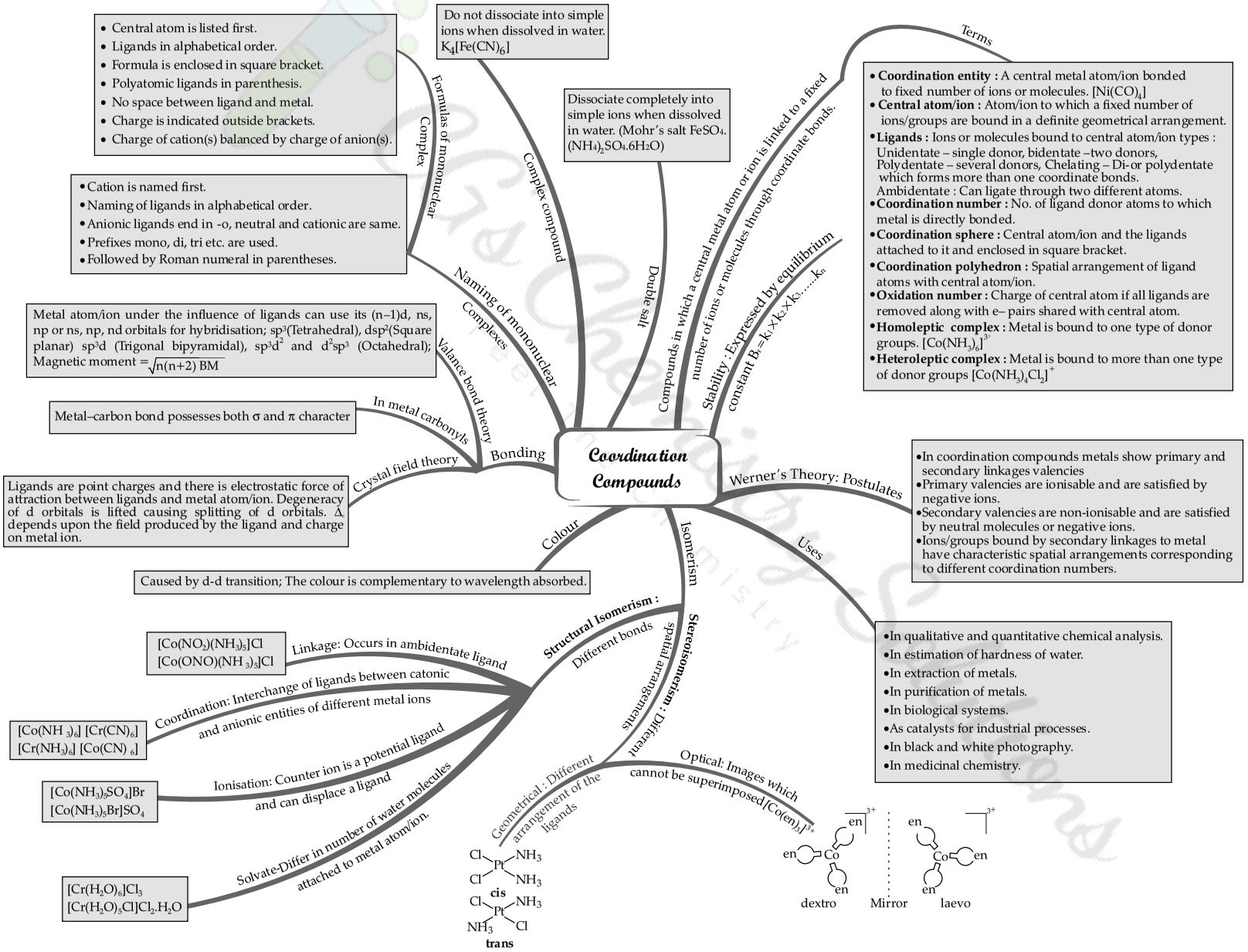
- General Electronic configuration: $[Rn]5f^{1-14}\ 6d^{0-2}\ 7s^2$
- Ionic sizes : Gradual decrease along the series.
- Oxidation states : Most common is +3. They show ON of +4, +5, +6 and +7.
- **General characteristics :**
  - –Silvery in appearance.
  - –Display variety of structures.
  - –Highly reactive metals.
  - –Irregularities in metallic radii, greater than lanthanoids.
  - –Magnetic properties more complex than lanthanoids.

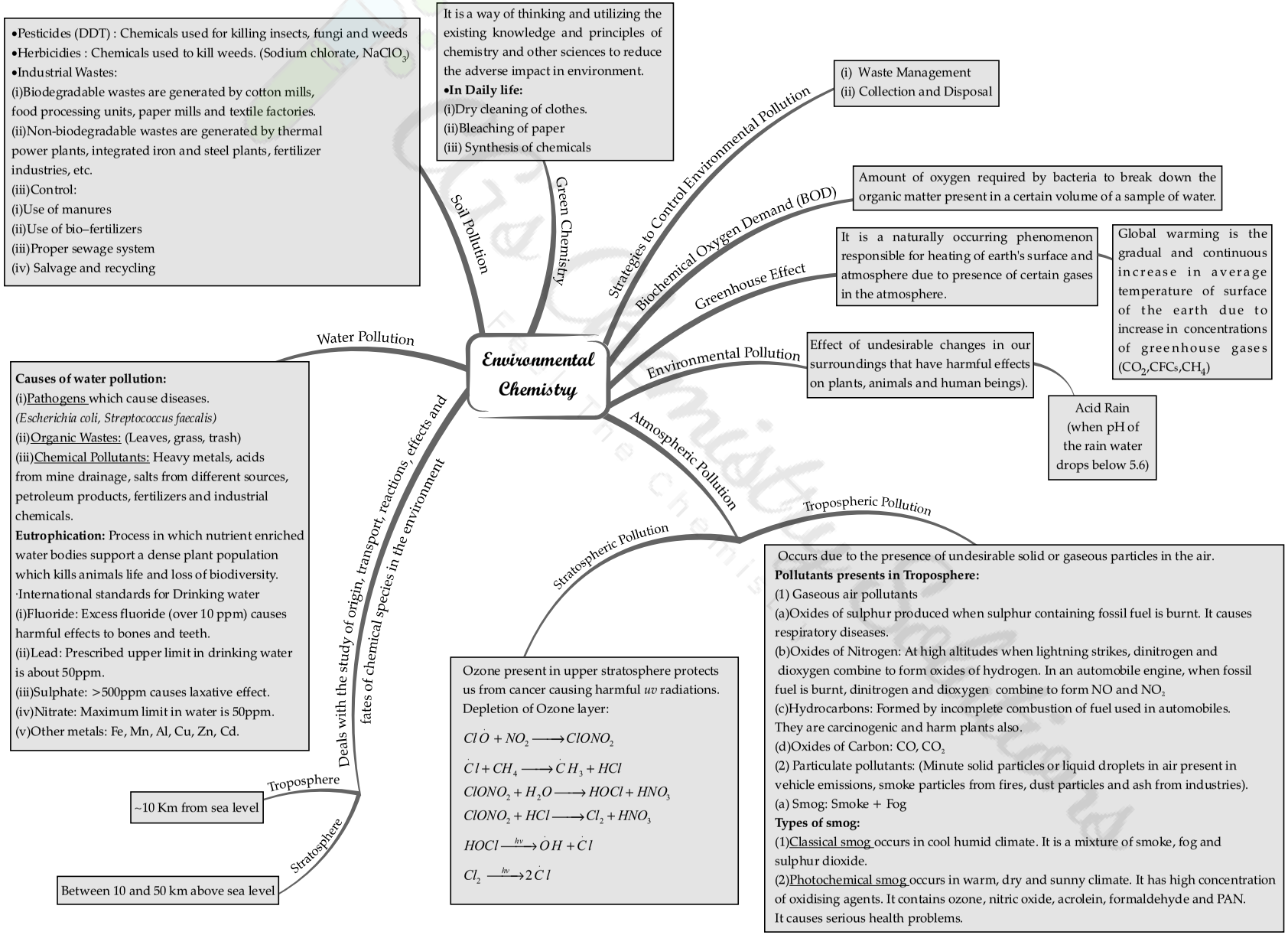
Lanthanoids

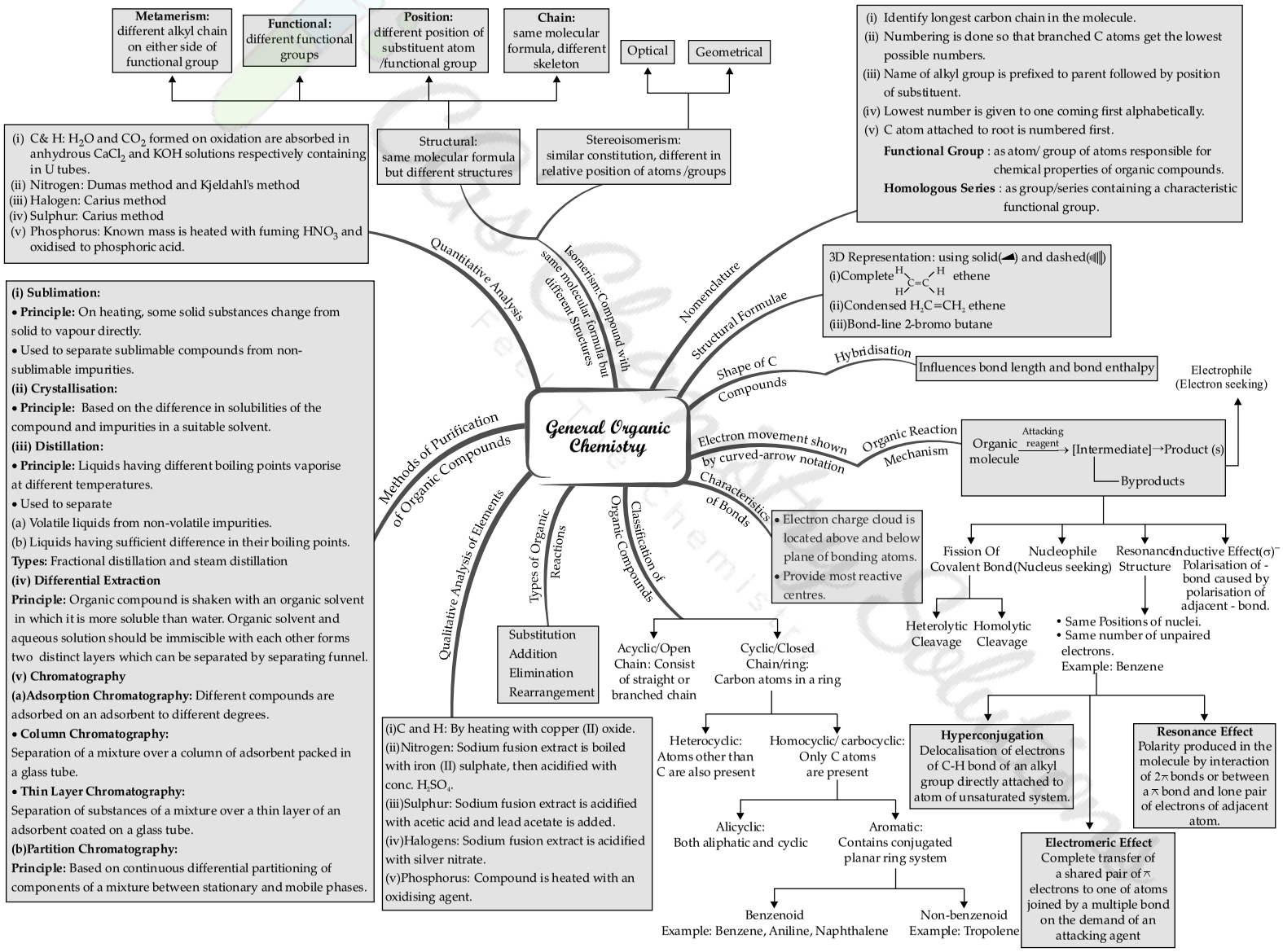
- General Electronic configuration : $4f^{1-14}\ 5d^{0-1}\ 6s^2$
- Atomic and ionic sizes : Decrease from La to Lu
- Oxidation states : Most common is +3. Some elements exhibit +2 and +4.
- **General characteristics :**
  - Silvery white soft metals and tarnish rapidly in air.
  - Hardness increases with increasing atomic number.
  - Metallic structure and good conductors of heat and electricity.
  - Variable density.
  - Trivalent lanthanoid ions are coloured.
- Ionisation Enthalpies : Low third ionisation enthalpies.
- Good reducing agents.

Chemical Properties







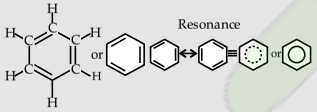


Hydrocarbons

Compounds of Carbon and Hydrogen

Aromatic Hydrocarbon

- Types: Benzenoids – contain benzene ring, Non-benzenoids – does not contain benzene ring.
- Isomerism: Ortho (o-), Meta (m-), Para (p-)
- Structure:



- Aromaticity: Planarity, complete delocalisation of the π–electrons in the ring, presence of (4n + 2) π electrons in the ring where n is an integer (n = 0,1,2,.....) (Huckel rule)

Preparation:

- Cyclic polymerisation of ethyne

$$C_6H_5COONa + NaOH \xrightarrow[\Delta]{CaO} C_6H_6 + Na_2CO_3$$

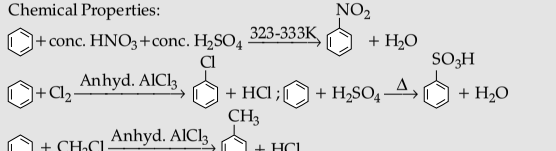
$$C_6H_5OH + Zn \xrightarrow{\Delta} C_6H_6 + ZnO$$

Physical Properties

- Non-polar, usually colourless liquids or solids with characteristic aroma.
- Immiscible with water but miscible with organic solvents.
- Burns with sooty flame.

Chemical Properties

Chemical Properties:



Mechanism of Electrophilic substitution reactions

(i) Generation of Electrophile
(ii) Formation of carbocation intermediate
(iii) Removal of proton

Classification

- **Saturated:** Contain C-C and C-H single bonds. (alkanes)
- **Unsaturated:** Contain C-C multiple bonds (alkenes, alkynes)
- **Aromatic**: Contain cyclic compounds

Alkynes (C_nH_{2n-2})

- IUPAC name: replacing 'ane' by the suffix 'yne'.
- Shows position and chain isomerism

- Preparation:

$$CaCO_3 \xrightarrow{\Delta} CaO + CO_2$$

$$CaO + 3C \longrightarrow CaC_2 + CO$$

$$CaC_2 + 2H_2O \longrightarrow Ca(OH)_2 + C_2H_2$$

$$CH_2Br-CH_2Br + KOH \xrightarrow[-KBr\ -H_2O]{alcohol} H_2C=CHBr \xrightarrow[-NaBr\ -NH_3]{NaNH_2} CH\equiv CH$$

- Physical Properties:
  - First three members are gases, next eight are liquids and higher ones are solids.
  - Colourless, ethyne has characteristic odour and other are odourless.
  - Lighter than water, immiscible with water but soluble in organic solvents.
  - M.p, b.p. and density increase with increase in molar mass.
- Chemical Properties:

$$HC\equiv CH + Na \longrightarrow HC\equiv CNa + 1/2\,H_2$$

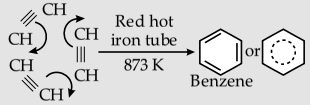
$$HC\equiv CH + H_2 \xrightarrow{Pt/Pd/Ni} [H_2C=CH_2] \xrightarrow{H_2} CH_3-CH_3$$

$$CH_3-C\equiv CH + Br_2 \longrightarrow [CH_3CBr=CHBr] \xrightarrow{Br_2} CH_3-\underset{Br}{\overset{Br}{C}}-\underset{Br}{CH}$$

$$HC\equiv C-H + HBr \longrightarrow [CH_2=CH-Br] \xrightarrow{HBr} \underset{CH_3}{CHBr_2}$$

$$HC\equiv CH + H_2O \xrightarrow[333\ K]{Hg^{2+}/H^+} [CH_2=\underset{OH}{C}-H] \xrightarrow{Isomersation} CH_3-\underset{O}{C}-H$$

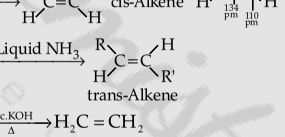
Polymerisation



Alkenes (C_2H_{2n})

- Shows structural and geometrical isomerism

Preparation:



$$H_3C-CH_2X \xrightarrow[\Delta]{Alc.KOH} H_2C=CH_2$$

$$CH_2Br-CH_2Br + Zn \longrightarrow CH_2=CH_2 + ZnBr_2$$

$$CH_3CH_2OH \xrightarrow[\Delta]{conc.H_2SO_4} CH_2=CH_2 + H_2O$$

- Physical Properties :
  - Ethene is a colourless gas with faint sweet smell.
  - All others are colourless and odourless, insoluble in water but fairly soluble in non-polar solvents.
  - Increase in b.p. with increase in molecular size.
- Chemical Properties:

$$CH_2=CH_2 + Br_2 \xrightarrow{CCl_4} BrCH_2-CH_2Br$$

$$CH_2=CH_2 + HBr \longrightarrow CH_3CH_2Br$$

$$CH_3-CH=CH_2 + HBr \xrightarrow{Markovnikov\ rule} \begin{cases} CH_3-\underset{Br}{CH}-CH_3 \\ CH_3-CH_2-CH_2-Br \end{cases}$$

$$H_3C-\underset{CH_3}{C}=CH_2 + H_2O \xrightarrow{H^+} CH_3-\underset{CH_3}{\overset{CH_3}{C}}-OH$$

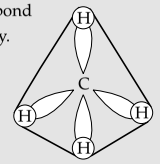
$$CH_3-CH=CH-CH_3 \xrightarrow{KMnO_4/H^+} 2CH_3COOH$$

$$n(CH_2=CH_2) \xrightarrow[Catalyst]{HighTemp/Pressure} -(CH_2-CH_2)-_n$$

$$n(CH_3-CH=CH_2) \xrightarrow[Catalyst]{HighTemp/Pressure} -(CH_3-CH_2-CH_2)-_n$$

Alkane (C_nH_{2n+2})

- H-C-H bond angles – 190.5, C-C and C-H bond lengths are 154 pm and 112 pm respectively.



- Shows structural and chain isomerism.

Preparation :

$$CH_2=CH_2 + H_2 \xrightarrow{pd/pt/Ni} CH_3-CH_3$$

Wurtz reaction :

$$CH_3Br + 2Na + BrCH_3 \xrightarrow{Dry\ ether} CH_3-CH_3 + 2NaBr$$

$$CH_3COO^-Na^+ + NaOH \xrightarrow[\Delta]{CaO} CH_4 + Na_2CO_3$$

$$2CH_3COONa + 2H_2O \longrightarrow C_2H_6 + 2CO_2 + H_2 + 2NaOH$$

- Physical Properties:

  Non-polar, weak van der Waals forces, colourless, odourless.

  B.P. increases with increases in molecular size.
- Chemical Properties:

$$CH_4 \xrightarrow[hv/-HCl]{+Cl_2} CH_3Cl \xrightarrow[hv/-HCl]{+Cl_2} CH_2Cl_2 \xrightarrow[hv/-HCl]{+Cl_2} CHCl_3 \xrightarrow[hv/-HCl]{+Cl_2} CCl_4$$

$$C_nH_{2n+2} + \left(\frac{3n+1}{2}\right)O_2 \longrightarrow nCO_2 + (n+1)H_2O$$

$$2CH_4 + O_2 \xrightarrow[100\ atm]{Cu/523K} 2CH_3OH$$

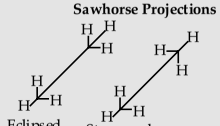
$$CH_4 + O_2 \xrightarrow[\Delta]{Mn_2O_3} HCHO + H_2O$$

$$CH_4(CH_2)CH_3 \xrightarrow{Anhyd.AlCl_3/HCl} CH_3-CH-(CH_2)_2-\underset{CH_3}{CH_2} + CH_3-\underset{CH_3}{CH_2}-CH-CH_2-CH_3$$

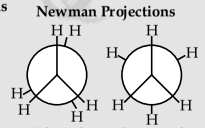
$$CH_4 + H_2O \xrightarrow[\Delta]{Ni} CO + 3H_2$$

$$C_6H_{14} \xrightarrow{733\ K} \begin{cases} C_6H_{12} + H_2 \\ C_4H_8 + C_2H_6 \\ C_3H_6 + C_2H_4 + CH_4 \end{cases}$$

Sawhorse Projections



Newman Projections



Haloalkanes and Haloarenes

Haloalkanes

=>Preparation

- From alcohol :

$R–OH + HCl \xrightarrow{ZnCl_2} R–Cl + H_2O$

$3R–OH + PX_3 \longrightarrow 3R–X + H_3PO_3$

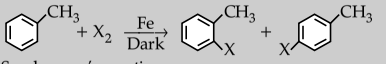
$ROH + PCl_5 \longrightarrow R–Cl + POCl_3 + HCl$

- From hydrocarbons :

(a) By free radical halogenation

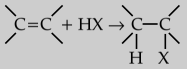
$CH_3CH_2CH_2CH_3 \xrightarrow{Cl_2/UV} CH_3CH_2CH_2CH_2Cl + CH_3CH_2CHClCH_3$

(b) By electrophilic substitution



(c) Sandmeyer's reaction

(d) From alkenes



$H_2C=CH_2 + Br_2 \xrightarrow{CCl_4} BrCH_2–CH_2Br$

- Halogen exchange :

$R–X + NaI \rightarrow R – I + NaX$

=>Properties

- Physical : Colourless, volatile, sweet smell.

Lower members are gases at room temperature while higher are solids.

B.P : RI > RBr > RCl > RF.

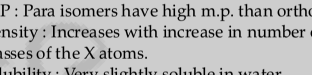
M.P : Para isomers have high m.p. than ortho and meta – isomers.

Density : Increases with increase in number of C/X atoms and atomic masses of the X atoms.

Solubility : Very slightly soluble in water.

- Chemical :

(a) Nucleophilic substitution

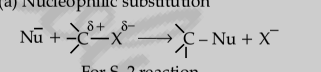


For S_N2 reaction

Tertiary, Secondary, Primary

For S_N1 reaction

(b) Elimination reaction



B = Base; X = Leaving group

(c) Reaction with metals

$CH_3CH_2Br + Mg \longrightarrow CH_3CH_2MgBr$

Wurtz reaction :

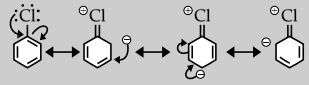
$2RX + 2Na \xrightarrow{\text{Dry ether}} RR + 2NaX$

Haloarenes

- Reactions :

(a) Nucleophilic substitution

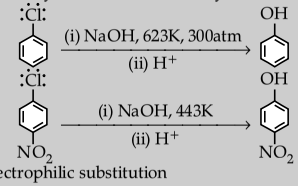
(i) Resonance effect



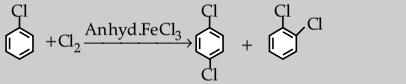
(ii) Hybridization of C – X bond in :

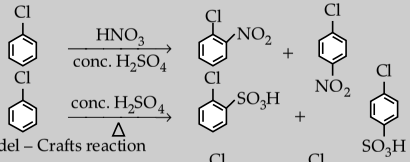
Haloalkane –sp^3; Haloarene –sp^2

(iii) Phenyl cation unstabilised by resonance

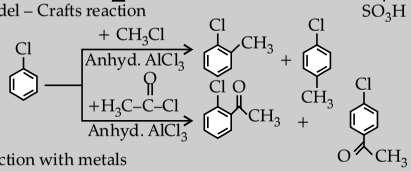


(b) Electrophilic substitution



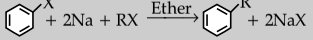


Friedel – Crafts reaction



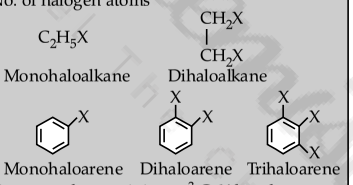
(c) Reaction with metals

Wurtz – Fitting reaction



Fittig reaction

- No. of halogen atoms

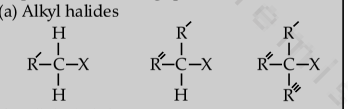


Monohaloalkane Dihaloalkane

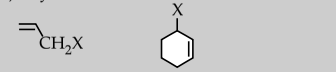
Monohaloarene Dihaloarene Trihaloarene

- Compounds containing sp^3 C–X bond

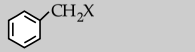
(a) Alkyl halides



(b) Allylic halides

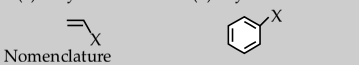


(c) Benzylic halides



- Compounds containing sp^2 C–X bond

(a) Vinylic halides (b) Aryl halides



- Nomenclature

Common name : Alkyl group followed by halides. Dihalogen derivatives, prefixes o–, m–, p– are used.

IUPAC name : Numerals are used.

- Nature of C –X bond

: Carbon –halogen bond is polarized.

Classification

- (a) Dextro (+/d)
  (b) Laevo (–/l)

- Chiral : Objects which are non-superimposable.
- Achiral : Objects which are superimposable.

Racemisation S_N1

S_N2 Stereochemical inversion

- Manufacture of refrigerants and propellants.
- Cleaning fluid.

- Solvent for fats, alkaloids, I etc.
- Production of freon.

Antiseptic — Iodoform

Carbon tetrachloride

Chloroform

For aerosol propellants, refrigeration and air conditioning purposes.

Freons

DDT

As insecticide

Polyhalogen compounds

- Paint remover.
- Propellant in aerosols.
- Metal cleaning and finishing solvent.

Dichloromethane

Organic Compounds Containing Oxygen, Alcohols, Phenols And Ethers

Classification

Mono, Di, Tri, or polyhydric :

(i) Containing C_{sp3} – OH bond
$-CH_2OH$ (1°) $>CHOH$ (2°) $>COH$ (3°)
(ii) Containing C_{sp2} -OH bond
Vinylic alcohol : $CH_2 = CH - OH$ Phenols 

Ethers

(i) Simple/symmetrical : Alkyl or aryl attached to O_2 are same.
(ii) Mixed/unsymmetrical : Two groups are different.

Nomenclature

Alcohols

Common name : Alkyl group + ol; IUPAC name : substituting 'e' of alkane with suffix 'ol'

Phenols

Common name : Terms ortho, meta and para are used. IUPAC name : Dihydroxy derivatives as 1,2–, 1,3– and 1,4 –benzenediol

Ethers

Common name : Alkyl/aryl groups in alphabetical order followed by ether. IUPAC name : In alkyl /aryl group 'e' replaced by oxy followed by parent hydrocarbon.

Structures of functional groups

•Oxygen of –OH group is attached to C by a σ bond formed by the overlap of sp^3 orbital of C with a sp^3 orbital of oxygen.
•In ethers, tetrahedral arrangement for four electron pairs.

Properties

Alcohols

(i) Physical : •Boiling point increases with increase in the number of C atoms.
•Solubility decreases with increase in size of alky/aryl groups.

(ii) Chemical : $2–R–O–H + 2Na \longrightarrow 2R–O–Na + H_2$;Acidity – primary > secondary > tertiary

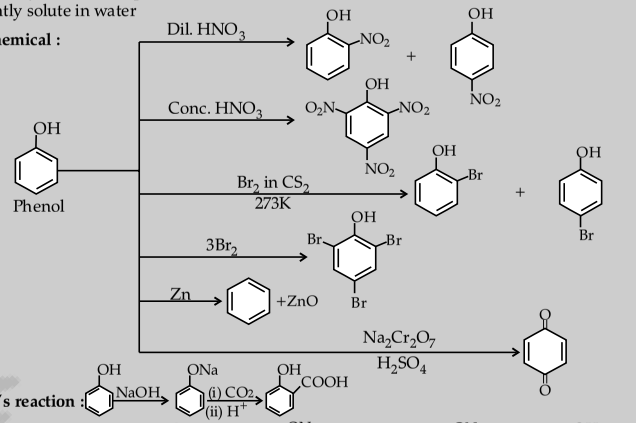
$Ar/RO - H + R' - COOH \rightleftharpoons[H^+] Ar/ROCOR' + H_2O$; $ROH + HX \longrightarrow R-X + H_2O$

$C_2H_5OH \xrightarrow[443\ K]{H_2SO_4} CH_2 = CH_2 + H_2O$; $RCH_2OH \xrightarrow{Oxidation} R\text{-}\underset{H}{\overset{O}{C}}=O \longrightarrow R\text{-}\underset{OH}{\overset{O}{C}}=O$

Phenol

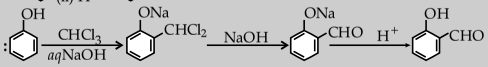
(i) Physical :
• Generally colourless liquids and solids
• Slightly solute in water

(ii) Chemical :



Kolbe's reaction :

Reimer Tiemann reaction :



Preparation

Alcohols

1. From alkenes :- (i) By acid catalysed hydration

$>C=C< + H_2O \rightleftharpoons[H^+] >\underset{H}{\overset{|}{C}}-\underset{OH}{\overset{|}{C}}<$

(ii) By hydroboration – oxidation

$CH_3–CH=CH_2 + (H–BH_2)_2 \longrightarrow CH_3–\underset{H}{\overset{|}{C}}H–\underset{BH_2}{\overset{|}{C}}H_2 \xrightarrow{CH_3–CH=CH_2} (CH_3–CH_2–CH_2)_2BH$

$3CH_3–CH_2–CH_2–OH + B(OH)_3 \xleftarrow[3H_2O_2,OH]{H_2O} CH_3–CH_2–CH_2)_3B \xleftarrow{(CH_3–CH=CH_2)}$

2. From carbonyl compounds :

(i) By reduction of aldehydes and ketones

$RCHO + H_2 \xrightarrow{Pd} RCH_2OH, RCOR' \xrightarrow{NaBH_4} R–\underset{OH}{\overset{|}{C}}H–R'$

(ii) By reduction of carboxylic acids and esters

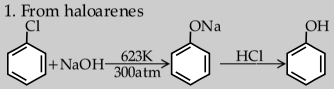
$RCOOH \xrightarrow[H^+]{R'OH} RCOOR' \xrightarrow[catalyst]{H_2} RCH_2OH + R'OH$

3. From Grignard reagent

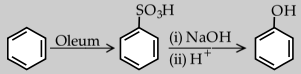
$>C=O + R \longrightarrow RMgX \longrightarrow \left[>\underset{R}{\overset{|}{C}}–OMg–X\right] \xrightarrow{H_2O} >\underset{R}{\overset{|}{C}}–OH + Mg(OH)X$

Phenols

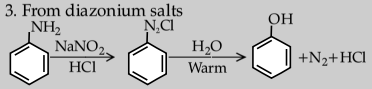
1. From haloarenes



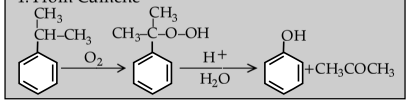
2. From benzene sulphonic acid



3. From diazonium salts



4. From Cumene



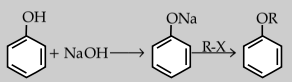
Ethers

1. By dehydration of alcohols

$CH_3CH_2OH \xrightarrow[413\ K]{H_2SO_4} C_2H_5OC_2H_5$

2. Williamson synthesis

$RX + R'ONa \longrightarrow R–O–R' + NaX$



Commercially important alcohols

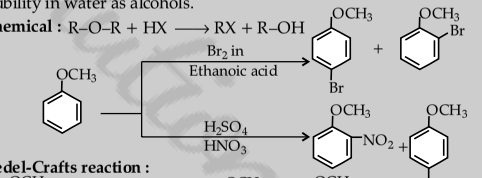
• **Methanol (Wood spirit) :**
Used as solvent in paint, varnishes and making formaldehyde.

• **Ethanol :**
Used as solvent in paint industry and preparation of a number of carbon compounds.

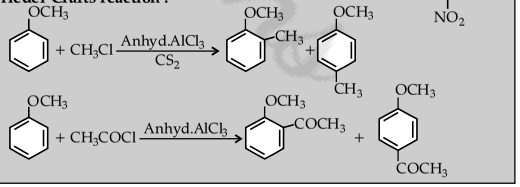
Ethers

(i)Physical :
• C–O bonds are polar.
• Boiling points comparable to those of alkanes.
• Solubility in water as alcohols.

(ii)Chemical : $R–O–R + HX \longrightarrow RX + R–OH$



Friedel-Crafts reaction :



Aldehydes, Ketones and Carboxylic Acids

Properties

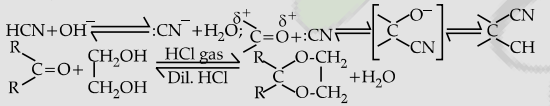
Aldehydes and Ketones:

(i) Physical:

Boiling points are higher than hydrocarbons and ethers of comparable molecular masses.

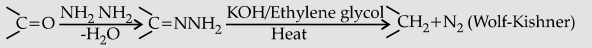
(ii)Chemical :Nucleophilic addition reactions :

Aldehydes are more reactive than ketones due to steric and electronic reasons.



Reduction : (a) To alcohols – aldehydes and ketones reduce to primary and secondary alcohols respectively by $NaBH_4$ or $LiAlH_4$.

(b) To hydrocarbons –

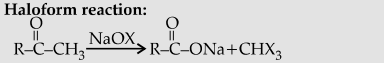


Oxidation: $RCHO \xrightarrow{[O]} R\text{–}COOH$

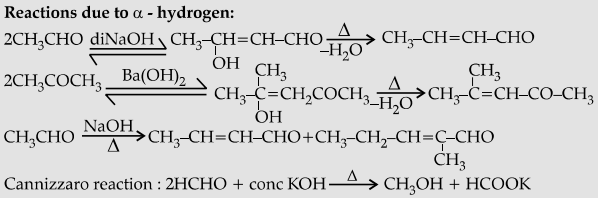
Tollen's test : $RCHO + 2[Ag(NH_3)]_2^+ + 3OH^- \longrightarrow RCOO^- + 2Ag + 2H_2O + 4NH_3$

Fehling's test : $RCHO + 2Cu^{2+} + 5OH^- \longrightarrow RCOO^- + Cu_2O + 3H_2O$ (Red brown ppt)

Haloform reaction:

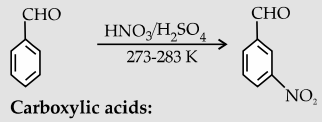


Reactions due to α - hydrogen:



Cannizzaro reaction : $2HCHO + \text{conc } KOH \xrightarrow{\Delta} CH_3OH + HCOOK$

Electrophilic substitution reaction:

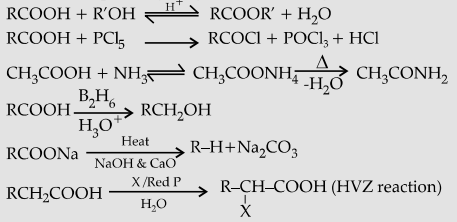


Carboxylic acids:

(i) Physical: Higher boiling points than aldehydes, ketones or alcohols. Solubility decreases with increasing number of C atoms

(ii) Chemical : $2RCOOH + 2Na \longrightarrow 2RCOONa + H_2$

Forms corresponding anhydride on heating with mineral acids



Nomenclature and uses

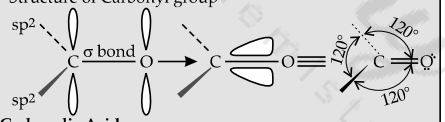
1. Aldehydes and Ketones

Common names :

- Replace corresponding carboxylic acids with aldehyde.
- Alkyl phenyl ketones by adding acyl group as prefix to phenone.

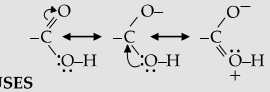
IUPAC names :

- Replacing –e with –al and –one as required.
- Structure of Carbonyl group



2. Carboxylic Acids

- Common names : end with –oic acid
- IUPAC names : replace –e in the corresponding alkane with –oic acid.
- Structure of Carboxyl Group



USES

(a) Carboxylic acids

- Methanoic acid in rubber, textile, dyeing, leather industries.
- Ethanoic acid as solvent
- Higher fatty acids in manufacture of soaps and detergents.

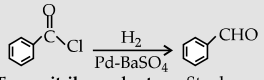
(b) Aldehydes of ketones

- As solvents.
- Starting materials and reagents for synthesis of products.

Preparations

Aldehydes :

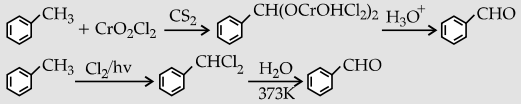
1. From acyl chloride



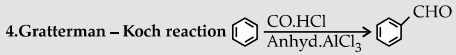
2. From nitriles and esters : Stephen reaction

$RCN + SnCl_2 + HCl \longrightarrow RCH = NH \xrightarrow{H_3O^+} R\,CHO$

3. From hydrocarbons : Etard reaction

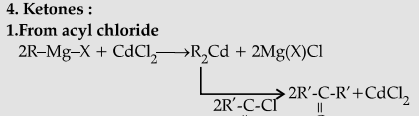


4.Gratterman – Koch reaction

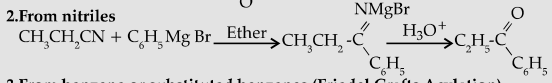


4. Ketones :

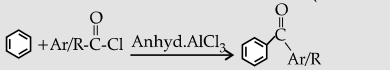
1.From acyl chloride



2.From nitriles



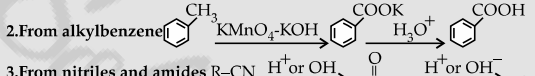
3.From benzene or substituted benzenes (Friedel Crafts Acylation)



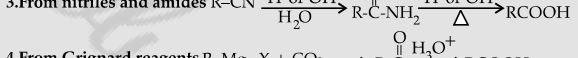
Carboxylic Acids:

1.From primary alcohols and aldehydes $RCH_2OH \xrightarrow[H_3O^+]{\text{alk. } KMnO_4} RCOOH$

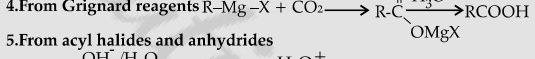
2.From alkylbenzene



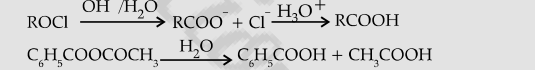
3.From nitriles and amides



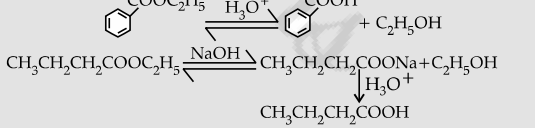
4.From Grignard reagents



5.From acyl halides and anhydrides



6.From esters



Organic Compounds Containing nitrogen

Chemical reactions

(i) Basic character of amines

- Reacts with acids to form salts $R-NH_2 + HX \rightleftharpoons R-NH_3X$ (salt)
- Reacts with base to regenerate parent amines
  $RNH_3X + OH^- \longrightarrow RNH_2 + H_2O + X$
- Order of stability of ions : $1^\circ > 2^\circ > 3^\circ$

(ii) $C_2H_5-NH-CH_3 + Cl-C(=O)-CH_3 \xrightarrow{\text{Base}} C_2H_5-N(C_2H_5)-C(=O)-CH_3 + HCl$

(iii) Carbylamine reaction : $R-NH_2 + CHCl_3 + 3KOH \xrightarrow{\Delta} R-NC + 3KCl + 3H_2O$

(iv) With nitrous acid

$RNH_2 + HNO_2 \xrightarrow{NaNO_2+HCl} [R-N_2Cl] \xrightarrow{H_2O} ROH + N_2 + HCl$

$C_6H_5NH_2 \xrightarrow[273-278K]{NaNO_2+HCl} C_6H_5N_2Cl + NaCl + 2H_2O$

(v) $C_6H_5-SO_2-Cl + H_2N-C_2H_5 \longrightarrow C_6H_5-SO_2-HNC_2H_5 + HCl$

(vi) Electrophilic substitution

$C_6H_5NH_2 + 3Br_2 \xrightarrow{Br_2/H_2O} 2,4,6\text{-}Br_3C_6H_2NH_2 + 3HBr$

$C_6H_5NH_2 \xrightarrow[288K]{HNO_3, H_2SO_4}$ p-nitroaniline (51%) + m-nitroaniline (47%) + o-nitroaniline (2%)

$C_6H_5NH_2 \xrightarrow{H_2SO_4} C_6H_5NH_3HSO_4 \xrightarrow{453-473K} 4\text{-}NH_2C_6H_3(SO_3H) \rightleftharpoons 4\text{-}NH_3C_6H_3(SO_3^-)$

Alkyl Isocyanides

Preparation :

$RI + AgCN \longrightarrow RNC + AgI$

Physical Properties :

Colourless, extremely poisonous unpleasant liquid insoluble in water

Chemical Properties :

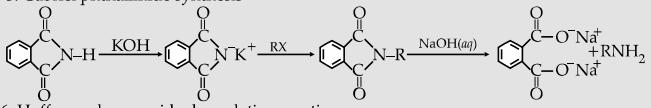
$R-N\equiv C \xrightarrow{H_3O^+} RNH_2 + HCOOH$

$R-N\equiv C \xrightarrow[C_2H_3O_4]{Na} RNHCH_3$

$R-N\equiv C \xrightarrow{HgO} R-N=C=O$

Preparation

1. Reduction of nitro compounds: $C_6H_5NO_2 \xrightarrow[\text{Ethanol}]{H_2/Pd} C_6H_5NH_2$; $C_6H_5NO_2 \xrightarrow[\text{or Fe+HCl}]{Sn+HCl} C_6H_5NH_2$
2. Ammonolysis of alkyl halides: $NH_3 + R-X \longrightarrow R-\overset{+}{N}H_3\,\overset{-}{X}$
3. Reduction of nitriles: $R-C\equiv N \xrightarrow[Na(Hg)/C_2H_5OH]{H_2/Ni} R-CH_2NH_2$
4. Reduction of amides: $R-C(=O)-NH_2 \xrightarrow[H_2O]{LiAlH_4} R-CH_2-NH_2$
5. Gabriel phthalimide synthesis



6. Hoffmann bromamide degradation reaction

$R-C(=O)-NH_2 + Br_2 + 4NaOH \longrightarrow R-NH_2 + Na_2CO_3 + 2NaBr + 2H_2O$

Physical properties

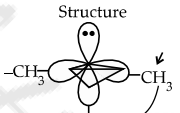
- Lower aliphatic amines are gases. Primary amines with three or more C atoms are liquid and higher ones are solid.
- Arylamines are colourless but get coloured on storage.
- Lower aliphatic amines are soluble in water, while higher are insoluble.
- Primary and secondary amines form intermolecular association.
- Boiling point : primary > secondary > tertiary

Importance of diazonium salts in synthesis of aromatic compounds

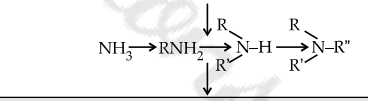
In preparation of substituted aromatic compounds which cannot be prepared by direct substitution in benzene/ substituted benzene.

Derivatives of ammonia, obtained by replacement of one, two or all the three H-atoms by alkyl and/or aryl groups

Structure



Classification



Nomenclature:

Common name : Aliphatic amine is named by prefixing alkyl group to amine. In secondary and tertiary amines prefix di or tri is put before name of alkyl group. IUPAC name : replacement of 'e' of alkane by the word amine. Suffix 'e' of arene is replaced by amine.

Diazonium Salts ($RN_2^+X^-$)

Preparation :

$C_6H_5NH_2 + NaNO_2 + 2HCl \xrightarrow{273-278K} C_6H_5N_2Cl + NaCl + 2H_2O$

Physical properties : Colourless crystalline solid, soluble in water, stable in cold but reacts with water on warming.

Chemical properties :

(i) Sandmeyer reaction: $ArN_2X \xrightarrow{Cu_2Cl_2/HCl} ArCl + N_2$; $\xrightarrow{Cu_2Br_2/HBr} ArBr + N_2$; $\xrightarrow{CuCN/KCN} ArCN + N_2$

(ii) Gattermann reaction :

$ArN_2X \xrightarrow{Cu/HCl} ArCl + N_2 + CuX$; $\xrightarrow{Cu/HBr} ArBr + N_2 + CuX$

(iii) $ArN_2Cl + KI \longrightarrow ArI + KCl + N_2$

(iv) $ArN_2Cl + HBF_4 \longrightarrow ArN_2BF_4 \xrightarrow{\Delta} ArF + BF_3 + N_2$

(v) $ArN_2Cl + H_3PO_2 + H_2O \longrightarrow ArH + N_2 + H_3PO_3 + HCl$

(vi) $ArN_2Cl + H_2O \longrightarrow ArOH + N_2 + HCl$

(vii) **Coupling reaction :**

$ArN_2Cl + H-C_6H_4-OH \xrightarrow{OH^-} ArN=N-C_6H_3(OH) + Cl^- + H_2O$ (Orange dye)

$ArN_2Cl + H-C_6H_4-NH_2 \xrightarrow{H^+} ArN=N-C_6H_3(NH_2) + Cl^- + H_2O$ (Yellow dye)

Alkyl Cyanides

Preparation :

$RI + KCN \xrightarrow{\Delta} RCN + KI$

Physical Properties :

Neutral with unpleasant smell moderately soluble in water

Chemical Properties :

$R-C\equiv N \xrightarrow[NaOH]{H_2O} RCOOH + NH_3$

$R-C\equiv N \xrightarrow[Na/C_2H_5OH]{(H)} RCH_2NH_2$

$R-C\equiv N \xrightarrow{R'MgX} R-C(R')=NMg\times \xrightarrow[-NH_3]{H_2O} R-C(R')=O$

Polymers

Origin

(i) Natural polymers : Found in plants and animals. (Proteins, rubber)
(ii) Semi–synthetic polymers : (Cellulose derivatives)
(iii) Synthetic polymers : Manmade. (Polythene, Buna –S)

Structure

(i) Linear polymers : Polythene
(ii) Branched polymers : PVS
(iii) Cross-linked polymers : Bakelite

Heating Behavior

(i) Thermoplastics :
regain their original propenties on cooling
e.g., Nylon-6, 6
(ii) Thermosetting Polymeres :
Do not regain their original properties in cooling
e.g., Bakelite

Synthesis

(i) Addition polymers : formed by intermolecular combination by repeating units without elimination of small molecular.
e.g., PVC, PAN etc.
(ii) Condensation polymers : formed by intermolecular combination of repeating units with the elimination of small moleculars
e.g., Nylon–6, 6 etc.

Configuration

(i) Isotactic polymers : Substituents are arranged on same side.
(ii) Synditactic polymers : substituents are arranged in alternate manner.
(iii) Atactic polymers : Substituents are arranged in random manner.

Monomer Units

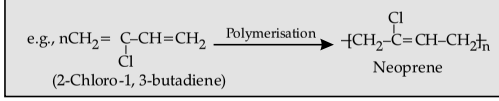
(i) Homopolymer : formed by same repeating units
–A–A–A–A–
(ii) Copolymers : formed by different repeating units
–A–B–A–B–A–B

Classification on the basis of

Very large molecules having high molecular mass

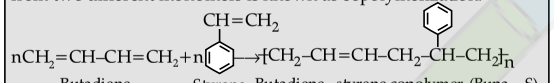
Rubber

Types :
(i) Natural rubber : Natural and obtained from rubber latex. It is polymer of isoprene.
(ii) Synthetic rubber : Any vulcanizable rubber or elastomer



Copolymerization : A mixture of more than one monomeric species undergoes polymerization

The process by which polymers are made by addition polymerisation from two different monomers is known as copolymerization.



Molecular mass of polymers

- Expressed as an average.
- Determined by chemical and physical methods.

Biodegradable polymers

Contain functional groups similar to biopolymers (PHBV, Nylon 2–nylon 6)

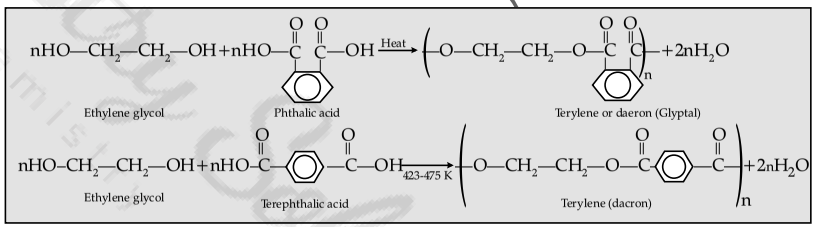
Non-Biodegradable polymers

Those polymers which do not degrade in environment and accumulate in the form of waste, e.g., polythene, polystyrene, etc. They consist of long chains of carbon and hydrogen atoms joined by strong interatomic bonding making it hard for microbes to break the bonds and digest them.

Examples

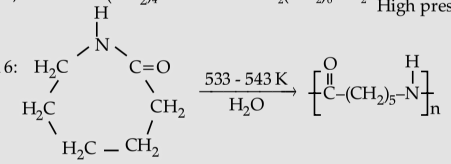
Polyesters

Polymers having large number of ester linkages

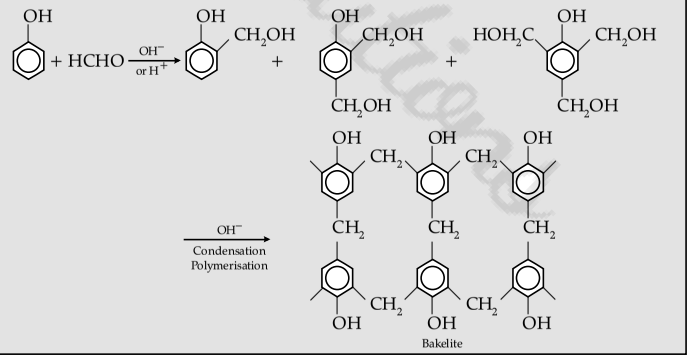


Preparations

- Polythene
  Low density : Polymerization of ethene under 1000–2000 atm at 350–570 K + catalyst.
  High density : Addition polymerization of ethene in a hydrocarbon solvent at 333–343 K and 6–7 atm + catalyst.
- Teflon: $nCF_2 = CF_2 \xrightarrow[\text{High pressure}]{\text{Catalyst}} -[CF_2-CF_2]-_n$
- Polyacrylonitrile: $nCH_2=CHCN \xrightarrow[\text{Peroxide}]{\text{Polymerisation}} -[CH_2-\underset{CN}{CH}]-_n$
- Nylon 6,6: $nHOOC(CH_2)_4COOH + nNH_2(CH_2)_6NH_2 \xrightarrow[\text{High pressure}]{533K} -[NH-(CH_2)_6-NH-CO-(CH_2)_4-CO]-_n$
- Nylon 6:



- Phenol-formaldehyde resin (Bakelite) : It is heat resistant thermosetting plastic.



Biomolecules

Proteins

-(Polymers of α–amino acids)
-Amino acids contain $–NH_2$ and –COOH group.

Classification:

- On the basis of relative number of $–NH_2$ and –COOH group:
  - (i) Neutral : Equal number of $–NH_2$ and –COOH group.
  - (ii) Basic : More number of $–NH_2$ than –COOH group.
  - (iii) Acidic : More number of –COOH than $–NH_2$ group.
- On the basis of place of synthesis:
  - (i) Essential – cannot be synthesized in the body.
  - (ii) Non-essential – synthesized in the body.
- On the basis of shape :
  - (I) Fibrous : Fibre-like structure
  - (ii) Globular : Spherical

Structure : $H_2N – CH_2 –$ [CO–NH] (Peptide linkage) $– CH(CH_3) – COOH$

Denaturation of proteins :
When a protein in its native form is subjected to physical change, globules unfold, helix get uncoiled and protein loses its biological activity.

Carbohydrates

Optically active polyhydroxy aldehydes or ketones or compounds which produce such units on hydrolysis.

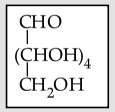
- **Classification:**

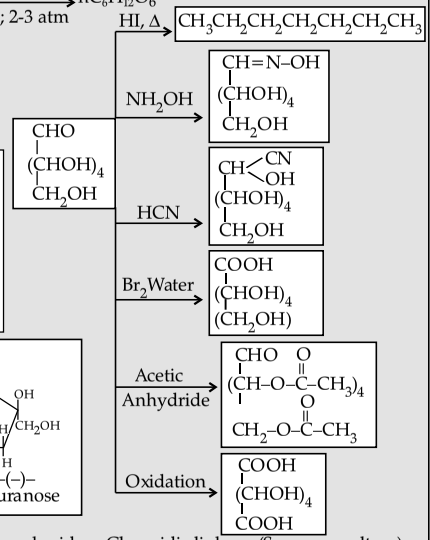
(I) Monosaccharides : (Aldehyde group – aldose, Keto group –ketose)
Glucose : Preparation :

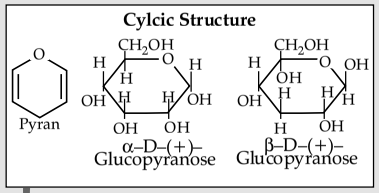
(a) From sucrose : $C_{12}H_{22}O_{11} + H_2O \xrightarrow{H^+} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$ (Sucrose)

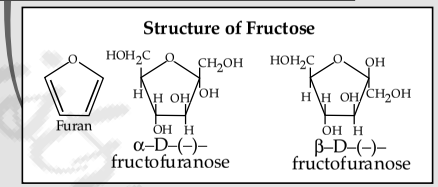
(b) From starch : $(C_6H_{10}O_5)_n + nH_2O \xrightarrow[393K;\ 2\text{-}3\ atm]{H^+} nC_6H_{12}O_6$

- **Structure:**









(II) Disaccharides : Linkage between 2 monosaccharides– Glycosidic linkage (Sucrose, maltose)
(III) Polysaccharides : Large number of monosaccharides units joined by glycosidic linkages.
(a) Starch : Polymer of α–glucose with two components amylose and amylopectin
(b) Cellulose
(c) Glycogen

Importance:
- Form a major portion of food.
- As storage molecules.
- Cellulose forms cell wall of bacteria and plants.
- Raw materials for industries like textiles, paper, lacquers and breweries.

Hormones

Chemical substances prodwed by ductless gland called endocrine glanh.
e.g., Adrenalin, thyroxine etc.

Vitamins

Organic compounds required in diet in small amounts to perform specific biological functions for maintenance and growth.

Classification:
(i) Fat soluble : Soluble in fats and oils but insoluble in water. (Vitamins A,D,E and K)
(ii) Water soluble : B group and vitamin C are soluble in water.

Nucleic Acids

Chromosomes : Particles in nucleus responsible for heredity. Chromosomes are made up of proteins and nucleic acid.
Two types : Deoxyribonucleic acid (DNA), Ribonucleic acid (RNA)
Composition : In DNA, sugar is β–D–2–deoxyribose whereas in RNA is β–D–ribose. DNA contains A,G,C,T whereas RNA has A,G,C,U.
Structure : –
Nucleoside : Formed by attachment of a base to 1′ of sugar
Nucleotide : Formed by link to phosphoric acid at 5′ of sugar.

Base / Sugar–Phosphate–[Sugar–Phosphate]– Base / Sugar

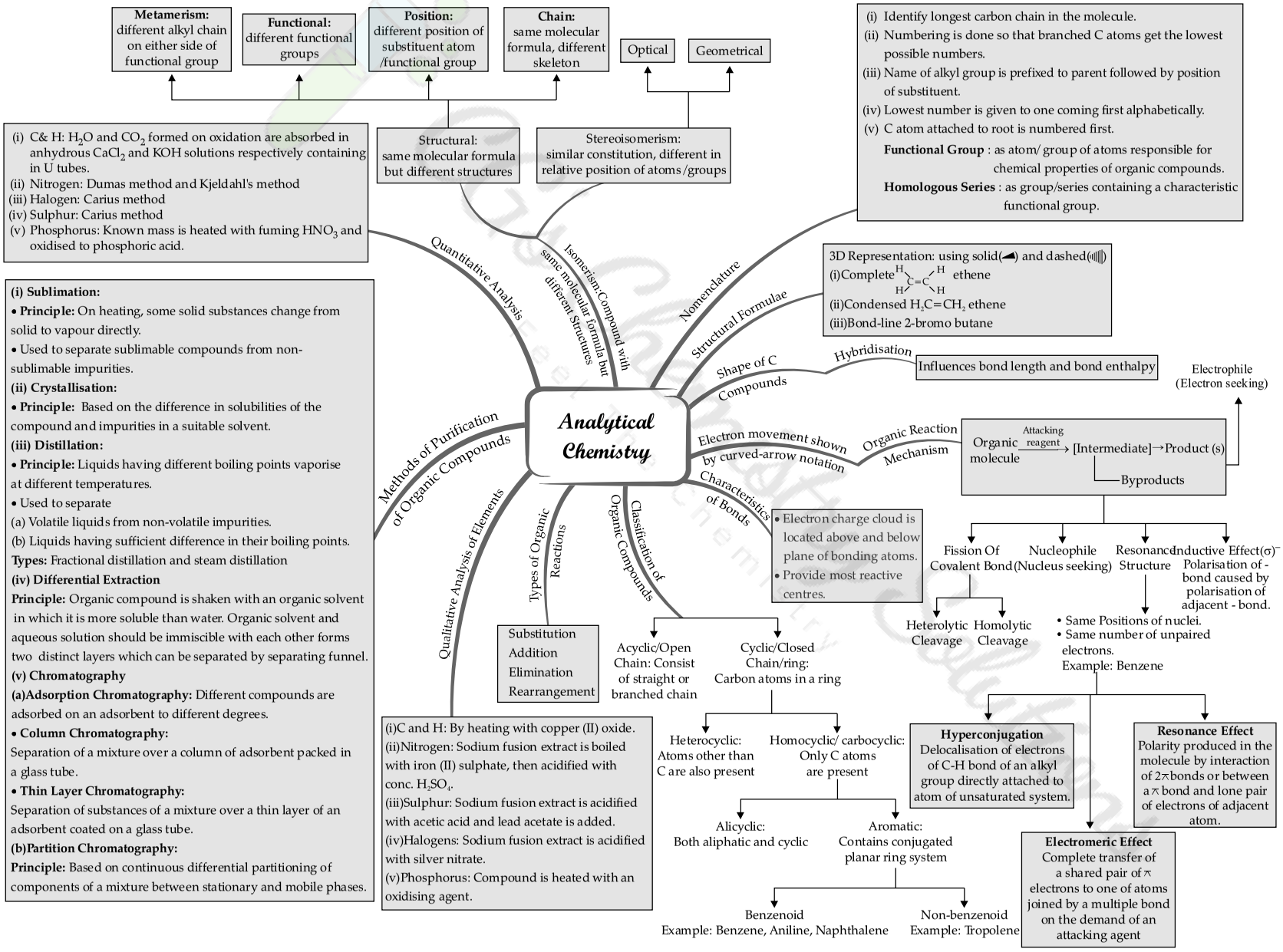
Types of RNA : m–RNA, r–RNA, t–RNA

Biological Functions :
- Chemical basis of heredity.
- Responsible for identity of different species of organisms.
- Nucleic acids are responsible for protein synthesis in cell.

DNA Fingerprinting: Unique sequence of bases on DNA.

Enzymes

Globular proteins specific for particular reaction and for particular substrate. Mechanism : Reduces the magnitude of activation energy



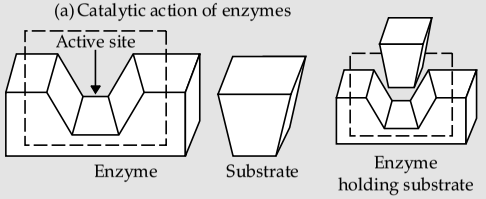
Chemistry in Everyday Life

Therapeutic Action of Different Classes of Drugs

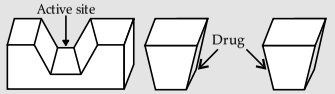
- **Antacids :** Substances that neutralize the excess HCl and raise pH in stomach (Ranitidine, Cimetidine).
- **Antihistamines :** Interfere with natural action of histamine by competing with histamine for binding sites of receptor where histamine exerts its effect.
- **Neurologically Active Drugs**
  - (a) **Tranquilizers :** Class of chemical compounds used for the treatment of stress and mild or even severe mental diseases. (Iproniazid, Phenelzine)
  - (b) **Analgesics :** Reduce/abolish pain without causing impairment of consciousness, mental confusion, incoordination or paralysis or other disturbances of nervous system. These are classified as:
    - (i) Non-narcotic (non-addictive) : (Aspirin, Paracetamol)
    - (ii) Narcotic : (Morphine)
- **Antimicrobials**
  - (a) **Antibiotics :** Drugs to treat infections because of their low toxicity for humans and animals. (Prontosil)
  - (b) **Antiseptics and Disinfectants :** Chemicals which either kill or prevent the growth of microorganisms. Antiseptics are applied to living tissues whereas disinfectants are applied to inanimate objects.
- **Antifertility Drugs :** Birth control pills. (Norethindrone, ethynylestradiol)

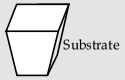
Medicines: Chemicals which generate therapeutic and useful biological response

- Drugs are chemicals of low molecular masses. Interact with macromolecular targets to produce a biological response.
- **Classification of drugs:**
  - (a) On the basis of pharmalogical effect : Provides range of drugs available for a particular type of problem. (Analgesics, Antiseptics).
  - (b) On the basis of drug action : (Antihistamines inhibit action of histamine responsible for causing inflammation in the body.
  - (c) On the basis of chemical structure : Common structural features. (Sulphonamides)
  - (d) On the basis of molecular targets : Most useful.
- **Drugs-Target Interaction:**
  - (i) Enzymes as Drug Targets
    - (a) Catalytic action of enzymes

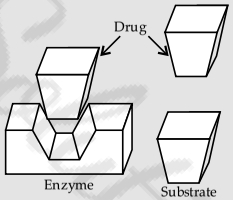


(b) Drug–enzyme interaction

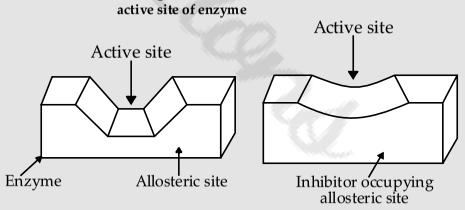




Drug and substrate competing for active site of enzyme



Drug blocks the active site of enzyme



(ii) **Receptors as Drug Targets**: Receptors are proteins crucial for body's communication and are embedded in cell membrane.

Chemicals In Food

Purpose:

- For their preservation.
- Enhancing their appeal.
- Adding nutritive value.
  - (a) Artificial Sweetening Agents : Natural sweeteners (sucrose), artificial sweeteners (Aspartame, Saccharin)
  - (b) Food Preservatives : Prevent spoilage of food due to microbial growth. (Table salt, sugar)

Cleansing Agents

Detergents

Types

(i) **Soap (Saponification)**

Glyceryl ester of stearic acid (fat) + Sodium hydroxide ⟶ Sodium stearate + Glycerol

(ii) **Synthetic Detergents :**

- Anionic detergents : Sodium salts of sulphonated long chain alcohols or hydrocarbons. (Sodium salts of alkyl benzene sulphonates)
- Cationic detergents : Quaternary ammonium salts of amines with acetates, chlorides or bromides as anions. (Cetyltrimethylammonium bromide)
- Non-ionic Detergents : Non-ionic type.

CHEMISTRY

Chapter - 1
Some Basic Concepts in Chemistry

1. Metric System

The **G**reat **M**orning **K**ing **H**enry **D**oesn't **U**sually **D**rink **c**hocolate **M**ilk **M**ixed with **N**atural **P**owder

The → Tera ($\times 10^{12}$)
Great → Giga ($\times 10^{9}$)
Morning → Mega ($\times 10^{6}$)
King → Kilo ($\times 10^{3}$)
Henry → Hecto ($\times 10^{2}$)
Doesn't → Deca ($\times 10$)
Usually → Unit ($\times 1$)
Drink → Deci ($\times 10^{-1}$)
Chocolate → Centi ($\times 10^{-2}$)
Milk → Milli ($\times 10^{-3}$)
Mixed with → Micro ($\times 10^{-6}$)
Natural → Nano ($\times 10^{-9}$)
Powder → Pico ($\times 10^{-12}$)

Chapter - 2
States of Matter

1. Gas Law's

PTV
(**l**etters **t**hat **t**ouches are **d**irectly **p**roportional & **l**etter **d**on't are **i**ndirectly **p**roportional)

[P∝T], [V∝T], $\left[P \propto \frac{1}{V}\right]$

2. Const terms in Gas Laws

Paid **T**V **C**an **B**e **G**ood

Const terms → Pressure (P) Temp (T) Volume (V)
Gas Law → Boyle's (Gay-Lussac's)

3. Ideal Gas Behavior

PLIGHT

High temp & Low pressure to achieve ideal Gas behavior
PL → Pressure Low
IG → Inert Gas
HT → High Temp

4. Kinetic Theory of Gas

Mother **SPEAKS**

M → Motion (Gas Particle are in Random Motion)
S → Size (negligible size of particle to total volume)
P → Pressure (Pressure exerted due to Collision with walls of container)
E → Elastic Collision
A → Attractive forces are not present
K → K.E ∝ Temp
S → Speed (Distribution of speed of particles remain const.)

5. Crystal System

Cu **T**e **M**OTHe **R** 3224

Unit Cell - Cubic, Tetragonal, Monoclinic, Orthorhombic, Triclinic, Hexagonal, Rhombohetral
Edge Length - a=b=c, a=b≠c, a≠b≠c, a≠b≠c, a≠b≠c, a=b≠c, a=b=c
Axial Length - α=β=γ, α=β=γ, α=β≠γ, ∝=β=γ, α≠β≠γ, α=β≠γ, α=β=γ
No. of Bravias Lattice - 3, 2, 2, 4, 1, 1, 1

6. Edge Length

TOM **H**andpicked **T**ag **(HT)** of **C**lass **R**epresentative **(CR)**

Triclinic, Orthorhombic, Monoclinic (a≠b≠c)
Hexagonal, Tetragonal (a=b≠c)
Cubic, Rhombohetral (a=b=c)

7. Axial Angles

TORC **H**as **M**ore **(HM)** **T**wists **(T)**

Tetragonal, Orthorhombic, Rhombohedral, Cubic (α=β=γ)
Hexagonal, Monoclinic (∝=β≠γ)
Triclinic (∝≠β≠γ)

Chapter - 3
Atomic Structure

1. Atomic No & Mass No

APEMAN

Atomic No. = No. of Protons
= No. of Electrons
Mass No. = Atomic No. + No. of neutrons

2. Isotopes, Isobars & Isotones

Bring **T**op **T**alented **M**AN (**B**TT **M**AN)

Atoms having same
Isobars → Mass Number
Isotopes → Atomic Number
Isotones → Neutrons

3. Electromagnetic Spectrum

Roman **M**en **I**nvented **V**ery **U**nusual **X**-ray **G**un

Roman → Radiowaves
Men → Microwaves
Invented → IR waves
Very → Visible rays
Unusual → UV waves
X-ray → X-rays
Gun → γ-rays (Gamma rays)

4. Visible Region of EMR

VIBGYOR

Visible
(a) Violet
(b) Indigo
(c) Blue
(d) Green
(e) Yellow
(f) Orange
(g) Red

5. Planck's Quantum theory

Employee's **P**rovident **F**und **(EPF)**

Energy = Planck's constant × Frequency
[E = hr]

6 . H-atom spectral lines

Myan **M**er **P**asta **B**read **F**und

Lyman (n_1=1)
Balmer (n_1=2)
Paschen (n_1=3)
Brackett (n_1=4)
Pfund (n_1=5)

7. Bohr Model of an atom

Electronic **v**ideo **R**ecording **(EVR)**

Energy (E) $\propto \frac{Z^2}{n^2}$

Velocity $\propto \frac{z}{n}$

Radius $\propto \frac{n^2}{z^2}$

8. Quantum Numbers

SPAM

S → Spin Quantum no. (m_s)
P → Principal Quantum no. (n)
A → Azimuthal Quantum no. (l)
M → Magnetic Quantum no. (m_2)

9. Sequence of orbitals

Sober **P**hysicists **D**on't **F**ind **G**iraffes **H**iding **I**n **K**itchen

s,p,d,f,g,h,i,k

Chapter - 4
Chemical Bonding & Molecular Structure

1. Formal Charge

For **V**ery **L**ovely **S**on!

[Formal Charge (F.C) = Valence e^- in free state (V.E) – Lone pair (l.p) –1/2 × Shared e^- (S.E)]

2. H–bonding

H-**b**onding is **FON (Fun)!**

Fluorine, Oxygen, Nitrogen

3. Diatomic Molecules

Have **N**o **F**ear of **I**ce **C**old **B**eer

H_2, N_2, F_2, O_2, I_2, Cl_2, Br_2

4. Chemical Bond Strength

I can't **H**andle **D**irty **V**ans

Ionic > Covalent > H–bonds > Dipole > Vanderwaal

5. Bond Polarity

SNAP

Symmetrical → Non Polar
Asymmetrical → Polar

6. Hybridisation

(VMCA)

Steric No. = 1/2 [V+M–C+A]
V → Valence e^- of central atom
M → Monovalent atoms (H/X)
C → Cationic Charge
A → Anionic Charge

Chapter - 5
Chemical Thermodynamics

1. **Process Boring ACT**

Peer's **H**ard **V**erified **T**est

Process ISO Bar Adiabatic ISO Choric ISO Therm Const → Pressure (P) Heat (q) Volume (V) Temp (T)

2. **State Function**

PVT HUGS

Pressure, Volume, Temp, Enthalpy (H), Internal Energy (U), Gibbs free energy (G) Entropy (S)

3. **First law of Thermodynamics**

I Work **H**ard

Change in internal energy (U) = Work (w)+Heat (q)

4. **Heat Capacity**

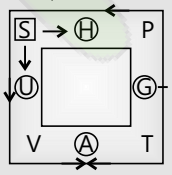
PVR Cinemas

$C_P - C_V = R$

5. **Criteria of Spontaneity**

Good Physicists Have Studied Under Very Ambitious Teachers

$(dH)_{S,P} < 0$
$(dU)_{S,V} < 0$
$(dG)_{P,T} < 0$
$(dA)_{V,T} < 0$
$(dS)_{H,P} > 0$
$(dS)_{U,V} > 0$



6. **Gibb's Free Energy**

Get **H**igh **T**est **S**cores

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

Chapter - 6
Solutions

Ideal & Non ideal Solutions

HIV

	Ideal	Non-Ideal
Enthalpy (ΔH)	ΔH=0	ΔH≠0
Intermolecular Forces	A–A & B–B is same as A–B	A–A & B–B is not same as A–B
Volume (ΔV)	ΔV=0	ΔV≠0

Chapter - 7
Equilibrium

Bronsted Acid-Base Concept

Strong **A**rmy, **L**ost to **C**arelessly **W**eak **B**andits

Strong Acid gives Weak Conjugate Base

Chapter - 8
Redox Reactions and Electrochemistry

1. **Redox Reaction**

Leo **S**ay **G**er !

Loss of e^- is oxidation
Gain of e^- is reduction

2. **Redox Reaction**

Red **C**at

Reduction at Cathode

3. **Redox Reaction**

An **O**x

Anode for Oxidation

4. **Metal Activity Series**

Please **S**top **C**alling **M**e **A** **Z**ebra **C**rab. **I** **L**ike **C**alling **H**er **S**mart **G**oat

Potassium > Sodium > Calcium > Magnesium > Aluminium > Zinc > Chromium > Iron > Lead > Copper > Mercury (Hg) > Silver > Gold

5. **Metal activity series**

FAT **C**AT

Flow of e^- from anode to cathode

6. **Metal activity series**

Amount **o**f **H**undred **C**eins

Balancing Half Cell
Steps : (1) Atoms
(2) Oxygen
(3) Hydrogen
(4) Charge

7. **Electro Chemical Series**

Priyanka **C**hopra **S**ees **M**ovie **A**bout **Z**ebra **I**n **T**he **L**ibya **H**iring **C**obra **S**tudying **A**lgebra

Potassium < Calcium < Sodium < Magnesium < Aluminium < Zinc < Iron < Tin < Lead < Hydrogen < Copper < Silver < Gold (Au)

8. **For Galvanic Cell**

LOAN

Loss of e^-
Oxidation
Anode
Negative

9. **Electrolytic Cell**

LOAP

Loss of e^-
Oxidation
Anode
Positive

Chapter - 9
Chemical Kinetics and Surface Chemistry

1. **Mechanism of Heterogeneous Catalysis**

RAID **P**rogram

(a) Reactant diffusion on surface
(b) Adsorption of Reactant
(c) Intermediate formation
(d) Desorption of product
(e) Product leaves the surface

2. **Types of Colloids**

Soft **S**AGE **A**nd **S**hredded **F**ace **(SSAGEASF)**

Dispersed Phase	Dispersion Medium	Type of Colloids Solid Sol
Solid	Solid	Solid Sol
Solid	Liquid	Sol
Solid	Gas	Aerosol
Liquid	Solid	Gel
Liquid	Liquid	Emulsion
Liquid	Gas	Aerosol
Gas	Solid	Solid Sol
Gas	Liquid	Foam

Chapter - 10
Classification of Elements and Periodicity in Properties

1. **Elements of Atomic No (1-18)**

Happy **H**arry **L**isten **B**BC **N**etwork **O**ver **F**rench **N**etwork. **N**ative **M**agpies **A**lways **S**it **P**eacefully **S**earching **C**lear **A**reas

H, He, Li, Be, B, C, N, O, F, Ne, Na, Al, Si, P, S, Cl, Ar

2. **Group I Elements**

Little **N**asty **K**ids **R**ub **C**ats **F**ur

Lithium (Li), Sodium (Na), Potassium (K), Rubidium (Rb) Caesium (Cs), Francium (Fr)

3. **Group II Elements**

Beer **M**ugs **C**an **S**nap **B**ar's **R**eputation

Beryllium (Be), Magnesium (Mg), Calcium (Ca), Strontium (Sr), Barium (Ba), Radium (Ra)

4. **Group III Elements**

BAGIT

Boron (B), Aluminium (Al), Gallium (Ga), Indium (In), Thallium (Tl)

5. **Group IV B Elements**

Can **S**imple **G**ermans **S**urprise **P**ublic

Carbon (C), Silicon (Si), Germanium (Ge), Tin (Sn), Lead (Pb)

6. **Group V B Elements**

New **P**olice **A**ssign **S**ubordinate **B**ikram on **D**uty

Nitrogen (N), Phosphorus (P), Arsenic (As), Antimony (Sb), Bismuth (Bi)

7. Group VI B Elements

Old **S**ahranpur **S**eems **T**erribly **P**olluted

Oxygen (O), Sulphur (S), Selenium (Se), Tellurium (Te), Polonium (Po)

8. Group VII B Elements

First **C**lass **B**iryani **I**n **A**ustralia

Fluorine (F), Chlorine (Cl), Bromine (Br), Iodine (I), Astatine (Al)

9. Group VIII B/18 Elements

He **n**ever **A**rrived; **K**aran **e**xited **w**ith **R**ohan

Helium (He), Neon (Ne), Argon (Ar), Krypton (Kr), Xenon (Ex), Radon (Rn)

10. 3d-Series

Scary **T**iny **V**icious **C**reatures are **M**ean **f**emales **c**ome to **N**ight **C**lub **Z**en

Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn,

11. 4d-Series

Yes **S**(z)sir **N**ob. **M**ost **T**echnicians **R**ub **R**od's **P**ale **S**ilver **C**adillac

Y, Zr, Nb>Mo, Tc, Ru, Rh, Pd, Ag, Cd

12. 5d-Series

Late **H**arry **T**ook **W**alk, **R**eached **O**ffice **I**n **P**ajamas **A**fter an **H**our

La....., Hf, Ta, W, Re, OS, Ir, Pt, Au, Hg

13. Lanthanides

Ladies **C**an't **P**ut **N**eedles **P**roperly in **S**lot-**m**achnies. **E**very **G**irl **T**ries **D**aily **H**owever, **E**very **T**ime **Y**ou'd be **l**ose

La, Ce, Pr, Nd, Pm, Sm, Eu Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu

Chapter - 11
General Principles and Process of Isolation of Metal

1. Process of Metallurgy

CIP (Read **o**pp **P**IC**)**

(a) Concentration of Ore
(b) Isolation
(c) Purification

2. Concentration of Ore

Honest **M**an **F**eeling **L**ow **(HMFL)**

(a) Hydraulic Washing
(b) Magnetic Separation
(c) Froath Floatation Method
(d) Leaching

3. Conversion to Oxide

CRAP

Calcination $\rightarrow$ Absence of O_2
Roasting $\rightarrow$ Presence of O_2

4. Ores

MISH

Prime **M**inister **G**oing **C**hina

Iron ores $\rightarrow$ Magnetite, Iron pyrites, Siderite, Haematite
Copper ores $\rightarrow$ Copper pyrites, Malachite, Copper Glance, Cuprite

Chapter - 12
Hydrogen, s & p-Block Elements

Hydrogen

1. Isotopes of Hydrogen

Pro-**D**iabetic **T**reatment **PDT)**

Protium $\left({}^{1}_{1}H\right)$

Deuterium $\left({}^{2}_{1}H\right)$

Tritium $\left({}^{3}_{1}H\right)$

2. H–Bonding

iso **F**ON ! (**S**ay **F**un)

Fluorine, Oxygen, Nitrogen

3. Hardness of Water

CM is **t**emporarily **h**ard with **H**ead **C**lerks **(HC)** but **p**ermanently

Temporary hardness due to $Mg(HCO_3)_2$, $Ca(HCO_3)_2$
Permanent hardness due to MgCl2, $CaCl_2$, $MgSO_4$, $CaSO_4$ Hard with civil servants (CS) Cl^-, SO^{2-}
hydrogen Carbonate (HCO_3^-)

s-block elements

4. Group I Elements

Little **N**asty **K**ids **R**uts **C**ats **F**ar

Lithium (Li), Sodium (Na), Potassium (K), Rubidium (Rb), Caesium (Cs), Francium (Fr)

5. Group II Elements

Beer **M**ug **C**an **S**nape **B**ar's **R**eputation

Beryllium (Be), Magnesium (Mg), Calcium (Ca), Strontium (Sr), Barium (Ba), Radium (Ra)

6. Castner Kellnar Cell

Cement **M**odified **S**oil **(CMS)** **O**xidised

Cathode Mercury (Hg) on which
Sodium ion(Na+) is oxidised
ACC → reduced→Anode of carbon on which Cl^- is reduced

7. Properties of Birch Reagent

Roman **P**eople **C**an **C**ommute **(RPCC)**

($Na/Li + liq.NH_3$) –
(Reducing in nature, Paramagnetic, conducting, Coloured)

p-block elements

8. Group 13 Elements

BAGIT

Boron (B), Aluminium (Al), Gallium (Ga), Indium (In), Thallium (Tl)

9. Group 14 Elements

Can **S**imple **G**ermans **S**urprise **P**ublic

Carbon (C), Silicon (Si), Germanium (Ge), Tin (Sn), Lead (Pb),

10. Borax bead Test

Multiple **P**rogram **C**ombined **(MPC)** for **Y**our **G**rowth **(FYG)**. **N**ew **B**oys **G**et **(NBG)** **C**ommon **B**oys **R**oom **(CBR)** for **C**ombining **D**esktop **D**rawing **(CDD)**

Ion	Oxidising Flame	Reducing Flame		
Mn_2+	Pink	Colour less	→	MPC
Fe_2+/Fe_3+	Yellow	Green	→	FYG
Ni_2+	Brown	Grey	→	NBG
Cu_2+	Blue	Red	→	CBR
Co_2+	Deep Blue	Deep Blue	→	CDD

p-block elements

11. Group 15 Elements

New **P**olice **A**ssigns **S**ubordinate **B**ikram on **d**uty

Nitrogen (N)
Phosphorus (P)
Arsenic (As)
Antimony (Sb)
Bismuth (Bi)

12. Group 16 Elements

Old **S**ahranpur **S**eems **T**erribly **P**olluted

Oxygen (O)
Sulphur (S)
Selenium (Se)
Tellurium (Te)
Polonium (Pu)

13. Group 17 Elements

First **C**lass **B**iryani **I**n **A**ustralia

Fluorine (F)
Chlorine (Cl)
Bronine (Br)
Iodine (I)
Astatine (At)

14. Group 18 Elements

He **N**ever **A**rrived; **K**aran **e**xited with **R**ohan

Helium (He)
Neon (Ne)
Argon (Ar)
Krypton (Kr)
Xenon (Xe)

Chapter - 13
d & f block elements and Coordination Compounds

1. **3d-Series**

Scary **T**iny **V**icious **C**reatures are **M**ean; **F**emales **C**ome to **N**ight **C**lub **Z**en

Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn

2. **4d-Series**

Yes **S**(z)ir, **N**ob **M**ost **T**echnicians **R**ub **R**od's **P**ale **S**ilver **C**adillac

Y, Zr, Nb, Mo,Tc, Ru, Rh, Pd, Ag, Cd

3. **5d-Series**

Late **H**arry **T**ook **W**alk, **R**eached **O**ffice **I**n **P**ajamas **A**fter an **H**our

La..... Hf, Ta, W, Re, Os, Ir, Pt, Au, Hg

4. **Lanthanides**

Ladies **C**an't **P**ut **N**eedles **P**roperly is **S**lot-machines. **E**very **G**irl **T**ries **D**aily, **H**owever, **E**very **T**ime **Y**ou'd **b**e **L**ose

La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu

5. **Spectrochemical Series**

I **B**ought **S**ome **C**opies to **S**tudy **F**undamental of **C**hemistry. **H**e **N**urtured **E**xcellence in **N**ecessary **C**oordination **C**ompound

$I < Br^- < SCN^- < Cl^- < S^{2-} < OH^- < C_2O_4^{2-} < H_2O <$ $NC5^- < EDTA^{4-} < NH_3 < CN^- < CO$

6. **Pairing of e^- Octahedral Complexes**

Common **L**eague **P**eople win **H**earts

CFSE (Δ_0) < Pairing Energy
Ligand → Weak field
Type of complex → High spin
Pairing of e^- in t_2g orbital

7. **Werner's theory**

Plcturesque **S**Now

Primary valency → Ionisable (Charge on Ionisation sphere)
Secondary valency → Non Ionisable (Coordination Number)

8. **Spectrochemical series**

I **B**ought **S**ome **C**opies to **S**tudy **F**undamental of **C**hemistry **H**e **N**utured **E**xcellence in **N**ecessary **C**oordination **C**ompounds

$I^- < Br^- < SCN^- < Cl^- < S^{2-} < OH^- < C_2O_4^{2-} < H_2O <$ $NCS^- < EDTA^{4-} < NH_3 < CN^- < CO$

I^- = I
Br^- = Brought
SCN^- = Some
Cl^- = Copies to
S^{2-} = Study
F = Fundamental
OH^- = Of
$C_2O_4^{2-}$ = Chemistry
H_2O = He
NCS^- = Nutured
$EDTA^{4-}$ = Excellence in
NH_3 = Necessary
CN^- = Coordination
CO = Compounds

9. **Pairing of e^- Octahedral Complexes**

Common **L**eague **P**eople **w**in **H**earts **V**ice-**V**ersa

(i) CFSE (Δ_0) < Pairing Energy (P.E)
Ligand → Weak field ligand
Type of complex → High spin Complex
Pairing of e^- in t2g orbital
(ii) CFSE (Δ_0) < Pairing Energy (P.E)

10. **Werner's theory**

Plcturesque **S**Now

Primary valency → Ionisable i.e., Charge on Ionisation sphere (PIcturesque)
Secondary valency → Non Ionisable i.e., Coordination number (SNow)

Chapter - 14
Environmental Chemistry

1. **Gases air Pollutants**

HOSCN

Hydrocarbons, Oxides of Sulphur (SO_2, SO_3), Carbon (CO, CO_2), Nitrogen (NO, NO_2)

2. Components of Photochemical Smog

O FAN **P**AN

Ozone, Formaldehyde, Acrolein, Nitric oxide, PAN

Chapter - 15
Purification, Basic Principles and Characteristics of Organic Compounds

1. Functional group preference order

ASEHA **N**AKAA **D**elhi **T**raining **C**amp

Carboxylic Acid > Sulphonic Acid > Ester > Acid Halides > Acid Amides >Nitrile > Aldehyde > Ketone > Alcohol > Amnes = > =

2. No Preference Functional Group

NAHE

Nitro, Alkyl / Aryl, Halo, Ethers

3. Carbon Chain

Monkey **E**at **P**eeled **B**ananas

Meth, Eth, Prop, But

4. 3-D Representation

So **t**owards **D**o **a**way

Solid → Towards observer (◀)
Dashed → Away from observer (IIIII)

5. Types of Organic Reaction

EARS

(a) Elimination
(b) Addition
(c) Rearrangement
(d) Substitution

6. Structural Isomerism

Poor **F**armer **M**anaging **C**rops **(PFMC)**

(a) Position
(b) Functional Group
(c) Metamerism
(d) Chair

7. Optical Isomerism

GO

(a) Geometrical
(b) Optical

Chapter - 16
Hydrocarbons and their Halogen Derivatives

1. m-directing Group

Queen **E**lizabeth **S**econd's **N**avy **C**ommands, **C**ontrols

Qiatonary,

2. o, p–directing

AHA AHA P

Alkyl (–R)
Halogen (–X)
Alkoxyl (–OR)
Amino (–NH_2, NHR, NR_2)
Hydroxyl (–OH)
Amide (–NHCl)
Phenyl (C_6H_5)

3. SN1 reaction

CURT-I

Carbocation Intermediate
Unimolecular Reaction
Racemic mixture is obtained
Two step process
Ist order kinetics

4. Chirality

CANS

Chiral → Non-Super imposable mirror Images
Achiral → Super imposable Mirror Images

Chapter - 17
Organic Compound Containing Oxygen

1. Detection test

TASte **F**AAR **I**MLy

TASte → Tollen's test, Aldehyde group, Silver Mirror

FAAR → Fehling's test, Aliphatic Aldehyde, Red-Brown ppt

IMLY → Iodoform test, Methyl group linked to $-\overset{\overset{O}{\|}}{C}-$, Yellow ppt

2. **Common Names of Carboxylic Acid**

Frog **A**re **P**olite, **B**eing **V**ery **C**ourteous

Formic, Acetic, Propionic, Butyric, Valeric, Caproic

3. **Dicarboxylic Acid**

Oh **M**y, **S**uch **G**ood **A**pple **P**ie, **S**weet **A**s **S**ugar

Oxalic, Malonic, Succinic, Glutaric, Adipic, Pimelie, Subric, Azelaic, Sebacic

4. **Clemmenson and wolf Reaction**

Can **Z**ebra **W**oo **N**ightingale

Reaction to convert –C– to alkane
(to remember regents of reaction)
Clemmen → son → Zn–Hg/HCl
Wolf → Reaction → NH_2–NH_2/OH^-

Chapter - 18
Organic Compounds Containing Nitrogen

1. **Carbylamine test**

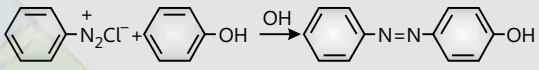
PAFSI (Say **P**epsi**)**

Primary amine gives Foul smell of Isocyanicle with $CHCl_3$+KOH Amine Smell
$RNH_2+CHCl_3+KOH \quad RNC+KCl+H_2O$

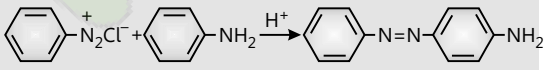
2. **Coupling Reaction**

DSPO DAY **(S**ay**, D**e**SPO D**AY**)**

Diazonium Salt + Phenol → Orange dye
Diazonium Salt + Aniline → Yellow dye



(orange dye)



(yellow dye)

Chapter - 19
Polymers and Biomolecules

1. **Disaccharides**

Non-**r**educing **SGF**

Sucrose → Glucose + Fructose
Non-Reducing Sugar

2. **Essential Amino Acids**

PVT TIM HALL

(Phenylalanine, Valine, Threonine, Tryptophan, Isoleucine, Methionine, Histidine, Arginine, Leucine, Lysine)

3. **Fatsoluble Vitamins → Vitamin K, E, D, A**

KEDA

Rest all Vitamins are water Soluble

4. **DNA & RNA**

G3**C**inema **A**T 2PM

DNA A=T, G≡C
(2 H–bonds b/w Adenine & Thymine
3 H–bonds b/w Guanine & Cytosine)
G≡C A=T
Also, GCAT

Chapter - 20
Analytical Chemistry and Chemistry in Everyday life

1. **Artificial Sweetening Agents**

ASSA

Aspartame, Saccharin, Sucrolose, Alitame
Also, Assac Sue Ali

2. **Antiseptic & Disinfectants**

Bitter **C**hlor

Bithionol , Terpineol, Chloroxylenol

3. **Antacids**

His **I**nteraction **P**resented by **l**ime **R**an (**S**ay **S**imran)

Interaction of Histamine prevented by limetidine, Ranitidine