SOLID STATE

PHYSICS WALLAH

01 ▪ CRYSTALLINE & AMORPHOUS SOLID

CRYSTALLINE SOLID	AMORPHOUS SOLID
	
Constituent particles are arranged in a regular, repeating & alternating manner	Constituent particles are arranged in an irregular, random manner
True solid	Pseudo solid or super cooled liquid
Long range order	Short range order
Gives regular cleavage on cutting	Gives an irregular cleavage on cutting
Anisotropic	Isotropic
Sharp melting point	Range of melting point
NaCl, Diamond, Ice etc.	Plastic, Rubber, Glass etc.

Q. Which of the following is a pseudo solid?

(A) CaF_2 (B) Glass

(C) NaCl (D) All of these

02 ▪ CLASSIFICATION OF CRYSTALLINE SOLID

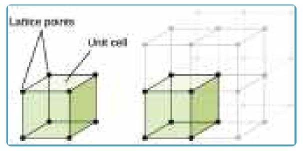
Name	Constituent Particles	Attractive Force	Propersties	Examples
Ionic Solid	Ions	Ionic bond	Brittle, High melting point, poor conductors of heat & electricty	NaCl, KCl, LiCl, etc.
Covalent Solid	Atoms	Covalent bond	Hard, High melting point, poor conductors of heat & electricty	Diamond, Graphite, Quartz, Silica, etc.
Molecular Solid	Molecules	Inter molecular force of attraction	Soft, low melting point, poor conductors of heat & electricty	Wax, ice, Naphthaline, Dry ice, camphor, etc
Metallic Solid	Cations & Mobile electrons	Metallic bond	Soft - hard, low m.p- high m.p, good conductors of heat & electricty	All metals

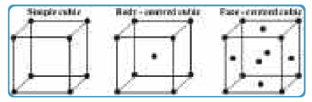
Q. Which one has the highest melting point?

(A) Ionic crystal (B) Molecular crystal

(C) Covalent crystal (D) Metallic crystal

03 ▪ UNIT CELL





- Corner → $\frac{1}{8}$
- Body center → 1
- Face center → $\frac{1}{2}$
- Edge center → $\frac{1}{4}$

} contribution per unit cell

Q. How many formula units are there in the unit cell of sodium chloride having FCC structure

(A) 2 (B) 4 (C) 6 (D) 8

04 ▪ DENSITY OF UNIT CELL

$$\rho = \frac{z \times M}{a^3 \times N_A}$$

▪ RADIUS & EDGE LENGTH

- Simple Cube → $r = \frac{a}{2}$
- BCC → $r = \frac{\sqrt{3}a}{4}$
- FCC → $r = \frac{a}{2\sqrt{2}}$

▪ PACKING EFFICIENCY

Unit cell	Packing efficiency
Simple cubic	52.3%
bcc	68%
fcc	74%

Q. An element has a bcc structure with a cell edge length of 288pm. The atomic radius is:

(A) $\frac{\sqrt{2}}{4}$ x 288pm (B) $\frac{4}{\sqrt{3}}$ x 288pm

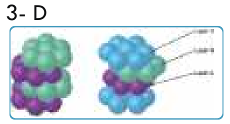
(C) $\frac{4}{\sqrt{2}}$ x 288pm (D) $\frac{\sqrt{3}}{4}$ x 288pm

05 ▪ CLOSE PACKING

1- D

2- D

3- D



NUMBER OF OCTAHEDRAL VOID = N

NUMBER OF TETRAHEDRAL VOID = 2N

Q. A compound is formed by cation C and anion A. The anions form hcp lattice & the cations occupy 75% of octahedral voids. The formula of the compound is

(A) C_4A_3 (B) C_2A_3 (C) C_3A_2 (D) C_3A_4

06 ▪ ELECTRICAL & MAGNETIC PROPERTIES

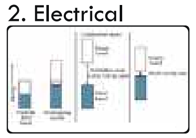
1. Magnetic

↑↑↑↑ ferro magnetic

↑↓↑↓ anti ferro magnetic

↑↓↑↓↑ ferri magnetic

2. Electrical



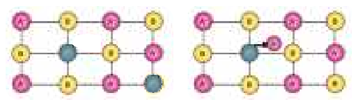
Q. Silicon doped with arsenic is an example of which type of semiconductor?

(A) p-type (B) n-type

(C) n, p-type (D) Intrinsic

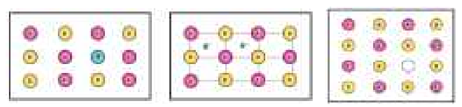
07 ▪ CRYSTAL DEFECT

1. Stoichiometric



Schottky defect Frenkel defect

2. Non-stoichiometric



metal excess defect metal deficiency defect

Q. Which is the incorrect statement?

(A) Density decreases in case of crystals with Schottky defect.

(B) NaCl is insulator, silicon is semiconductor, silver is conductor, quartz is piezoelectric crystal.

(C) Frenkel defect is favoured in those ionic compounds in which sizes of cation and anions are almost equal.

(D) $FeO_{0.98}$ has non-stoichiometric metal deficiency defect.

08 ▪ CRYSTAL SYSTEM

Crystal system	Axial relationships	Interaxial angles
Cubic	a = b = c	α=β=γ=90°
Tetragonal	a = b ≠ c	α=β=γ=90°
Orthorhombic	a ≠ b ≠ c	α=β=γ=90°
Hexagonal	a = b ≠ c	α=β=90°, γ=120°
Rhombohedral or Trigonal	a = b = c	α=β=γ≠90°
Monoclinic	a ≠ b ≠ c	α=γ=90° ≠ β
Triclinic	a ≠ b ≠ c	α≠ β≠ γ≠90°

Q. The correct option for the number of body centred unit cells in all 14 types of Bravais lattice unit cells is

(A) 7 (B) 5 (C) 2 (D) 3

SOLUTIONS

Types

Gaseous
- Gas-Gas → Mixture of O_2 and N_2
- Liquid-Gas → Chloroform with N_2
- Solid-Gas → Camphor in N_2

Liquid
- Gas-Liquid → O_2 dissolved in water
- Liquid-Liquid → Ethanol dissolved in water
- Solid-Liquid → Glucose dissolved in water

Solid
- Gas-Solid → O_2 in Pd
- Liquid-Solid → Amalgam of Hg with Na
- Solid-Solid → Cu dissolved in gold

Expressing Concentration of solutions

- **Mass by volume percentage (w/v)**: $\frac{\text{Mass of solute}}{\text{Volume of solution}} \times 100$
- **Volume percentage (v/v)**: $\frac{\text{Volume of component}}{\text{Total volume of solution}} \times 100$
- **Mass percentage (w/w)**: $\frac{\text{Mass of component in solution}}{\text{Total mass of solution}} \times 100$
- **Parts per million : For trace quantities**: $\frac{\text{No. of parts of components} \times 10^6}{\text{Total no. parts of components of solution}}$
- **Mole fraction**: $\frac{\text{No. of moles of component}}{\text{Total No.of moles of all components}}$
- **Normality**: Number of gram equivalents of the solute dissolved in one litre of solution
  $\frac{\text{No. of gram equivalent of solute} \times 100}{\text{Volume of solution (in L)}}$
  Gram Equivalents of solute $= \frac{\text{Mass of solute}}{\text{Equivalent weight}}$
  Equivalent weight $= \frac{\text{Molecular mass}}{\text{valency}}$
- **Molality**: Number of moles of solute per kilogram of the solvent
  $\frac{\text{No. of moles of solute} \times 1000}{\text{Mass of solvent (in g)}}$
- **Molarity**: Number of moles of solute in 1L solution
  $\frac{\text{No. of moles of solute} \times 100}{\text{Volume of solution (in L)}}$

Solubility

Solid in liquid
- **Effect of temperature**
  - Endothermic $\Delta_{sol} H > 0$, Solubility Increases at high temp.
  - Exothermic $\Delta_{sol} H < 0$, Solubility decreases at high temp.
- **Effect of Pressure**: Not significant

Gas in liquid
- **Effect of temperature**: Increases with decrease in temperature
- **Effect of Pressure**: Increases with increase in Pressure

Henry's Law

Partial pressure of gas in vapour phase is proportional to the mole fraction of gas in the solution.

$$p = K_H x$$

Colligative properties

- Osmotic pressure → $\pi = CRT$
- Depression in freezing point → $\Delta T_f = \frac{K_f \times W_2 \times 1000}{M_2 \times W_1}$
- Elevation of boiling point → $\Delta T_b = \frac{K_b \times 1000 \times W_2}{M_2 \times W_1}$
- Relative lowering of vapour pressure (for dilute solutions) → $\frac{W_2 \times M_1}{M_2 \times W_1} = \frac{P^\circ_1 - P_1}{P^\circ_1}$

Abnormal molecular mass

Molecular mass different from expected value

Van't Hoff factor (i) $= \frac{\text{Normal molar mass}}{\text{Abnormal molar mass}}$

Raoult's Law

For any solution, the partial vapour pressure of each volatile component is directly proportional to its mole fraction in solution phase

Obey raoult's law
Ideal solution → $\Delta H_{mix} = \Delta V_{mix} = 0$
eg: n-hexane and n-heptane
Ethyl bromide + Ethyl chloride,
Chlorobenzene + Bromobenzene, etc.

Do not Obey raoult's law
Non-Ideal solution → ΔH_{mix} or $\Delta V_{mix} \neq 0$

Positive Deviation
$\Delta H_{mix} > 0$

$\Delta V_{mix} > 0$

eg: Acetone + Ethyl alcohol,
Water + Ethyl alcohol,
Carbon tetrachloride + Chloroform,
Chloroform + Ethanol,
Acetone + Carbon disulphide,
Acetone + Benzene, etc.

Negative Deviation
$\Delta H_{mix} < 0$

$\Delta V_{mix} < 0$

eg: Acetone + Aniline,
$HCl + H_2O$, $HNO_3 + H_2O$,
$H_2SO_4 + H_2O$,
Acetone + Chloroform,
HNO_3 + Chloroform,
Benzene + Chloroform,
Pyridine + Glacial acetic acid, etc.

Azeotropes

Azeotropes:
The mixtures of liquids which boil at constant temperature like a pure liquid and possess same composition of components in liquid as well as vapour phase are called constant boiling mixtures or azeotropic mixtures.

Minimum boiling azeotropes:
They are formed by those liquid pairs which show positive deviations from ideal behaviour. eg: ethanol-water mixture.

Maximum boiling azeotropes:
They are formed by those liquid pairs which show negative deviations from ideal behaviour e.g nitric acid-water mixture.

ELECTROCHEMISTRY

PHYSICS WALLAH

1 Electrochemical Cell

Left side	Right side
Oxidation	Reduction
Anode	Cathode
Negative	Positive

2 Representation of cell

Zn| Zn^{2+}|| Cu^{2+}| Cu

R_a| P_a|| R_c| Pc

Product at anode ↙ ↘ Reactant at cathode

- Electrode potential ($E_{M^{n+}/M}$)

E.P= Reduction Potential (R.P)
= -Oxidation potential (O.P)

If R.P=x, then O.P=-x

Representation of Reduction half reaction:

M^{n+} + ne⁻ ⟶ M

- Standard Reduction Potential(SRP) ($E^o_{M^{n+}/M}$)

R.P at 1M and 298K.
SRP is calculated by using SHE

Respresentation of SHE

$H^+_{(1M)}$| $H_{2\,(g,1\ bar)}$ | $Pt_{(s)}$, E^o_{SHE}=0

3 Electrochemical series

Table 1: Electrochemical Series

Equilibrium (Oxidant ⟷ Reductant)	E° (volts)
Lithium: $Li^+(aq) + e^- ⟷ Li(s)$	-3.03
Potassium: $K^+(aq) + e^- ⟷ K(s)$	-2.92
Calcium: $Ca^{2+}(aq) + 2e^- ⟷ Ca(s)$	-2.87
Sodium: $Na^+(aq) + e^- ⟷ Na(s)$	-2.71
Magnesium: $Mg^{2+}(aq) + 2e^- ⟷ Mg(s)$	-2.37
Aluminium: $Al^{3+}(aq) + 3e^- ⟷ Al(s)$	-1.66
Zinc: $Zn^{2+}(aq) + 2e^- ⟷ Zn(s)$	-0.76
Iron: $Fe^{2+}(aq) + 2e^- ⟷ Fe(s)$	-0.44
Lead: $Pb^{2+}(aq) + 2e^- ⟷ Pb(s)$	-0.13
Hydrogen: $2H^+(aq) + 2e^- ⟷ H_2(g)$	0.00
Copper: $Cu^{2+}(aq) + 2e^- ⟷ Cu(s)$	+0.34
Silver: $Ag^+(aq) + e^- ⟷ Ag(s)$	+0.80
Gold: $Au^{3+}(aq) + 3e^- ⟷ Au(s)$	+1.50
Flourine: $F_2 + 2e^- ⟷ 2F^-$	+2.87

SRP↑=O.A.
SRP↓= R.A.

Metals with high SRP = less reactive
Metals with low SRP = highly reactive

4 EMF of a cell

$E^0_{cell} = E^0_{Cathode} - E^0_{Anode}$

$E_{cell} = RP_{Cathode} - RP_{Anode}$

$E_{cell} = RP_{Cathode} + OP_{Anode}$

$E_{cell} = OP_{Anode} - OP_{Cathode}$

In cell, Cathode with high RP, Anode with low RP makes spontaneous reactions

5 Nernst equation

$E_{cell} = E^0_{cell} - \frac{0.0591}{n} \log\left[\frac{Product}{Reactant}\right]$

For Zn| Zn^{2+}|| Cu^{2+}| Cu

$E_{cell} = E^0_{Cell} - \frac{0.0591}{2} \log\left[\frac{Zn^{2+}}{Cu^{2+}}\right]$

For Ni| Ni^{2+}|| Ag^+| Ag

$E_{cell} = E^0_{Cell} - \frac{0.0591}{2} \log\left[\frac{Ni^{2+}}{(Ag^+)^2}\right]$

R_1| P_1|| R_2| P_2

If R_2↑, P_1↓ then E_{cell}↑

6 Application of Nernst Equation

- Electrode Potential

$E_{M^{n+}/M} = E^0_{M^{n+}/M} - \frac{0.0591}{n} \log \frac{1}{[M^{n+}]}$

- Nernst equation in SHE

1) $E_{H^+/H_2} = -\frac{0.0591}{2} \log \frac{P_{H_2}}{[H^+]^2}$

2) If, P_{H_2} =1 atm

(R.P.)= E_{H^+/H_2}=-0.0591 pH

(O.P.)= E_{H_2/H^+}=+0.0591 pH

- Concentration Cells

Zn | $Zn^{2+}_{(C_1)}$ || $Zn^{2+}_{(C_2)}$ | Zn

$E_{cell} = \frac{0.0591}{n} \log \left(\frac{cathode.C_2}{anode.C_1}\right)$

$\frac{C_2}{C_1} > 1 \Rightarrow \log\left(\frac{C_2}{C_1}\right) > 0 \quad \therefore E_{cell} > 0$

7 EMF; K_c & ΔG

$E^0_{cell} = \frac{0.0591}{n} \log K_c$, $\log K_c = \frac{nE^0_{cell}}{0.0591}$

$\Delta G = -nFE_{cell}$

Spontaneous	Non-spontaneous
ΔG<0	ΔG>0
E^0_{cell}>0	E^0_{cell}<0
log K_c>0	log K_c<0
K_c>1	K_c<1

Galvanisation is applying coating of Zn

3 Faraday's law

Product formed

$m = \frac{EM}{96500} \times It$

$EM = \frac{AM}{valency}$

1F=charge of 1 mole of e⁻
=96500 C

1F=96500 C

- 1mol ⇐ 23g ⇐ Na^+
- O_2 ⇒ 8g ⇒ $\frac{1}{4}$ mol=5.6L
- H_2 ⇒ 1g ⇒ $\frac{1}{2}$ mole= 11.2L
- Cl_2 ⇒ 35.5g ⇒ $\frac{1}{2}$ mole= 11.2L
- $\frac{1mol}{3}$ ⇐ 9g ⇐ Al^{3+}
- Ag^+ ⇒ 108g ⇒ 1mol
- Cu^{2+} ⇒ 31.75g= 1/2 mole

$Na^+ + e^- \to Na$ ⇒ 1F
$Mg^{2+} + 2e^- \to Mg$ ⇒ 2F
$Al^{3+} + 3e^- \to Al$ ⇒ 3F

} 1F displaces & gives 1 equivalent of product

1 Electrolytic cell

ANODE	CATHODE
Anion goes to anode	Cation goes to cathode
+ve electrode	-ve electrode
Oxidation	Reduction
A → A^++e⁻	B+1e⁻ → B⁻
A → A^{n+}+ne⁻	B^n+ne⁻ → B⁻

2 Product of electrolysis

Deposition order of cation: (order of R.P)

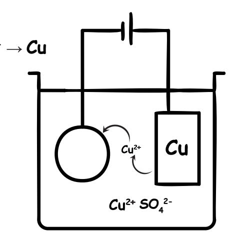
$Li^+ < K^+ < Ca^{2+} < Na^+ < Mg^{2+} < Al^{3+} < Zn^{2+} < Fe^{2+} < Ni^{2+} < H^+ < Cu^{2+} < Hg^{2+} < Ag^+ < Au^{3+}$

Deposition order of anion

$SO_4^{2-} < NO_3^- < OH^- < Cl^- < Br^- < I^-$

Note:

1) For conc. H_2SO_4	3) For $CuSO_4$ with Cu electrode
Anode: $H^+ + 1e^- \to 1/2\ H_2$ Cathode: $2SO_4^{2-} \to S_2O_8^{2-} + 2e^-$ (peroxo disulphate ion)	Anode: $Cu \to Cu^{2+} + 2e^-$ Cathode: $Cu^{2+} + 2e^- \to Cu$
2) Very dil. NaCl(H_2O>>NaCl)	
Anode: $H^+ + 1e^- \to 1/2\ H_2$ Cathode: $2OH^- \to 1/2\ O_2 + H_2O + 2e^-$	Electroplating



4 Electrolytic conduction

Resistance(R)= $\rho \frac{l}{A}$

Conductance(C) = $\frac{1}{R}$

Conductivity(K) = $\frac{1}{\rho}$

Unit of R = Ω
ρ = Ωm
C = $Ω^{-1}$=S=mho
K = $Ω^{-1}m^{-1}$ or Sm^{-1}
1Scm^{-1} = 100 Sm^{-1}

Molar Conductivity (λ_m)	Equivalent Conductivty (λ_{eq})
$\lambda_m = \frac{1000\ K}{M}$	$\lambda_{eq} = \frac{1000\ K}{N}$
K→Scm^{-1}	K→Scm^{-1}
M→mol L^{-1}	N→eq L^{-1}
λ_m→$Scm^2\ mol^{-1}$	λ_{eq}→$Scm^2\ eq^{-1}$

1$Scm^2\ mol^{-1}$ = $10^{-4}\ Sm^2mol^{-1}$

$\lambda_m = \lambda_{eq} \times Z$

N>M ∴ $\lambda_m > \lambda_{eq}$

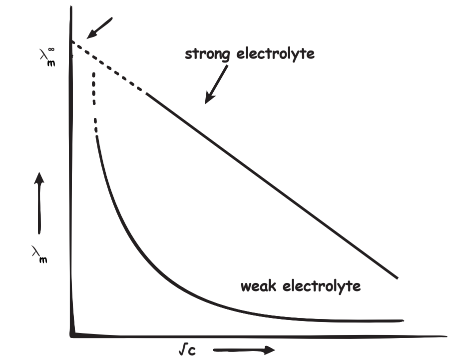
For H_2SO_4, Z = 2 ($2H^+$)
NaCl, Z = 1 ($1Na^+$)
$Al_2(SO_4)_3$, Z = 6 ($2Al^{3+}$)

λ_m for SE increases with dilution (interionic attraction decreases)

$\lambda_m = \lambda^\infty_m - b\sqrt{c}$ (Debye-Huckel Onsagar equation)

At $\sqrt{c}$=0, $\lambda_m = \lambda^\infty_m$ (limiting molar conductivity)

λ_m of weak electrolytes increases with dilution (degree of dissociation increases)



λ^∞_m order : KCl > NaCl > LiCl

Conductance ∝ $\frac{1}{\text{Hydrated Radii}}$

5 Kohlrausch's law

$\lambda^\infty_M(AB_2) = \lambda^\infty_M(A^{2+}) + 2\,\lambda^\infty_M(B^-)$

$\lambda^\infty_{eq}(AB_2) = \lambda^\infty_M(A^{2+}) + \lambda^\infty_{eq}(B^-)$

For $Al_2(SO_4)_3$

$\lambda^\infty_M(Al_2(SO_4)_3) = 2\lambda^\infty_M(Al^{3+}) + 3\lambda^\infty_M(SO_4^{2-})$

$\lambda^\infty_{eq}(Al_2(SO_4)_3) = \lambda^\infty_{eq}(Al^{3+}) + \lambda^\infty_{eq}(SO_4^{2-})$

Application

$\lambda^\infty_M\ NH_4OH = \lambda^\infty_M NH_4Cl + \lambda^\infty_M NaOH - \lambda^\infty_M NaCl$

$\lambda^\infty_M\ CH_3COOH = \lambda^\infty_M CH_3COONa + \lambda^\infty_M HCl - \lambda^\infty_M NaCl$

$\lambda^\infty_M\ BaSO_4 = \lambda^\infty_M BaCl_2 + \lambda^\infty_M Na_2SO_4 - 2\lambda^\infty_M NaCl$

PHYSICS WALLAH

CHEMICAL KINETICS

01

RATE OF A CHEMICAL REACTION

$\frac{\text{decrease in conc of reactant}}{\text{Time taken}}$ OR $\frac{\text{Increase in conc of reactant}}{\text{Time taken}}$

AVERAGE RATE

Consider a reaction: $A + B \longrightarrow C + D$

$$-\frac{\Delta[A]}{\Delta t} = -\frac{\Delta[B]}{\Delta t} = \frac{\Delta[C]}{\Delta t} = \frac{\Delta[D]}{\Delta t}$$

INSTANTANEOUS RATE

Consider a reaction: $aA + bB \longrightarrow cC + dD$

$$-\frac{1}{a}\frac{d[A]}{dt} = -\frac{1}{b}\frac{d[B]}{dt} = \frac{1}{c}\frac{d[C]}{dt} = \frac{1}{d}\frac{d[D]}{dt}$$

Unit of Rate = mol $litre^{-1}$ s^{-1}

Q During the decomposition of H_2O_2, 48 g O_2 is formed per minute at a certain point of time. The rate of formation of water at this point is

(a) 0.75 mol min^{-1} (b) 1.5 mol min^{-1}

(c) 2.25 mol min^{-1} (d) 3.0 mol min^{-1}

02

FACTORS INFLUENCING RATE OF REACTION

Factors	Effect on reaction rate
Increase in concentration	Increases
Increase in temperature	Increases
Presence of catalyst	Increases

Q Which of the following will lead to an increase in the rate of the reaction?

a) Decrease in temperature

b) Decreasing concentration of reactants

c) Addition of catalyst

d) Addition of inhibitor

03

RATE LAW

Consider a general reaction,

$aA + bB \longrightarrow$ product

Rate = $k[A]^a [B]^b$ (law of mass action)

Rate = $k[A]^x [B]^y$ (rate law expression)

x & y are determined experimentally and may or may not be equal to a & b

x & y represents the order of reaction with respect to A & B

RATE CONSTANT

- Larger the value of k, faster is the reaction.
- The value of k changes only with temperature for given reaction.

unit of rate constant = $(mol)^{1-n} L^{n-1} s^{-1}$

Q The rate constant of a zero-order reactions has the unit

(a) s^{-1} (b) mol L^{-1} s^{-1}

(c) L^2 mol^{-2} s^{-1} (d) L mol^{-1} s^{-1}

04

ORDER AND MOLECULARITY

Consider a general reaction,

$aA + bB \longrightarrow$ product

Rate = $k[A]^x [B]^y$

molecularity = a + b

order = x + y

Molecularity	Order
Theoretical concept.	An experimentally determined quantity.
It cannot be zero, fractional, infinite and imaginary.	It can be equal to zero positive, negative and fractional.

Q When the rate of the reaction is equal to the rate constant, the order of the reaction is

(a) zero order

(b) first order

(c) second order

(d) third order

05

PSEUDO ORDER REACTIONS

Consider the reaction

$$C_{12}H_{22}O_{11} + H_2O \xrightarrow{H^+} C_6H_{12}O_6 + C_6H_{12}O_6$$

In these reactions, concentration of water (one of the reactants) is in excess and its concentration remains constant throughout the reaction.

Thus, rate $\propto [C_{12}H_{22}O_{11}]$

Therefore, order= 1

Q For a pseudo first-order reaction, what is the unit of the rate of the reaction?

(a) s^{-1}

(b) mol $L^{-1} s^{-1}$

(c) mol^{-1} L s^{-1}

(d) mol^{-2} L^2 s^{-1}

06

ELEMENTARY & COMPLEX REACTIONS

- Reactions occurring only in one step are called elementary reactions while that involving a sequence of elementary reactions, are called complex reactions.
- In case of complex reactions, the slowest step is called rate determining step.

Note Consider the reaction

$2O_3 \longrightarrow 3O_2$

Step - 1

$O_3 \rightleftharpoons O_2 + O$ (fast)

Step - 2

$O + O_3 \longrightarrow 2O_2$ (slow)

From slow step

$r = k[O][O_3]$

Here

$[O] \propto \frac{[O_3]}{[O_2]}$; From fast step

$r = k[O_3]^2[O_2]^{-1}$

Q Suppose the reaction: $A + 2B \longrightarrow AB_2$ occurs by the following mechanism:

Step 1 : $A + B \longrightarrow$ AB slow

Step 2 : $AB + B \longrightarrow$ AB_2 fast

Overall $A + 2B \longrightarrow$ AB_2

(a) k[A] (b) k[B] (c) k[A][B] (d) $k[B]^2$

07

INTEGRATED RATE EQUATIONS

Zero order

$$k = \frac{[A]_0 - [A]_t}{t}$$

First order

$$k = \frac{2.303}{t}\log\frac{[A]_0}{[A]_t}$$

Second order

$$k = \frac{1}{t}\left[\frac{1}{[A]_t} - \frac{1}{[A]_0}\right]$$

Q A first order reaction has a specific reaction rate of 10^{-2} sec^{-1}. How much time will it take for 20 g of the reactant to reduce to 5 g?

(a) 138.6 sec (b) 346.5 sec

(c) 693.0 sec (d) 238.6 sec

08

HALF LIFE PERIOD

Zero order

$$t_{\frac{1}{2}} = \frac{[A]_0}{2k}$$

First order

$$t_{\frac{1}{2}} = \frac{0.693}{k}$$

Second order

$$t_{\frac{1}{2}} = \frac{1}{k[A]_0}$$

FIRST ORDER TRICKS

$t_{75\%} = 2t_{\frac{1}{2}}$

$t_{90\%} = \frac{2.303}{k}$

$t_{99.9\%} = 10t_{\frac{1}{2}}$

Q The half-life period of zero order reaction is directly proportional to the ___________

a) Rate constant

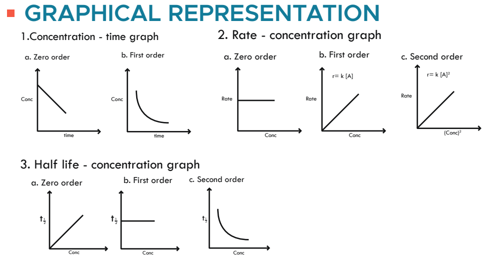
b) Initial concentration of reactants

c) Final concentration of reactants

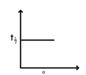
d) Concentration of products

09

GRAPHICAL REPRESENTATION



Q The graph of $t_{\frac{1}{2}}$ versus initial concentration 'a' is for



a) First order

b) Second order

c) Zero order

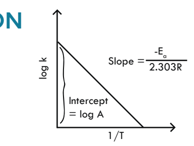
d) Can't predict

10

ARRHENIUS EQUATION

$$k = Ae^{-Ea/RT}$$

$$\log k = \log A - \frac{E_a}{2.303R}\left(\frac{1}{T}\right)$$



NOTE

- For every 10° rise in temperature, rate becomes double and hence, rate constant becomes double.
- A reaction with higher value of E_a will have smaller value of rate constant.

Q The slope of Arrhenius plot ($\ln k$ vs $\frac{1}{T}$) of first order reaction is - 5 x 10^3 K. The value of E_a of the reaction is [Given: R=8.314 J K^{-1} mol^{-1})

(a) -83 kJ mol^{-1} (b) 41.5 kJ mol^{-1}

(c) 83 kJ mol^{-1} (d) 166 kJ mol^{-1}

SURFACE CHEMISTRY

PHYSICS WALLAH

Adsorption

- Accumulation of molecular species at the surface rather than in the bulk of a solid or liquid.
- Surface phenomenon
- Concentration on the surface of adsorbent different from that in bulk.

ADSORBATE
Molecular species which concentrates at the surface.

SORPTION
Both adsorption & absorption takes place simultaneously

ADSORBENT
Material on the surface of which the adsorption takes place.

TYPES

Physisorption

- Adsorption when accumulation of gas on the surface of solid occurs due to weak van der Waals' forces.
- Non-specific
- Depends on nature of adsorbate
- Reversible
- Increases with increases in surface area.
- Low enthalpy of adsorption.

Chemisorption

- Adsorption when gas molecules or atoms are held to surface by chemical bonds.
- Highly specific
- Irreversible
- Increases with increase of surface area
- High enthalpy of adsorption

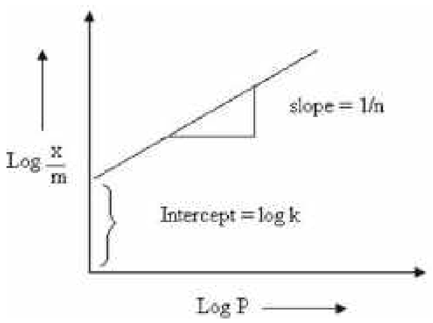
Features

- ΔG, ΔH and ΔS are all negative.
- Extent of adsorption increase with surface area

Freundlich Adsorption Isotherm

$\frac{x}{m} = kp^{1/n}$ (n> 1)

$\log \frac{x}{m} = \log k + \frac{1}{n} \log p$



Catalysis

- Substances which accelerate the rate of reaction and remain chemically and quantitatively unchanged after the reaction are known as catalysts and phenomenon is know as catalysis.

Homogeneous Catalysis

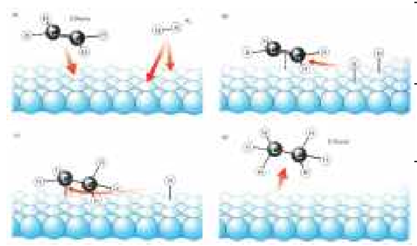
Reactants and catalyst are in same phase.
(oxidation of SO_2 to SO_3 by NO as catalyst)

Heterogenous Catalyst

Reactants and catalyst are in different phases.
(Oxidation of SO_2 to SO_3 by Pt as catalyst)

Adsorption Theory

→ Diffusion of reactants to surface of catalyst
→ Adsorption of reactant molecules on the surface of catalyst.



→ Chemical reaction on the surface of catalyst through formation of intermediate.
→ Desorption of products creating surface for further reaction.
→ Diffusion of products away from catalyst surface.

Enzyme catalysis

Enzymes that catalyse many life processes in bodies of plants and animals are termed as Biochemical catalysts and phenomenon is known as Biochemical catalysis
(Inversion of sugar, Conversion of milk into curd)

Mechanism

Step 1:
Binding of enzyme to substrate to form an activated complex.
E + S → ES

Step 2: Decomposition of activated complex to form product.
ES → E + P

Shape Selective catalysis

Catalytic reaction that depends upon pore structure of catalyst and size of reactant and product molecules.
(Zeolites)

Activity

The reactants must get adsorbed reasonably strongly on to the catalyst to become active.

Selectivity

It is the ability to direct a reaction to yield a particular product selectively.

Uses in Industry

Manufacture of nitric acid by ostwald's process
(platinised asbestos, 573 K)

Manufacture of ammonia by Haber's process
(Fe + Mo, 200 bar, 723-773 K)

Colloids

Heterogeneous system where one substance is dispersed (dispersed phase) in another substance called dispersion medium. Particle size from 1-1000nm.(10^{-6} to 10^{-9} m)

Classification

Based on the type of particles of dispersed phase
Multimolecular : Large number of atoms/molecules aggregate (size 1-1000 nm)
Macromolecular :At Formed by molecules of large size.
Associated:At low concentration behave as normal range electrolytes and at high concentration behave as colloids. (associated colloidal particles are also called Micelles)

Based on nature of interaction
Lyophilic: Liquid loving
(solvation of colloidal particles)
Lyophobic: Liquid-hating

Based on physical state
Sol: solids in liquids (Paints)
Gel: Liquids in solids (cheese)
Emulsion: Liquid in liquids
Aerosol: Liquid in gas

Properties

Colligative Properties:
Values of colligative properties are of small order in comparison to values shown by true solutions.

Tyndall Effect:
When a beam of light is passed & viewed perpendicular to the path of incident light, the path of beam is illuminated by a bluish light. This process is Tyndall effect.

Conditions

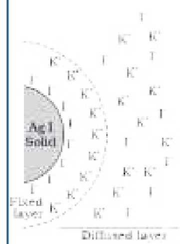
1) The diameter of the dispersed particle is not much smaller than the wavelength of the light

2) The refractive indices of the dispersed phase and dispersion mediun differ greatly in magnitude

Brownian Movement: Zig-zag movement of particles due to unbalanced bombardment by the molecules of dispersion medium.

Charge
Due to preferential adsorption of positive or negative ions

Helmholtz electrical double layer
The combination of the two layers of opposite charges around the colloidal particle



Electrokinetic potential or Zeta potential
The potential difference between the fixed layer and the diffused layer of opposite charges

Electrophoresis: Movement of colloidal particles toward electrode in an electric field.

Electroosmosis: Movement of dispersion medium toward electrode in an electric field.

Coagulation or Precipitation: The process of settling of colloidal particles is called coagulation or precipitation of the sol

Coagulating power $\propto \frac{1}{\text{Coagulating value}}$

Hardy schulze Rule
Coagulating power $\propto$ charge of coagulating ion

Protection of colloids
Gold number $\propto \frac{1}{\text{Protective power}}$

Purification

Dialysis: Process of removing dissolved impurities from a colloidal solution by means of diffusion through a suitable membrane

Electro-dialysis: Dialysis of impure colloidal solution of an electrolyte in the presence of electric field

Ultrafiltration: Process of separating the colloidal particles from the solvent and solute present in the colloidal solution by specially prepared filters called as ultra filter-paper

Colloidion solution
A 4% solution of nitrocellulose in a mixture of alcohol and ether

Preparation

Bredig's Arc method: For metallic colloids
Peptization: Process of converting a precipitate into colloidal sol by shaking it with dispersion medium in the presence of a small amount of electrolyte

Chemical methods
1:Oxidation
2:Reduction
3:Hydrolysis
4:Double decomposition method

Emulsions:

O/W-Milk, Vanishing cream
W/O-Butter, Cod liver oil

Emulsifying agents
Stabilise an emulsion
O/W- proteins,gums, natural and synthetic soaps, etc.,
W/O- heavy metal salts of fatty acids, long chain alcohols, lampblack, etc.

Application:

- Purification of drinking water (alum)
- Medicines
- Tanning
- Cleansing action of soaps & detergents
- Rubber industry
- Industrial Products.

METALLURGY

PHYSICS WALLAH

01 CONCENTRATION

LEVIGATION

Hydraulic washing/Gravity separation

Cassiterite(tin stone - SnO_2)

02 CONCENTRATION

MAGNETIC SEPARATION

Cassiterite

Pyrolusite (MnO_2)

Chromite ($FeO.Cr_2O_3$)

Magnetite (Fe_3O_4)

03 CONCENTRATION

FROTH FLOATATION METHOD

Concentration of sulphide ore

Frothers - Pine oil, Eucalyptus oil

Collectors - Pine oil, Xanthates

Stabilisers - Cresol, Aniline

04 CONCENTRATION

LEACHING

Based on solubility in solvents

Bauxite ($Al_2O_3.2H_2O$) - Bayer's process (NaOH is leaching agent)

Silver & Gold ores (NaCN/KCN - leaching agent)

05 OXIDATION

CALCINATION

Heating in absence of air

Hydroxides, Carbonates, Hydrates are calcined

$ZnCO_3 \longrightarrow ZnO + CO_2$

$Al_2O_3.2H_2O \longrightarrow Al_2O_3 + 2H_2O$

06 OXIDATION

ROASTING

Heating in presence of air

Sulphides ores are roasted

$2ZnS + 3O_2 \longrightarrow 2ZnO + 2SO_2$

$2PbS + 3O_2 \longrightarrow 2PbO + 2SO_2$

07 REDUCTION

SMELTING

Heating before with coke or CO in presence of flux

Done in Blast furnace

Flux + Gangue $\longrightarrow$ Slag

SiO_2 FeO/CaO/MgO

FeO SiO_2/P_2O_5

08 REDUCTION

ELECTROLYTIC REDUCTION

Oxides of highly reactive metals

Alkali metals

Alkaline earth metals

Aluminium

9 REFINING

DISTILLATION

For low boling metals

Zn, Cd & Hg

10 REFINING

LIQUATION

For low melting metals

Sn, Pb & Bi

11 REFINING

ELECTROLYCTIC REFINING

Anode : Impure metal

Cathode : Pure metal

Electrolyte : Metal salt solution

Cu, Sn, Pb, Zn, Mn, Cr, Ni, Ag & Au

Au, Ag, Pt, etc are obtained from anode mud of Cu

12 REFINING

ZONE REFINING

To prepare semi-conductors & metals of high purity

Si, Ge, Ga, B & In

13 REFINING

VAPOUR PHASE REFINING

For Zr, Ni, Ti & Th

Mond process	van Arkel method
$Ni + 4CO \xrightarrow{330 - 350K} Ni(CO)_4$	$Zr + 2I_2 \longrightarrow ZrI_4$
$Ni(CO)_4 \xrightarrow{450 - 470K} Ni + 4CO$	$ZrI_4 \xrightarrow{1800K} Zr + 2I_2$

14 REFINING

CHROMATOGRAPHY

Based on adsorption

Al_2O_3 is the adsorbent in coloumn chromatography

FE

Ore - Fe_2O_3

Concentration: Froth Floatation

Extraction is done in blast furnace

Raw Materials: Ore + lime stone + coke

Pig Iron (4% Carbon)
↓
Cast Iron (3% Carbon)
↓
Steel (0.2 - 2% Carbon)
↓
Wrought Iron (0.2% Carbon)

Alloys

Stainless Steel (Fe + Cr + Ni + C)

1. Combustion Zone
   $C + O_2 \longrightarrow CO_2 + Heat$
2. Fusion Zone
   $CO_2 + C \longrightarrow 2CO - Heat$
3. Slag Formation Zone
   $CaCO_3 \longrightarrow CaO + CO_2$
   $CaO + SiO_2 \longrightarrow CaSiO_3$
4. Reduction Zone
   $Fe_2O_3 + CO \longrightarrow 2FeO + CO_2$
   $Fe + CO \longrightarrow Fe + CO_2$

04 extraction of iron

HOTS

Bauxite - $Al_2O_3.2H_2O$

Cryolite - Na_3AlF_6

Kaolinite (a form of clay) - $[Al_2(OH)_4Si_2O_5]$

Haematite - Fe_2O_3

Magnetite - Fe_3O_4

Siderite - $FeCO_3$

Iron pyrites - FeS_2

Copper pyrites - $CuFeS_2$

Malachite - $CuCO_3.Cu(OH)_2$

Cuprite - Cu_2O

Copper glance - Cu_2S

Zinc blende or Sphalerite - ZnS

Calamine - $ZnCO_3$

Zincite - ZnO

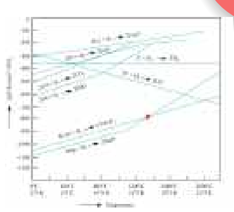
ore

Q. Which one is malachite from the following?

(a) $Cu(OH)_2$ (b) Fe_3O_4

(c) $CuCO_3.Cu(OH)_2$ (d) $CuFeS_2$

HOTS



Element represented by lower line can reduce compound represented by upper line

ellingham diagram

Q. Considering Ellingham diagram, which of the following metals can be used to reduce alumina?

(a) Mg (b) Zn (c) Fe (d) Cu

ZN

Ore - ZnS

Concentration : Gravity separation
Froth floatation method

ZnS —Roasting→ ZnO —Producer gas Δ→ $ZnO + C \rightarrow Zn + CO$

Refining : Distillation

Alloys : Brass (Cu+Zn)
German silver (Ni+Cu+Zn)

01 extraction of zinc

Q. Extraction of gold and silver involves leaching with CN^- ion. Silver is later recovered by

(a) Liquation (b) Distillation

(c) zone refining (d) displacement with Zn

CU

Ore - $CuFeS_2$

Concentration : Froth floatation method

$CuFeS_2$ —Roasting→ Cu_2S+FeS (Molten matte) —Bessemerisation / Self reduction→ Cu (Impure (Blister Cu))

Refining : Electrolysis

Alloys : Constantan (Cu+Ni)
Monel metal (Ni+Cu+Fe)
Bell metal (Cu+Sn) 80%
Bronze (Cu+Sn) 90%

02 extraction of copper

Q. Which can be used to obtain highly pure metal which is liquid at room temperature?

(a) Electrolysis (b) Chromatography

(c) Distillation (d) Zone refining

AL

Ore - $Al_2O_3.2H_2O$

Concentration : Leaching (Baeyer's)

$Al_2O_3.2H_2O$ —Calcination→ Al_2O_3 —Hall Heroult Electrolysis→ Al (Impure)

Electrolyte : $Al_2O_3 + Na_3AlF_6 + CaF_2$
Anode : Graphite rod
Cathode : Carbon lining

Alloys: Aluminium bronze (Al+Cu)
Duralumin (Al+Cu+Mg+Mn)
Alnico (Al+Ni+Co+Fe)

03 extraction of aluminium

Q. The maximum temperature that can be achieved in blast furnace is

(a) Upto 1200 K (b) Upto 2200 K

(c) Upto 1900 K (d) Upto 5000 K

p-BLOCK ELEMENTS

PHYSICS WALLAH

NITROGEN FAMILY

PREPARATION OF N_2

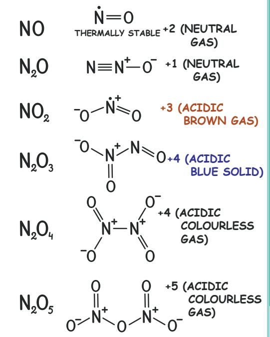
NH_4NO_2, $(NH_4)_2Cr_2O_7$, $Ba(N_3)_2$ } Heating

PROPERTIES OF N_2

$Mg + N_2 \rightarrow Mg_3N_2$

$CaC_2 + N_2 \rightarrow CaCN_2 + C$ (NITROLIME)

OXIDES OF NITROGEN



OXIDES OF NITROGEN

N_2O $NH_4NO_3 \xrightarrow{\Delta}$

NO BROWN RING TEST

N_2O_3 $NO + N_2O_4 \rightarrow$

NO_2 $Pb(NO_3)_2 \xrightarrow{\Delta}$

N_2O_4 $2NO_2(g)$ $\underset{\text{high P}}{\overset{\text{low T}}{\rightleftharpoons}}$

N_2O_5 $P_4O_{10} + HNO_3 \rightarrow$

OXYACIDS OF NITROGEN

COMMERCIAL PREPARATIONS

OSTWALD'S PROCESS

$NH_3 + O_2 \xrightarrow{Pt} NO$

$NO + O_2 \rightarrow NO_2$

$NO_2 + H_2O \rightarrow HNO_3$

REACTION WITH NON METALS

$I_2 + HNO_3 \rightarrow HIO_3 + NO_2$

$P_4 + HNO_3 \rightarrow H_3PO_4 + NO_2$

$S/SO_2 + HNO_3 \rightarrow H_2SO_4 + NO_2$

$C + HNO_3 \rightarrow CO_2 + NO_2$

REACTION WITH METALS

Zn+dil. $HNO_3 \rightarrow Zn(NO_3)_2 + N_2O$

Cu+dil. $HNO_3 \rightarrow Cu(NO_3)_2 + NO$

Zn+Conc. $HNO_3 \rightarrow Zn(NO_3)_2 + NO_2$

AMMONIA

COMMERCIAL PREPARATIONS

HABER'S PROCESS

$N_2 + 3H_2 \xrightarrow[\text{Mo (Promoter)}]{\text{Fe catalyst,}} 2NH_3$

REACTIONS

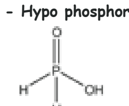
$CuSO_4 + NH_3 + H_2O \rightarrow$

$[Cu(NH_3)_4]SO_4 + (NH_4)_2SO_4$

OXOACIDS OF PHOSPHORUS

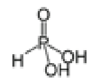
PHOSPHORUS TYPE

- Hypo phosphorous acid (H_3PO_2)



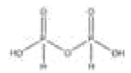
P-H → 2, P-OH → 1, Basicity=1

- Orthophosphorous acid (H_3PO_3)



P-H → 1, P-OH → 2, Basicity=2

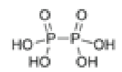
- Pyrophosphorous acid ($H_4P_2O_5$)



P-H → 2, P-OH → 2, Basicity=2

PHOSPHORIC TYPE

- Hypophosphoric acid ($H_4P_2O_6$)

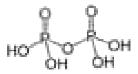


P-OH → 4, Basicity=4

- Orthophosphoric acid (H_3PO_4)

P-OH → 3, Basicity=3

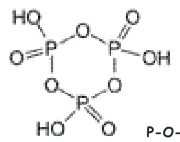
- Pyrophosphoric acid ($H_4P_2O_7$)



P-OH → 4, Basicity=4

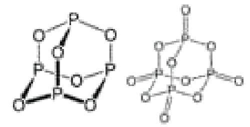
META PHOSPHORIC

- cyclo metaphosphoric $(HPO_3)_3$



P-O-P Bond=3, P-OH → 3, Basicity=3

OXIDES OF PHOSPHORUS



{ P-O-P=6, P=O=12 } { P-O-P=6, P-O=16 }

HALIDES OF PHOSPHORUS

1) PCl_3

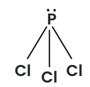
Preparation

$P_4 + 2SOCl_2 \rightarrow PCl_3$ (white) (thionyl chloride) $+ SO_2 + S_2Cl_2$

Properties

PCl_3 $\left[\frac{5+3}{2} = 4 \rightarrow (3,1)\right]$

Shape : Pyramidal



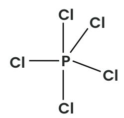
2) PCl_5

Preparation

$P_4 + SO_2Cl_2 \rightarrow PCl_5 + SO_2$ (white) (sulphuryl chloride)

Properties

PCl_5 $\frac{5+5}{2} = 2 \rightarrow (5,0)$



- In PCl_5 gaseous & liquid phase exist as trigonal bipyramidal
- In solid phase, it exist as ionic crystal

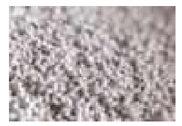
$PCl_5 \rightarrow [PCl_4]^+[PCl_6]^-$

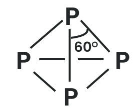
PH_3, phospheni

- Holmes signal ($Ca_3P_2 + CaC_2$)
- $CaC_2 + H_2O \rightarrow C_2H_2$(Flammable)

PHOSPHOROUS & ITS ALLOTROPES

1. White phosphorous

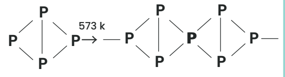




- Translucent white waxy solid
- Poisonous & show chemiluminescence
- Soluble in CS_2 but insoluble in H_2O
- Occurs in descrete units
- Highly reactive due to angle strain
- Fumes in air due to formation of P_4O_{10}
- In basic medium, it disproportionate to form PH_3 & NaH_2PO_2

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

2. Red phosphorous



- Grey lustre
- Insoluble in water and CS_2
- Non poisonous
- No chemiluminescence
- Obtained by heating white P at 573 K
- Occurs as polymer.

So it is less reactive

3. Black phosphorous

α - black phosphorous

- Prepared by heating Red P at 803 K

β - black phosphorous

- Prepared by heating white P at 473 K

CHEMICAL PROPERTIES

Hydrides

Bond Angle

$NH_3 > PH_3 > AsH_3 > SbH_3 > BiH_3$

Basicity

$NH_3 > PH_3 > AsH_3 > SbH_3 > BiH_3$

(Reducing nature/ ability to act as RA)

Acidity

$BiH_3 > SbH_3 > AsH_3 > PH_3 > NH_3$

(Due to large size of Bi, it can easily release H^+)

Thermal stability/ Bond dissociation energy

$NH_3 > PH_3 > AsH_3 > SbH_3 > BiH_3$

(Bi can easily release H^+ and hence have low thermal stability)

BP

$BiH_3 > SbH_3 > NH_3 > AsH_3 > PH_3$

(As molecular mass ↑ → BP ↑)

MP

$NH_3 > SbH_3 > AsH_3 > PH_3$

(due to similar size of N and H, NH_3 has high M.P)

Oxides

- Generally it forms oxides of the type A_2O_3 and A_2O_5
- Acidic character increases with increase in oxidation number

$N_2O < NO < N_2O_3 < NO_2 < N_2O_4 < N_2O_5$

- In a group thermal stability of oxides decreases down the group

$N_2O_5 > P_2O_5 > As_2O_5 > Sb_2O_5 > Bi_2O_5$

Nature of Oxides

N_2O_5, P_2O_5 } Acidic

As_2O_5, Sb_2O_5 } Amphoteric

Bi_2O_5 } Basic

OXYGEN FAMILY

PHYSICAL PROPERTIES

Electron affinity

- S > Se > Te > Po > O

CHEMICAL PROPERTIES

Hydrides

Bond Angle

$H_2O > H_2S > H_2Se > H_2Te$

Thermal Stability

$H_2O > H_2S > H_2Se > H_2Te$

Acidic Character

$H_2Te > H_2Se > H_2S > H_2O$

Reducing Power

$H_2Te > H_2Se > H_2S > H_2O$

B.P

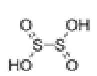
$H_2O > H_2Te > H_2Se > H_2S$

OXOACIDS OF SULPHUR

1) Thionous type

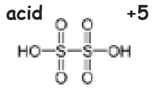
i) Dithionous acid +3

$H_2S_2O_4$ ($S_2O_4^{2-}$)



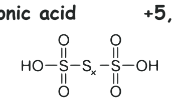
ii) Dithionic acid +5

$H_2S_2O_6$ ($S_2O_6^{2-}$)



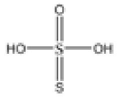
iii) Polythionic acid +5,0

$H_2S_xO_6$ ($S_xO_6^{2-}$)



iv) Thiosulphuric acid +6,-2

$H_2S_2O_3$ ($S_2O_3^{2-}$)



2) Sulphurous type

i) Sulphurous acid H_2SO_3

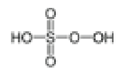
ii) Sulphuric acid H_2SO_4

iii) Pyrodisulphuric acid $H_2S_2O_7$ (Oleum)

3) Peroxo type

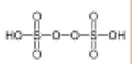
i) Peroxomono sulphuric acid

H_2SO_5 (Caro's acid)



i) Peroxo disulphuric acid

$H_2S_2O_8$ (Marshall's acid)



H_2SO_4

Preparation

Contact process

$FeS_2 + O_2 \rightarrow Fe_2O_3 + SO_2$

$2SO_2 + O_2 \xrightarrow[Pt]{V_2O_5} 2SO_3$

$SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$

$H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4(98\%)$

Properties

Oxidising property

$3S + 2H_2SO_4 \rightarrow 3SO_2 + 2H_2O$

$Cu + H_2SO_4 \rightarrow CuSO_4 + SO_2 + 2H_2O$

$C + 2H_2SO_4 \rightarrow CO_2 + 2SO_2 + 2H_2O$

SO_2

Properties

- Act as reducing agent (in aqueous medium)

$SO_2(aq) + HNO_3 + H_2O \rightarrow NO + H_2SO_4$

- Act as oxidising agent in the presence of → Strong reducing agent

$\overset{+4}{S}O_2 + CO \rightarrow \overset{0}{S} + CO_2$

$\overset{+4}{S}O_2 + Fe \rightarrow Fe\overset{-2}{S} + FeO$

Uses:

1. Act as a bleaching agent due to the formation of nascent atomic hydrogen in H_2O

SO_3

Properties

$SO_3 \rightarrow 6/2=3(3,0) \rightarrow$ bent shape (120°)

100% oleum/sulphan → liquid SO_3

ALLOTROPES OF SULPHUR

1) Rhombic Sulphur [α]

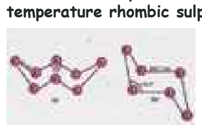
- Exist in room temperature
- Soluble in CS_2 but insoluble in H_2O
- Yellow in colour
- Exist below 369 K

2) Monoclinic Sulphur [β]

- Soluble in CS_2
- Obtained by melting rhombic sulphur above 369 K

Transition Temperature:

369 K, at which both monoclinic & sulphur exist. Above this temperature monoclinic exist, below this temperature rhombic sulphur exist.



At elevated temperature (1000K) S_2 is dominant species and is paramagnetic like O_2 (Vapour) state partly exist as S_2 molecule which has two unpaired electrons in π orbitals like O_2

HALOGENS & NOBLE GAS

PHYSICAL PROPERTIES

Electron affinity/EGE

- Cl > F > Br > I

Oxidation State

- F shows only (-1) O.S. in its compounds
- All other shows -ve & +ve O.S

Bond dissociation energy

- $Cl_2 > Br_2 > F_2 > I_2$

Bond dissociation energy of F_2 is lower than that of Cl_2 & Br_2 due to its inter electronic repulsion

CHEMICAL PROPERTIES

1) Oxidising Power:

- F is the strongest oxidizing agent
- $F_2 > Cl_2 > Br_2 > I_2$ (OA)
- F_2 displaces Cl_2, Br_2 & I_2
- Cl_2 displaces Br_2 and I_2
- $Br_2 + 2KI \rightarrow 2KBr + I_2$
- $I_2 + KBr \rightarrow$ No reaction

2) With H_2O:

- $F_2 + H_2O \rightarrow HF + O_2$ (Release O_2 from H_2O, good oxidizing agent)
- $Cl_2/Br_2 + H_2O \rightarrow HCl + HOCl$ / $HBr + HOBr$
- $I_2 + H_2O \rightarrow$ No reaction

3) With H_2: Hydrides

Acidic Character

→ HI > HBr > HCl > HF

Reducing Power

→ HI > HBr > HCl > HF

Thermal Stability

→ HF > HCl > HBr > HI

BP → HF > HI > HBr > HCl

COMPOUNDS OF CHLORINE

1) Cl_2

Preparation : Commercial

Deacon's Process

$HCl + 1/2O_2 \xrightarrow[723\ K]{CuCl_2} H_2O + 1/2\ Cl_2$

Properties

- Greenish yellow coloured gas
- $Cl_2 + H_2O \rightarrow HOCl + HCl$

greenish yellow → colourless

- With NH_3

1) NH_3 (excess) $+ Cl_2 \rightarrow NH_4Cl + N_2$

2) $NH_3 + Cl_2$ (excess) $\rightarrow NCl_3 + HCl$

- With Alkali

a) $NaOH + Cl_2 \rightarrow NaClO + NaCl + H_2O$ (Cold & dilute)

$NaOH + Cl_2 \rightarrow NaClO_3 + NaCl + H_2O$ (Cold & Conc.)

b) $Ca(OH)_2 + Cl_2 \rightarrow Ca(OCl)_2 + CaCl_2 + 2H_2O$ (calcium hypochlorite)

$Ca(OCl)_2 + CaCl_2 \rightarrow$ Bleaching powder

uses

- Powerful bleaching agent due to oxidizing property
- Bleaching powder → $Ca(OCl)_2 + CaCl_2$
- Preparation of poisonous gas

1) Tear gas → CCl_3NO_2

2) Phosgene → $COCl_2$

3) Mustard gas → $Cl-(CH_2)_2-S-(CH_2)_2-Cl$

2) HCl

$NH_3 + HCl \rightarrow NH_4Cl$

Aqua regia (HCl:HNO_3=3:1) dissolve Au and Pt by release of nitric oxide

$Au \xrightarrow{\text{Aqua regia}} [AuCl_4]^- + NO$

$Pt \xrightarrow{\text{Aqua regia}} [PtCl_6]^{2-} + NO$

HCl is a strong acid which decomposes salt of weak acid

OXOACIDS OF HALOGEN

F → HOF

Cl → HOCl, $HClO_2$, $HClO_3$, $HClO_4$

Br → HOBr, $HBrO_2$, $HBrO_3$, $HBrO_4$

I → HOI, HIO_2, HIO_3, HIO_4

1) Acidic character → $HClO < HClO_2 < HClO_3 < HClO_4$

2) Oxidising character → $HClO < HClO_2 < HClO_3 < HClO_4$

3) Stability: → $HClO < HClO_2 < HClO_3 < HClO_4$

INTERHALOGEN COMPOUNDS

Compounds formed b/w 2 different halogens

Types: $XX^1 \rightarrow$ ICl, BrF

$XX_3^1 \rightarrow ClF_3$, BrF

$XX_5^1 \rightarrow BrF_5$

$XX_7^1 \rightarrow IF_7$, ClF_7

Properties and uses

- ClF_3 & BrF_3 → Uranium enrichment for flurinating (U^{235})
- IF → Spectroscopically detected
- ICl → Exist in 2 polymeric form α & β
- Inter halogens are very reactive than halogens (except F_2)

Structure

$XX' \rightarrow$ X-X → linear

$XX_3' \rightarrow \frac{7+3}{2}$ =5(3,2) T-Shaped

$XX_5' \rightarrow \frac{7+5}{2}$ =6(5,1) Square Pyramidal

$XX_7' \rightarrow \frac{7+7}{2}$ =7(7,0) Pentagonal bipyramidal

NOBLE GASES

All these, except Radon & Oganesson occur in the atmosphere.

Physical properties

- Atomic radii → ↑ down the group
- IE → ↓ down the group
- He is having maximum ionisation energy of all known substances
- Ne is having high positive value of electron gain enthalpy
- B.P → ↑ down the group
- He is having lowest B.P among all known substance (4.2K)

COMPOUNDS OF Xe

Xenon Fluoro compounds

Preparation:

- $Xe(g) + F_2(g) \xrightarrow{673\ K, 1\ bar} XeF_2(S)$ (Xenon in excess)
- $Xe(g) + 2F_2(g) \xrightarrow{673\ K, 7\ bar} XeF_4(S)$ [1:5 ratio]
- $Xe(g) + 3F_2(g) \xrightarrow{573\ K, 60\text{-}70\ bar} XeF_6(S)$ [1:20 ratio]
- $XeF_4 + O_2F_2 \rightarrow XeF_6 + O_2$

Structure

$XeF_2 \rightarrow \frac{8+2}{2}$ =5(2,3) → linear

$XeF_4 \rightarrow \frac{8+4}{2}$ =6(4,2) → square planar

$XeF_6 \rightarrow \frac{8+6}{2}$ =7(6,1) → Distorted Octahedral

Properties On reacting with H_2O, they get hydrolysed when XeF_6 hydrolyses, it gives Xe, HF & O_2

- $XeF_2 + H_2O \rightarrow Xe + HF + O_2$

XENON-OXYGEN COMPOUND

Structure $XeO_3 \rightarrow 8/2=4(3,1)$ Pyramidal

$XeOF_4 = \frac{8+4}{2}$ =6(5,1) Sq. Pyramidal

$XeO_2F_2 = \frac{8+2}{2}$ =5(4,1) Sea saw

Preparation

$XeF_6 + H_2O \rightarrow XeOF_4 + HF$

$XeF_6 + 2H_2O$ (excess) $\rightarrow XeO_2F_2 + HF$

d – Block transition elements (group 3–12)

- Electronic configuration : $(n-1)d^{1-10}\ ns^{1-2}$

Exceptions { $Cr = 4s^1 3d^5$; $Cu = 4s^1 3d^{10}$, $Pd = 5s^0 4d^{10}$

Non-typical transition elements Zn, Cd & Hg

- Physical properties:

-High melting and boiling point

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

Sc < Ti < V < Cr > Mn < Fe > Co > Ni > Cu > Zn (3d Series)

Melting point { Zn > Cd > Hg ; Cu > Ag ≤ Au

-High enthalpies of atomization(Highest for V in 3d, series)

Atomic Radius:

3d series: Sc > Ti > V > Cr > Mn ≥ Fe ≈ Co ≈ Ni ≤ Cu < Zn

In a group 3d < 4d ≈ 5d (Lanthanide contraction)

eg : Ti < Zr ≈ Hf { Smallest radius – Ni ; Largest radius – La

Density:

s-Block < d-Block

3d series: Sc < Ti < V < Cr < Mn < Fe < Co ≤ Ni < Cu > Zn

In a group 3d < 4d << 5d

- Ionisation enthalpy:increases from left to right
- Oxidation states : Variable; higher O.S. stable down the group
- Trends in $E^\circ_{M^{2+}/M}$: E° for Mn, Ni and Zn are more negative than expected.
- Trends in $E^\circ_{M^{3+}/M^{2+}}$: variable
- Chemical reactivity and E° values : Variable Ti^{2+} , V^{2+} and Cr^{2+} are strong reducing agents
- Magnetic properties : Diamagnetism and paramagnetism. $\mu = \sqrt{n(n+2)}$ BM
- Formation of coloured ions : due to d – d transitions
- Form a large number of complex compounds
- Forms interstitial compounds : Non - stoichiometric and are neither ionic nor covalent.
- Alloy formation : Due to similar atomic sizes.(15% difference in metallic radius)

Uses

- In production of iron and steels.
- TiO in pigment industry
- MnO_2 in dry battery cells.
- As catalysts in industry.
- Ni complexes:polymerization of alkynes and other organic compounds
- AgBr in photographic industry.

Catalysts

Contact process = V_2O_5

Haber process = Fe_2O_3 + Al_2O_3 + K_2O

Decomposition of $KClO_3$ = MnO_2

Ostwald process = Pt/Rh

Zeigler Natta catalyst = $TiCl_4$+$(C_2H_5)_3Al$

Hydrogenation of Alkene = Ni/Pd

Wilkinson's catalyst=$RhCl(PPh_3)_3$

Compounds of d-block elements

Potassium dichromate $K_2Cr_2O_7$

Preparation :

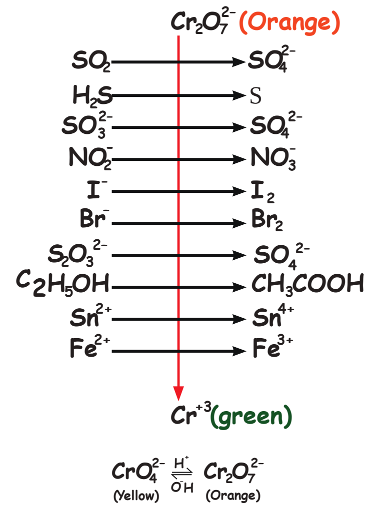
$4FeCr_2O_4 + 8Na_2CO_3 + 7O_2 \rightarrow 8Na_2CrO_4 + 2Fe_2O_3 + 8CO_2$

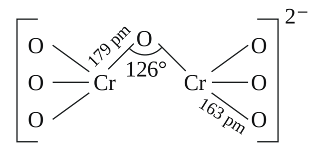
$2Na_2CrO_4 + 2H^+ \rightarrow Na_2Cr_2O_7 + 2Na^+ + H_2O$

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

Properties : Strong oxidising agent

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





Potassium permanganate $KMnO_4$

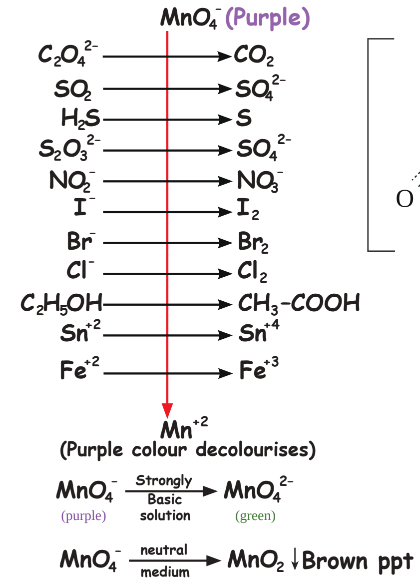
- Preparation : $2MnO_2 + 4KOH + O_2 \rightarrow 2KMnO_4 + 2H_2O$

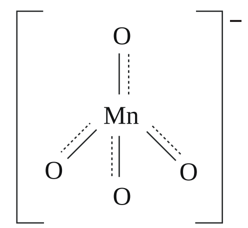
$3MnO_4^{2-} + 4H^+ \rightarrow 2MnO_4^- + MnO_2 + 2H_2O$

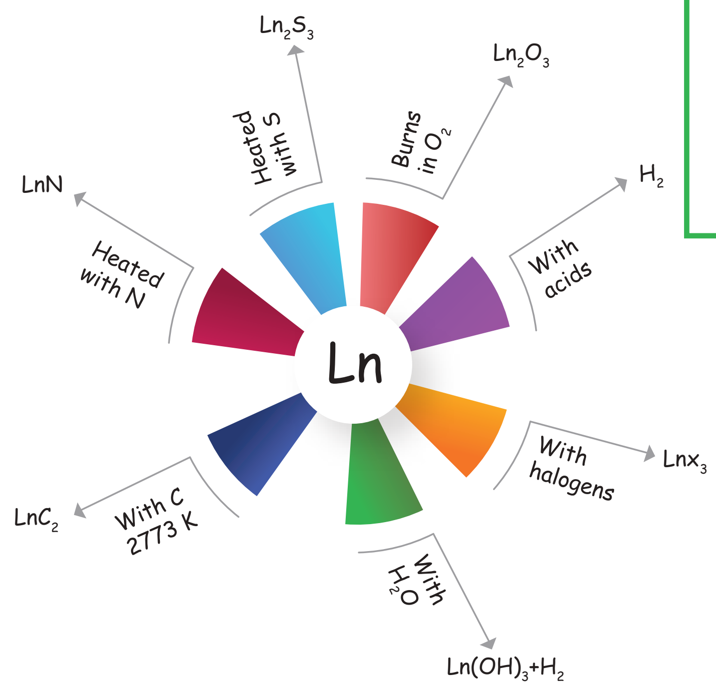
$2Mn^{2+} + 5S_2O_8^{2-} + 8H_2O \rightarrow 2MnO_4^- + 10SO_4^{2-} + 16H^+$

- Intense colour
- Paramagnetism
- Strong oxidising agent

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







Lanthanoids

- Electronic configuration: $4f^{1-14}\ 5d^{0-1}\ 6s^2$ (Gd:$4f^7\ 5d^1\ 6s^2$)
- Atomic and ionic sizes: Decreases from La to Lu(Eu is the largest)
- 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.

MISCH METAL-Alloy of Ln (95%), Fe (5%) & S,C,Ca,Al etc..

Actinoids

- Electronic configuration : $[Rn]5f^{1-14}\ 6d^{0-1}\ 7s^2$
- Ionic sizes : Gradual decrease along the series
- Oxidation states : Most common is +3 . They show O.S. of +4, +5, +6 and +7.
- General characteristics :

-Highly reactive metals

-Irregularities in metallic radii,greater than in Lanthanoids.

-Magnetic properties more complex than lanthanoids

Actinoid Contraction > Lanthanoid Contraction

The element that usually does not show variable oxidation state is ?

a) Cu b) Ti

c) Sc d) V

Which of the following is not formed when H_2S reacts with acidic $K_2Cr_2O_7$ solution ?

a) $CrSO_4$ b) $Cr_2(SO_4)_3$

c) K_2SO_4 d) S

d&f BLOCK ELEMENTS

COORDINATION COMPOUNDS

PHYSICS WALLAH

MONODENTATE LIGAND

Anionic
- X^- – Halido
- OH^- – Hydroxo
- NO_2^- – Nitrito
- SO_4^{2-} – Sulphato
- O^{2-} – Oxo(Oxido)
- S^{2-} – Sulphido

Neutral
- H_2O – Aqua
- NO – Nitrosyl
- NH_3 – Ammine
- CO – Carbonyl

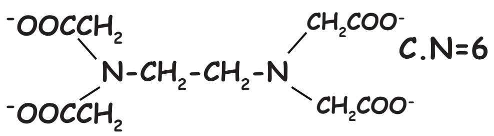
Cationic
- NO_2^+ – Nitronium
- NO^+ – Nitrosonium

BIDENTATE LIGAND

1) Oxalato COO^- | COO^-
2) Ethane-1,2-diamine[en] $H_2N-CH_2-CH_2-NH_2$

POLYDENTATE LIGAND

1) Trien,$N(CH_2CH_2NH_2)_3$ – Tetradentate
2) Ethylene Diamine Tetra Acetato [EDTA]



Donor – 4O Atoms, 2N Atoms

AMBIDENTATE LIGAND

1) NO_2^- 2) SCN^-

CHELATE LIGAND

1) $EDTA^{4-}$, en, ox
2) greater Stability

WERNER'S THEORY

1) 1° Valency – O.N
2) 2° Valency – C.N

$[Pt(NH_3)_5Cl]Cl_3$

1) 1° Valency – O.N = 4
2) 2° Valency – C.N = 6
3) AgCl Formed per mole of complex ⟶ 3
4) Total ions per mole of complex – 4

GEOMETRICAL ISOMERISM

1) $[Ma_2b_2]$ – 2 (cis + trans)
2) $[Ma_2bc]$ – 2 (cis + trans)
3) $[Mabcd]$ – 3
4) $[Ma_4b_2]$ / $[Ma_4bc]$ – 2 (cis + trans)
5) $[Ma_3b_3]$ – fac & mer
6) $[Ma_2b_2c_2]$ – 5
7) $[Mabcdef]$ – 15
8) $[M(en)_2b_2]$ or $[M(en)_2bc]$ – 2

OPTICAL ISOMERISM

① $M(AA)_3$

2 Optical isomers (d cis + l cis)

② $M(AA)_2B_2$

Total 3 Stereoisomer (d cis + l cis + trans)

VBT

SPECTROCHEMICAL SERIES

$I^- < Br^- < SCN^- < Cl^- < F^- < C_2O_4^{2-} < H_2O < NCS^- <$ $EDTA^{4-} < NH_3 < en < NO_2^- < CN^- < CO$

- $[ML_4]$ – dsp^2 → Square planar; sp^3 → Tetrahedral
- $[ML_5]$ – sp^3d, dsp^3 } Trigonal bipyramidal
- $[ML_6]$ – sp^3d^2, d^2sp^3 } Octahedral

UNPAIRED ELECTRONS – PARAMAGNETIC
PAIRED ELECTRONS – DIAMAGNETIC

$\mu = \sqrt{n(n+2)}$

1=1.73 BM
2=2.84 BM
3=3.87 BM
4=4.90 BM
5=5.92 BM

$[NiCl_4]^{2-}$ – sp^3, Tetrahedral n=2
$[NiCO_4]$ – sp^3, Tetrahedral n=0
$[Ni(CN)_4]^{2-}$ – dsp^2, Sq. planar n=0

H_2O act as SFL with Co^{3+}

Cr^{3+} – ↿ ↿ ↿ forms d^2sp^3

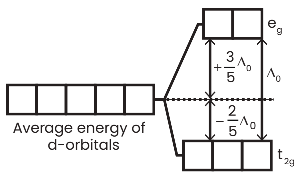
4d and 5d metals with all ligands act as SFL

$[Pt(CN)_4]^{2-}$, $[Pt(Cl)_4]^{2-}$, $[Pd(Cl)_4]^{2-}$ = dsp^2 (diamagnetic)

$C_2O_4^{2-}$ act as SFL with Co^{3+}
F^- act as SFL with Ni^{4+}

CFT

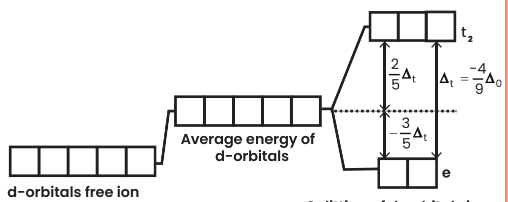
1) Octahedral – Ligand approaches along the axis ($e_g > t_{2g}$)



Splitting of d-orbitals in octahedral crystal field.

CFSE = a x (– 0.4 Δ_o) + b x (0.6 Δ_o) + np

2) Tetrahedral – Ligand approaches b/w the axis ($t_2 > e$)



Splitting of d-orbitals in tetrahedral crystal field.

CFSE = a x – (0.6Δ_t) + b x (0.4Δ_t) + np

here a,b are number of electrons in low energy and high energy d-orbitals

HIGH SPIN COMPLEX	LOW SPIN COMLEX
Δ_o < Pairing Energy	Δ_o > Pairing Energy

For calculation of n, Crystal field stabilisation energy consider newly formed pairing only

CFSE

1) Stability ∝ CFSE
2) $\Delta_o > \Delta_t$, $\Delta_t = \frac{-4}{9}\Delta_o$
3) $[Fe(CN)_6]^{4-} < [Fe(CO)_6]$
4) Jahn Teller distortion by – d^4, d^7, d^9
5) Dissociation constant = $\frac{1}{\beta_n}$ (β_n = stability constant)
6) Color of d–d transition, $E \propto \frac{1}{\lambda}$

$[Co(en)_3]^{3+} < [Co(NH_3)_6]^{3+} < [Co(H_2O)_6]^{3+}$

E↑ λ↓ (E = energy of d-d transition) E↓ λ↑

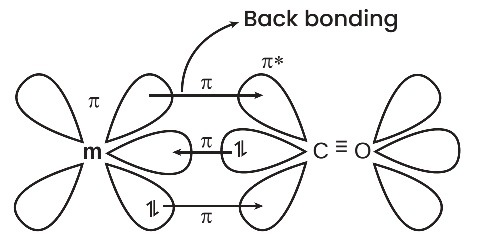
OMC

1) σ bonded – RMgX (Grignard reagent) – R_2SiCl_2
2) π bonded – Ferrocene
3) σ & π bonded – Metal Carbonyls
Mononuclear – $[Fe(CO)_5]$

$[Mn(CO)_6]^+ < [Cr(CO)_6] < [V(CO)_6]^-$

B.O.↑ B.L.↓ B.O.↓ B.L.↑

(w.r.to C-O bond)



Synergic Bonding

APPLICATION OF ORGANO METALLIC COMPOUNDS

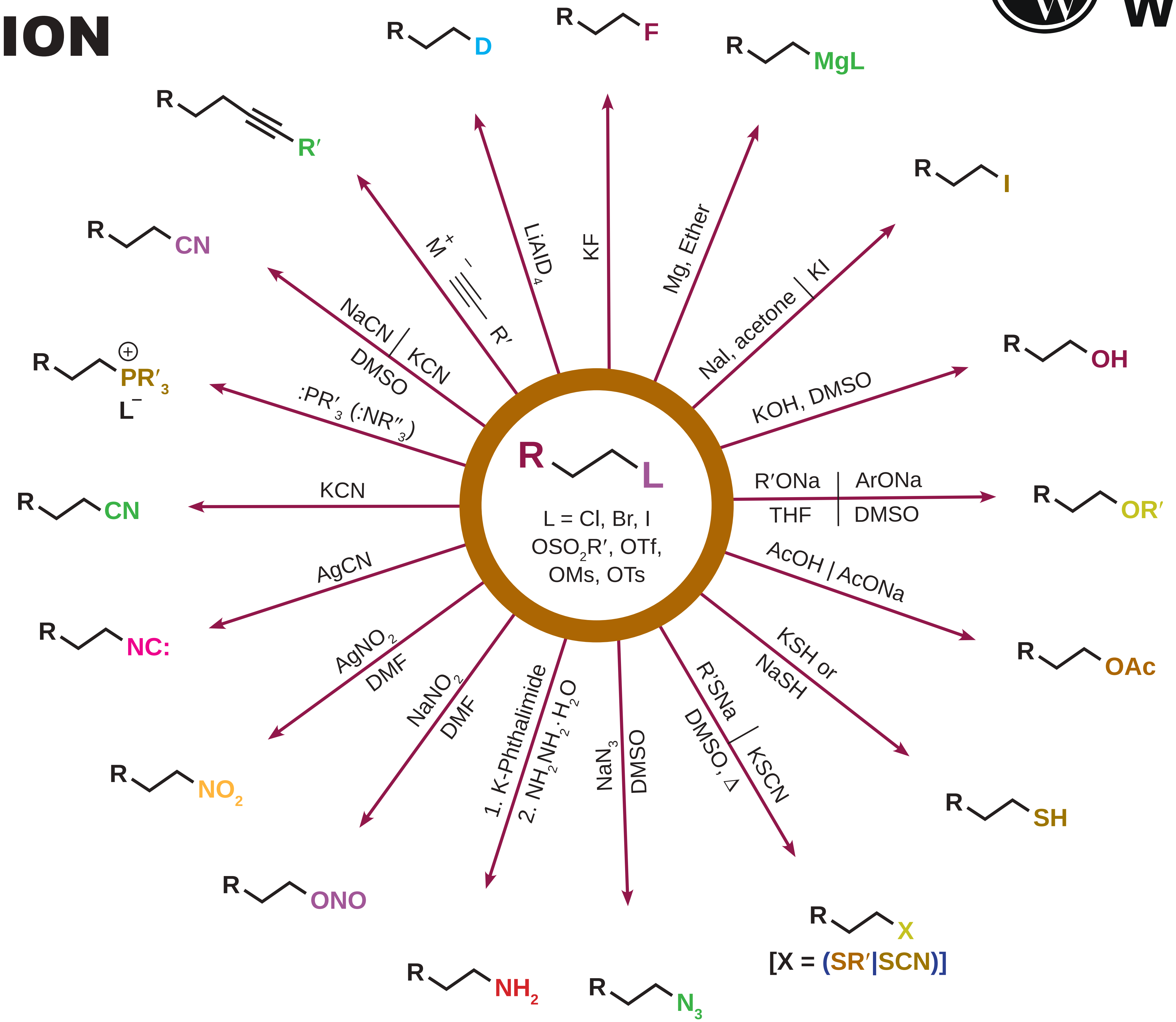
1) Ziegler Natta Catalyst is used in polymerisation of alkene
$TiCl_4 + AlEt_3$
2) Wilkinson's Catalyst is used in hydrogenation
$[\{(C_6H_5)_3P\}_3Rh]Cl$

APPLICATION OF COORDINATION COMPOUNDS

1) Cisplatin ($[Pt(NH_3)_2Cl_2]$) is used as an anticancerous agent
2) EDTA is used in Lead poisoning
3) Copper and iron poisoning – penicillamine & deferoxamine
4) Vitamin B-12 – Cobalt
5) Chlorophyll – Magnesium
6) Carboxy peptidase – Zinc

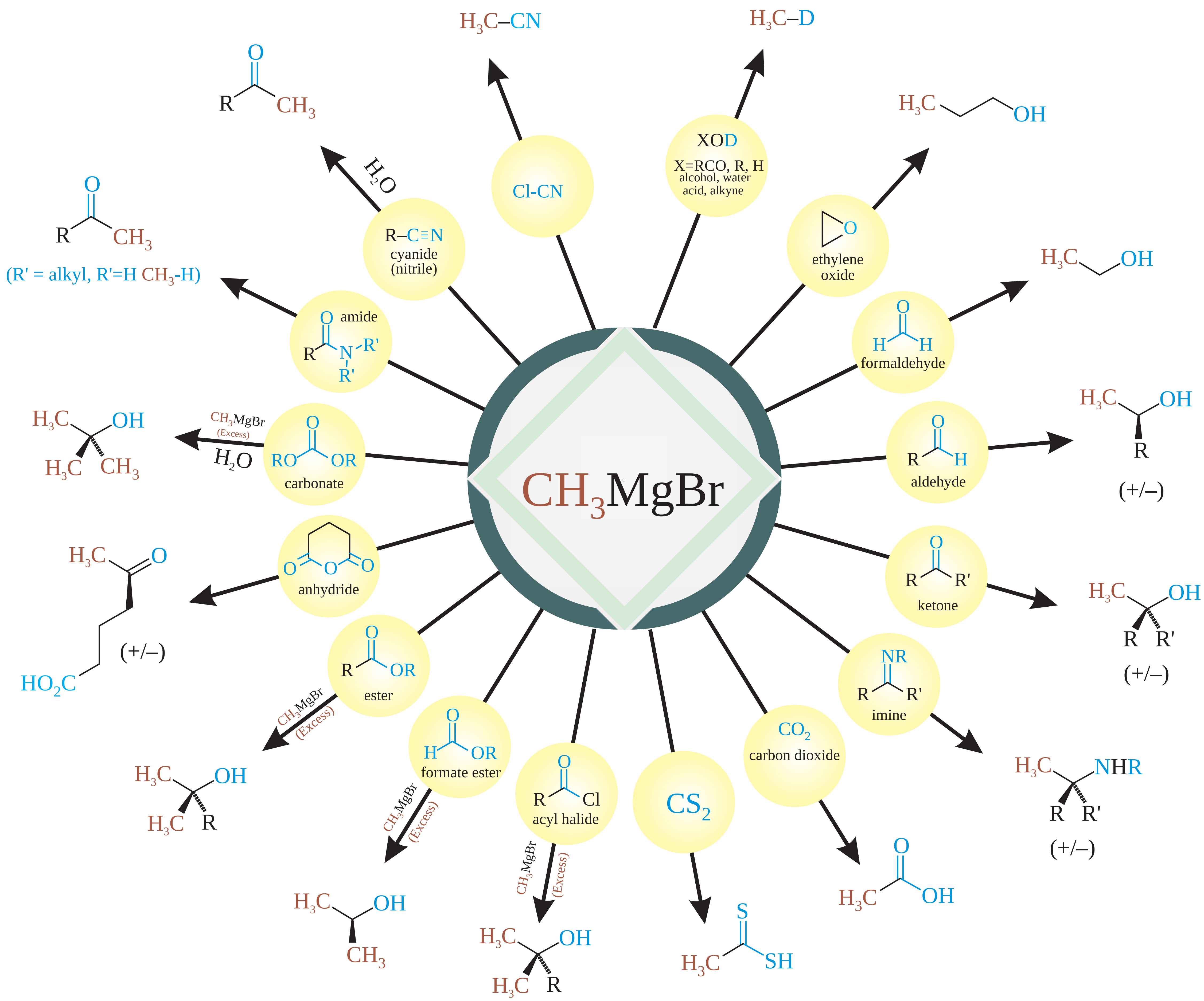
NUCLEOPHILIC SUBSTITUTION

PHYSICS WALLAH

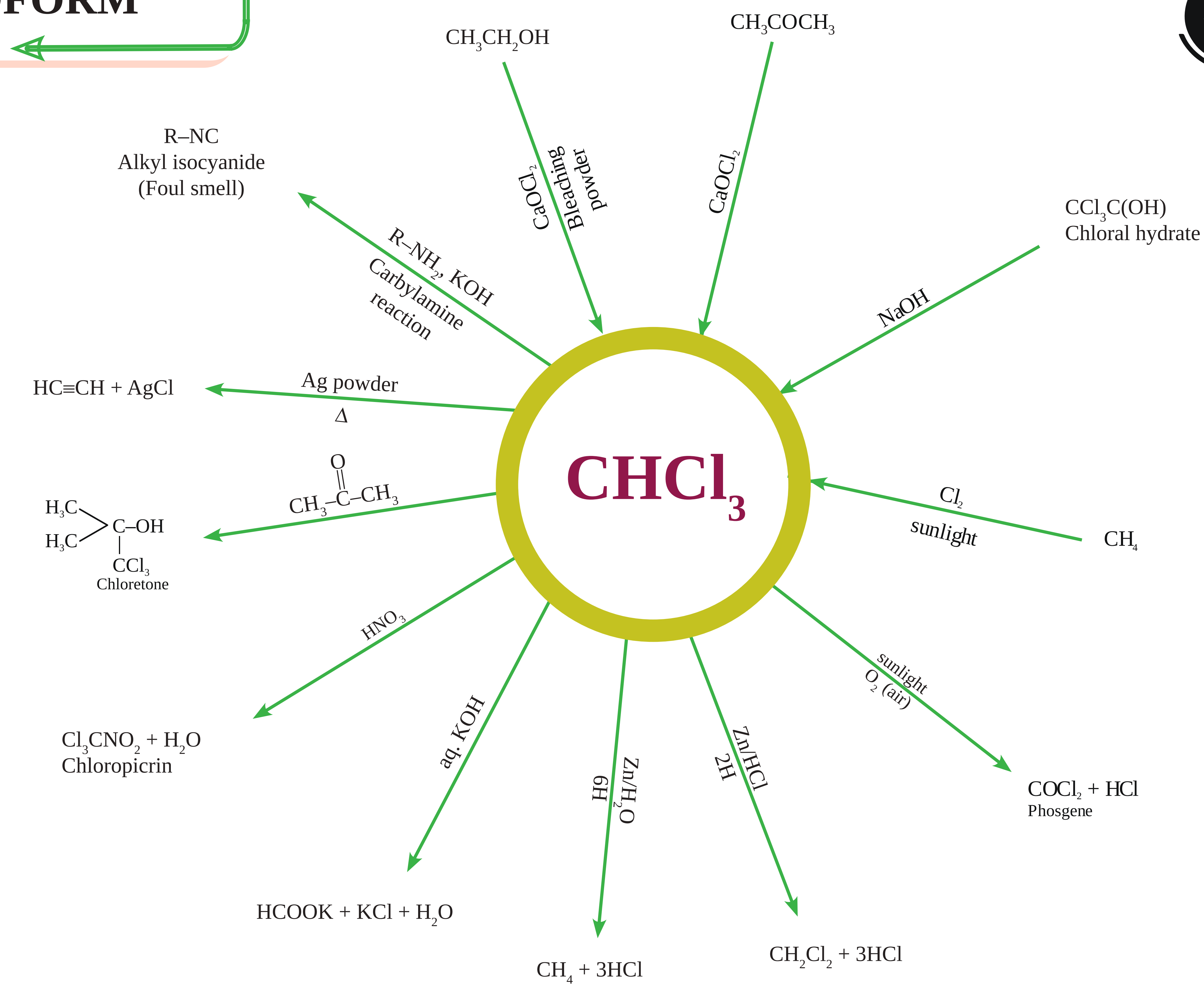


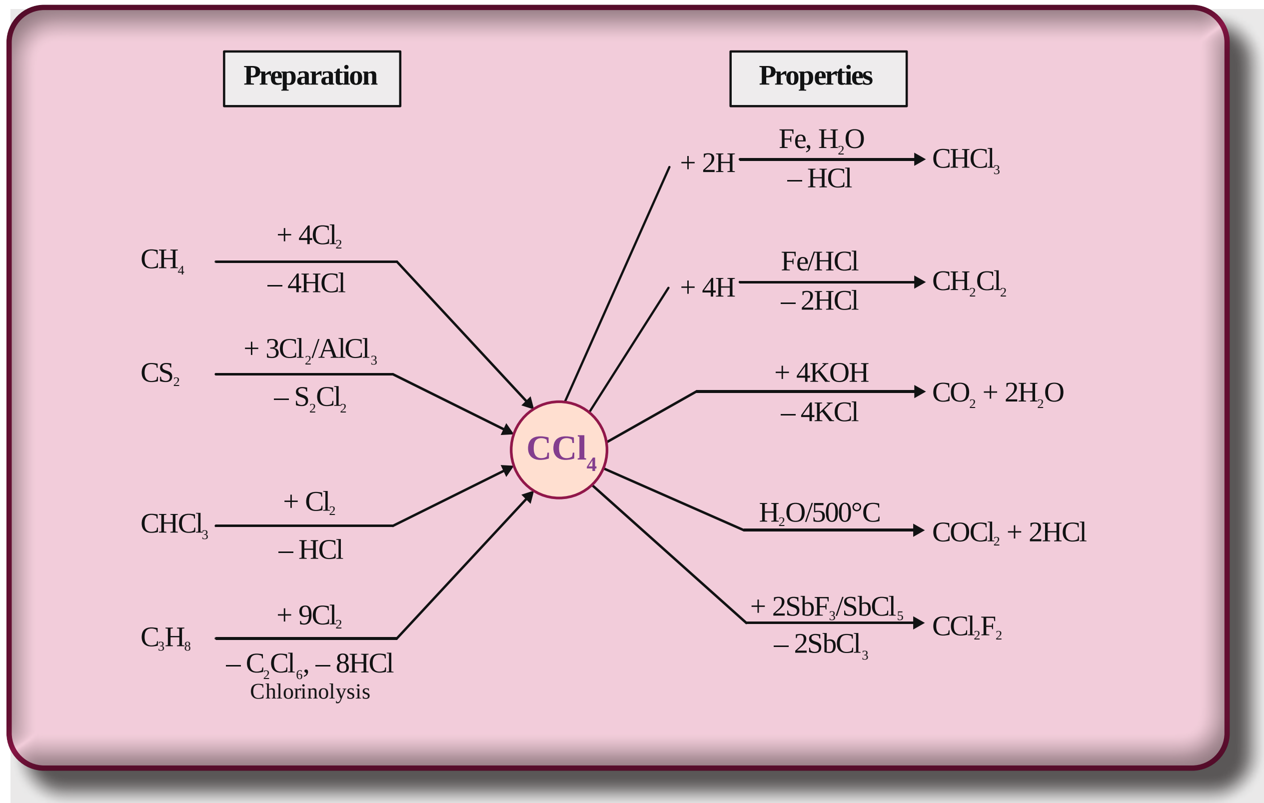
GRIGNARD REAGENT C-C BOND

PHYSICS WALLAH

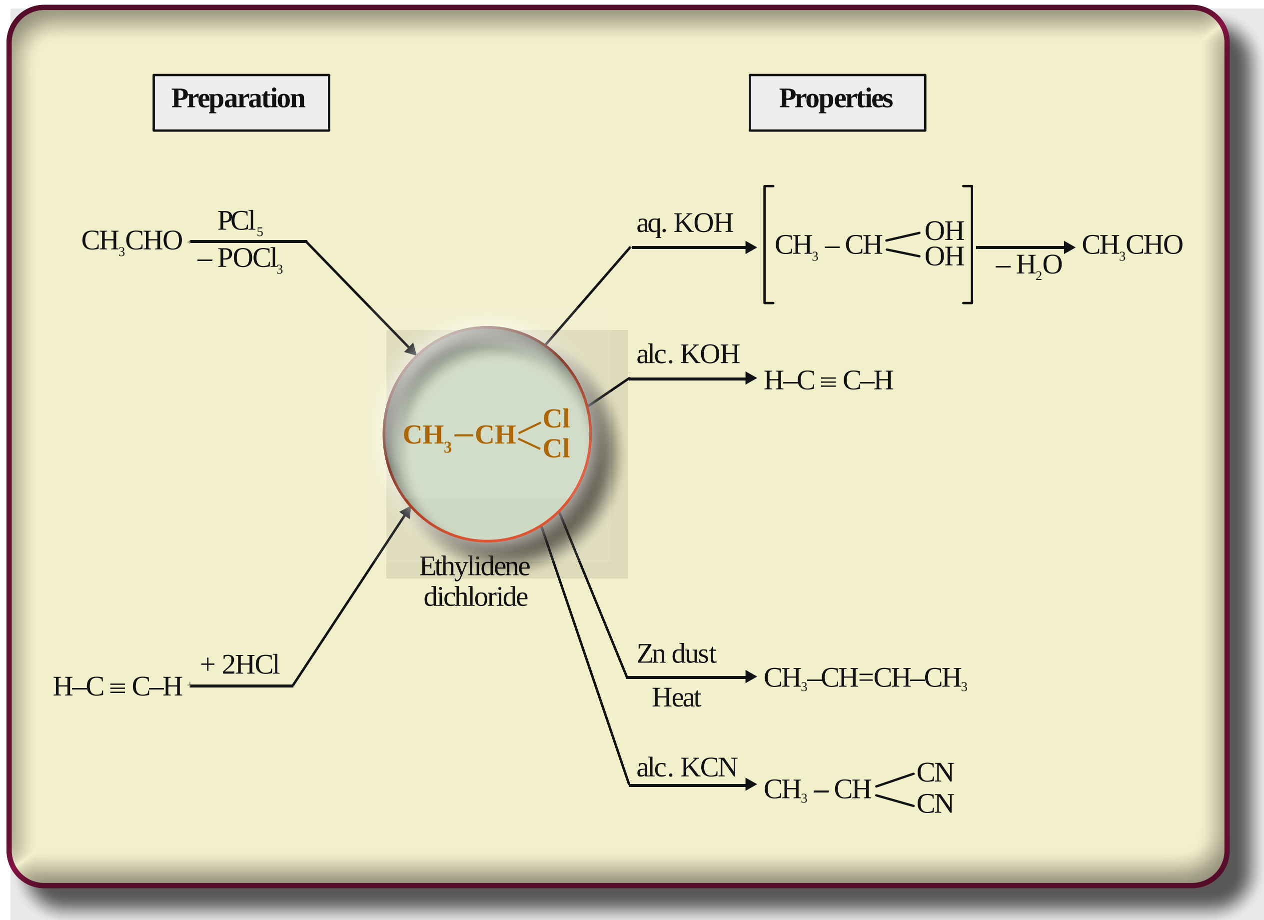


CHLOROFORM


CHCl3
CH3CH2OH
CaOCl2
Bleaching powder
CH3COCH3
CaOCl2
CCl3C(OH)
Chloral hydrate
NaOH
Cl2
sunlight
CH4
sunlight
O2 (air)
COCl2 + HCl
Phosgene
Zn/HCl
2H
CH2Cl2 + 3HCl
Zn/H2O
6H
CH4 + 3HCl
aq. KOH
HCOOK + KCl + H2O
HNO3
Cl3CNO2 + H2O
Chloropicrin
CH3–C(=O)–CH3
H3C, H3C, C–OH, CCl3
Chloretone
Ag powder
Δ
HC≡CH + AgCl
R–NH2, KOH
Carbylamine reaction
R–NC
Alkyl isocyanide
(Foul smell)

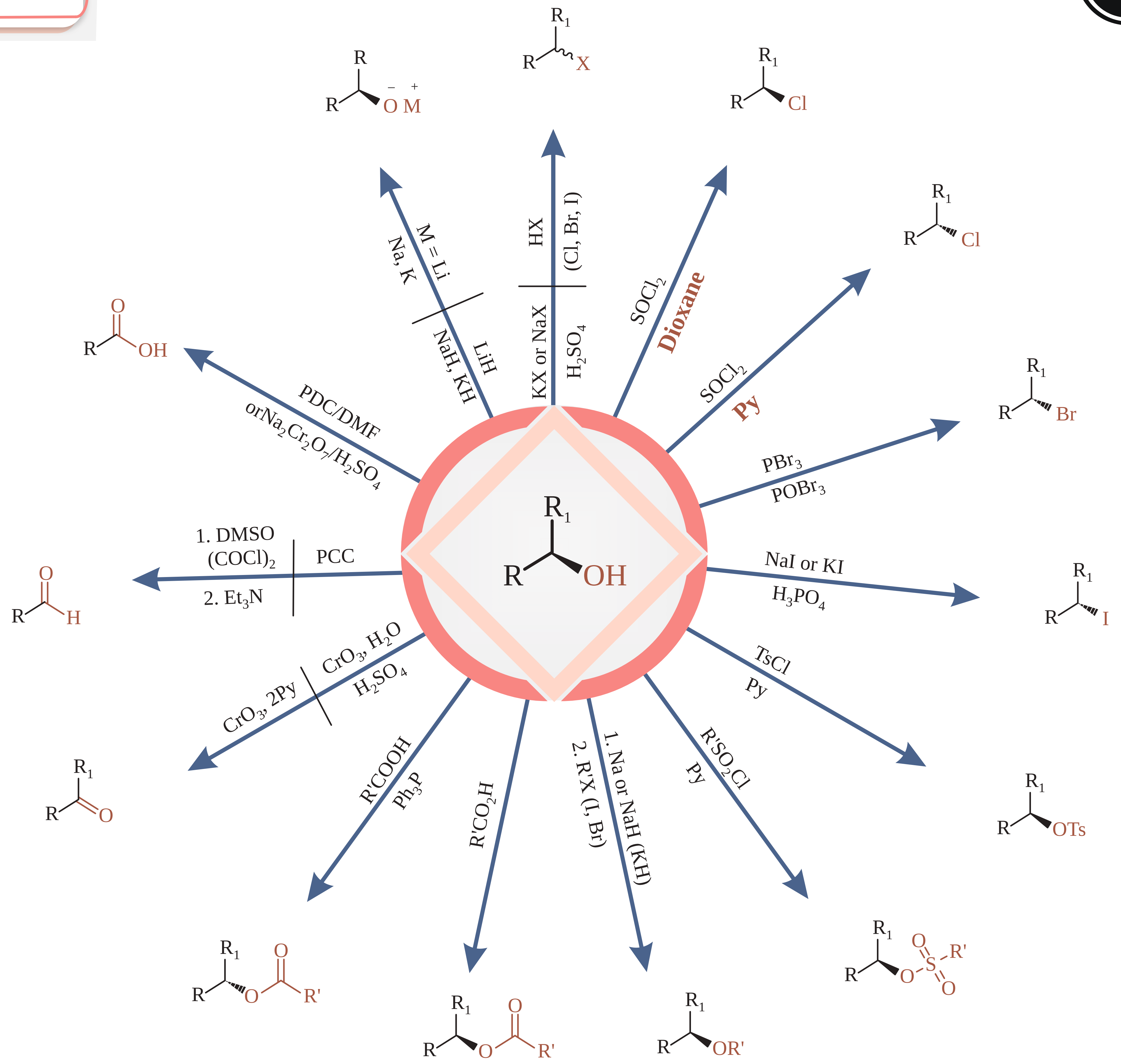


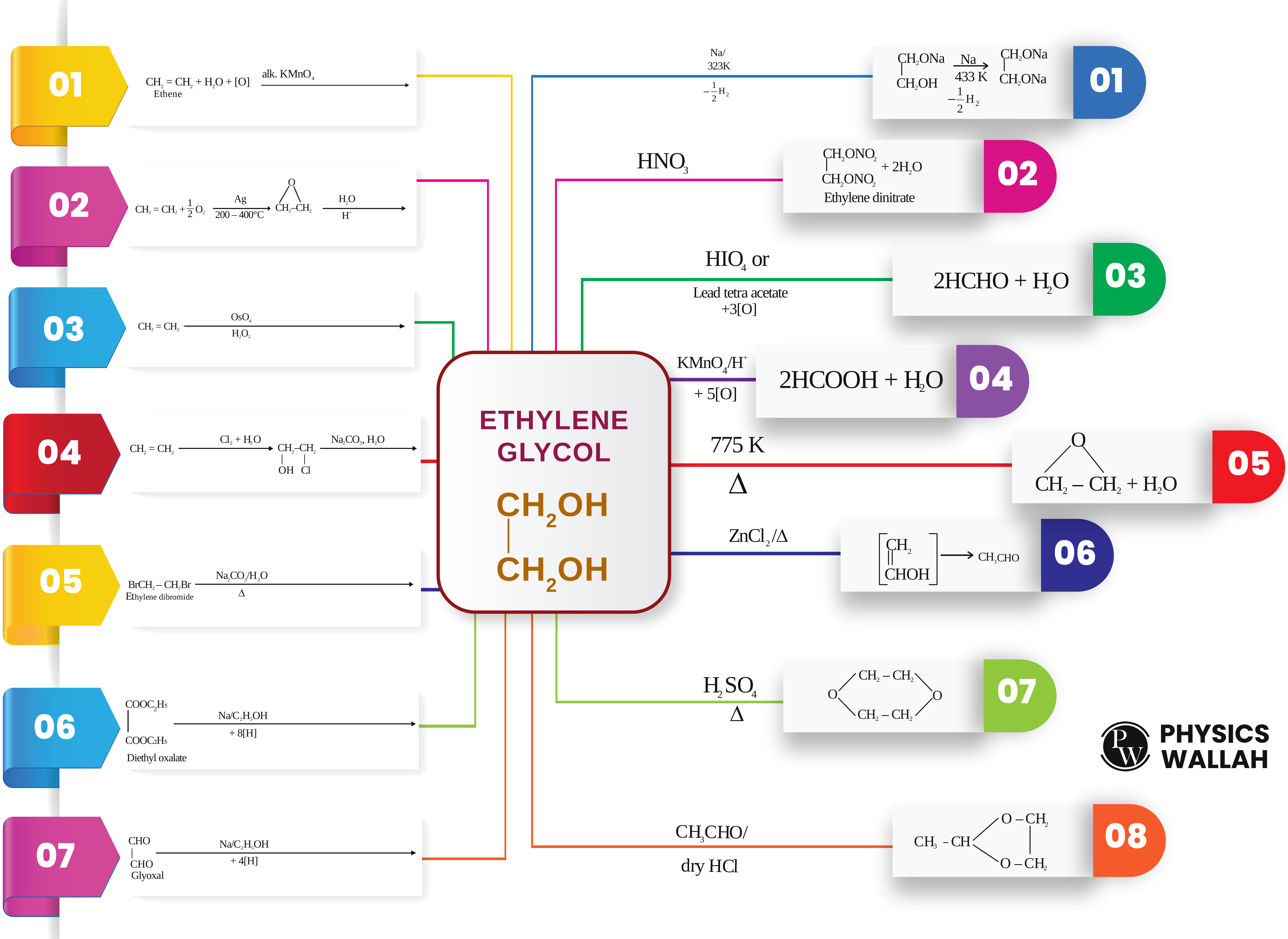
POLYHALOGENATED COMPOUNDS



ALCOHOLS

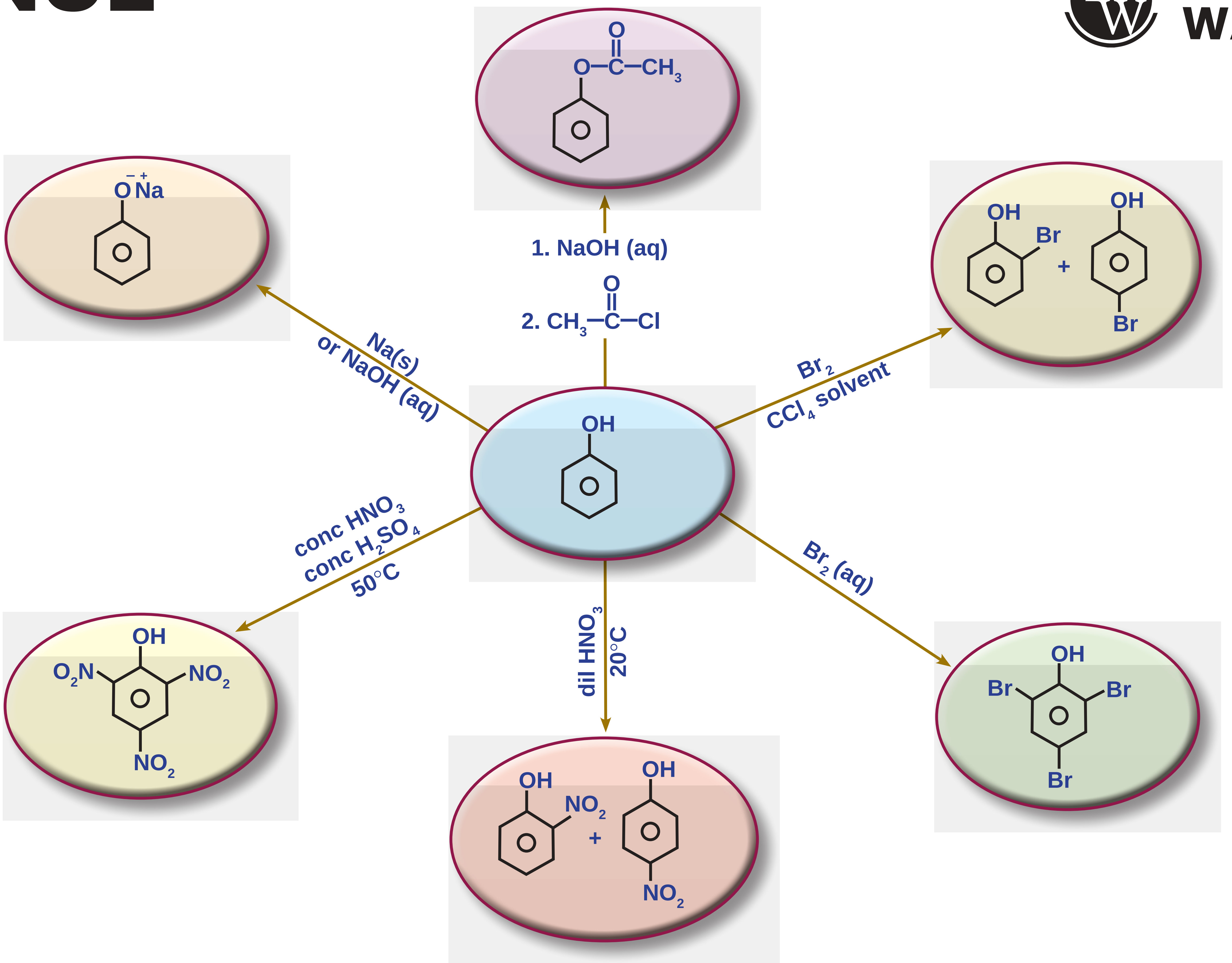
PHYSICS WALLAH



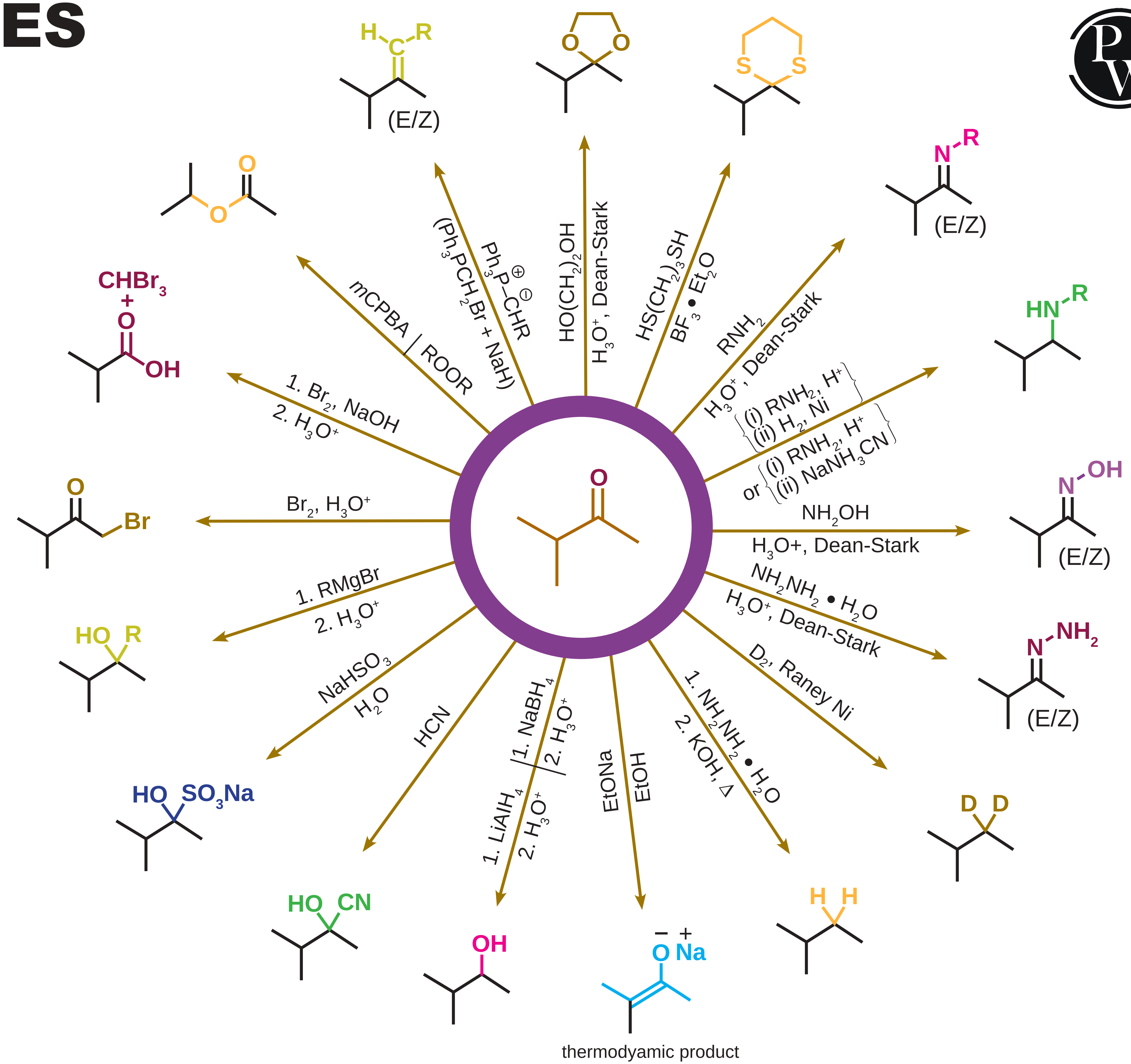

ETHYLENE GLYCOL
CH2OH
CH2OH
01
CH2 = CH2 + H2O + [O]
Ethene
alk. KMnO4
02
CH2 = CH2 + 1/2 O2
Ag
200 – 400°C
O
CH2–CH2
H2O
H+
03
CH2 = CH2
OsO4
H2O2
04
CH2 = CH2
Cl2 + H2O
CH2–CH2
OH Cl
Na2CO3, H2O
05
BrCH2 – CH2Br
Ethylene dibromide
Na2CO3/H2O
Δ
06
COOC2H5
COOC2H5
Diethyl oxalate
Na/C2H5OH
+ 8[H]
07
CHO
CHO
Glyoxal
Na/C2H5OH
+ 4[H]
Na/
323K
−1/2 H2
CH2ONa
CH2OH
Na
433 K
−1/2 H2
CH2ONa
CH2ONa
01
HNO3
CH2ONO2
CH2ONO2
+ 2H2O
Ethylene dinitrate
02
HIO4 or
Lead tetra acetate
+3[O]
2HCHO + H2O
03
KMnO4/H+
+ 5[O]
2HCOOH + H2O
04
775 K
Δ
O
CH2 – CH2 + H2O
05
ZnCl2/Δ
CH2
CHOH
CH3CHO
06
H2SO4
Δ
CH2 – CH2
O O
CH2 – CH2
07
CH3CHO/
dry HCl
CH3 - CH
O – CH2
O – CH2
08
PHYSICS WALLAH

PHENOL

PHYSICS WALLAH



KETONES



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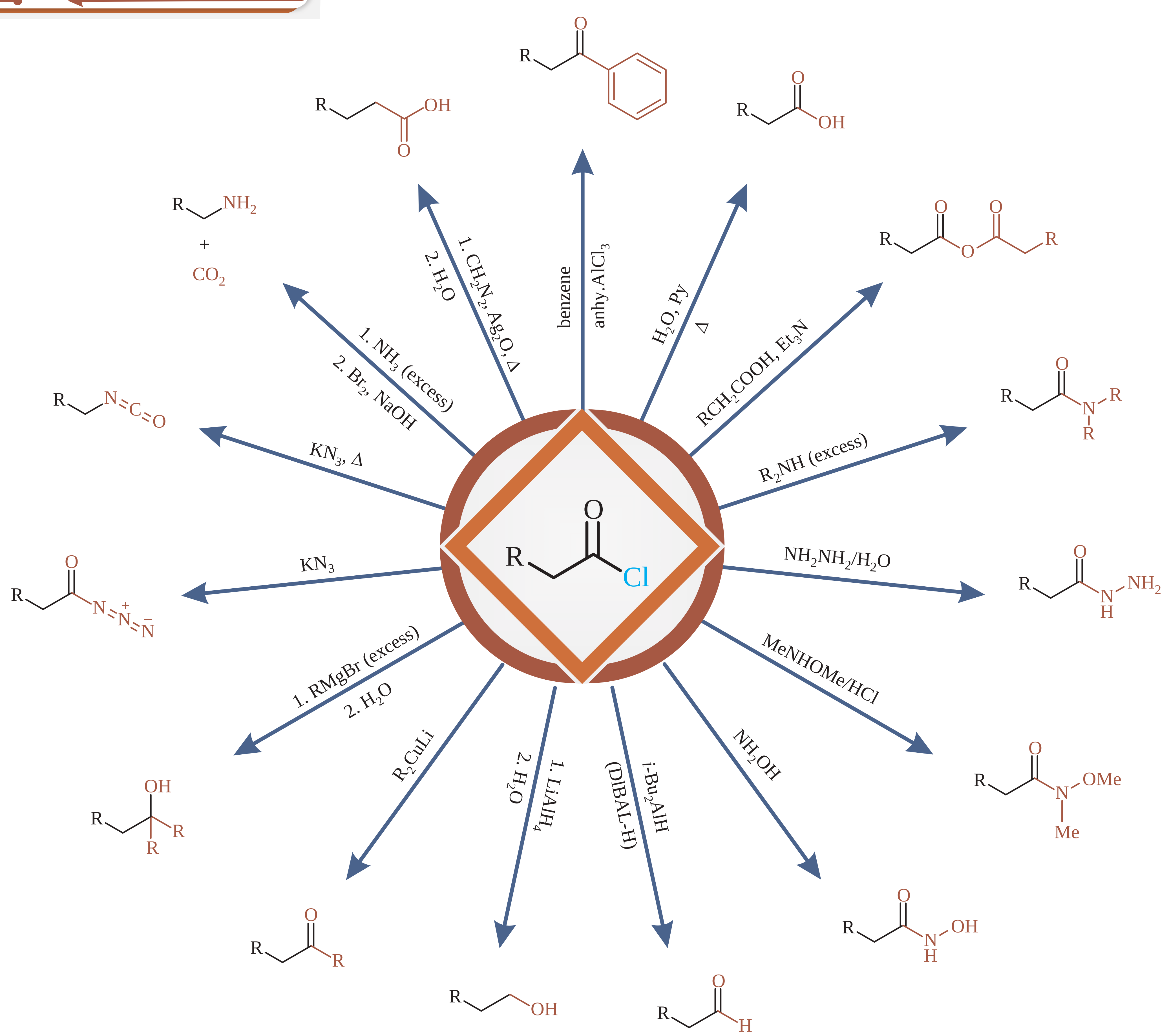
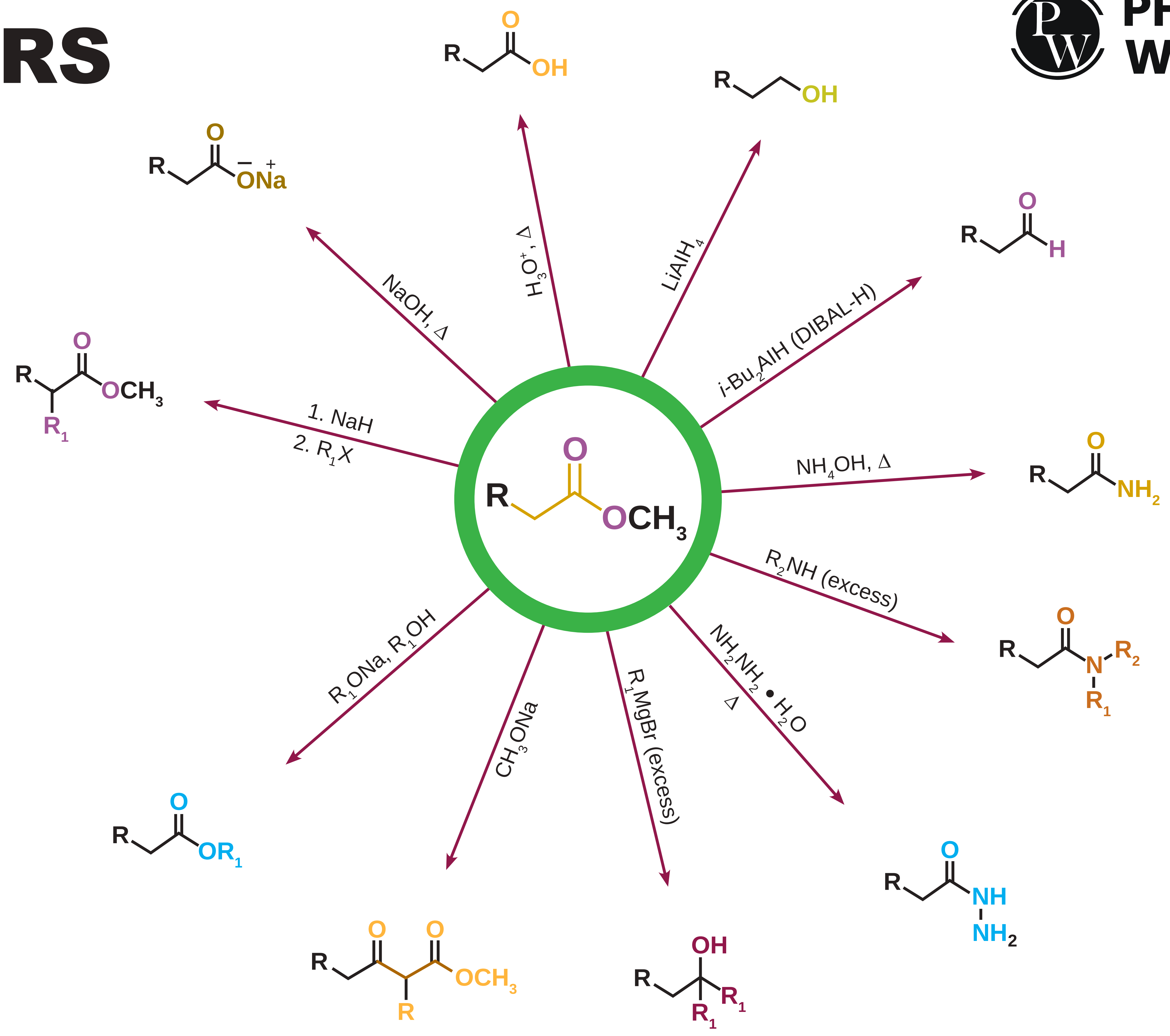
ACYL (ACID) CHLORIDE



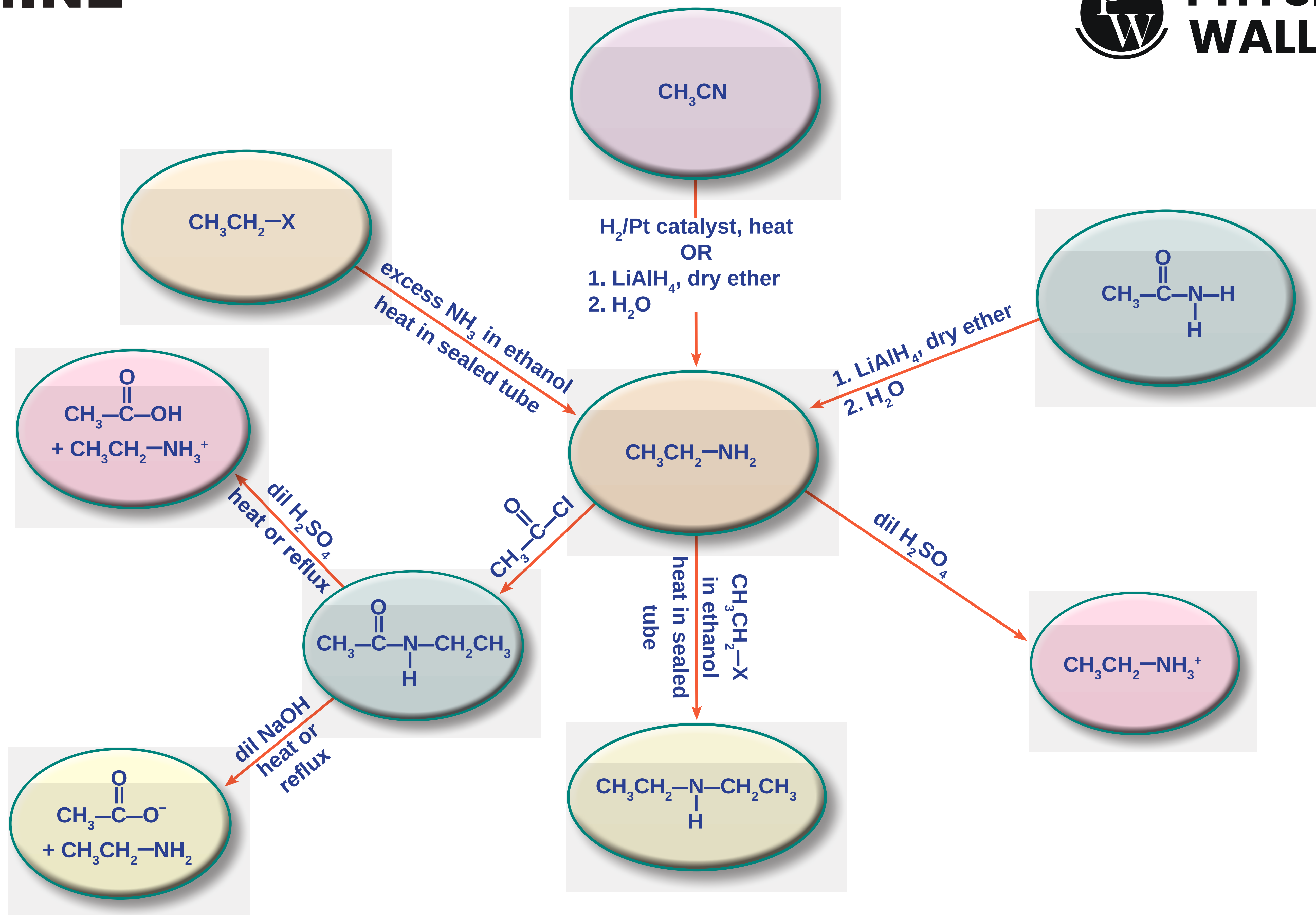
ESTERS

PHYSICS WALLAH

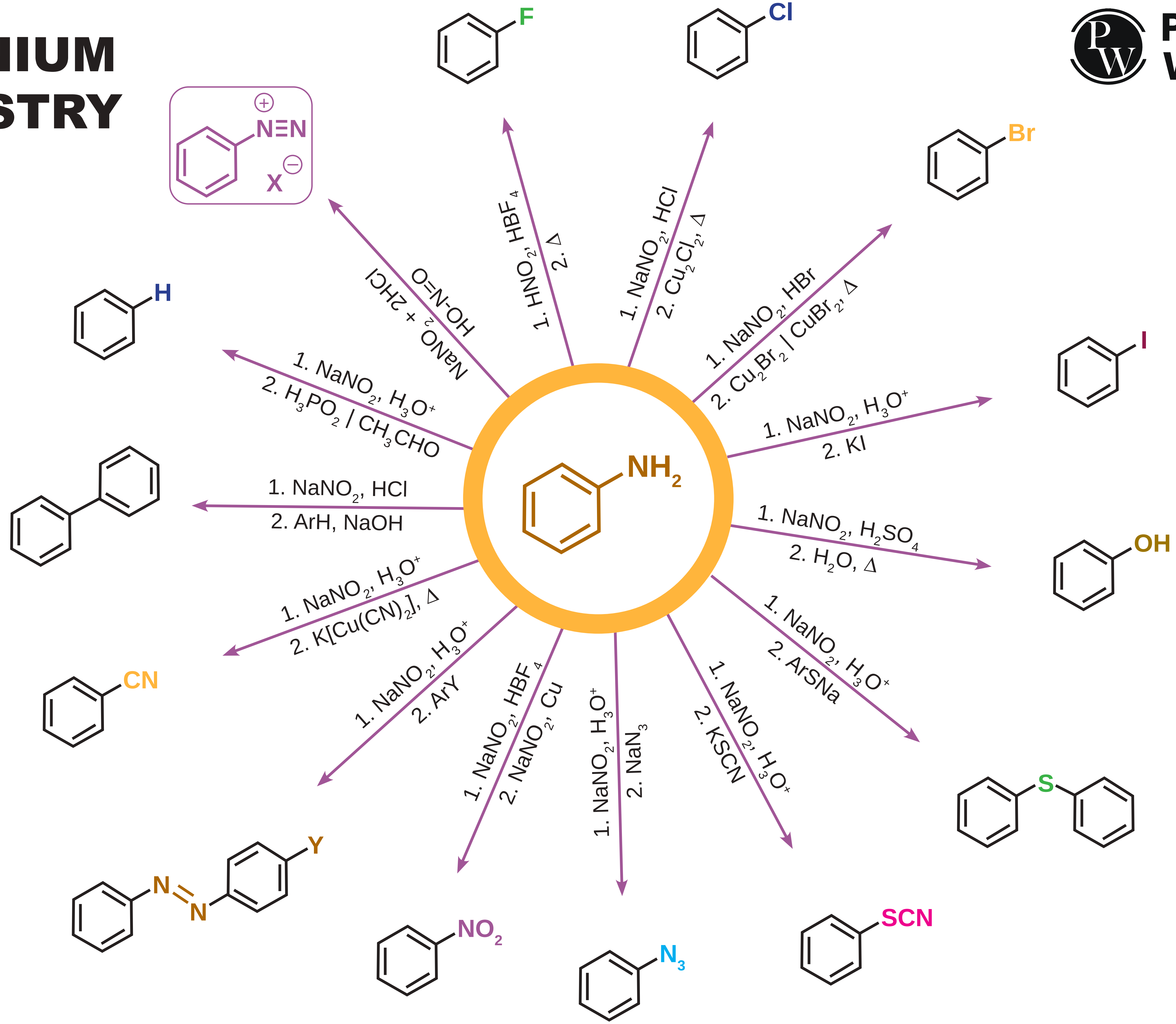


AMINE

PHYSICS WALLAH



DIAZONIUM CHEMISTRY



MONOSACCHARIDES

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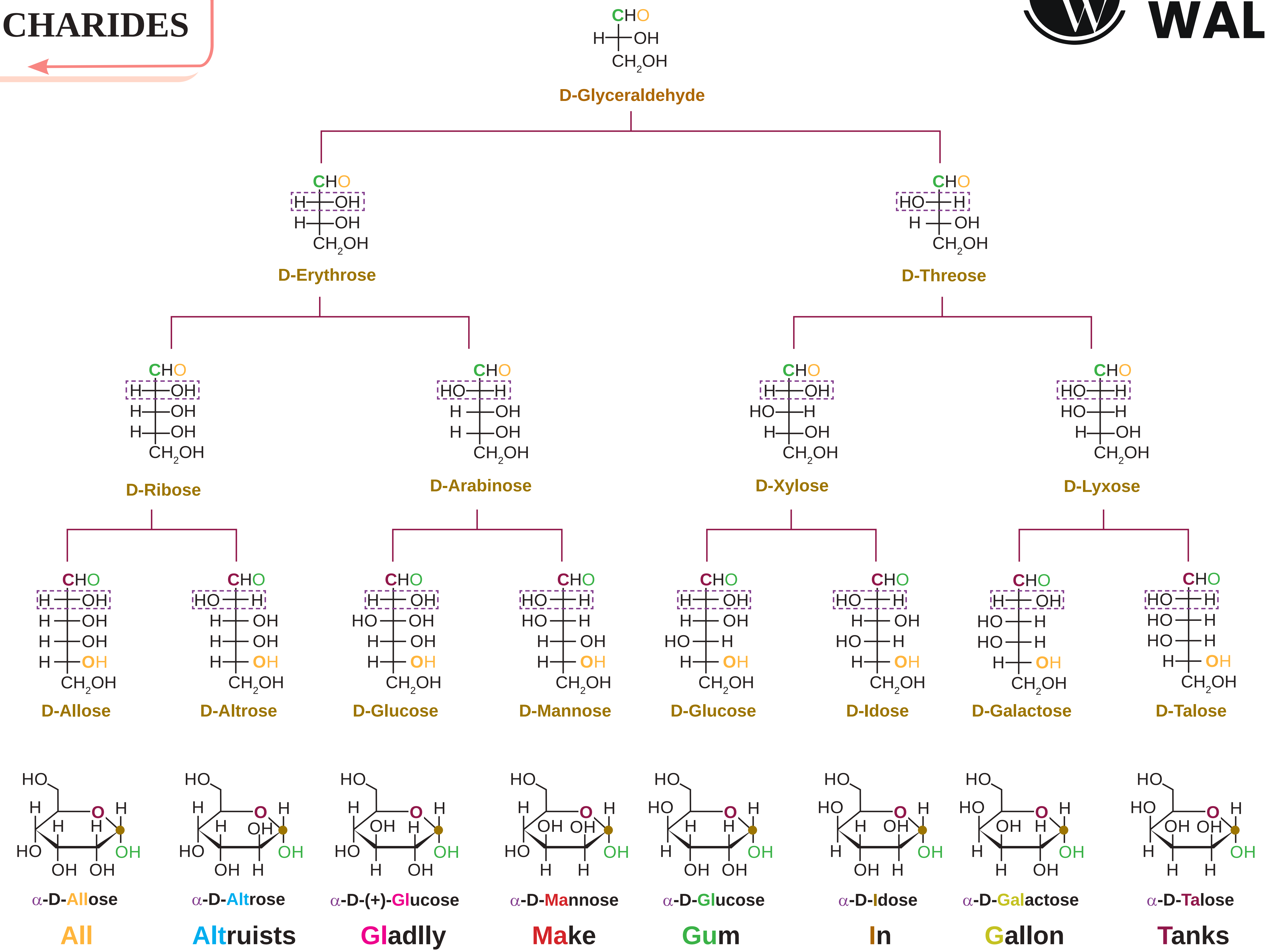
All Altruists Gladly Make Gum In Gallon Tanks



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BIO MOLECULES

Proteins

(Polymers of α - amino acids)

Amino acids contain $-NH_2$ and $-COOH$ groups.

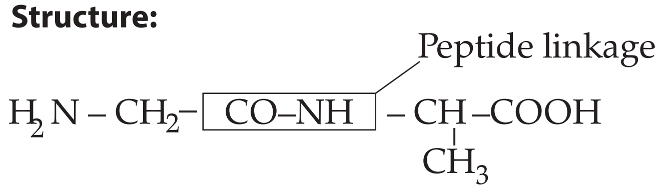
Classification:

-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:



Denaturation of proteins:

When a protein in its native form is subjected to physical change, globules unfold, helix get uncoiled and protein losses its biological activity

Enzymes

Globular proteins specific for particular reaction and for particular substrate.

Mechanism : Reduces the magnitude of activation energy

Carbohydrates

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

Classification:

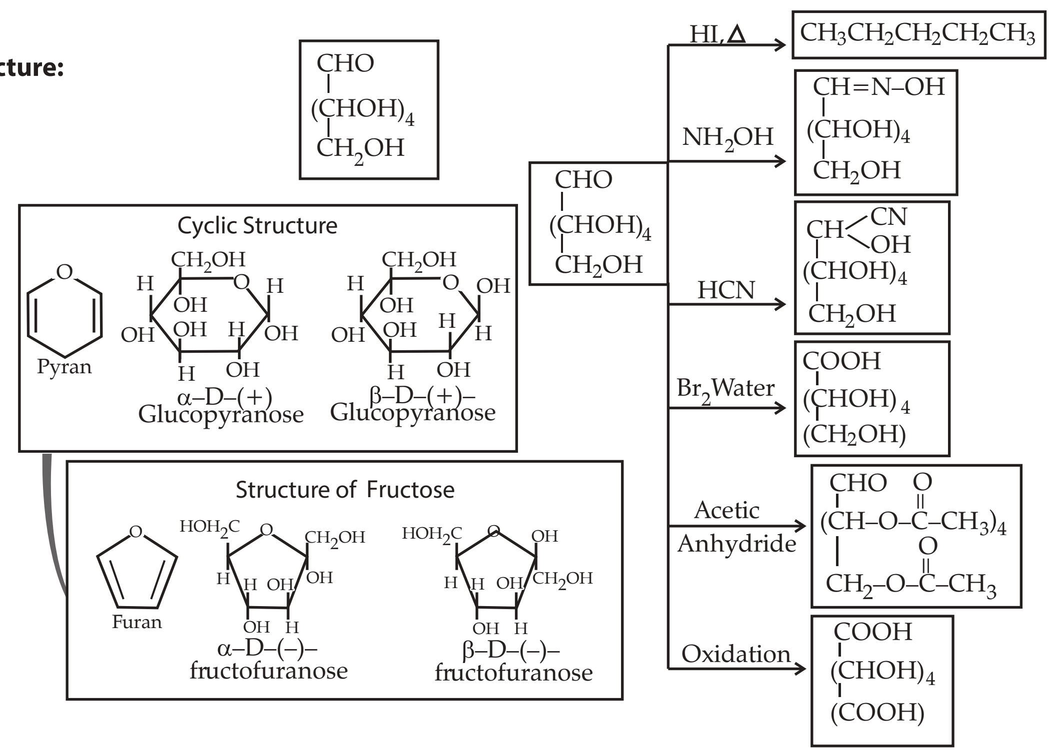
(I) Monosaccharides : (Aldehyde group - aldose, keto group -ketose)

Glucose : Preparation :

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

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
1) Sucrose-C-1 of a-glucose and C-2 of β-fructose
2) maltose-C-1 of a-D-glucose with C-4 of another a-D-glucose
3) lactose-C-4 of β-D-glucose with C-1 of β-D-galactose

(iii) Polysaccharides : Large number of monosaccharides units joined by glycosidic linkages.
(a) Starch : Polymer of a-glucose with two components amylose and amylopectin
(b) Cellulose: Polymer of β-D-glucose
(c) Glycogen: Animal starch-Polymer of glucose

Importance:

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

Nucleic acids

Two types: Deoxyribonucleic acid (DNA), ribonucleic acid (RNA)

Deoxyribonucleic acid (DNA)	Ribonucleic acid (RNA)
Sugar is β-D-2-deoxyribose	Sugar is β-D-ribose
DNA Contains A=T, G=C	RNA Contains A=U, G=C.

Biological Functions:

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

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

POLYMERS

PHYSICS WALLAH

ADDITION POLYMERS

POLYTHENE
[ETHYLENE]
$CH_2=CH_2$

POLYPROPYLENE
[PROPYLENE]
$CH_2=CHCH_3$
Ropes, Toys, Pipes, Fibres, etc.

POLY VINYL CHLORIDE (PVC)
[VINYL CHLORIDE]
$CH_2=CHCl$
Rain coats, Hand bags, Vinyl flooring

POLY STYRENE
[STYRENE]
$CH_2=CHC_6H_5$
Insulator, wrapping material,

POLY ACRYLONITRILE
[PAN, ORLON, ACRILAN]
[ACRYLONITRILE]
$CH_2=CH-CN$
blankets, clothing

POLY TETRAFLUORO ETHYLENE (TEFLON)
[TETRAFLUORO ETHYLENE]
$CF_2=CF_2$
Non-stick surface coated utensils

POLY METHYL METHACRYLATE
[PMMA, Lucite, Plexiglas]
[METHYL METHACRYLATE]
$CH_2=C(CH_3)\ CO_2CH_3$

Low density polythene

* High pressure of 1000 to 2000 atm at a temperature of 350K to 570 K
* Presence of traces of dioxygen or a peroxide initiator
* Highly branched structure
* Chemically inert & tough but flexible. Poor conductor of electricity
* Used in the insulation of electricity carrying wires and manufacture of squeeze bottles, toys & flexible pipes

High density polythene

* Low pressure of 6-7 atm and a temperature of 333 K to 343 K
* Presence of a catalyst such as triethylaluminium and titanium tetrachloride (Ziegler-Natta catalyst
* Linear polymers
* Chemically inert and more tough and hard
* Used in the manufacturing buckets, dustbins, bottles, pipes, etc

CLASSIFICATION OF POLYMERS

Based on molecular forces
- Elastomers: Rubber like solids with elastic property eg: Buna-S, Buna-N, Neoprene
- Fibres: High tensile strength & high modules eg: Polyamides (nylon-6,6) Polyesters (terylene)
- Thermoplastic polymers: Intermediate b/w elastomer & fibres. Capable of repeat softening on heating & hardening on cooling eg: Polythene, polystyrene, polyvinyl etc.
- Thermosetting polymers: Crosslinked & heavily branched polymers. These cannot be reused eg: Bakelite, resins, urea-formaldehyde etc.

Based on structure
- Linear eg: high density polythene, poly vinyl chloride
- Branched eg: low density polythene
- Cross-linked eg: Bakelite, melamine - formaldehyde resin

Based on source
- Natural polymers eg: protein, cellulose, starch, resins, rubber
- Semi-Synthetic polymers eg: Cellulose acetate (rayon), cellulose nitrate etc.
- Synthetic polymers eg: Nylon-6, 6, Buna-S

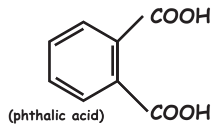
Based on mode of polymerisation
- Addition polymers
- Condensation polymers Eg: Nylon 6,6

Types of Polymerisation Reactions
- Addition Polymerisation or Chain Growth Polymerisation
- Condensation Polymerisation or Step Growth Polymerisation

CONDENSATION POLYMERISATION

POLYESTERS

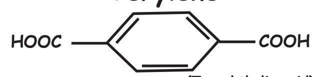
Glyptal



+
HO - CH_2 - CH_2 - OH
(Glycol)

Paints & Lacquers

Dacron or Terylene



(Terephthalic acid)
+
HO - CH_2 - CH_2 - OH
(Glycol)

Crease resistant, used in blending with cotton & wool fibres, glass reinforcing materials in safety helmets, etc

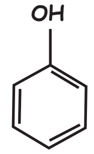
Poly β-hydroxybutyrate-co-β-hydroxy valerate (PHBV)

$CH_3-CH(OH)-CH_2-COOH$ + $CH_3-CH_2-CH(OH)-CH_2-COOH$
(3 - hydroxy butanoic acid) (3 - hydroxy pentanoic acid)

PHBV is used in speciality packaging, orthopaedic devices and in controlled release of drugs

RESINS

Phenol - Formaldehyde polymer

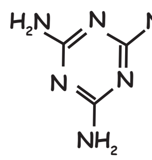


+ CH_2O

Novolac used in paints

- Novolac on heating with formaldehyde undergoes cross linking to form an infusible solid mass called bakelite
- Electrical switches and handles of various utensils

Melamine - Formaldehyde polymer



+ HCHO

Manufacture of unbreakable crockery

Urea-Formaldehyde polymer
$NH_2-CO-NH_2$ + HCHO

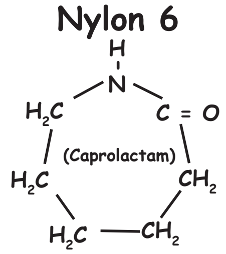
For making unbreakable cups & laminated sheets

POLYAMIDES

Nylon 6,6
$nHOOC(CH_2)_4COOH + n\ H_2N\ (CH_2)_6\ NH_2$
(Adipic acid) (Hexa methylene diamine)

Making sheets, bristles for brushes & in textile industry.

Nylon 6



(Heating with H_2O)

Manufacture of tyre cords, fabrics and ropes

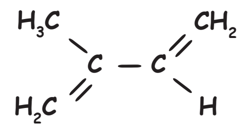
Nylon 2 - Nylon 6
$H_2N - CH_2 - COOH$
(Glycine)
+
$H_2N - (CH_2)_5 - COOH$
(Amino caproic acid)

RUBBER

1. NATURAL RUBBER

1. Natural rubber

(Isoprene)
(2-methyl-1, 3-butadiene)



Vulcanisation of rubber:

Heating a mixture of raw rubber with sulphur and an appropriate additive at a temperature range between 373K to 415 K.

2. SYNTHETIC RUBBER

Neoprene

(Chloroprene)
(2-Chloro-1, 3-butadiene)

$CH_2 = C(Cl) - CH = CH_2$

Manufacturing of conveyor belts, gaskets & hoses

Buna - N

1,3-Butadiene+Acrylonitrile

$CH_2 = CH - CH = CH_2 + CH_2 = CH(CN)$

Making of oil seals, tank lining, etc

Buna - S

1, 3 - Butadiene + Styrene

$CH_2=CH-CH=CH_2+C_6H_5CH=CH_2$

Auto tyres, floor tiles, foot wear, cable insulation

CHEMISTRY IN EVERYDAY LIFE

Drug Target Interaction

DRUGS
Chemicals of low molecular masses (~100-500u) and produce a biological response

RECEPTORS
Proteins for communication system in the body

ENZYME INHIBITORS
Drugs that block the binding site of the enzyme and prevent the binding of substrate.

COMPETITIVE INHIBITORS
Drugs compete with natural substrate for their attachment on the active sites of enzymes.

ALLOSTERIC SITE:
Some drugs do not bind to the enzyme's active site. These bind to a different site of enzyme.

CHEMICAL MESSENGERS
In human body, message between two neurons and the neurons to muscles is communicated through certain chemicals. These are called messengers.

ANTAGONISTS
Drugs that bind to the receptor site and inhibit its natural function

AGONISTS
Drugs that mimic the natural messenger by space on the called agonists.

PHYSICS WALLAH

Therapeutic Actions of Drugs

Antacid
Neutralise stomach acids
- Sodium hydrogencarbonate
- Aluminium hydroxide
- Magnesium hydroxide
- Magnesium carbonate
- Cimetidine, Ranitidine } Reduce secretion of pepsin & HCl in stomach due to histamine

N.A.D
(Neurologically active drugs)
Tranquilizers and analgesics are neurologically active drugs. These affect the message transfer mechanism from nerve to receptor.

Antihistamines
Anti allergic & antacid
- Diphenylhydramine
- Chlorpheniramine
- Brompheniramine
- Promethazine
- Terfenadine

Tranquilizers
Treatment for stress & mental diseases
- Chlordiazepoxide
- Meprobamate
- Equanil
- Veronal
- Amytal
- Nembutal
- Luminal
- Seconal
- Valium
- Serotonin

Antifertility Drugs
(Synthetic progesterone derivatives)
progesterone supresses ovulation
- Norethindrone
- Novestrol
- Mestranol
- Mifepristone

Analgesics
Pain killers
- Aspirin — Relief skeletal pain due to arthritis; Antipyretic; Antiblood clotting agent (prevention of heart-attack)
- Paracetamol
- Novalgin
- Phenacetin
- Brufane
- Morphine
- Heroine
- Codeine

Non narcotic
Non addictive
- Aspirin
- Paracetamol

Narcotic
Addictive
- Morphine

Antiseptics
on living tissues
- Furacine
- Soframicine
- Chloroxylenol, Terpineol } Dettol
- Tincture of iodine (2-3% solution in alchohol-water mixture)
- Iodoform
- Bithional (In soaps)
- 0.2% Phenol
- Iodine (Powerful)
- Boric acid (Weak antiseptic for eyes)

Antimicrobials
- An antimicrobial destroy prevent development or inhibit the pathogenic action of microbes such as bacteria, fungi, virus, parasites selectively
- Antibiotics antiseptics and disinfectats are antimicrobial drugs

Disinfectants
Either kill or prevent the growth of microorganisms
- 1% Phenol
- DDT
- 0.2-0.4 ppm solution of chlorine SO_2 in very low concentration

Antibiotics

On basis of mode of control of microbial diseases

Bactericidal	Bacteriostatic
Penicillin Aminoglycosides Ofloxacin	Erythromycin Tetracycline Chloramphenicol

Salvarsan (arsenic based) used for treatment of syphilis

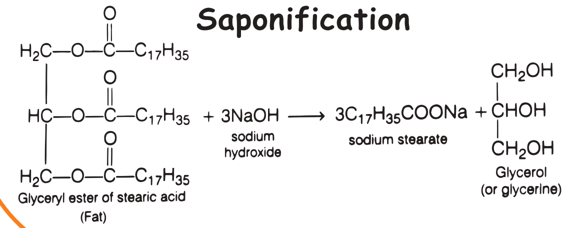
On basis of mode of its spectrum of action

Broad spectrum	Narrow spectrum
Ampicillin, Amoxycillin } Synthetic modifications of penicillins Chloramphenicol Chloromycetin Tetracycline Vancomycin Ofloxacin	Penicillin G Clindamycin Metronidazole
	Limited spectrum
	Dysidazirine

Soaps & Detergents

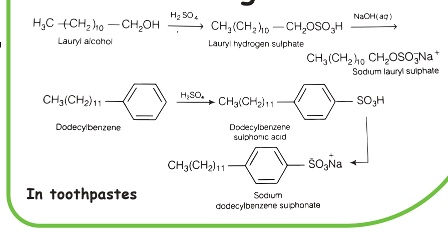
Soaps
Sodium and Potassium salts of higher fatty acids (carbon atoms 12 or highter)

Saponification



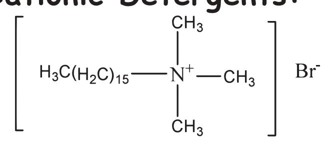
Detergents
Are sodium and potassium salts of long chain sulphonic acids

Anionic Detergents:



In toothpastes

Cationic Detergents:



Cetyltrimethylammonium bromide

Germicidal properties

Non-ionic Detergents:

$CH_3(CH_2)_{16}COOH +$
$HO(CH_2CH_2O)_nCH_2CH_2OH \longrightarrow$
$CH_3(CH_2)_{16}COO(CH_2CH_2O)_nCH_2CH_2OH$

Liquid dishwashing detergents

Chemicals in foods

(i) Artificial sweetening agents:

Artificial Sweetener	Sweetness value in comparison to cane sugar
Aspartame (Widely used, unstable at cooking T)	100
Saccharin	550
Sucralose (stable at cooking T, Does not provide calories)	600
Alitame (Stable than Aspartame, High potency sweetener)	2000

(ii) Food preservatives:
Prevent spoilage of food due to microbial growth. *Eg:* Table salt, sugar, vegetable oils, C_6H_5COONa, Salts of sorbic acid & propanoic acid

(iii) Antioxidants in Food
Butylated hydroxytoluene (BHT), butylated hydroxy anisole (BHA)-Increases shelf life of butter from months to years, SO_2,& sulphite-In beer & sugar syrups