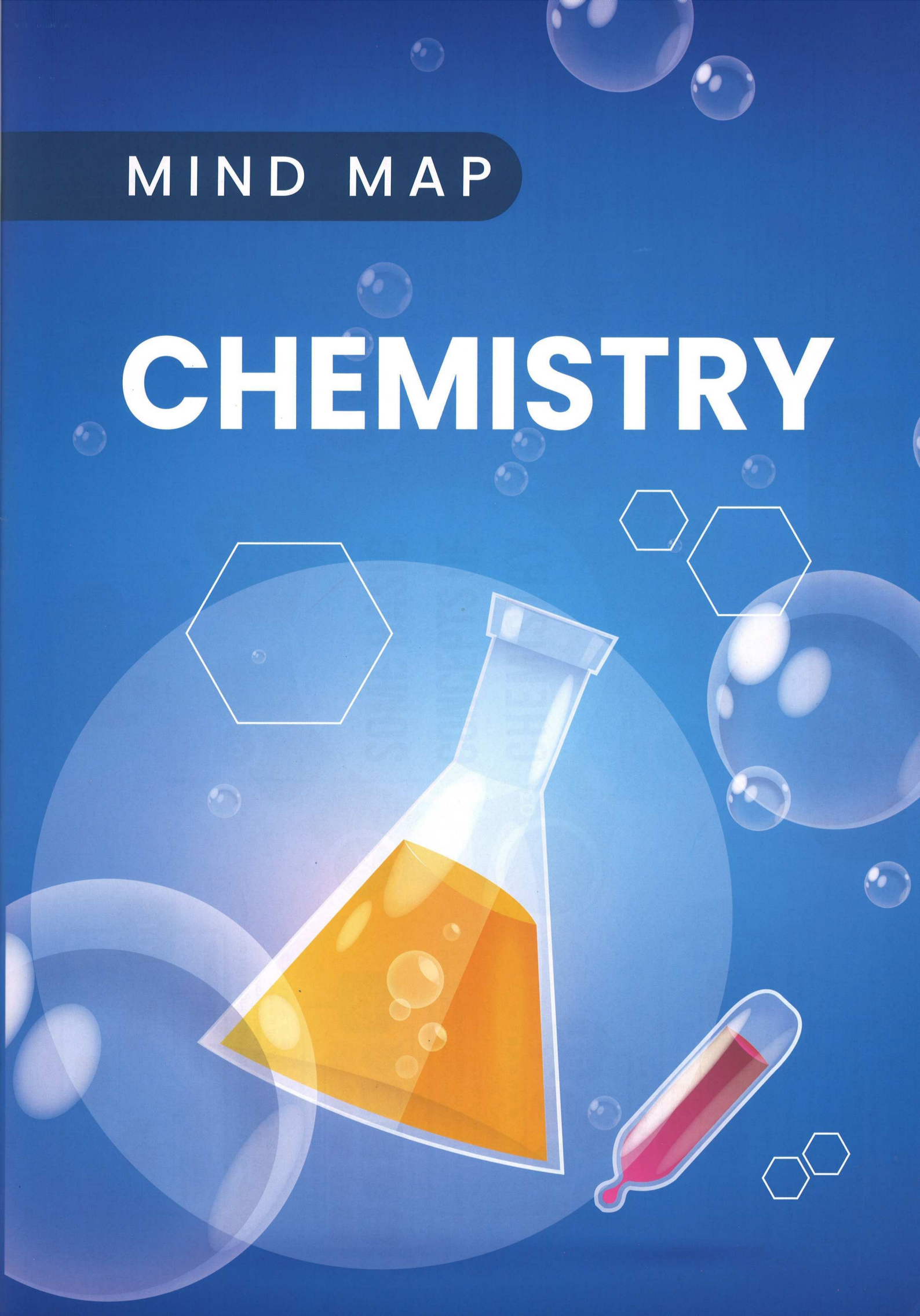


MIND MAP

CHEMISTRY





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CHEMISTRY



08

FIRST IDENTIFY THE LIMITING REACTANT BY CALCULATING THE REQUIRED MOLES & AVAILABLE MOLES OF REACTANTS.

THEN CALCULATE THE AMOUNT OF PRODUCT FROM THE AMOUNT OF LIMITING REACTANT

Q) When 22.4L of $H_2(g)$ is mixed with 11.2L of $Cl_2(g)$, each at STP, the moles of $HCl(g)$ formed is equal to:
(A) 0.5 (B) 1.5 (C) 1 (D) 2

AIPMT



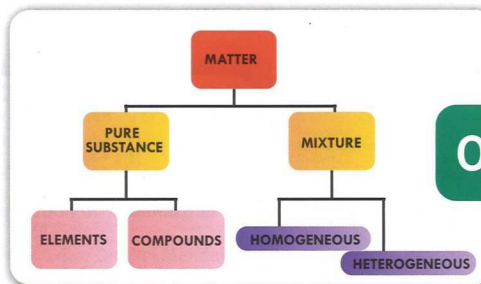
08

STOICHIOMETRIC CALCULATIONS

01

NATURE OF MATTER

01



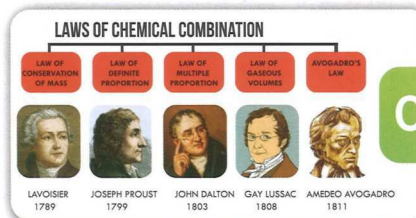
Q) Which one of the following is not a mixture?
(A) Tap water (B) Distilled water
(C) Salt in water (D) Oil in water



02

LAWS OF CHEMICAL COMBINATIONS

02



Q) Which one of the following pairs of compound illustrate the law of multiple proportions?

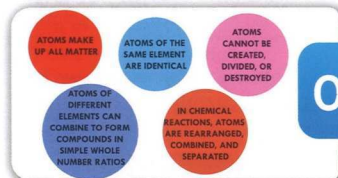
- (A) H_2O , Na_2O (B) MgO , Na_2O
(C) Na_2O , BaO (D) $SnCl_2$, $SnCl_4$



03

DALTON'S ATOMIC THEORY

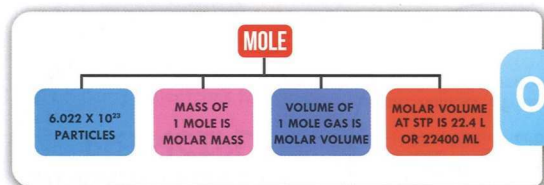
03



04

MOLE CONCEPT

04



Q) Which one of the followings has maximum number of atoms?

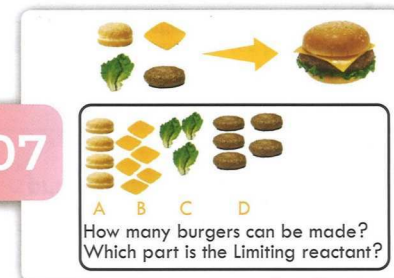
- (A) 1 g of $Mg(s)$ [Atomic mass of $Mg = 24$]
(B) 1 g of O_2 [Atomic mass of $O = 16$]
(C) 1 g of $Li(s)$ [Atomic mass of $Li = 7$]
(D) 1 g of $Ag(s)$ [Atomic mass of $Ag = 108$]



07

LIMITING REACTANT

07



Q) The number of moles of hydrogen molecules required to produce 20 moles of ammonia through Haber's process is:

- (A) 40 (B) 10 (C) 20 (D) 30

NEET



06

EF & MF

06

ACTUAL FORMULA Molecular Formula	SIMPLEST FORMULA Empirical Formula
$C_3H_6O_3$	CH_2O
$C_{10}H_{14}N_2$	C_5H_7N
$C_{12}H_{22}O_{11}$	$C_{12}H_{22}O_{11}$

Q) An organic compound contains 80% (by wt.) C & the remaining percentage of H. The empirical formula of this compound is:

- (A) CH_3 (B) CH_4 (C) CH (D) CH_2

NEET



05

Percentage composition of H_2O

$$\text{MASS \% OF H} = \frac{2}{18} \times 100$$

$$\text{MASS \% OF O} = \frac{16}{18} \times 100$$

Percentage composition of CO_2

$$\text{MASS \% OF C} = \frac{12}{44} \times 100$$

$$\text{MASS \% OF O} = \frac{32}{44} \times 100$$

Q) Mass % of carbon in ethanol is :

- (A) 52 (B) 13 (C) 34 (D) 90



SOME BASIC CONCEPTS OF CHEMISTRY

QUANTUM NUMBER

01

UNCERTAINTY PRINCIPLE

$$\Delta x \cdot \Delta p \geq \frac{h}{4\pi}$$

$$\Delta x \cdot m \Delta v \geq \frac{h}{4\pi}$$

Q. According to Heisenberg's uncertainty principle, $\Delta x \cdot \Delta p \geq \frac{h}{4\pi}$ which of the following is correct?

- If $\Delta x = 0$ then $\Delta p = \infty$
- If $\Delta v = 0$ then $\Delta p = 0$
- If $\Delta p = 0$ then $\Delta x = \infty$
- All are correct

Q. Find uncertainty in velocity, if uncertainty position is equal to uncertainty in momentum.

- $\frac{h}{2\sqrt{\pi m}}$
- $\frac{1}{2m} \sqrt{\frac{h}{\pi}}$
- $\frac{1}{m} \sqrt{\frac{h}{\pi}}$
- $\frac{1}{2} \sqrt{\frac{h}{m\pi}}$

Q. The uncertainty involved in the measurement of velocity within a distance of $0.1 \text{ \AA}$ is:

- $5.79 \times 10^4 \text{ m/s}$
- $5.79 \times 10^7 \text{ m/s}$
- $5.79 \times 10^4 \text{ m/s}$
- $5.79 \times 10^6 \text{ m/s}$

Angular momentum in n^{th} orbital
 $= mvr = n\hbar$

Orbital angular momentum
 $= \sqrt{l(l+1)}\hbar$

Spin angular momentum
 $= \sqrt{s(s+1)}\hbar$

PRINCIPLE QUANTUM NUMBER

In n^{th} Shell,
 Number of subshells = n
 Number of orbitals = n^2
 Max. number of electrons = $2n^2$

1 It describes shell or orbit
 $n = 1, 2, 3, 4, \dots$
 K, L, M, N, $\dots$

2 It describes size & energy of shell.
 $r \propto n^2$ $E \propto \frac{1}{n^2}$

3 It defines the angular momentum
 $mvr = \frac{nh}{2\pi}$

Q. Find angular momentum of
 (i) 2s orbital (ii) 3d orbital
 (iii) 4p orbital (iv) e⁻ in 4th orbit

Q. Find maximum no. of e⁻ having
 (i) $n=4, s=-\frac{1}{2}$ (ii) $n=3, l=1, m=0$
 (iii) $n=2, l=0$ (iv) $n=3, l=1$

AZIMUTHAL QUANTUM NUMBER

1 It describes subshell value from 0 to $n-1$
 $l=0 \rightarrow s$ $l=2 \rightarrow d$
 $l=1 \rightarrow p$ $l=3 \rightarrow f$

2 Orbital angular momentum
 $= \sqrt{l(l+1)}\hbar$ $\hbar = \frac{h}{2\pi}$

3 Maximum no. of orbital in a subshell = $2l + 1$
 Maximum no. of electrons in a subshell = $4l + 2$

Q. Which of the following set of quantum numbers is correct?

	n	l	m	s
1)	4	0	0	$+\frac{1}{2}$
2)	5	2	3	$-\frac{1}{2}$
3)	2	-1	0	$+\frac{1}{2}$
4)	6	3	0	$-\frac{1}{2}$

If $l=2$

- Orbital = d
- No. of orbitals = $2(2+1)=5$
 $(d_{xy}, d_{xz}, d_{yz}, d_{x^2-y^2}, d_{z^2})$
- Total e⁻s = $2(2l+1) = 10 \text{ e}^-$
- Orbital angular momentum = $= \sqrt{2(2+1)}\hbar = \sqrt{6}\hbar$

MAGNETIC QUANTUM NUMBER

Value of $m = -l \leq m \leq l$
 Total values of $m = 2l + 1$

$n = 4$
 $l = 0 \quad m = 0$
 $l = 1 \quad m = -1, 0, +1$
 $l = 2 \quad m = -2, -1, 0, +1, +2$
 $l = 3 \quad m = -3, -2, -1, 0, +1, +2, +3$

SPIN QUANTUM NUMBER

SPIN
 CLOCKWISE ($+\frac{1}{2}$)
 ANTICLOCKWISE ($-\frac{1}{2}$)

STRUCTURE OF ATOM

ENERGY OF ORBITALS

1) Mono electronic species
 Energy defined upon n

3s, 3p, 3d
 2s, 2p
 1s
 $1s < 2s < 2p < 3s < 3p < 3d$

2) Multi electronic species
 $3s < 3p < 4s < 3d$
 (n+l) rule

$\rightarrow As (n+l) \uparrow, E \uparrow$

$\rightarrow If (n+l) \text{ is same, then } n \uparrow, E \uparrow$

Orbital	2s	3d
(n+l) value	$n = 2$ $l = 0$ $n+l = 2$	$n = 3$ $l = 2$ $n+l = 5$

SHAPE OF ORBITALS

- s orbital - Spherical shape
- p orbital - dumb bell shape
- d orbital - double dumb bell shape

NODES

$\Psi \rightarrow e^-$ wave function

$\Psi^2 \rightarrow$ probability of finding the electrons

* Node $\rightarrow$ Probability of finding the electron is zero.

* Node plane $\rightarrow$ Plane; where $\Psi = 0$

* Radial nodes $\rightarrow n-l-1$

* Angular nodes = l

* Total nodes = $n-1$

FILLING OF ATOMIC ORBITAL

n = 1	1s
n = 2	2s, 2p
n = 3	3s, 3p, 3d
n = 4	4s, 4p, 4d, 4f
n = 5	5s, 5p, 5d, 5f, 5g
n = 6	6s, 6p, 6d, 6f, 6g, 6h
n = 7	7s, 7p, 7d, 7f, 7g, 7h, 7i
n = 8	8s, 8p, 8d, 8f, 8g, 8h, 8i, 8j

Aufbau principle

Electrons are filled in the increasing order of energy

$1s < 2s < 2p < 3s < 3p < 4s < 3d \dots$

Pauli's exclusion principle

No two electrons can have same four quantum numbers

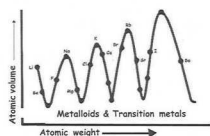
$1s^3$ - against Pauli's exclusion principle

Hund's rule

Pairing is only takes place after each orbital is singly occupied.

$\uparrow \downarrow \uparrow \uparrow$ - Against Hund's rule

- Law of Triads: Johann Dobereiner (1829)
- Law of Octaves: John Alexander Newlands (1865)
- Lothar Meyer plotted a graph between atomic volume and atomic weight. Elements with similar properties occupied the similar positions on the graph.
- Periodic Law: Dimitri Mendeleev and Lothar Meyer.
It states that the 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, Vertical columns - Groups are numbered from 1 to 18.



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

Genesis of periodic classification

Purpose

Periodic table classification based on electronic configuration

• Electronic Configuration is the distribution of electrons into subshells of an atom.

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

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

IUPAC Nomenclature of elements with atomic no. > 100

CLASSIFICATION OF ELEMENTS AND PERIODICITY IN PROPERTIES

Periodic trends in properties of elements

Periodic table classification based on types of elements

Isoelectronic species

Atoms and ions with same number of electrons
eg: O^{2-} , F^{-} , Na^{+} , Mg^{2+} have same number of electrons
Size $\propto \frac{1}{(+)\text{ve charge}}$ $\propto (-)\text{ve charge}$

Q) The increasing order of the ionic radii of the given isoelectronic species is:

- (a) S^{2-} , Cl^{-} , Ca^{2+} , K^{+} (b) Ca^{2+} , K^{+} , Cl^{-} , S^{2-}
(c) K^{+} , S^{2-} , Ca^{2+} , Cl^{-} (d) Cl^{-} , Ca^{2+} , K^{+} , S^{2-}

Q) Which of the following statements is not correct?

- (a) Ionisation energy increases on going down a group in the periodic table.
(b) Among alkaline earth metals, reducing character increases down the group.
(c) Fluorine is the most electronegative element.
(d) Metallic character increases on going down a group in the periodic table.

Properties	Down the Group	Period (Left to Right)
(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 to form anion.	Becomes less negative	Becomes more negative
(c) Ionization Energy: The minimum amount of energy required to remove the electron from the outermost orbit of an isolated atom in gaseous state.	Decreases	Increases
(d) Electro-negativity: 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	Increase from 1 to 4 and then decrease from 4 to 0.
(g) Metallic Character	Increases	Decreases
(h) Non-Metallic Character	Decreases	Increases

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

d-Block Elements

- Group 3-12
- Outer configuration is $(n-1) d^{1-10} ns^{0-2}$
- Forms coloured ions.
- Exhibit variable valence, 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

f-Block Elements

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

Q) In the long form of the periodic table, the valence shell electronic configuration of $5s^2 5p^4$ corresponds to the element present in

- (a) Group 16 and period 6
(b) Group 17 and period 5
(c) Group 16 and period 5
(d) Group 17 and period 6

01

VSEPR

- 2,0- Linear - 180°
 3,0- Trigonal planar - 120°
 2,1- Bent shape
 4,0- Tetrahedral - 109°28'
 3,1- Pyramidal - 107°
 2,2- Bent - 104.5°
- 5,0- Trigonal Bipyramidal
 4,1- See saw
 3,2- T-shape
 2,3- Linear - 180°
- 6,0- Octahedral - 90°
 5,1- Square pyramidal
 4,2- Square planar
 7,0- Pentagonal bipyramidal
 6,1- Distorted octahedral

Q1

In which of the following pairs are the two species trigonal pyramidal?

- 1) BrO_3^- and XeO_3 2) SF_4 and XeF_4
 2) SO_3^{2-} and NO_3^- 4) BF_3 and NF_3

02

$$\text{EP} = \text{CVE} + \text{no. of MV}$$

MV Remaining
 BP LP
 Monoatomic surrounding atoms

$$\text{EP} = \text{CVE} + 0$$

DV Remaining
 BP LP
 Diatomic surrounding atoms

$$\text{EP} = \text{CVE} + \text{negative charge} - \text{positive charge}$$

MV/DV Remaining
 BP LP
 Charged Compound

LP-LP > LP-BP > BP-BP
 (Repulsion)

Q2

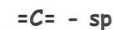
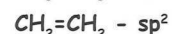
Total no. of Lone pairs in I_3^- is

- 1) 3 2) 6
 3) 9 4) 12

03

HYBRIDISATION

- 2- sp - Linear
 3- sp^2 - Trigonal planar
 4- sp^3 - Tetrahedral
 5- sp^3d - Trigonal pyramidal
 6- sp^3d^2 - Octahedral
 7- sp^3d^3 - Pentagonal bipyramidal



Q3

In XeF_6 , oxidation state and state of hybridisation of Xe and shape of the molecule are, respectively

- 1) +6, sp^3d^3 , distorted octahedral
 2) +4, sp^3d^2 , square planar
 3) +6, sp^3 , pyramidal
 4) +6, sp^3d^2 , square pyramidal

04

VALENCE BOND THEORY

- $\text{C} - \text{C} = 1\sigma \text{ bond}$
 $\text{C} = \text{C} = 1\sigma + 1\pi$
 $\text{C}\equiv\text{C} = 1\sigma + 2\pi$

MOLECULAR ORBITAL THEORY

Up to N_2 the energy order is,

$$\sigma 1s < \sigma^* 1s < \sigma 2s < \sigma^* 2s < (\pi 2p_x = \pi 2p_y) < \sigma 2p_z < (\pi^* 2p_x = \pi^* 2p_y) < \sigma^* 2p_z$$

After N_2 the energy order is, (for $\text{O}_2, \text{F}_2, \text{Ne}_2$)

$$\sigma 1s < \sigma^* 1s < \sigma 2s < \sigma^* 2s < \sigma 2p_z < (\pi 2p_x = \pi 2p_y) < (\pi^* 2p_x = \pi^* 2p_y) < \sigma^* 2p_z$$

- $\text{B}_2 - 10$ Paramagnetic $\pi 2p_x^1 = \pi 2p_y^1$
 $\text{O}_2 - 16$ Paramagnetic $\pi^* 2p_x^1 = \pi^* 2p_y^1$

Q4

The no. of unpaired electrons in O_2 molecule is:

- 1) 0 2) 1
 3) 2 4) 3

05

BOND ORDER

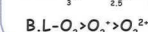
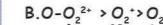
Total no. of e ⁻	2 - 1	- Diamagnetic
	3 - 0.5	- Paramagnetic
	4 - 0	- Diamagnetic
	5 - 0.5	- Paramagnetic
	6 - 1	- Diamagnetic
	7 - 0.5	- Paramagnetic
	8 - 0	- Diamagnetic
	9 - 0.5	- Paramagnetic
	10 - 1	- Paramagnetic
	11 - 1.5	- Paramagnetic
	12 - 2	- Diamagnetic
	13 - 2.5	- Paramagnetic
	14 - 3	- Diamagnetic
	15 - 2.5	- Paramagnetic
	16 - 2	- Paramagnetic
	17 - 1.5	- Paramagnetic
	18 - 1	- Diamagnetic
	19 - 0.5	- Paramagnetic
	20 - 0	- Diamagnetic

Odd number + 10 & 16 - Paramagnetic
 Even number except 10 & 16 - Diamagnetic

BOND PARAMETERS

BOND ORDER

$$\text{B.O.} \propto \frac{1}{\text{B.L.}} \propto \text{Stability} \propto \text{Bond strength}$$



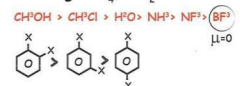
CHEMICAL BONDING

BOND ENERGY

- 1) Hybridisation
 $\text{sp} > \text{sp}^2 > \text{sp}^3$
 2) $\text{B.E.} \propto \text{B.O.}$ (No. of Bonds)
 $\text{N}_2 > \text{O}_2 > \text{F}_2$
 3) $\text{B.E.} \propto \text{E.N. difference}$
 $\text{HF} > \text{HCl} > \text{HBr} > \text{HI}$
 4) Halogens (B.E.)
 $\text{Cl}_2 > \text{Br}_2 > \text{F}_2 > \text{I}_2$

DIPOLE MOMENT (μ)

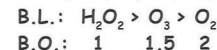
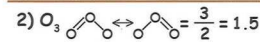
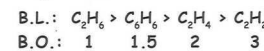
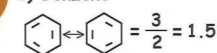
- 1) Polar molecule, $\mu \neq 0$
 Irregular geometry.
 a) Different bonds
 b) Lone pairs
 c) Different surrounding atoms
 eg: SF_4 , CH_3Cl
 2) Non polar molecule, $\mu = 0$
 Regular geometry
 a) Same bonds
 b) Zero lone pairs
 c) Same surrounding atoms
 eg: CH_4 , CO_2



RESONANCE

Resonance Changes B.O.

1) Benzene



BOND ANGLE

- 1) Max B.A. - 180° [sp]
 2) Hybridisation
 $\text{sp} > \text{sp}^2 > \text{sp}^3$
 $\text{NO}_2^+ > \text{NO}_2 > \text{NO}_2^-$
 $\text{sp} > \text{sp}^2 > \text{sp}^3$
 3) If $\text{LP} \uparrow$ B.A. $\downarrow$
 $\text{CH}_4 > \text{NH}_3 > \text{H}_2\text{O}$ [sp³]
 0 LP 1 LP 2 LP
 4) If electronegativity of C.A. $\uparrow$ B.A. $\uparrow$
 $\text{NH}_3 > \text{PH}_3 > \text{AsH}_3 > \text{SbH}_3$
 5) If electronegativity of S.A. $\uparrow$ B.A. $\downarrow$
 $\text{NI}_3 > \text{NB}_3 > \text{NCl}_3 > \text{NF}_3$

BOND LENGTH

- 1) B.L. $\uparrow$ with Size of atom
 $\text{HI} > \text{HBr} > \text{HCl} > \text{HF}$
 2) B.L. decreases with multiplicity
 $\text{C} > \text{C} > \text{C} > \text{C} > \text{C}$

Q5

Which of the following molecules has the maximum bond enthalpy?

- 1) N_2 2) CO
 3) F_2 4) HF

Q6

Which of the following will have maximum dipole moment?

- 1) NF_3 2) NH_3
 3) CH_4 4) PCl_3

Q7

The correct order in which the O-O bond length decreases in the following is

- 1) $\text{O}_3 > \text{H}_2\text{O}_2 > \text{O}_2$ 2) $\text{O}_2 > \text{O}_3 > \text{H}_2\text{O}_2$
 3) $\text{O}_2 > \text{H}_2\text{O}_2 > \text{O}_3$ 4) $\text{H}_2\text{O}_2 > \text{O}_3 > \text{O}_2$

Q8

The correct order of bond angle is:

- 1) $\text{H}_2\text{O} > \text{NH}_3 > \text{CH}_4 > \text{CO}_2$
 2) $\text{H}_2\text{O} < \text{NH}_3 < \text{CO}_2 > \text{CH}_4$
 3) $\text{H}_2\text{O} < \text{NH}_3 > \text{CO}_2 > \text{CH}_4$
 4) $\text{CO}_2 > \text{CH}_4 > \text{NH}_3 > \text{H}_2\text{O}$

Q9

The correct order of increasing bond length of C-H, C-O, C-C & C=C is:

- 1) $\text{C} < \text{C} < \text{C} < \text{C} < \text{C} < \text{C} < \text{C} < \text{C}$
 2) $\text{C} < \text{O} < \text{C} < \text{H} < \text{C} < \text{C} < \text{C} < \text{C}$
 3) $\text{C} < \text{H} < \text{C} < \text{O} < \text{C} < \text{C} < \text{C} < \text{C}$
 4) $\text{C} < \text{H} < \text{C} < \text{C} < \text{C} < \text{O} < \text{C} < \text{C}$

Hydrogen bond- Formation of bond between hydrogen & most electronegative elements like F, O, N

Intramolecular - H - Bonding occur within one single molecule.

Intermolecular - H Bonding between two different molecules of same or different compounds.

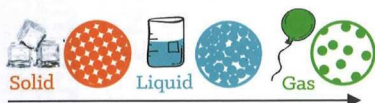
Intramolecular H bonding increases the boiling point. eg: Intermolecular H bond in p-nitrophenol increases the boiling point. $\text{HF}(\text{HB}) > \text{HI} > \text{HBr} > \text{HCl}$, $\text{H}_2\text{O}(4\text{HB}) > \text{H}_2\text{Te} > \text{H}_2\text{Se} > \text{H}_2\text{S}$

Fajan's Rule - Indicates Covalent character in an ionic bond.

- 1) Size of the cation- Smaller the cation higher is the polarisation, so covalent character increases
 $\text{LiCl} > \text{NaCl} > \text{KCl} > \text{RbCl} > \text{CsCl}$
 2) Size of anion- As the size of anion increases, polarisation increases, covalent character increases
 $\text{AgF} < \text{AgCl} < \text{AgBr} < \text{AgI}$
 3) Charge on the cation- As the charge increases, Covalent character also increases
 $\text{LiCl} < \text{BeCl}_2 < \text{BCl}_3 < \text{CCl}_4$

01

THREE STATES OF MATTER



INTERMOLECULAR FORCES

Weakest - London dispersion force
 Strongest - Ion dipole
 Other 2 types are dipole - dipole & dipole - induced dipole interactions

Q Dipole-induced dipole interactions are present in which of the following pairs?

- (A) HCl and He atoms (B) SiF_4 and He atoms
 (C) H_2O and alcohol (D) Cl_2 and CCl_4

STATES OF MATTER

02

GAS LAWS

(1) BOYLE'S LAW (n, T-CONSTANT)

$$V \propto \frac{1}{P}$$

$$P_1 V_1 = P_2 V_2$$

(2) CHARLE'S LAW (n, P-CONSTANT)

$$V \propto T$$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

(3) COMBINED GAS LAW (n-CONSTANT)

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

(4) GAY LUSSAC'S LAW (n, V-CONSTANT)

$$P \propto T$$

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

(5) AVOGADRO'S LAW (P-CONSTANT)

$$V \propto n$$

$$\frac{V_1}{n_1} = \frac{V_2}{n_2}$$

(6) DALTON'S LAW for mixture of Non-reacting gases in container

$$P = P_A + P_B$$

A & B - Non reacting gases

Q If two moles of an ideal gas at 546 K occupy volume 44.8 L, then pressure must be
 (A) 2 atm (B) 3 atm (C) 4 atm (D) 1 atm

03

IDEAL GAS EQUATION

$$PV = nRT$$

$$R = 0.0821 \text{ L atm K}^{-1} \text{ mol}^{-1}$$

$$R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$$

$$R = 2 \text{ cal K}^{-1} \text{ mol}^{-1}$$

$$d = \frac{PM}{RT}$$

d = Density of ideal gas

$$P = CRT$$

C = Concentration

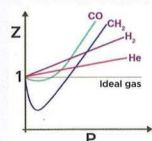
GASES SHOWS IDEAL BEHAVIOUR AT HIGH TEMPERATURE & LOW PRESSURE

Q A gas will approach ideal behaviour at

- (A) low T & low P (B) high T & high P
 (C) low T & high P (D) high T & low P

04

DEVIATION FROM IDEAL BEHAVIOUR



Z = Compressibility Factor

$$Z = \frac{PV}{nRT} \quad [Z = 1, \text{ for ideal gas}]$$

REAL GAS OBEYS IDEAL BEHAVIOUR AT BOYLE POINT OR BOYLE TEMPERATURE

Q The compressibility factor of an ideal gas is

- (A) 1 (B) < 1 (C) > 1 (D) ∞

05

VAN DER WAAL'S EQUATION

$$\left(P + \frac{n^2 \cdot a}{V^2}\right)(V - n \cdot b) = n \cdot R \cdot T$$

'a' and 'b' are Vander Waals constants.

unit of a — atm $\text{L}^2 \text{ mol}^{-2}$

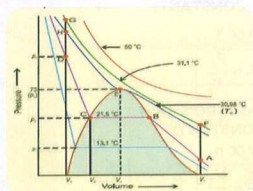
unit of b — L mol^{-1}

$$\text{ease of liquefaction} \propto \frac{a}{b}$$

Q The value of van der Waal's constant 'a' for the gases O_2 , H_2 , NH_3 & CO_2 are 1.36, 0.244, 4.17 & 3.59 $\text{L}^2 \text{ atm mol}^{-2}$ respectively. The gas which can most easily be liquefied is
 (A) O_2 (B) H_2 (C) NH_3 (D) CO_2

06

■ T_c, P_c & V_c



T_c - CRITICAL TEMPERATURE
 P_c - CRITICAL PRESSURE
 V_c - CRITICAL VOLUME

■ LIQUEFACTION OF GASES.

A gas can be liquefied by cooling below its critical temperature & applying pressure higher than P_c

Q A gas can be liquefied by

- (A) compressing (B) cooling
 (C) both (A) and (B) (D) heating

STATES OF MATTER

07

■ MOLECULAR SPEEDS

Most probable velocity (u or u_{mp})

$$u = \sqrt{\frac{2RT}{M}}$$

Average velocity ($\bar{v}$ or u_{av})

$$\bar{v} = \sqrt{\frac{8RT}{\pi M}}$$

Root mean square velocity (u or u_{rms})

$$u = \sqrt{\frac{3RT}{M}}$$

Kinetic energy per molecule, $K.E = \frac{3}{2} kT$ where k = Boltzmann constant

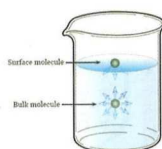
Q Average molar kinetic energy of CO and N_2

at same temperature is

- (A) $KE_1 = KE_2$ (B) $KE_1 > KE_2$
 (C) $KE_1 < KE_2$ (D) can't say anything

08

■ SURFACE TENSION



Surface tension decreases with the increase in temperature

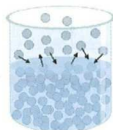
Surface tension increases with the increase in external pressure

Q Raindrops are spherical in shape because of

- (A) Capillary (B) Surface Tension
 (C) Downward motion (D) Acceleration

09

■ VAPOUR PRESSURE



Vapour pressure is an equilibrium pressure.

Vapour pressure depends only on temperature & nature of liquid.

Q Which of the following will increase with the increase in temperature?

- (A) Surface tension (B) Viscosity
 (C) Molality (D) Vapour pressure

10

■ VISCOSITY



As temperature increases viscosity decreases.

As pressure increases viscosity increases.

Q Which of these fluids has the highest viscosity?

- (A) Water (B) Honey (C) Blood (D) Air

STATE FUNCTION

Properties which depend only on initial and final state of system & do not depend on process or path
e.g. U, H, S etc.

PATH FUNCTION

Depends on path or process, as well as initial and final state of the system
e.g. work, heat

THERMODYNAMIC PROPERTIES

EXTENSIVE

Properties which are dependent of matter (size & mass) present in system
e.g. Mass, volume, Internal energy, heat capacity, Entropy, Enthalpy etc.

INTENSIVE

Properties which are independent of matter (size & mass) present in system
e.g. Pressure, temperature, Melting point, density, Specific heat, Surface tension etc.

Spontaneity

ENTHALPY

$$\Delta H = \Delta U + \Delta n_g RT$$

$$\Delta n_g = 0, \Delta H = \Delta U$$

$$\Delta n_g > 0, \Delta H > \Delta U$$

$$\Delta n_g < 0, \Delta H < \Delta U$$

All exothermic process are spontaneous

FIRST LAW OF THERMODYNAMICS

(Based on Law of conservation of energy)

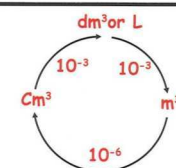
$$\Delta U = \Delta q + \Delta W$$

WORK

$$\Delta W = P \Delta V = \Delta nRT$$

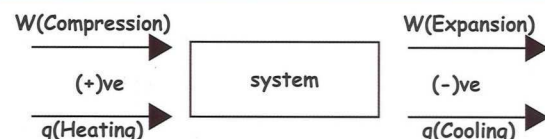
$$\Delta W = \text{Joule} \begin{cases} P \rightarrow \text{Pascal} \\ V \rightarrow \text{m}^3 \end{cases}$$

$$\begin{aligned} 1 \text{ atm} &= 1.01 \times 10^5 \text{ Pa} \\ 1 \text{ L atm} &= 101 \text{ J} \end{aligned}$$

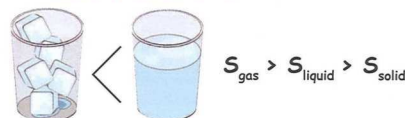


THERMODYNAMICS

SIGN CONVENTION



ENTROPY



ENTROPY CHANGE

1) Isothermal

$$\Delta S = nR \ln \frac{V_2}{V_1} = nR \ln \frac{P_1}{P_2}$$

2) Isochoric ($P \propto T$)

$$\Delta S = nC_v \ln \frac{T_2}{T_1} = nC_v \ln \frac{P_2}{P_1}$$

3) Isobaric

$$\Delta S = nC_p \ln \frac{T_2}{T_1} = nC_p \ln \frac{V_2}{V_1}$$

$\Delta S_{\text{total}} > 0$, Spontaneous

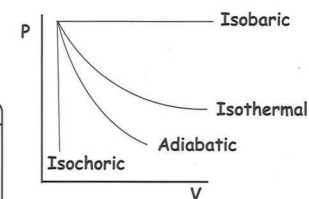
$\Delta S_{\text{total}} = 0$, Equilibrium

$\Delta S_{\text{total}} < 0$, Non-spontaneous

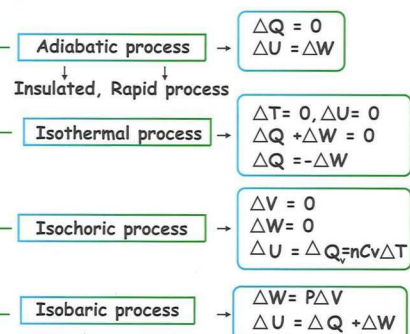
FREE EXPANSION $P_{\text{ext}} = 0, W = 0, \Delta U = 0, q = 0$

ISOTHERMAL $dT = 0; \Delta U = 0; q = -W$

Reversible Isothermal	Irreversible Isothermal
$W_{\text{rev}} = nRT \ln \left(\frac{V_2}{V_1} \right)$	$W_{\text{irr}} = -P_{\text{ext}} \left[\frac{nRT}{P_2} - \frac{nRT}{P_1} \right]$



FLAT



ΔH	ΔS	$\Delta G = \Delta H - T\Delta S$	Spontaneity
(-)	(+)	Always Negative	Spontaneous at all temp
(+)	(-)	Always Positive	Non-spontaneous at all temperature.
(+)	(+)	+ve @ low temp. -ve @ high temp.	Non spontaneous at low temperature Spontaneous at high temperature
(-)	(-)	-ve @ low temp. +ve @ high temp.	Spontaneous at low temperature, $T < T_c$ Non spontaneous at high temperature

GIBBS FREE ENERGY

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

$\Delta G < 0$ Or (-)ve, Spontaneous

$\Delta G > 0$ Or (+)ve, Non-spontaneous

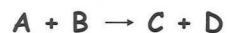
$\Delta G = 0$, Equilibrium

Equilibrium Temperature

$$T_e = \frac{\Delta H}{\Delta S}$$

THERMO DYNAMICS

BOND ENERGY



Bond energy: a b c d

$$\Delta H_{\text{reaction}} = \text{Bond energy of reactants} - \text{Bond energy of products} \\ = (a + b) - (c + d)$$

$$NH_3 \Rightarrow B.E = x$$

$$B.E \text{ of N-H} = \frac{x}{3}$$

$$CH_4 \Rightarrow B.E = x$$

$$B.E \text{ of C-H} = \frac{x}{4}$$

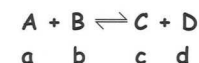
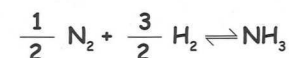
THERMOCHEMISTRY

1) Heat of Reaction (ΔH_{rxn})

$$\Delta H_{\text{rxn}} = \Delta H_{\text{products}} - \Delta H_{\text{reactants}}$$

2) Heat of Formation

Heat Change in formation of 1 mole of substance at 298 K and 1 atm Pressure (standard enthalpy of formation)



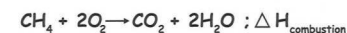
$$\Delta H_{\text{reaction}} = \text{Heat of formation of products} - \text{Heat of formation of reactants} \\ = (c + d) - (a + b)$$

Standard enthalpy of formation (298 K, 1 atm) of element at its standard state is zero e.g.,



3) Enthalpy of Combustion (1 mole, 298 K)

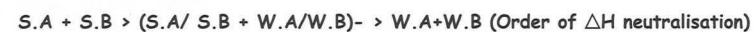
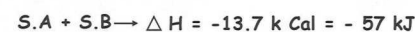
(standard enthalpy of combustion)



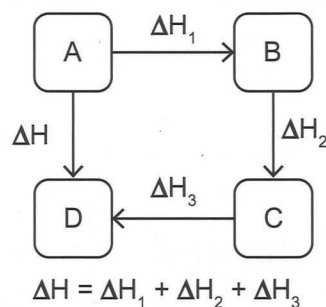
Enthalpy of a b c d
combustion:

$$\Delta H_{\text{reaction}} = \text{Heat of combustion of reactants} - \text{Heat of combustion of products} \\ = (a + b) - (c + d)$$

4) Heat of Neutralisation ($\Delta H = (-)$ ve)



HESS' LAW OF CONSTANT HEAT SUMMATION

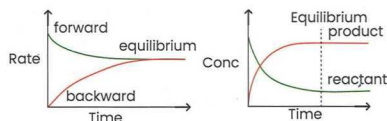


- $A \rightarrow B ; \Delta H_1$
 $B \rightarrow C ; \Delta H_2$
 $A \rightarrow C ; \Delta H_3 = \Delta H_1 + \Delta H_2$
- $A \rightarrow B ; \Delta H = x$
 $B \rightarrow A ; \Delta H = -x$
- $A \rightarrow B ; \Delta H = x$
 $nA \rightarrow nB ; \Delta H = nx$

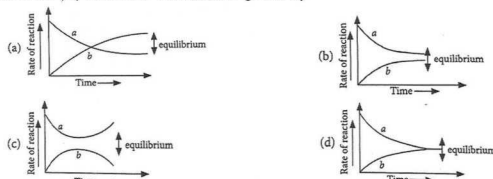
EQUILIBRIUM

- The chemical reactions which takes place in both directions are called reversible reactions
- Equilibrium is the end state of a reversible reaction.
- Gaseous Equilibrium is established only in a closed container.
- At equilibrium, the rate of forward and backward reactions are equal.
- At equilibrium, the concentration of reactants & products becomes constant.

GRAPHICAL REPRESENTATIONS



Q. For the equilibrium $A \rightleftharpoons B$, the variation of the rate of the forward (a) & reverse (b) reaction with time is given by



PHYSICAL EQUILIBRIUM

- Such equilibrium is established in physical reactions.
- It is dynamic in nature.

LIQUID $\rightleftharpoons$ VAPOUR EQUILIBRIUM

- Here vapour pressure is constant at a constant temp for given.

SOLID $\rightleftharpoons$ LIQUID EQUILIBRIUM

- Established only at a constant temperature
- Ice-water equilibrium established at 0°C (at 1 atm)

SOLID IN LIQUID EQUILIBRIUM

- Established only in a Saturated solution
- eg: Saturated sugar solution.
- Sugar (dissolved) $\rightleftharpoons$ Sugar (undissolved)

GAS IN LIQUID EQUILIBRIUM

- Here solubility depends upon pressure (Henry's law)
- eg: Soda water
- CO_2 (dissolved) $\rightleftharpoons$ CO_2 (undissolved)

Q. Which of the given statements does not elucidate the equilibrium state precisely?

- The equilibrium can be approached from either direction.
- The equilibrium can be attained only if the system is an isolated system.
- The free energy change at constant pressure and temperature is zero.
- It is dynamic in nature.

CHEMICAL EQUILIBRIUM

- Chemical equilibrium approaches from both forward & backward direction
- Chemical equilibrium is dynamic in nature.

EQUILIBRIUM CONSTANT $[K_c]$

- For a general reversible reaction
 $aA + bB \rightleftharpoons cC + dD$

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

REACTION QUOTIENT $[Q]$

- At any time during the reaction $aA + bB \rightleftharpoons cC + dD$ the ratio $\frac{[C]^c [D]^d}{[A]^a [B]^b}$ is known as concentration quotient, Q_c .

- At equilibrium $Q_c = K_c$

CHARACTERISTICS OF K [eqb. const]

- Value of K does not depends upon initial concentration of reactants and products.
- Value of K does not depends upon the direction from which equilibrium is attained.

Q. In the given reaction: $A + 2B \rightleftharpoons 2C$, 2 moles each of A & B present in 10 L of solution combine to form 1 mole of C. Calculate K_c for the reaction.

- (a) 1.5 (b) 6.67 (c) 0.15 (d) 2.3

CHEMICAL EQUILIBRIUM

Applications of K & Q

- Value of K depends only on temperature.
- If K for the reaction $aA + bB \rightleftharpoons cC + dD$ is K , then K for the reaction $cC + dD \rightleftharpoons aA + bB$ will be $\frac{1}{K}$
- If K for the reaction $aA + bB \rightleftharpoons cC + dD$ is K , then K for the reaction $naA + nbB \rightleftharpoons ncC + ndD$ will be $(K)^n$
- During the addition of two reactions having equilibrium constants K_1 & K_2 , then the net Constant $K = K_1 \times K_2$
- During the subtraction of a reaction having constant K_2 from a reaction having constant K_1 , then the net constant $K = K_1/K_2$
- If $Q < K$, the reaction will proceed in forward direction
- If $Q > K$, the reaction will proceed in backward direction
- If $Q = K$, the system is in equilibrium.
- If $K > 10^3$, the reaction is almost complete in forward direction.
- If $K < 10^{-3}$, the reaction is in backward direction.
- If K is in b/w 10^3 & 10^{-3} almost same reaction takes place in both forward and backward direction

Q At a given temperature, the equilibrium constants for the reactions,
 $\text{NO(g)} + \frac{1}{2}\text{O}_2\text{(g)} \rightleftharpoons \text{NO}_2\text{(g)}$ & $2\text{NO}_2\text{(g)} \rightleftharpoons 2\text{NO(g)} + \text{O}_2\text{(g)}$
are K_1 and K_2 respectively. If K_1 is 4×10^{-3} . then K_2 will be
(a) 8×10^{-3} (b) 16×10^{-3} (c) 6.25×10^{-4} (d) 6.25×10^5

HOMOGENEOUS EQUILIBRIUM

- If they are in solid or liquid phase (or aqueous), K can be represented as K_c .
- If they are in gaseous phase, K can be represented as K_p
- For a general reaction
 $aA + bB \rightleftharpoons cC + dD$

$$K_c = \frac{[C]^c [D]^d}{[A]^a [B]^b} \quad \& \quad K_p = \frac{P_C^c P_D^d}{P_A^a P_B^b}$$

$$K_p = K_c (RT)^{\Delta n_g} \quad \Delta n_g = \sum n_g - \sum n_g$$

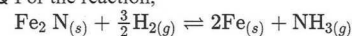
UNIT OF EQUILIBRIUM CONSTANT

- Unit of $K_c = (\text{mol/L})^{\Delta n_g}$
- Unit of $K_p = (\text{atm})^{\Delta n_g}$
- If $\Delta n_g = 0$, equilibrium constant has no unit

HETEROGENEOUS EQUILIBRIUM

- In heterogeneous equilibrium, concentration of pure solid & pure liquid is taken as one
- eg: $\text{CaCO}_3\text{(s)} \rightleftharpoons \text{CaO(s)} + \text{CO}_2\text{(g)}$
 $K_p = P_{\text{CO}_2}$

Q For the reaction,



- $K_c = K_p(RT)$
- $K_c = K_p(RT)^{-1/2}$
- $K_c = K_p(RT)^{1/2}$
- $K_c = K_p(RT)^{3/2}$

LE CHATELIER'S PRINCIPLE

According to Le-chatelier's principle, if a system at equilibrium is subjected to a change in concentration, temperature or pressure, the equilibrium will shift automatically in one direction which will nullify the effect of the change.

- Conc. of reactant increases $\rightarrow$ shift towards forward reaction.
- Conc. of product decreases $\rightarrow$ shift towards forward reaction.
- Conc. of reactant decreases $\rightarrow$ shift towards backward reaction.
- Conc. of product increases $\rightarrow$ shift towards backward reaction.
- Pressure increases $\rightarrow$ shift towards lesser number of gaseous moles
- Pressure decreases $\rightarrow$ shift towards higher number of gaseous moles
- No. of gaseous moles of reactants & products are equal, pressure has no effect.
- If temperature increases $\rightarrow$ shift towards endothermic
- If temperature decreases $\rightarrow$ shift towards exothermic
- Catalyst helps to attain eqm state easily.
After the establishment of eqm, catalyst has no effect.
- Addition of inert gas at constant volume, no effect.
- Addition of inert gas at constant pressure $\rightarrow$ shift towards higher number of gaseous moles

Q Which one of the following conditions will favour maximum formation of the product in the reaction $A_2\text{(g)} + B_2\text{(g)} \rightleftharpoons X_2\text{(g)}$. $\Delta H = -X \text{ kJ/mol}$?

- Low temperature and high pressure
- High temperature and high pressure
- Low temperature and low pressure
- High temperature and low pressure

01

Which of the following statements is/are incorrect?
 I. Aqueous solution of sugar conducts electricity.
 II. Conductance of electricity increases with an increase in concentration of common salt in aqueous glucose solution.
 III. Aqueous solution of acetic acid mainly contains unionized acetic acid molecules and only some CH_3COO^- and H_3O^+ ions.
 (a) I only (b) I only
 (c) II and III only (d) I, II and III

ELECTROLYTE

Substance which allow the flow of electricity through their aqueous solution or through their molten form.

01 STRONG ELECTROLYTE
 electrolyte which dissociates completely into ions.
 eg: HCl, NaOH

02 WEAK ELECTROLYTE
 electrolyte which dissociates partially into ions.
 eg: CH_3COOH , NH_4OH

IONIC EQUILIBRIUM

Equilibrium established in between ions and unionised Salt in a weak electrolyte.

Eg. In weak electrolytes, equilibrium is established between ions and the unionized molecules. This type of equilibrium

I. involves ions in aqueous solution. II. is called physical equilibrium.
 III. is due to complete ionization IV. is called ionic equilibrium.
 The correct statement(s) is/are

(A) I and IV only (B) II and III only (C) IV only (D) I, II, III and IV

ANS: (A)

02

Which of the following is conjugate acid of SO_4^{2-} ?

- (a) HSO_4^- (b) H^+
 (c) H_2SO_4 (d) SO_4^{2-}

ACID-BASE CONCEPTS

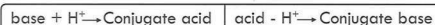
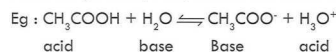
01 ARRHENIUS CONCEPT

Acids are H^+ ions donors and bases are OH^- ion donors.

■ $\text{HCl} \rightarrow \text{H}^+ + \text{Cl}^-$ (acid) ■ $\text{NaOH} \rightarrow \text{Na}^+ + \text{OH}^-$ (base)

02 BRONSTED - LOWRY CONCEPT

Acids are protons (H^+ ion) donors and bases are proton acceptors.



■ Conjugate acid of $\text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+$ ■ Conjugate base of $\text{H}_2\text{O} \rightarrow \text{OH}^-$

03 LEWIS CONCEPT

Bases are lone pair e^- donors & acids are lone pair e^- acceptors.

■ Lewis acid - Substances having Vacant space in their valence shell to accommodate lone pair of e^-

Eg: BF_3 , AlCl_3 , H^+ , Ag^+

■ Lewis base - Substances having lone pair of e^- in their valence shell

Eg: NH_3 , H_2O , Cl^- , OH^-

03

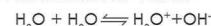
Which of the following species can act both as an acid as well as a base?

- (a) SO_4^{2-} (b) HSO_4^-
 (c) PO_4^{3-} (d) Cl^-

IONISATION AND IONISATION CONSTANT

In all ionisation reactions concentration of water $[\text{H}_2\text{O}]$ is taken as constant

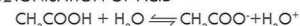
01 IONISATION OF WATER



Ionisation constant of water, $K_w = [\text{H}_3\text{O}^+][\text{OH}^-]$

$$\text{or } K_w = [\text{H}^+][\text{OH}^-]$$

02 IONISATION OF ACID



Ionisation constant, $K_a = \frac{[\text{CH}_3\text{COO}^-][\text{H}_3\text{O}^+]}{[\text{CH}_3\text{COOH}]}$

$$\text{or } K_a = \frac{[\text{CH}_3\text{COO}^-][\text{H}^+]}{[\text{CH}_3\text{COOH}]}$$

03 IONISATION OF BASE

Eg: NH_4OH

$$\text{Ionisation constant of base } K_b = \frac{[\text{NH}_4^+][\text{OH}^-]}{[\text{NH}_4\text{OH}]}$$

04

What will be the pH of a soft drink if hydrogen ion concentration in sample is $3.8 \times 10^{-3} \text{ M}$?

- (a) 3.8 (b) 5.04
 (c) 2.42 (d) 9.2

VALUE OF IONIC PRODUCT

At 25°C , $K_w = [\text{H}_3\text{O}^+][\text{OH}^-] = 1 \times 10^{-14}$

01 If $[\text{H}^+] = [\text{OH}^-] = 1 \times 10^{-7} \text{ mol/L}$: solution will be neutral

02 If $[\text{H}^+] > [\text{OH}^-]$ i.e. $[\text{H}^+] > 1 \times 10^{-7} \text{ mol/L}$ solution will be acidic

03 If $[\text{H}^+] < [\text{OH}^-]$ i.e. $[\text{H}^+] < 1 \times 10^{-7} \text{ mol/L}$ solution will be basic

pH

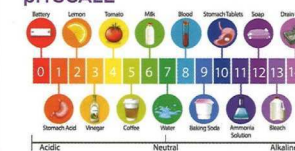
$$\text{pH} = -\log [\text{H}^+]$$

■ pH of a neutral solution is 7

■ pH of an acidic solution is < 7

■ pH of a basic solution is > 7

pH SCALE



IONIC EQUILIBRIUM

05

What will be the ionisation constant of formic acid if its 0.01 M solution is 14.5% ionised?

- (a) 2.1×10^{-4} (b) 14.5
 (c) 0.145 (d) 1.45×10^{-4}

IMPORTANT EQUATIONS

$$\text{pH} = -\log [\text{H}^+] \quad \text{pKa} = -\log [K_a]$$

$$\text{pOH} = -\log [\text{OH}^-] \quad \text{pKb} = -\log [K_b]$$

$$\text{pKw} = \text{pH} + \text{pOH} = 14$$

$$K_a \times K_b = K_w = 1 \times 10^{-14} \text{ at } 25^\circ\text{C}$$

$$\text{pKa} + \text{pKb} = 14 \text{ at } 25^\circ\text{C}$$

DEGREE OF DISSOCIATION (α)

$$\alpha = \frac{\text{Number of moles ionised}}{\text{Total no. of moles}} \quad \text{Eg: } 30\% \text{ ionisation means } \alpha = \frac{30}{100} = 0.3$$

Weak acid

$$K_a = \frac{C\alpha^2}{C - \alpha^2}$$

$$\alpha = \sqrt{\frac{K_a}{C}}$$

$$[\text{H}_3\text{O}^+] = C\alpha$$

$$[\text{H}^+] = \sqrt{K_a \cdot C}$$

Weak base

$$K_b = \frac{C\alpha^2}{C - \alpha^2}$$

$$\alpha = \sqrt{\frac{K_b}{C}}$$

$$[\text{OH}^-] = C\alpha$$

$$[\text{OH}^-] = \sqrt{K_b \cdot C}$$

06

Equimolar solutions of HF, HCOOH and HCN at 298 K have the values of K_a as 6.8×10^{-4} , 1.8×10^{-4} and 4.8×10^{-10} respectively. What will be the order of their acidic strength?

- (a) $\text{HF} > \text{HCN} > \text{HCOOH}$
 (b) $\text{HF} > \text{HCOOH} > \text{HCN}$
 (c) $\text{HCN} > \text{HF} > \text{HCOOH}$
 (d) $\text{HCOOH} > \text{HCN} > \text{HF}$

ACID STRENGTH

■ acid strength $\propto K_a$

■ acid strength $\propto \frac{1}{\text{pKa}}$

For an acid HA

■ As HA bond strength decreases, acid strength increases

■ As we move from top to bottom, size of anion increases
 $\therefore$ HA bond strength decreases & acid strength increases.

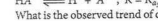
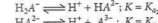
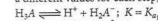
eg: $\therefore$ Acid strength of $\text{HI} > \text{HBr} > \text{HCl} > \text{HF}$

■ As we move from left to right, electronegativity increases
 $\therefore$ HA bond becomes more polar & acid strength increases.

eg: $\therefore$ Acid strength of $\text{HF} > \text{H}_2\text{O} > \text{NH}_3 > \text{CH}_4$

07

For a polybasic acid, the dissociation constants have a different values for each step, e.g.,



What is the observed trend of dissociation constants in successive stages?

- (a) $K_{a1} > K_{a2} > K_{a3}$ (b) $K_{a1} = K_{a2} = K_{a3}$
 (c) $K_{a1} < K_{a2} < K_{a3}$ (d) $K_{a1} = K_{a2} > K_{a3}$

POLYPROTIC ACIDS & POLYHYDROXY BASES

■ Acids having ionisable hydrogen are known as protic acids or basic acids. eg: HCl , H_2SO_4 , $\text{H}_2\text{C}_2\text{O}_4$, H_3PO_4 , CH_3COOH etc.

■ Here H_2SO_4 , $\text{H}_2\text{C}_2\text{O}_4$ & H_3PO_4 are having more than one ionisable hydrogen, they are known as polyprotic acids

■ Polyprotic acids ionises in stepwise.

■ Here the removal of H^+ ion from neutral molecule is easy, but it is difficult to remove further H^+ ions from their corresponding anions
 $\therefore K_{a1} > K_{a2} > K_{a3}$

■ In case of polyhydroxy bases or polyacidic bases like $\text{Fe}(\text{OH})_3$, $\text{Ba}(\text{OH})_2$ etc. $K_{b1} > K_{b2} > K_{b3}$

IONIC EQUILIBRIUM

08

Which of the following salts does not show its correct nature mentioned against it?

- (a) NaCl solution - Neutral
- (b) NaCN solution - Acidic
- (c) NH_4NO_3 solution - Acidic
- (d) KF solution - Basic

HYDROLYSIS OF SALTS

Salt + H_2O $\xrightarrow{\text{hydrolysis}}$ acid + base

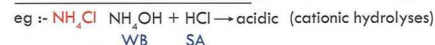
SALT OF STRONG ACID & STRONG BASE

Strong acid (SA) & strong base (SB) $\rightarrow$ Neutral, It's pH = 7

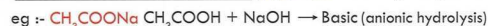


Note : Neutral salts do not undergo hydrolysis

SALT OF STRONG ACID & WEAK BASE. (SA + WB $\rightarrow$ acidic), It's pH < 7



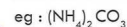
SALT OF WEAK ACID & STRONG BASE (WA + SB $\rightarrow$ Basic), It's pH > 7



SALT OF WEAK ACID & WEAK BASE

WA + WB $\rightarrow$ slightly acidic/basic

$$\text{pH} = 7 + \frac{1}{2} [\text{pK}_a - \text{pK}_b]$$



09

Which one of the following pairs of solution is not an acidic buffer?

- (a) CH_3COOH and CH_3COONa
- (b) H_2CO_3 and Na_2CO_3
- (c) H_3PO_4 and Na_3PO_4
- (d) HClO_4 and NaClO_4

COMMON ION EFFECT

Ionisation of a weak electrolyte can be suppressed by the addition of salt which contain common ion.

- Ionisation of a weak acid, CH_3COOH can be suppressed by the addition of a salt like CH_3COONa . Common ion : CH_3COO^-
- Ionisation of a weak base, NH_4OH can be suppressed by the addition of a salt like NH_4Cl . Common ion : NH_4^+

BUFFER SOLUTIONS

Solution which can resist the change in pH on addition of small drops of acids or base.

1. Acidic buffer : Mixture of equimolar concentrations of a weak acid and it's salt with a strong base. $\text{CH}_3\text{COOH} / \text{CH}_3\text{COONa}$.

$$\text{pH} = \text{pK}_a + \log \frac{[\text{salt}]}{[\text{acid}]} \quad \text{Henderson - Hasselbalch equation}$$

2. Basic buffer : Mixture of equimolar concentrations of a weak base and it's salt with a strong acid. $\text{NH}_4\text{OH} / \text{NH}_4\text{Cl}$.

$$\text{pOH} = \text{pK}_b + \log \frac{[\text{salt}]}{[\text{base}]}$$

10

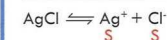
The solubility of $\text{AgCl}_{(s)}$ with solubility product

- 1.6×10^{-10} in 0.1 M NaCl solution would be
- (a) 1.26×10^{-5} M (b) 1.6×10^{-9} M
 - (c) 1.6×10^{-11} M (d) zero.

SOLUBILITY PRODUCT

- Solubility is the concentration of an ion in a saturated solution(S)
- Solubility product is the equilibrium constant for solubility equilibrium
- Sparingly soluble salt $\rightarrow$ salts which can dissolve only slightly into ions eg: AgCl , BaSO_4 , PbCl_2 , etc.
- K_{sp} can be calculated easily by using a sparingly soluble salt.

Consider the ionisation of a sparingly soluble salt AgCl



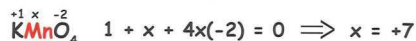
$$K_{sp} = [\text{Ag}^+][\text{Cl}^-] = \text{S} \times \text{S} = \text{S}^2$$

- If the value of ionic product = K_{sp} , solution is saturated.
- If the value of ionic product < K_{sp} , solution is unsaturated.
- If the value of ionic product > K_{sp} , solution is super saturated, here precipitation takes place

OXIDATION NUMBER

RULES TO ASSIGN OXIDATION NUMBER

- 1) Oxidation number of an element in free elemental state or Uncombined state zero
- 2) In polyatomic ion, the algebraic sum of all the oxidation numbers of atoms of the ion must equal the charge on the ion
- 3) The oxidation number of oxygen in most of the compounds is -2
In peroxides -1
In superoxides -1/2
In $O_2 F_2$ +1
In OF_2 +2
- 4) Oxidation number of hydrogen is +1 in most of its compounds (In metal hydrides -1)
- 5) Oxidation number of fluorine is always -1 in its compounds
- 6) Alkali metals have oxidation number +1 and alkaline earth metals have oxidation number +2 always in its compounds
- 7) The algebraic sum of the oxidation number of all the atoms in a compound must be zero.



OXIDATION:
Increase in the oxidation number

REDUCTION:
Decrease in the oxidation number

OXIDISING AGENT (OXIDANTS):
A reagent which can increase the oxidation number.

REDUCING AGENT (REDUCTANTS):
A reagent which can decrease the oxidation number.

REDOX REACTIONS:
Reactions which involve change in oxidation number of the interacting species

REDOX REACTION

TYPES OF REDOX REACTIONS

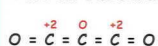
BALANCING OF REDOX REACTION

- 1) Identify oxidation and reduction
- 2) Make total increase and total decrease in O.N equal
- 3) Balance atoms except O & H
- 4)

ACIDIC	BASIC
Balance	Balance
- Oxygen with H_2O	- Charge with OH^-
- Hydrogen with H^+	- Oxygen with H_2O

POINTS TO REMEMBER

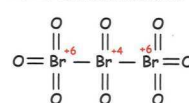
Carbon suboxide



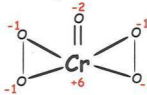
Fe_3O_4



Tribromooctaoxide



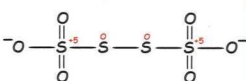
CrO_5



$CaOCl_2$



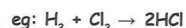
Tetrathionate ion



COMBINATION REACTION

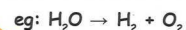
A redox reaction in the form $A+B \rightarrow C$

Either A and B or both A and B must be in the elemental form for such a reaction to be a redox reaction.



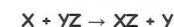
DECOMPOSITION REACTION

Reaction leads to the breakdown of a compound into two or more components at least one of which must be in the elemental state.



DISPLACEMENT REACTION

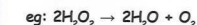
An ion (or an atom) in a compound is replaced by an ion (or an atom) of another element.



DISPROPORTIONATION REACTIONS

In a disproportionation reaction an element in one oxidation state is simultaneously oxidised and reduced.

It always contains an element that can exist in at least three oxidation states.



Comproportionation reaction:

A reaction in which an element in a higher oxidation state reacts with the same element in a lower oxidation state to give the element in an intermediate oxidation state



Highest O.S— Undergoes Reduction—Oxidising agent
Lowest O.S — Undergoes Oxidation—Reducing agent
Intermediate O.S — Oxidation & Reduction
—Oxidising Agent & Reducing Agent

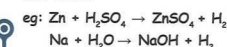
METAL DISPLACEMENT

A metal in a compound can be displaced by another metal in the uncombined state.



NON-METAL DISPLACEMENT

Non-metal in a compound can be displaced by a metal or a non-metal



REDOX REACTIONS

HYDROGEN

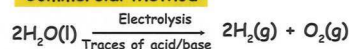
Occurrence: Most abundant in universe.

Preparation:

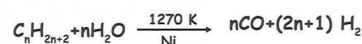
- Laboratory Method:



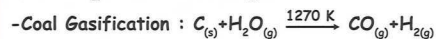
- Commercial Method:



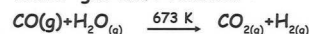
By electrolysis of warm aqueous barium hydroxide solution between Ni electrodes.



-CO + H₂ is called water gas



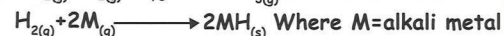
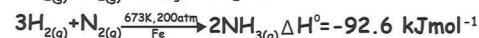
Water-gas shift reaction:



Physical Properties:

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

Chemical Properties:



Uses:

- Synthesis of ammonia.
- In manufacture of vanaspathi 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

Preparation

By exhaustive electrolysis of water

Uses

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

- 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 characters under normal conditions
- Forms diatomic molecules.

Protium: Predominant form. (^1_1H)

Deuterium: (^2_1H)

Tritium: Radioactive (^3_1H)

ISOTOPES

PROPERTIES

HYDRIDES

HYDROGEN

DIHYDROGEN

HYDROGEN PEROXIDE

WATER

Uses

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

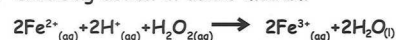
Physical properties

Colourless, miscible with water.

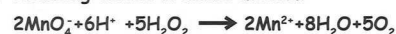
Structure: Non-Planar

Chemical Properties

1) Oxidising action in acidic medium



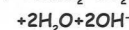
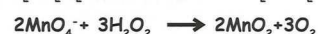
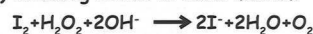
2) Reducing action in acidic medium



3) Oxidising action in basic medium



4) Reducing action in basic medium



TYPES

(i) **Ionic/saline/salt-like**

Stoichiometric compounds of dihydrogen formed with s-block elements

(ii) **Metallic/non-stoichiometric/interstitial**

Formed by d-block & f-block elements

(iii) **Covalent/molecular**

Formation of molecular compounds from dihydrogen and p-block elements

- Electron deficient (Group 13 hydrides)
- Electron Precise (Group 14 hydrides)
- Electron rich (Group 15, 16, 17 hydrides)

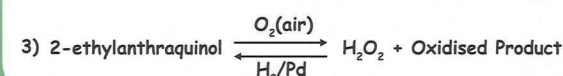
Temporary hardness

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

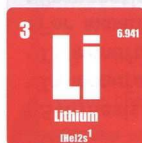
Permanent hardness

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

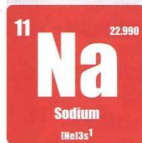
Preparation



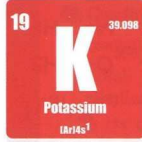
ALKALI METALS



Li/Li⁺
Crimson Red



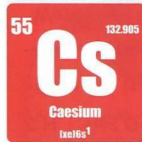
Na/Na⁺
Golden Yellow



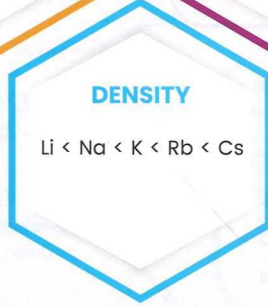
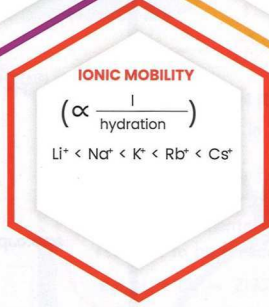
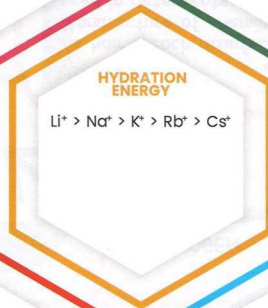
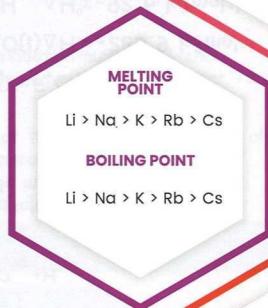
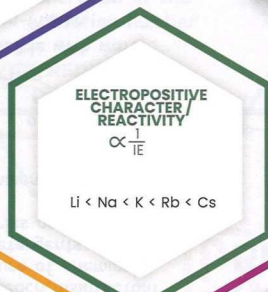
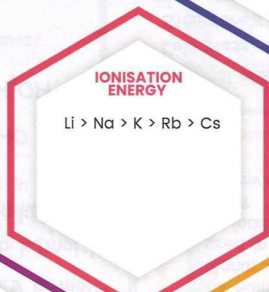
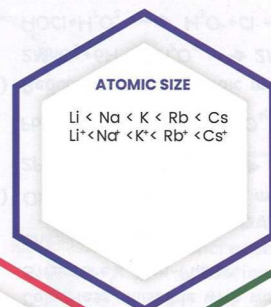
K/K⁺
Violet



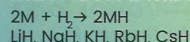
Rb/Rb⁺
Red Violet



Cs/Cs⁺
Blue



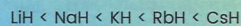
METAL HYDRIDES



• THERMAL STABILITY



• REDUCING CHARACTER



REACTION WITH OXYGEN

Li forms only normal oxide Li_2O
Na forms normal oxide (Na_2O) & Peroxide (Na_2O_2)
K forms normal oxide, Peroxide & Superoxide (KO_2)
Rb forms normal oxide, Peroxide & Superoxide
Cs forms normal oxide, Peroxide & Superoxide
 KO_2, RbO_2, CsO_2 (Superoxide) - Paramagnetic & coloured

METAL HYDROXIDES

BASIC CHARACTER



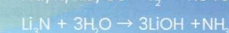
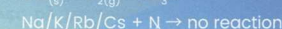
REACTION WITH H_2O

Li React with water
Na React easily with water (fast reaction)
K Give explosive reaction with water
Rb
Cs

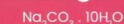


REACTION WITH NITROGEN

Only Li react with N_2 gas to form Li_3N which on hydrolysis give NH_3 gas.



Sodium carbonate/ washing soda



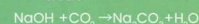
Solvay Process:

Reactants- NH_3, CO_2
Regeneration of NH_3 - Using $Ca(OH)_2$
Byproduct - $CaCl_2$

we can't obtain K_2CO_3 because $KHCO_3$ obtained in 2nd step is water soluble

Caustic Soda NaOH

- (i) It is a white crystalline solid
- (ii) Deliquescent in nature
- (iii) Reaction with acidic oxide



Sodium bicarbonate/ Baking Soda/ $NaHCO_3$

- (i) It is white crystalline solid
- (ii) It is sparingly soluble in water
- (iii) It is not stored with strong bases like NaOH, because it has acidic H



s-BLOCK ELEMENTS

1

Anomalous behaviour of Li (Due to small size & High charge density)

- The melting point and boiling point of lithium are higher than other alkali metals.
- The hardness of lithium is higher than other metals.
- The alkali metal chlorides do not have the capability to form hydrates but lithium chloride crystallizes to form a hydrate
- Lithium nitrate decomposes to form an oxide whereas other metals on heating give nitrites.
- Compounds of lithium are partially soluble in water whereas the alkali metals are highly soluble in water.

Diagonal relationship with Mg

- Same Charge Radius
- Li & Mg $\rightarrow$ harder
- Li & Mg react with cold water
- Li & Mg both form nitride which on hydrolysis give NH_3 gas
- $Li_3N + 3H_2O \rightarrow 3LiOH + NH_3$
- $Mg_3N_2 + 6H_2O \rightarrow 3Mg(OH)_2 + 2NH_3$
- $LiCl$ and $MgCl_2$ both are deliquescent in nature.

COMPOUNDS OF SODIUM

ALKALINE EARTH METALS

Be
4

Mg
12

Ca
20

Sr
38

Ba
56

Ra
88



Apple Green



METAL HYDRIDES

MgH₂, CaH₂, SrH₂, BaH₂
• **THERMAL STABILITY**
BeH₂ > MgH₂ > CaH₂ > SrH₂ > BaH₂
• **REDUCING CHARACTER**
BeH₂ < MgH₂ < CaH₂ < SrH₂ < BaH₂

REACTION WITH OXYGEN

- 1) Be, Mg → Normal oxide BeO & MgO
- 2) Ca, Sr, Ba → Normal oxide & Peroxide. Peroxide is diamagnetic, but shows colour due to Lattice defect

METAL HYDROXIDES

BASIC CHARACTER
Mg(OH)₂ < Ca(OH)₂ < Sr(OH)₂ < Ba(OH)₂

REACTION WITH H₂O

- 1) Be → Steam
- 2) Mg → Hot water
- 3) Ca, Sr, Ba → React with cold water



REACTION WITH NITROGEN

All elements react with nitrogen to form nitrides of type M₃N₂
Mg₃N₂ + H₂O → Mg(OH)₂ + 2NH₃

Calcium oxide/Quick lime/CaO

- 1) CaO + H₂O → Ca(OH)₂
Quick lime Slaked lime

Uses

Used as basic flux
CaO + SiO₂ → CaSiO₃
basic flux acidic impurity slag

Slaked lime/Ca(OH)₂

- 1) Used in white wash
- 2) In manufacturing of bleaching powder, glass etc
Ca(OH)₂ + Cl₂ → CaOCl₂ + H₂O
Bleaching powder
- 3) In removing temporary hardness of water

CaSO₄ · 2H₂O

Gypsum

CaSO₄ · 1/2H₂O

Plaster of Paris

CaSO₄

Dead burnt plaster

COMPOUNDS OF CALCIUM

Anomalous behaviour of Be (Due to small size & High charge density)

- 1) The coordinate number of Be is not more than 4 where as other alkali metals have coordination number of 6
- 2) The M.P and B.P are higher when compared to the other elements of the group
- 3) They forms covalent bonds whereas the other members of the group forms ionic bonds
- 4) Be does not react with H₂O like the other companions of the group

Diagonal relationship with Al

- Same $\frac{\text{Charge}}{\text{Radius}}$
- Be & Al are not attacked easily by acids [HNO₃] forms protective layer
- BeCl₂ & AlCl₃ → Lewis acid and form dimer
- BeCl₂ in vapour as dimer and solid as polymer
- BeO, Be(OH)₂, Al₂O₃, Al(OH)₃ → Amphoteric
- Both form complexes - [BeF₄]²⁻-sp³ [Al(H₂O)₆]³⁺-sp³d²

S-BLOCK ELEMENTS

BORON FAMILY

Non-metal ←	5 B	Most abundant metal Third most element in earth crust (O > Si > Al > Fe)
	13 Al	
	31 Ga	exists as Ga ₂ molecules & thus low M.P (29.67° C) -liquid up to 2000° C Used in high T thermometer
Metal ←	49 In	
	81 Tl	
	113 Nh	Radioactive

PHYSICAL PROPERTIES

Atomic radii B < Ga < Al < In < Tl	Ionic radii Decreases down the group
Ionisation enthalpy B > Tl > Ga > Al > In	Density Increases Down the group
Electronegativity B > Tl > In > Ga > Al	M.p decreases from B to Ga and then increases
	B.p Decreases down the group

CHEMICAL PROPERTIES

Reducing power Al > Ga > In > Tl

Stability order of O.S:

Tl⁺¹ > In⁺¹ > Ga⁺¹ > Al⁺¹ > B⁺¹ (Inert pair effect)

B⁺³ > Al⁺³ > Ga⁺³ > In⁺³ > Tl⁺³

Tl⁺³ = Strong oxidant, Ga⁺¹ = Strong reductant
Maximum covalency of B is 4 (absence of valence
d orbitals)

Halides - Lewis acids (BF₃ < BCl₃ < BBr₃)

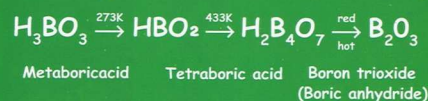
Acidic Character Decreases	B ₂ O ₃ Al ₂ O ₃ Ga ₂ O ₃ In ₂ O ₃ Tl ₂ O ₃	Basic Character Increases
Acidic Character Decreases	B(OH) ₃ Al(OH) ₃ Ga(OH) ₃ In(OH) ₃ Tl(OH) ₃	Basic Character Increases
Oxides		Hydroxides

BORIC ACID

- Weak monobasic acid (Lewis acid)



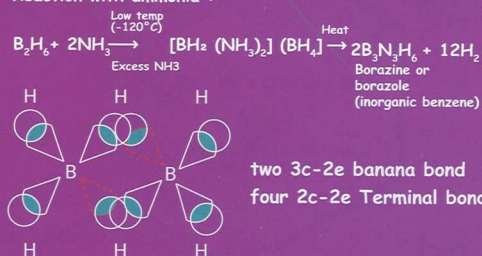
- Heating effect:



- Forms 6 H-bonds in aqueous solution.

DIBORANE

- Highly reactive: it catches fire
 $\text{B}_2\text{H}_6 + 3\text{O}_2 \rightarrow \text{B}_2\text{O}_3 + 3\text{H}_2\text{O}$, $\Delta H = -ve$
- With water: $\text{B}_2\text{H}_6(\text{g}) + 6\text{H}_2\text{O}(\text{l}) \rightarrow 2\text{B}(\text{OH})_3(\text{aq}) + 6\text{H}_2(\text{g})$
- Reaction with ammonia:



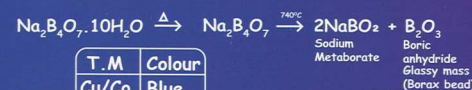
BORAX / TINCAL



- Aqueous solution of borax is alkaline in nature



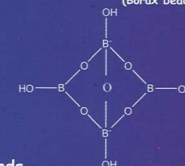
- Borax bead test (detection of transition metal)



T.M	Colour
Cu/Co	Blue

Uses: As flux
Water softening agent
As antiseptic
In making enamel
Manufacture of glass

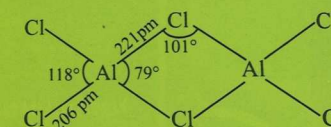
- There are 5 B-O-B bridge bonds



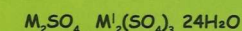
COMPOUNDS OF Al

AlCl₃

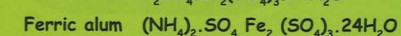
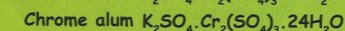
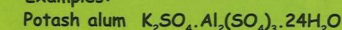
- $\text{Al}_2\text{O}_3 + 3\text{C} + 3\text{Cl}_2 \xrightarrow{\text{heat}} 2\text{AlCl}_3 + 3\text{CO}$
- Aqueous solution is acidic due to the formation of HCl.
 $\text{AlCl}_3 + 3\text{H}_2\text{O} \rightarrow \text{Al}(\text{OH})_3 + 3\text{HCl}$
- Anhyd. AlCl₃ is covalent & dimeric.



Alum



M - Monovalent metal M' - Trivalent metal
Examples:



Each cation is surrounded by 6 H₂O

p-BLOCK ELEMENTS

COMPOUNDS OF SILICON

SILICA

- SiO_2 - sand, quartz (piezoelectric)
- Insoluble in H_2O & inert at room temp.
- Reacts with HF (etching of glass)
 $\text{HF} + \text{SiO}_2 \rightarrow \text{SiF}_4$
 $\text{SiF}_4 + 2\text{HF} \rightarrow \text{H}_4\text{SiF}_6$
- 3D Network Covalent Solid

SILICONES

- general formula $(\text{R}_2\text{SiO})_n$
- $\text{R}_2\text{SiCl}_2 + \text{H}_2\text{O} \rightarrow \text{R}_2\text{Si}(\text{OH})_2$
 (Linear Chain Silicones)
- $\text{RSiCl}_3 \xrightarrow{\text{H}_2\text{O}} \text{RSi}(\text{OH})_3$
 (Cross linked silicones)
- $\text{R}_3\text{SiCl} \rightarrow$ stopping agent / Dimer

SILICATES

- Metal derivatives of silicic acid H_4SiO_4
- Basic unit is $(\text{SiO}_4)^{4-}$ Tetrahedral

ZEOLITES

- Sodium Aluminium silicates $(\text{Na}_2\text{Al}_2\text{Si}_2\text{O}_8 \cdot x\text{H}_2\text{O})$
- (i) Used for Purification of H_2O to remove hardness of water
- (ii) ZSM 5 is a shape selective catalyst to convert alcohol to gasoline

ALLOTROPES OF CARBON

DIAMOND

- C-C bond length is 154 pm
- C is sp^3 hybridised
- Good thermal conductor
- ΔH of formation is 1.9 KJ/mol
- Used as abrasive for sharpening of tools

GRAPHITE

- C-C bond length is 141.5 pm
- Thermodynamically most stable due to $\Delta_r H = 0$
- C is sp^2 hybridised
- Good electric conductor
- Hexagonal ring layers which are 340 pm apart
- Used as dry lubricant in machines

FULLERENES

- $\text{C}_{60} - \text{C}_{70}$
 (Bucky balls)
- C is sp^2 hybridised
- $\text{C}-\text{C} \rightarrow 143.5 \text{ pm}$
 $\text{C}=\text{C} \rightarrow 138.3 \text{ pm}$
- C_{60} has 12 pentagons and 20 hexagons

CARBON FAMILY

1) Oxidation State: +2, +4, -2

Stability of +4: $\text{C} > \text{Si} > \text{Ge} > \text{Sn} > \text{Pb}$
 Stability of +2: $\text{Pb} > \text{Sn} > \text{Ge} > \text{Si} > \text{C}$

2) Oxides

CO	Neutral	CO_2	Acidic
SiO	Neutral	SiO_2	Acidic
GeO	Acidic	GeO_2	Acidic
SnO	Amphoteric	SnO_2	Amphoteric
PbO	Amphoteric (Litharge)	PbO_2	Amphoteric

Halide

- Thermal stability order :
 $\text{CCl}_4 < \text{SiCl}_4 < \text{GeCl}_4 < \text{SnCl}_4 < \text{PbCl}_4$
 $\text{CCl}_4 > \text{SiCl}_4 > \text{GeCl}_4 > \text{SnCl}_4 > \text{PbCl}_4$
- CCl_4 can't be hydrolysed due to absence of valence d orbitals
- PbI_4 & PbBr_4 does not exist due to strong oxidising nature of Pb^{+4}

COMPOUNDS OF CARBON

CO

- $\text{HCOOH} \xrightarrow{\text{conc. H}_2\text{SO}_4} \text{CO} + \text{H}_2\text{O}$ (100% pure)
- Coal gasification
 $\text{C} + \text{H}_2\text{O} \rightarrow \text{CO} + \text{H}_2$
 (steam) Syn gas / Water gas
- Producer gas ($\text{CO} + \text{N}_2$)
- With Hb it forms 300 times stable Carboxy Hb (w.r. to oxyHb)

CO₂

- Solid CO_2 - Dry ice (Refrigerant)
- CO_2 in water gives carbonic acid (maintain pH 7.26-7.42)
- $\text{NaOH} + \text{CO}_2 \rightarrow \text{NaHCO}_3$
- Used in soft drinks
- Used as fire extinguisher

p-BLOCK ELEMENTS

Environmental Pollution

Atmospheric Pollution

Tropospheric Pollution

Gaseous pollutants

eg: $\text{SO}_x, \text{NO}_x, \text{CO}_x, \text{H}_2\text{S}, \text{C}_x\text{H}_y$

Green house effect:

Trapping of infrared radiation by green house gas will lead to heating of earth atmosphere

Green house gases:

$\text{CO}_2, \text{CH}_4, \text{O}_3, \text{CFC}$, Nitrous oxide and water vapour.

Global warming:

Increase in concentration of green house, will lead to rise in global temperature, which again leads to melting of polar ice caps & flooding in low areas.

Acid Rain:

Normal rain has pH = 5.6

When pH of rainwater is less than 5.6, it is acid rain. It is due to the presence of $\text{HNO}_3, \text{H}_2\text{SO}_4$

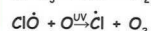
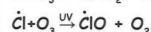
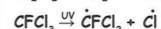
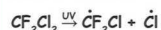
Effect:

1. Harmful for agriculture
 2. Damages aquatic ecosystem
 3. Respiratory Illness
 4. Damage building made up of stone, marble, metal.
- eg: Tajmahal and Acid Rain (discolouration and lustreless)

Stratospheric pollution

Ozone layer depletion

Main reason for depletion is CFC's (AC, Fridge)



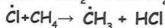
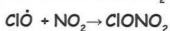
1 molecule of CFC's destroys 1000 ozone molecule.

Ozone hole

In September and October each year ozone hole develops over antarctica

- In summer

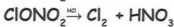
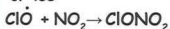
$\dot{\text{ClO}}$ reacts with NO_2 & CH_4 to form chlorine sink



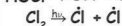
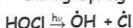
This prevents ozone layer depletion.

- In winter

Special type of clouds are formed called polar stratospheric clouds which contains $\text{HNO}_3 \cdot 3\text{H}_2\text{O}$ or ice



- During Spring



The chlorine radicals thus formed initiate the chain reaction for ozone depletion.

Water Pollution

Biological Oxygen Demand (B.O.D)

Oxygen required by bacteria to break down organic matter in a certain volume of water.

Pure water- BOD < 5 ppm

Highly polluted water- BOD > 17ppm

Eutrophication

Process in which nutrient enriched water bodies support a dense plant population, which kills animal life by depriving it of oxygen and results in subsequent loss of biodiversity is known as Eutrophication.

International standard of drinking water

Fluoride: 1ppm. Above 2ppm:- brown molting of teeth, over 10ppm :bones and teeth damage.

Lead: 50ppb. >50ppb- damages kidney, liver, reproductive system.

Nitrate: 50ppm. >50ppm- blue baby syndrome(methemoglobinemia)

Sulphate: 500ppm. >500ppm: laxative effect

Soil Pollution

Pesticide:

chemical used to kill/ stop growth of unwanted organism.

Insecticide:

DDT, BHC, Aldrin (stays in soil for long period & contaminates root crops like potato, carrot, radish etc.)

Herbicide: $\text{NaClO}_3, \text{Na}_3\text{AsO}_3$

Fungicide:

Organo mercury compound. It leaves mercury in soil which is toxic.

Green Chemistry

Dry cleaning of clothes:

Earlier used: $\text{Cl}_2\text{C}=\text{CCl}_2$ (carcinogenic)

Replaced by: liquid CO_2

Presently used: H_2O_2

Bleaching of paper:

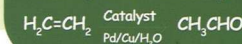
Earlier used: Cl_2 gas

Presently used: H_2O_2

Ethanal preparation

Done in a harmful method previously

Used: $\text{Pd/Cu/H}_2\text{O}$



ENVIRONMENTAL CHEMISTRY

Particulate pollutants

Smog:

Smog = smoke + fog

Classical smog or London smog	Photochemical smog/ Los Angeles smog
Cool and humid climate	Warm and dry climate
Contains oxides of sulphur	Contains oxides of Nitrogen
Contains primary pollutant	Contains secondary pollutant
Reducing nature/ Reducing smog	Oxidising nature/ oxidising smog

Formation of Photochemical Smog

Both NO_2 and O_3 are strong oxidising agent and reacts with unburnt hydrocarbon to produce formaldehyde, acrolein, PAN (peroxy acetyl nitrate)

?

Which one of the following is not a common component of photochemical smog ?

- (a) Ozone (b) Acrolein
(c) Peroxyacetyl nitrate (d) Chlorofluorocarbons

?

Which oxide of nitrogen is not a common pollutant introduced into the atmosphere both due to natural and human activity?

- (a) N_2O_5 (b) NO_2
(c) NaO (d) NO

?

Among the following, the one that is not a green house gas is:

- (a) sulphur dioxide (b) nitrous oxide
(c) methane (d) ozone

ENVIRONMENTAL CHEMISTRY

CONSTITUTIONAL ISOMERISM

CONSTITUTIONAL ISOMERISM [STRUCTURAL]

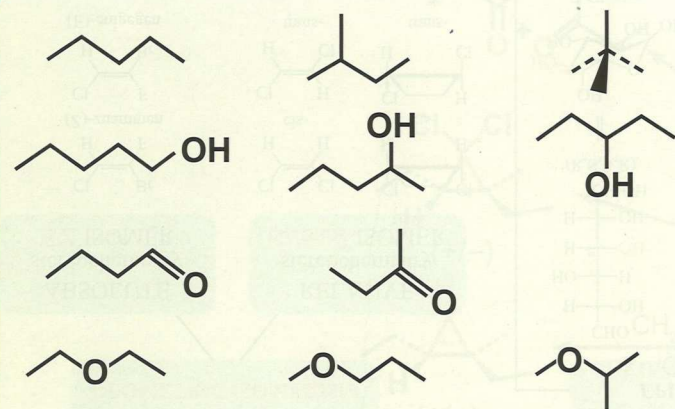
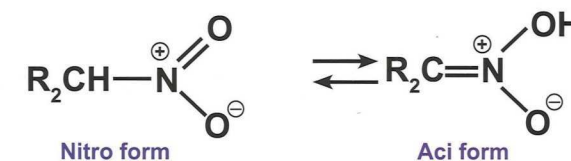
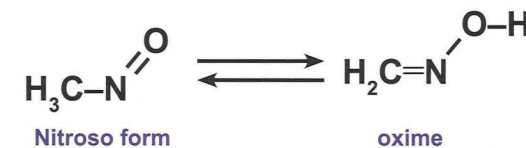
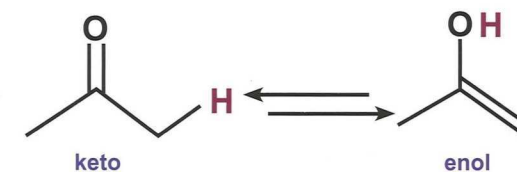
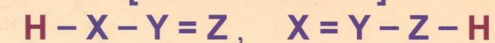
CHAIN [SKELETAL] ISOMERISM

POSITION ISOMERISM [REGIOISOMERISM]

FUNCTIONAL ISOMERISM

METAMERISM

PROTOTROPIC TAUTOMERISM [PROTOTROPY]



Pair of functional isomers:

- Alcohols and ethers ($C_n H_{2n+2} O$)
- Aldehydes and ketones ($C_n H_{2n} O$)
- Carboxylic acids and esters ($C_n H_{2n} O_2$)
- 1°, 2° & 3° amines ($C_n H_{2n+3} N$)

$$DBE = \frac{\sum n(v-2)}{2} + 1 = \text{sum of no. of } \pi \text{ bonds} + \text{rings}$$

in the molecule
(n is no of atoms of particular element & v is corresponding valency in given molecule).

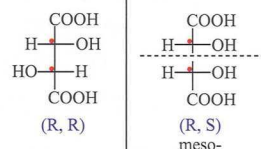
- Q. The number of structural isomers possible from the molecular formula is
(a) 4 (b) 5 (c) 2 (d) 3
- Q. Identify the compound that exhibits tautomerism
(a) 2-Pentanone (b) Phenol
(c) 2-Butene (d) Lactic acid
- Q. The number of structural isomers for C_6H_{14} is
(a) 3 (b) 4 (c) 5 (d) 6

STEREOISOMERISM

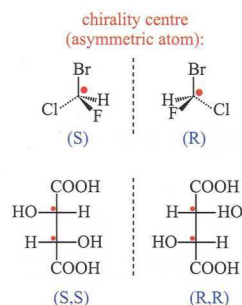
CONFIGURATIONAL ISOMERISM

OPTICAL ISOMERISM [(+)/d dextrorotatory (-)/l levorotatory]

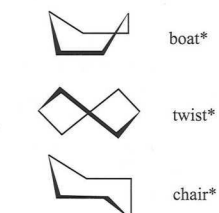
DIASTEREOMER



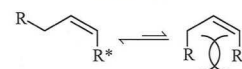
ENANTIOMER



RING CONFORMATIONS



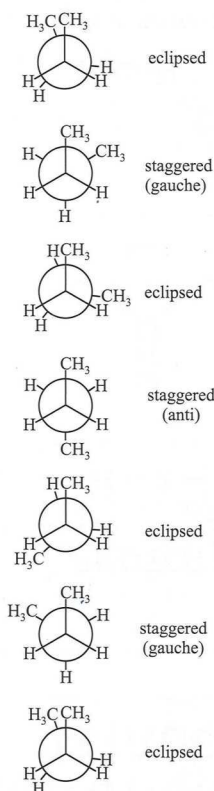
allylic strain:



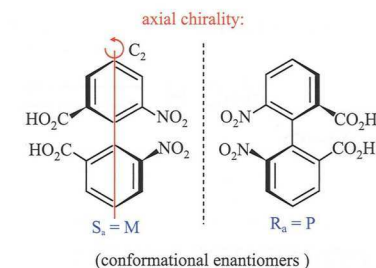
CONFORMATIONAL ISOMERISM

CONFORMER

ROTAMER

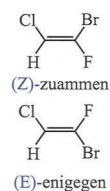


ATROPISOMER

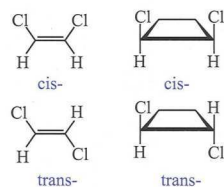


GEOMETRIC ISOMERISM

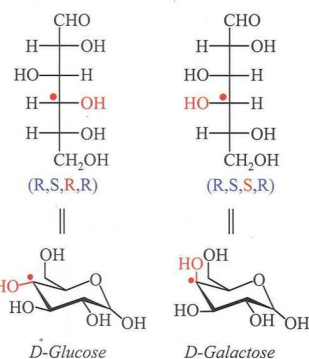
ABSOLUTE stereochemistry E/Z-ISOMER



RELATIVE stereochemistry cis/trans-ISOMER

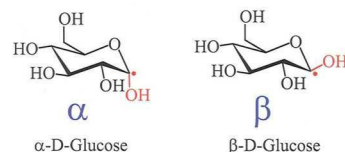


EPIMER



ANOMER

glycosides, hemiacetals, sugars

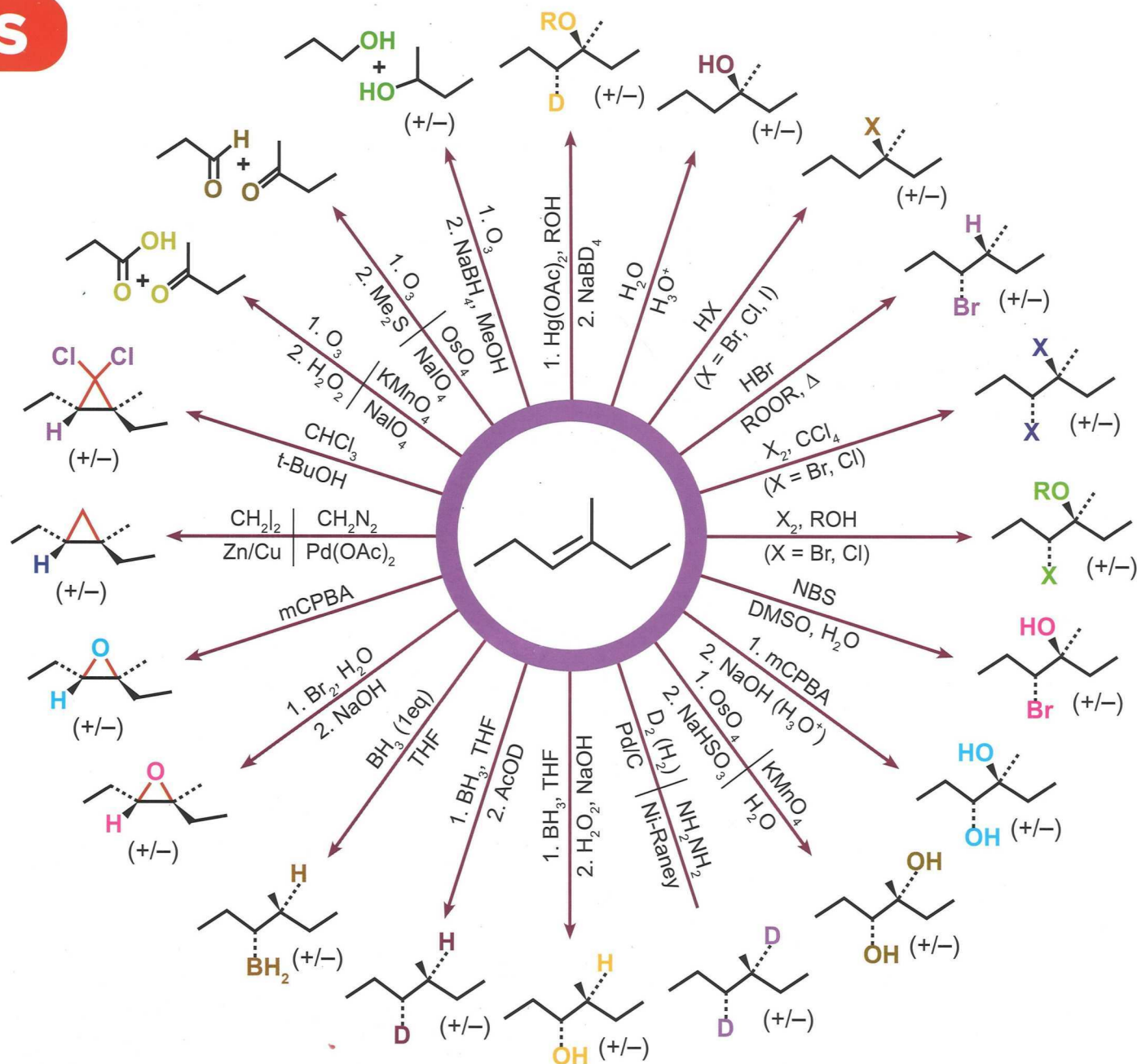


Q. Which of the following does not show geometrical isomerism?
(1) 1, 2-dichloro-1-pentene
(2) 1, 3-dichloro-2-pentene
(3) 1, 1-dichloro-1-pentene
(4) 1, 4-dichloro-2-pentene

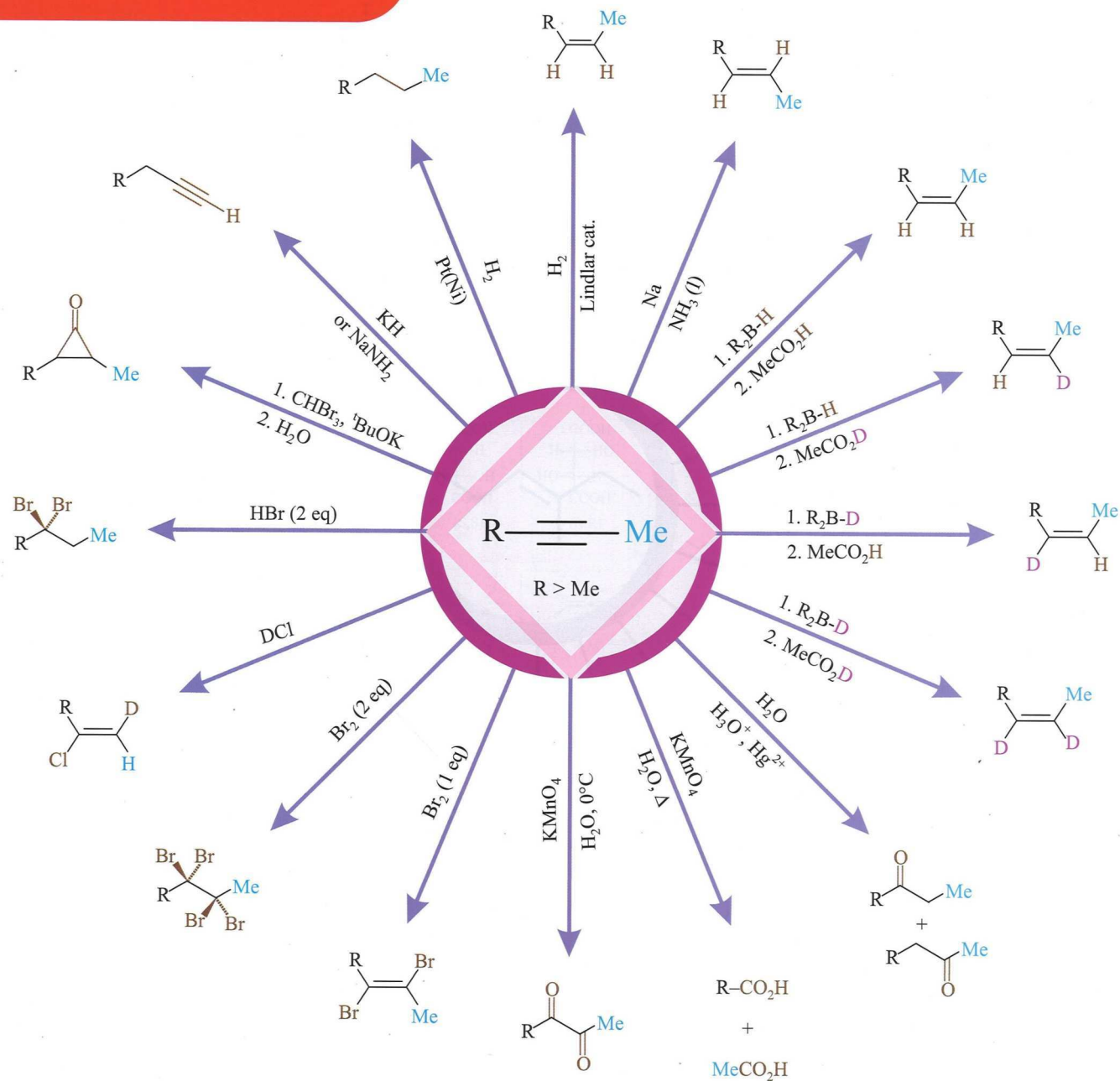
Q. With respect to the conformers of ethane, which of the following statements is true?
(1) Both bond angles and bond length remains same
(2) Bond angle remains same but bond length changes
(3) Bond angle changes but bond length remains
(4) Both bond angle and bond length change

STEREOISOMERISM

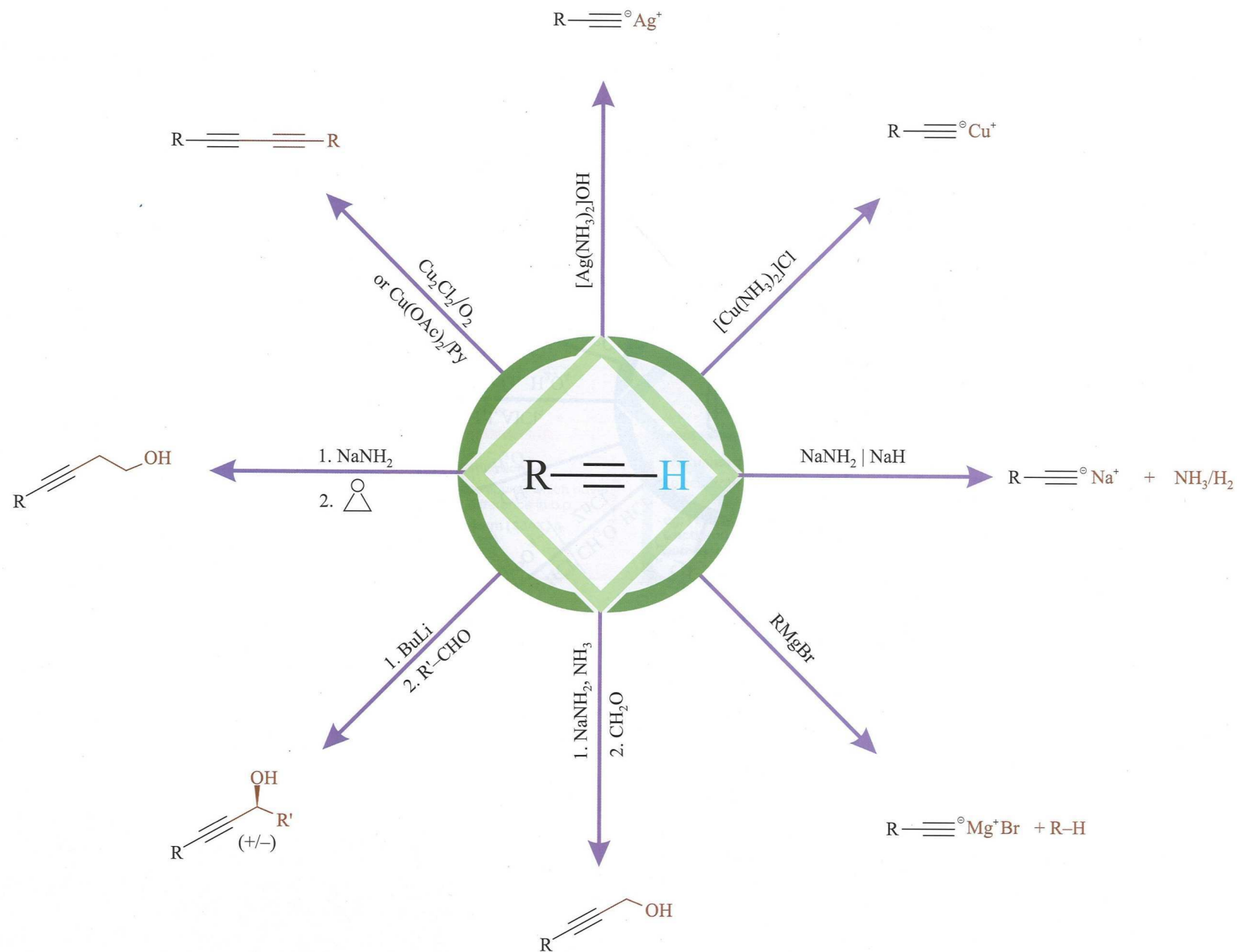
ALKENES



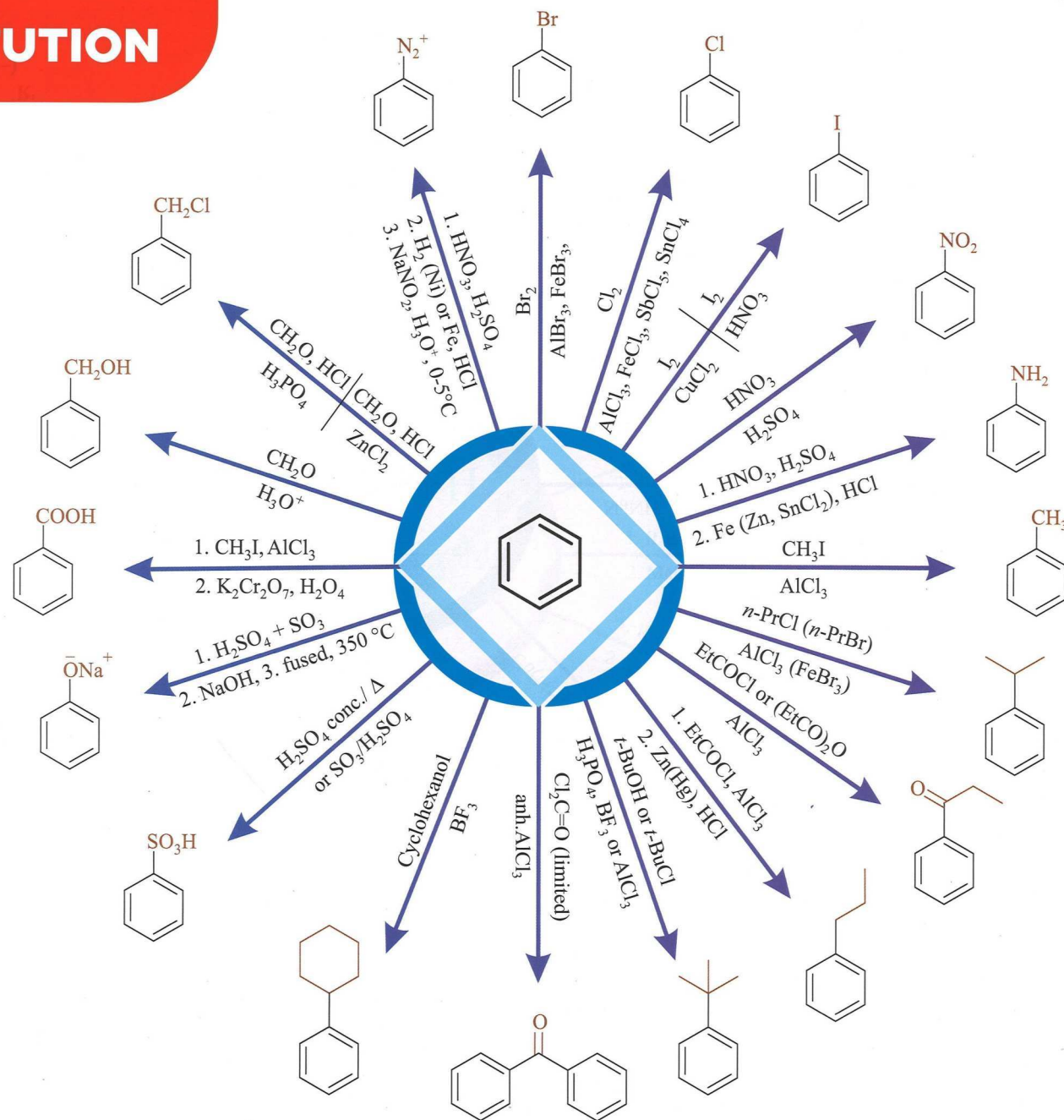
ALKYNES (NON TERMINAL)



ALKYNES TERMINAL

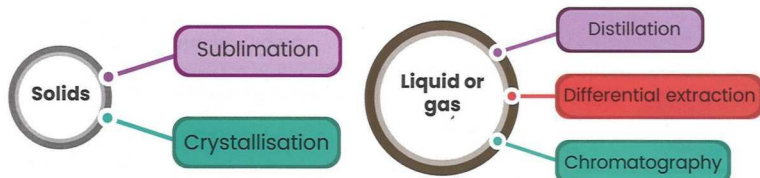


ELECTROPHILIC AROMATIC SUBSTITUTION



PURIFICATION OF ORGANIC COMPOUNDS

Methods of purification



Crystallisation:

- It is based on the difference in the solubilities of the compound & the impurities in a suitable solvent.
- The impure compound is dissolved in a solvent in which it is sparingly soluble at room temperature but appreciably soluble at higher temperature.
- If the compound is highly soluble in one solvent and very little soluble in another solvent, crystallisation can be satisfactorily carried out in a mixture of these solvents.
- eg: Purification of sugar, purification of potash alum etc.

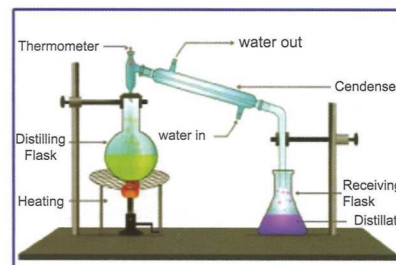
Differential Extraction Principle:-

Based on difference in solubility of organic compounds in different solvents.

When an organic compound is present in an aqueous medium, it is separated by shaking it with an organic solvent in which it is more soluble than in water.

The organic solvent & aq: solvent should be immiscible with each other so that they form 2 distinct layers which can be separated by separatory funnel.

The org. solvent is later removed by distillation or evaporation to get back org. comp.



Sublimation

- Solid is converted directly into vapour without undergoing liquid state.
- eg: Purification of iodine, Camphor, Naphthalene, ammonium chloride etc.

Distillation :

Principle : Based on difference in b.p. of components of mixture.

- Also used to separate: Volatile liquids from nonvolatile impurities

Types of distillation:

Simple distillation :

To separate liquids which have sufficient difference in b.p.
eg: chloroform (334K) & aniline (457K)

Fractional distillation:

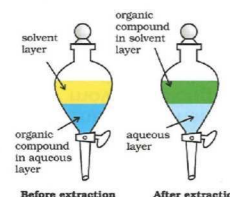
To separate liquids which have small difference in b.p.
eg: To separate different fractions of crude oil in petroleum industry.

Vacuum distillation (distillation under reduced pressure)

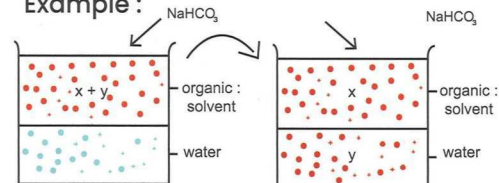
This method is used to purify liquids having very high boiling points but they decompose at or below their boiling points.
eg: Glycerol is separated from spent -lye in soap industry.

Steam Distillation

To separate substances which are steam volatile and are immiscible with water.
eg: Aniline, Nitrobenzene, o-nitro phenol.



Example :

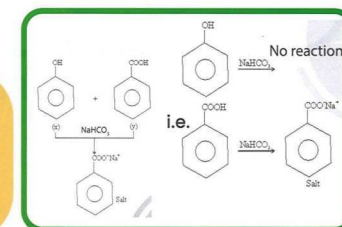


- Q. A mixture of camphor and benzoic acid can be separated by:
- Sublimation
 - Extraction with a solvent
 - Chemical method
 - Fractional distillation

- Q. In steam distillation, the sum of the vapour pressure of the volatile compound and that of water is:
- Equal to atmospheric pressure
 - Less than atmospheric pressure
 - More than atmospheric pressure
 - Exactly half of the atmospheric pressure

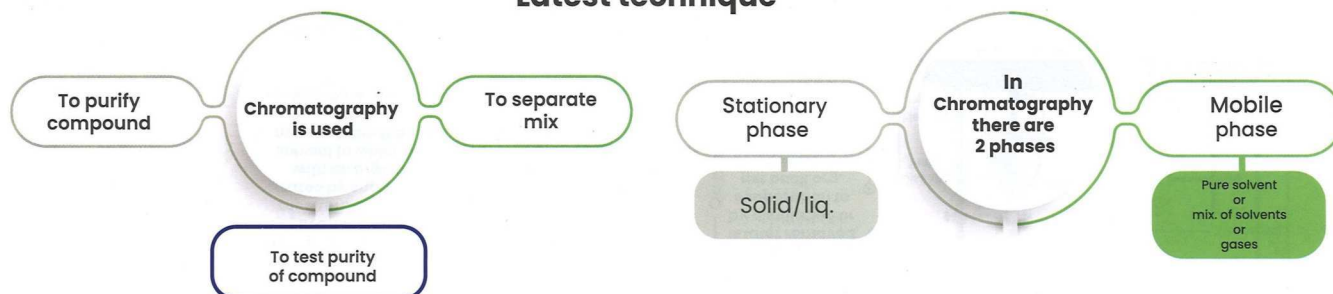
- Q. The best method for the separation of naphthalene and benzoic acid from their mixture is:
- Chromatography
 - Crystallisation
 - Distillation
 - Solvent extraction

- Q. A liquid compound can be purified by steam distillation only if it is
- Steam volatile, miscible with water
 - Not steam volatile, immiscible with water
 - Steam volatile, immiscible with water



CHROMATOGRAPHY

Latest technique

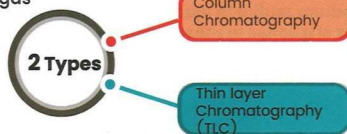


Types of chromatography

1) Adsorption Chromatography:

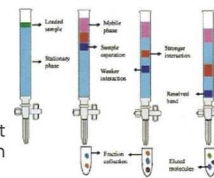
Based on the fact that different components of a mixture have different degrees of adsorption on adsorbent (silica gel or alumina)

Stationary phase - solid
Mobile phase - liquid/gas



a) Column Chromatography

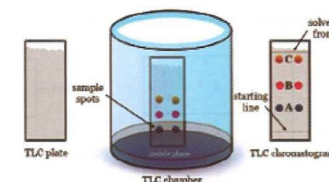
- Involves separation of a mixture over a column of adsorbent (stationary phase) packed in a glass tube.
- Component of the mixture which is more soluble in stationary phase is adsorbed first than the component which is less soluble in stationary phase.
- The most readily adsorbed substances are retained near the top and others come down to various distances in the column



b) Thin layer chromatography (TLC)

Involves separation of substances of a mixture over thin layer of an adsorbent coated on glass plate.

The components of the mixture move up along with the eluent to different distances depending on their degree of adsorption and separation takes place.

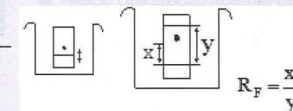


glass plate (loaded with adsorbent i.e. stationary phase)

Retardation factor:-

express degree of adsorption of each Component of mixture.

$$R_f = \frac{\text{distance moved by component of mixture from base line}}{\text{distance moved by solvent (mobile phase) from base line.}}$$



Q. Paper chromatography is an example of :

- Partition chromatography
- Thin layer chromatography
- Column chromatography
- Adsorption chromatography

Q. The most suitable method of separation of 1:1 mixture of ortho & para-nitrophenols is

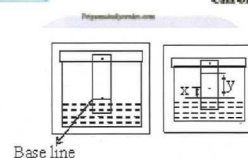
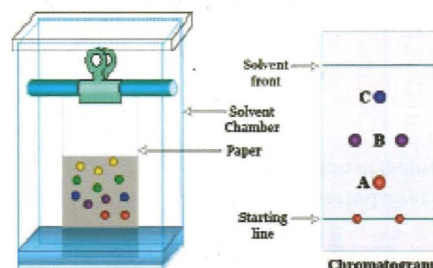
- Steam distillation
- Sublimation
- Chromatography
- Crystallisation

2) Partition chromatography:

- Based on continuous differential partitioning of components of a mixture between stationary & mobile phase. Also known as **liquid paper chromatography**

Stationary phase - liquid
Mobile phase - liquid

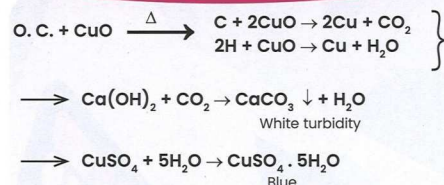
- A special quality paper known as chromatography paper is used.
eg: cellulose paper
- Chromatography paper contains water trapped in it, which works as Stationary phase.
- Moving phase is a solvent or a mixture of solvents in which spotted chromatography paper is suspended.
- The solvent rises up the paper by capillary action and flows over the spot. The paper selectively retains different components according to their differing partition in the two phases. The paper strip so developed is called Chromatogram



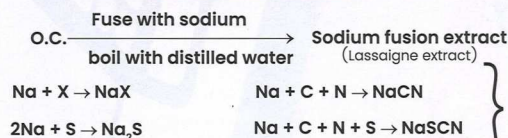
QUALITATIVE ANALYSIS OF ORGANIC COMPOUND

Quantitative Analysis

01 Detection of C & H

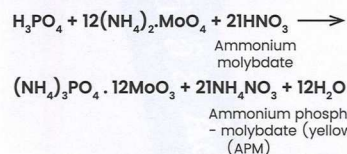


Detection of N, S, P & X

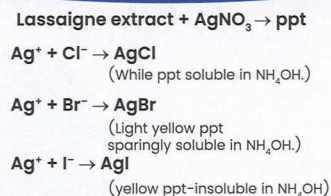


2d Detection of Phosphorus

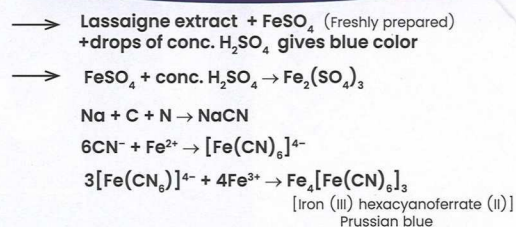
O.C. + Na_2O_2 gives H_3PO_4 which gives yellow ppt with ammonium molybdate



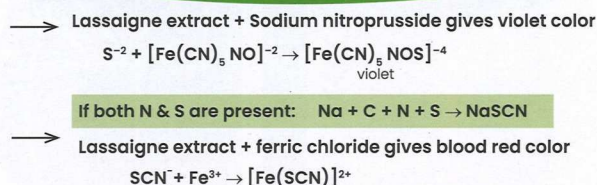
2a Detection of Halogen



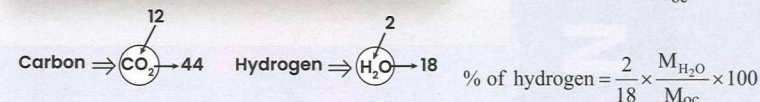
Detection of Nitrogen



2c Detection of Sulphur



01 Liebig's method



02 Estimation of Nitrogen

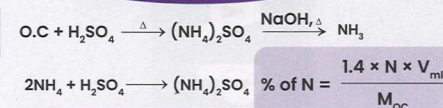
(2a) Duma's method

$$\frac{P_1 V_1}{T_1} = \frac{760 \times V_{\text{STP}}}{273}$$

$$\%(\text{N}) = \frac{V_{\text{STP}}}{22400} \times \frac{28}{m_{\text{oc}}} \times 100$$

Volume of nitrogen collected = V_1 mL, Temperature = T_1 K
 p_1 = Atmospheric pressure – Aqueous tension

(2b) Kjeldahl method



Kjeldahl's method is not used for

- Nitro
- Azo compounds

03 Estimation of X, S, P

Carius method

$$\% \text{ X} = \frac{M_{\text{X}} \times W_{\text{AgX}} \times 100}{M_{\text{Ag}} \times W_{\text{oc}}}$$

$$\% \text{ S} = \frac{32 \times W_{\text{BaSO}_4} \times 100}{233 \times W_{\text{oc}}}$$

$$\% \text{ P} = \frac{31 \times W_{\text{APM}} \times 100}{1877 \times W_{\text{oc}}}$$

$$\% \text{ P} = \frac{62 \times W_{\text{Mg}_2\text{P}_2\text{O}_7} \times 100}{222 \times W_{\text{oc}}}$$

Q. During estimation of nitrogen present in an organic compound by Kjeldahl's method, the ammonia evolved from 0.5 g of the compound in Kjeldahl's estimation of nitrogen neutralized 10 mL of $1\text{M H}_2\text{SO}_4$. The percentage of nitrogen in the compound is:

- (a) 56% (b) 45%
(c) 50% (d) 40%

Q. On complete combustion, 0.246 g of an O.C gave 0.198 g of carbon dioxide & 0.1014 g of water. Determine % composition of carbon & hydrogen in the compound.

- (a) 4.58, 21.95 (b) 21.95, 4.58
(c) 45.8, 21.95 (d) 2.195, 45.8

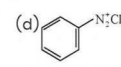
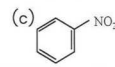
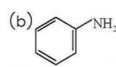
Q. In Dumas' method for estimation of nitrogen, 0.3g of an organic compound gave 50mL of nitrogen collected at 300 K temperature and 715 mm pressure. Calculate the percentage composition of nitrogen in the compound. (Aqueous tension at 300 K = 15 mm)

- (a) 17.5% (b) 28%
(c) 6.25% (d) 31%

Q. In Carius method of estimation of halogen, 0.15 g of an organic compound gave 0.12 g of AgBr. What is the percentage of bromine in the compound?

- (a) 68.08% (b) 45%
(c) 42.1% (d) 50%

Q. Which of the following compounds will be suitable for Kjeldahl's method for nitrogen estimation?



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