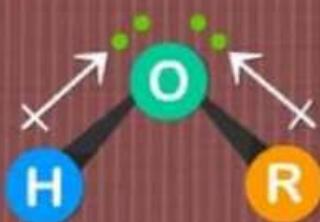


# **CHEMISTRY**

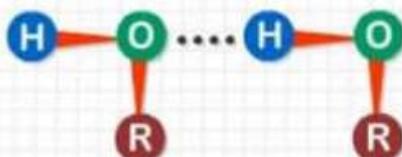
# **FLASHCARD**

Click on the above text to join our Telegram  
Channel For MORE AMAZING CONTENT

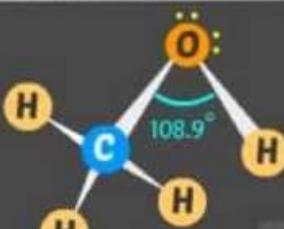


# ALCOHOLS

## BOILING POINT



**Existence of Intermolecular Hydrogen bonding results in higher boiling point than hydrocarbons.**



Oxygen acts as nucleophile due to the presence of lone pairs

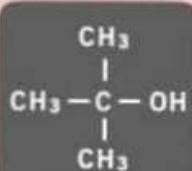
## SOLUBILITY



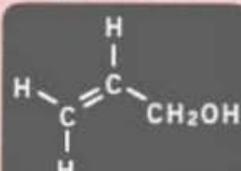
Alcohols are soluble in water, due to the presence of Hydrogen Bonds.

# NOMENCLATURE

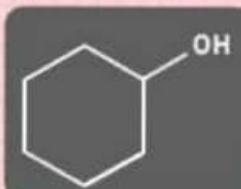
- Name the longest carbon chain that contains the carbon atom bearing the **-OH** group. Drop the final **-e** from the alkane name, and add the suffix **-ol**.
  - Number the longest carbon chain starting at the end nearest the **-OH** group, and use the appropriate number, if necessary, to indicate the position of the **-OH** group.
  - Name the substituents, and give their numbers as for an alkane or alkene.



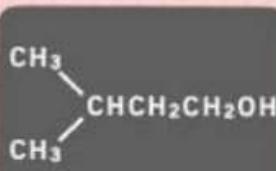
**IUPAC Name**  
2-methyl-2-propanol  
**Common Name**  
*t*-butyl alcohol



**IUPAC Name**  
2-propen-1-ol  
**Common Name:**  
Allyl alcohol



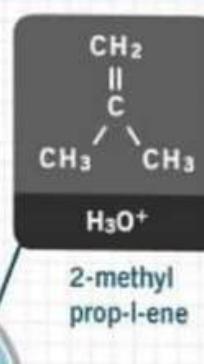
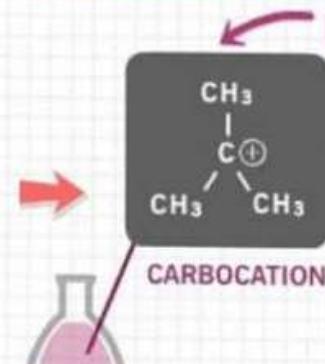
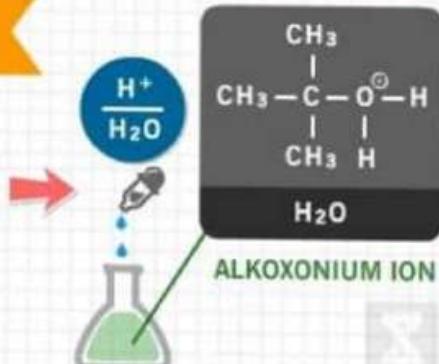
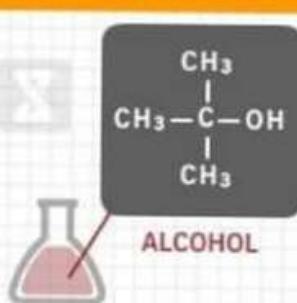
**IUPAC Name**  
Cyclohexanol  
**Common Name**  
Cyclohexanol alcohol



**IUPAC Name**  
3-methyl-1-butanol  
**Common Name**  
Isopentyl alcohol

# CHEMICAL REACTIVITY

## **DEHYDRATION**



Formation of carbocation is RDS here. So always try to make a stable carbocation by rearrangement

# HOW TO PREPARE ALCOHOL

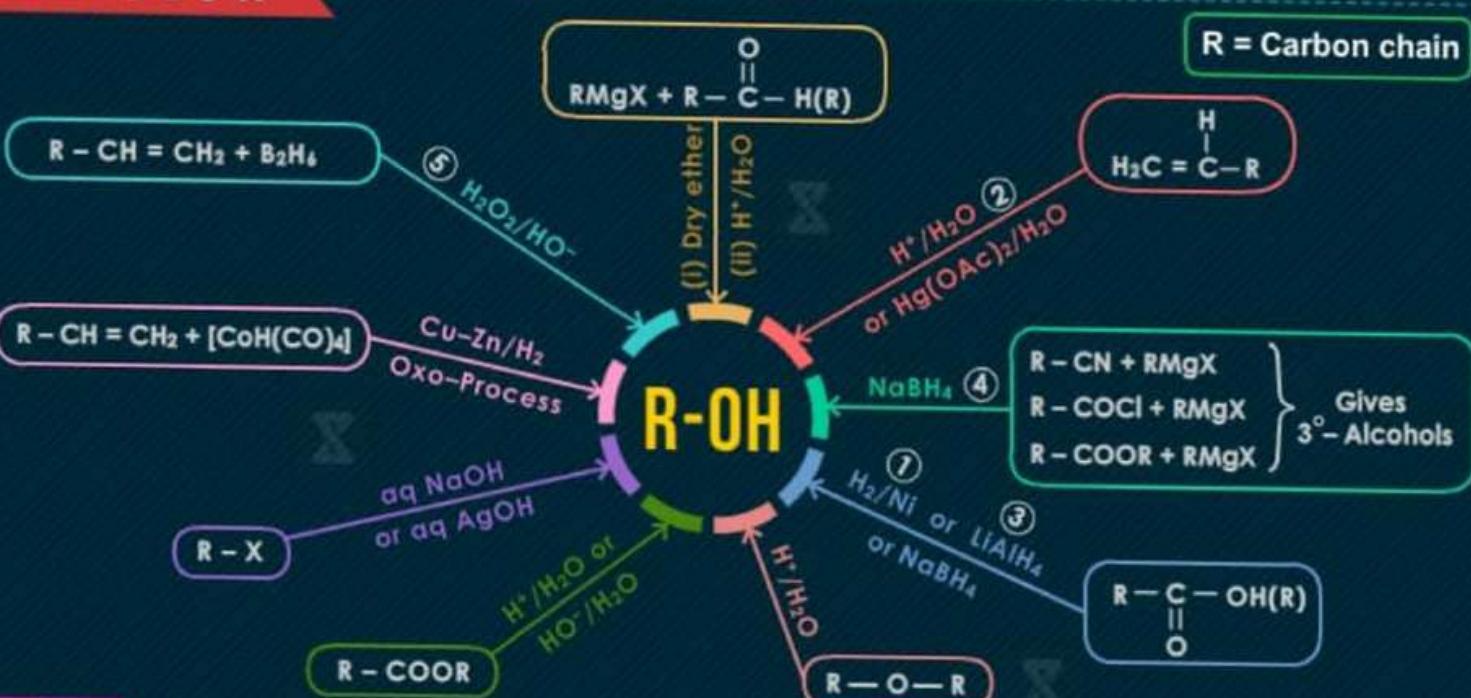


YOU NEED TO HAVE SOME **BASIC INFORMATION**

## HIERARCHY OF OXIDATION



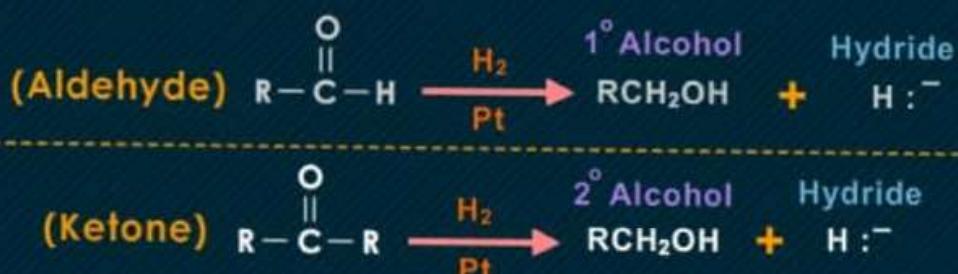
## WAYS TO DO IT



## Notes

- $\text{H}_2/\text{Ni}$  reduces all reducible groups including olefinic bonds.
- Reaction proceeds via carbocation, rearrangement may accompany.
- $\text{LiAlH}_4$  does not reduce olefinic bonds.
- Avoid rearrangement.
- Anti-Markownikoff's hydration takes place.

## CATALYTIC HYDROGENATION



# ETHERS



Ethers are a class of organic compounds that contain an oxygen between two alkyl or aryl groups. They have the formula  $\text{R}-\text{O}-\text{R}'$ , where  $\text{R}$  and  $\text{R}'$  are alkyl groups. These compounds are used in **dye, perfumes, oils, waxes** and **industrial use**. Ethers are named as **alkoxyalkanes**.

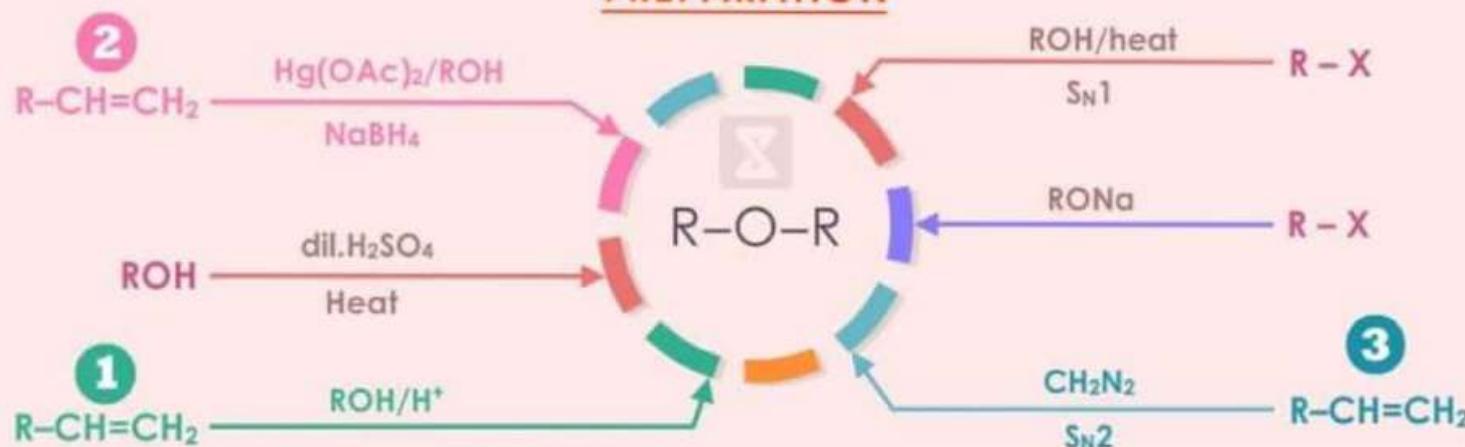
## NOMENCLATURE OF ETHERS

Ethers are compounds having two alkyl or aryl groups bonded to an oxygen atom, as in the formula  $\text{R}_1-\text{O}-\text{R}_2$ . The ether functional group does not have a characteristic **IUPAC** nomenclature suffix, so it is necessary to designate it as a substituent. To do so the common alkoxy substituents are given names derived from their alkyl component (**below**):

ALKYL GROUP	NAME	ALKOXY GROUP	NAME
$\text{CH}_3-$	Methyl	$\text{CH}_3\text{O}-$	Methoxy
$\text{CH}_3\text{CH}_2-$	Ethyl	$\text{CH}_3\text{CH}_2\text{O}-$	Ethoxy
$(\text{CH}_3)_2\text{CH}-$	Isopropyl	$(\text{CH}_3)_2\text{CHO}-$	Isopropoxy
$(\text{CH}_3)_3\text{C}-$	Tert-Butyl	$(\text{CH}_3)_3\text{CO}-$	Tert-Butoxy
$\text{C}_6\text{H}_5-$	Phenyl	$\text{C}_6\text{H}_5\text{O}-$	Phenoxy

Ethers can be named by naming each of the two carbon groups as a separate word followed by a space and the word ether. The **-OR** group can also be named as a substituent using the group name, alkoxy.

## PREPARATION



① Proceeds via carbocation intermediate, rearrangement may take place.

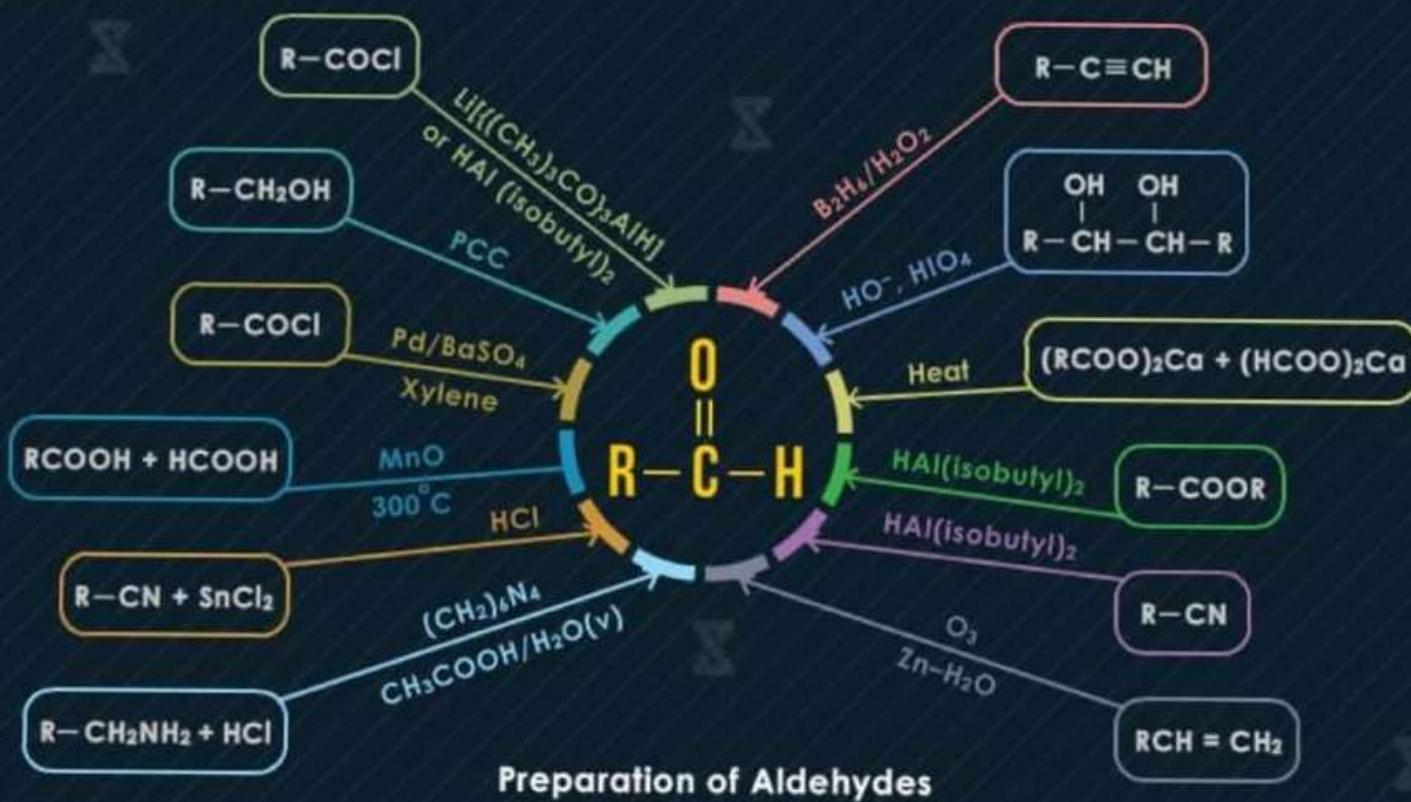
② Do not proceed via carbocation intermediate, rearrangement is avoided.

③ Gives methyl ether ( $\text{RCH}_2\text{CH}_2\text{OCH}_3$ )

# ALDEHYDE & KETONES

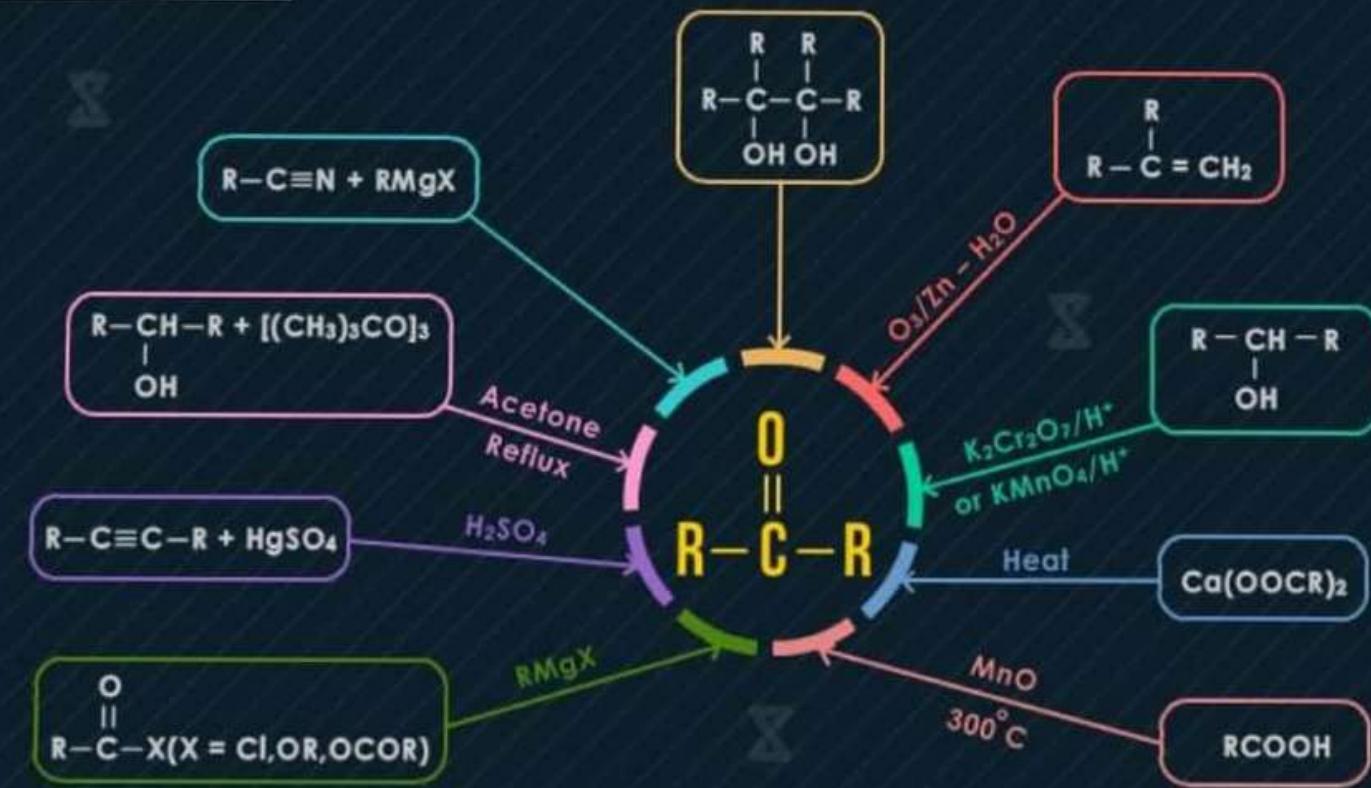
## Aldehydes

### PREPARATION



## Ketones

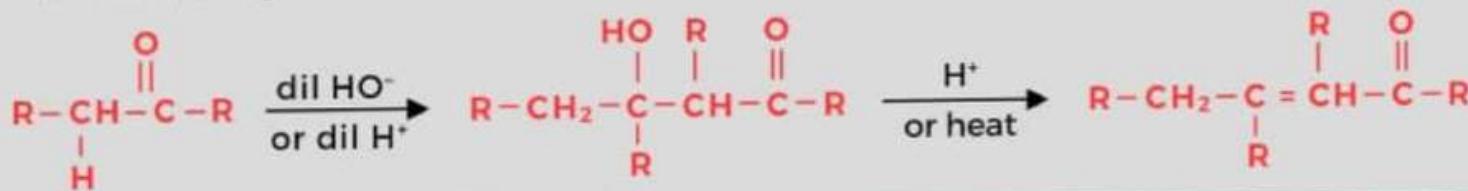
### PREPARATION



# IMPORTANT REACTIONS ALDYHYDE AND KETONE

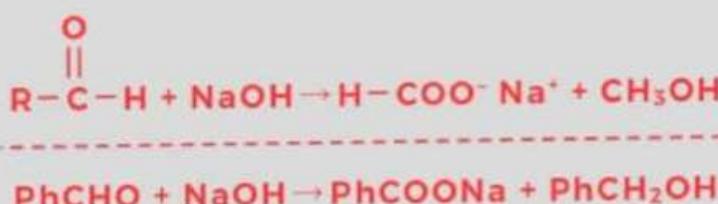
## ALDOL CONDENSATION

Aldehydes or ketones containing at least one  $\alpha$ -hydrogen on treatment with dilute alkali or dilute acid undergoes condensation to produce  $\beta$ -hydroxy aldehyde or  $\beta$ -hydroxy ketone.



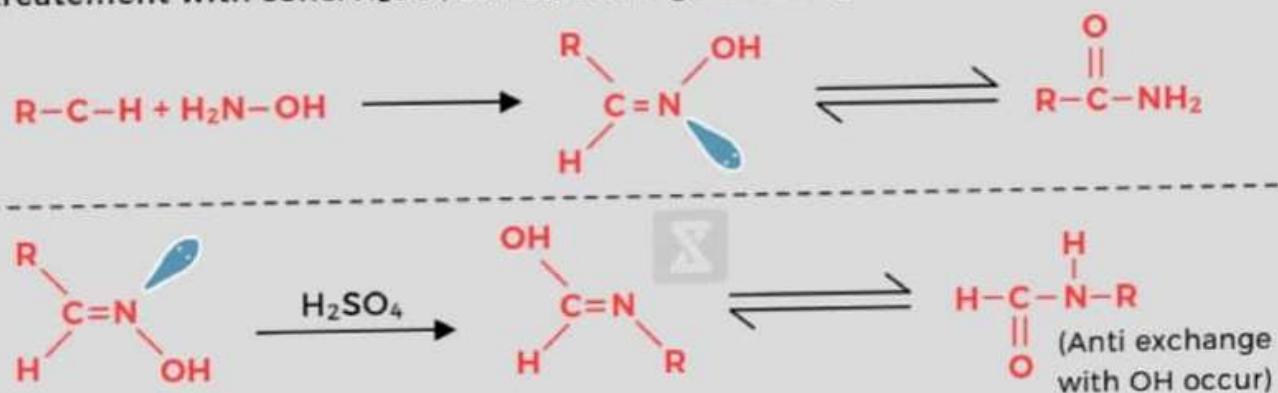
## CANNIZARO REACTION

Aldehydes lacking  $\alpha$ -hydrogen, when treated with concentrated solution of strong base, undergo mutual oxidation reaction.



## BECKMANN'S REARRANGEMENT

Aldehydes or ketones on treatment with hydroxyl amine gives oximes. Oximes on further treatment with conc.  $\text{H}_2\text{SO}_4$  or  $\text{PCl}_5$  undergo rearrangement as:



## WOLFF - KISHNER

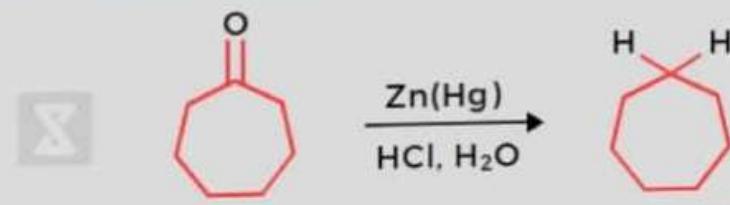
Ketone or aldehyde is converted to its hydrazone (by reaction with hydrazine) and is then treated with a strong base, which generates the reduced product.



The mechanism of hydrazone formation is analogous to imine formation.

## CLEMMENSEN REDUCTION

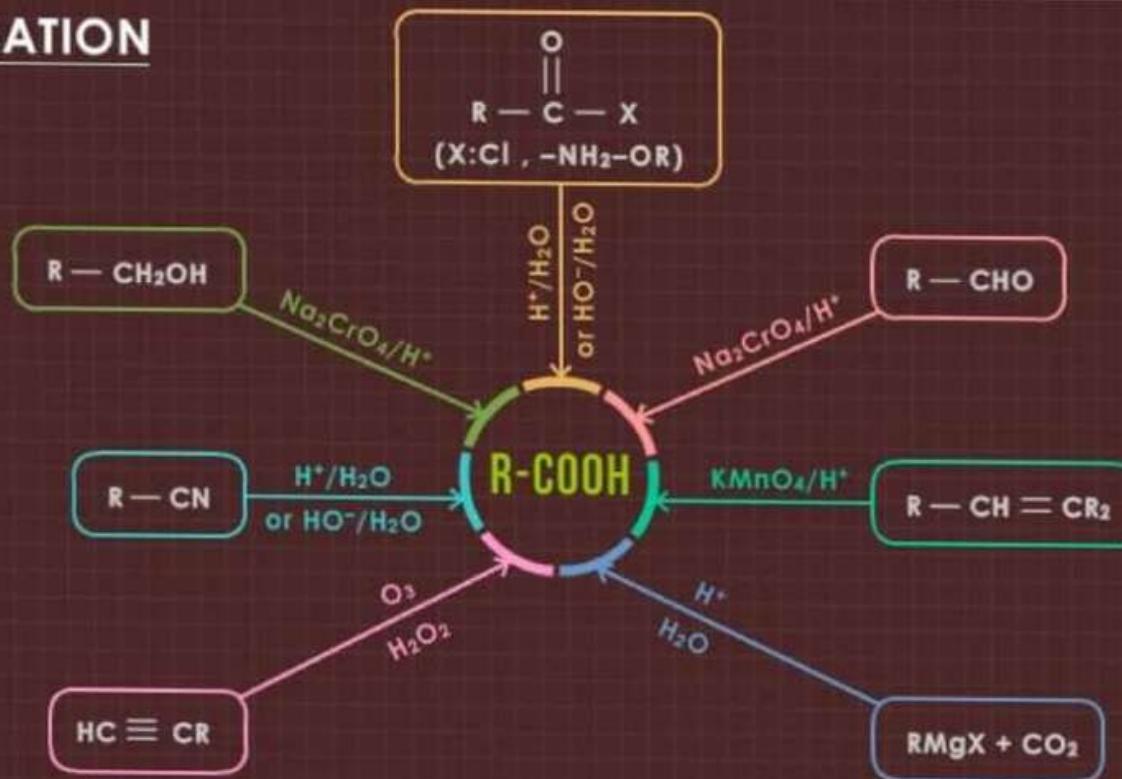
This was used in the reduction of acyl benzenes into alkyl benzenes, but it also works for other aldehydes and ketones.



# CARBOXYLIC ACIDS



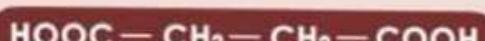
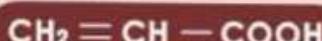
## PREPARATION



## NOMENCLATURE

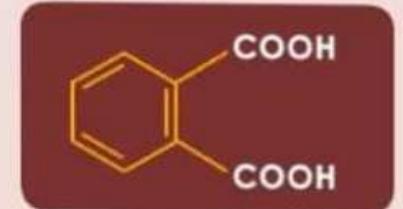
The **Systematic IUPAC name** consist of the corresponding hydrocarbon, in which the final -e is replaced with the suffix -oic (-dioic for dicarboxylic) and the word acid. When the carboxyl group is attached to a ring, the ending -carboxylic acid is added to the name of the parent structure. Many carboxylic acids have common names.

### EXAMPLE :



Propen-oic acid  
(acrylic acid)

Butan-di-oic acid  
(succinic acid)



## USES

- VINEGAR CONTAINS ETHANOIC ACID  
Ethanoic acid is used in the manufacturing of rayon



- ASPIRIN IS A CARBOXYLIC ACID  
It is used for pain relief and prevention of heart attacks



- SOUR FRUITS CONTAIN CITRIC ACID  
Fruits like lemon and orange contain citric acid



- VITAMIN C CONTAINS ASCORBIC ACID  
needed to maintain health of skin, cartilage and bone



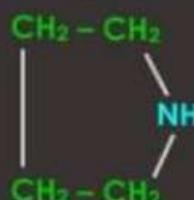
# Amines

Amine are member of a family of nitrogen-containing organic compounds that is derived, either in principle or in practice, from ammonia ( $\text{NH}_3$ ).

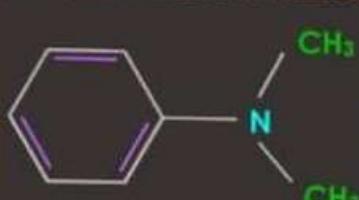
Ethylamine



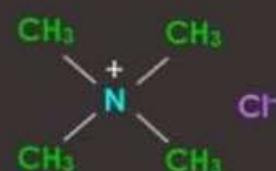
Pyrrolidine



N, N - dimethylaniline



Tetramethylammonium chloride



An open-chain aliphatic primary amine.

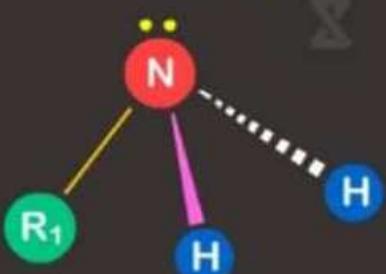
A cyclic aliphatic secondary amine.

An aromatic tertiary amine.

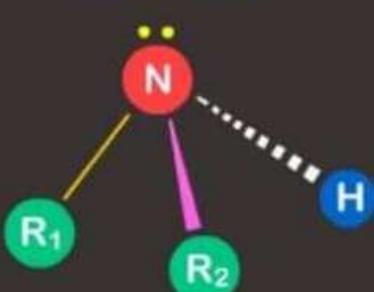
An aliphatic quaternary ammonium salt.

## STRUCTURE OF AMINES

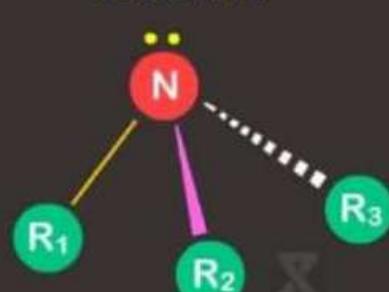
PRIMARY



SECONDARY



TERTIARY



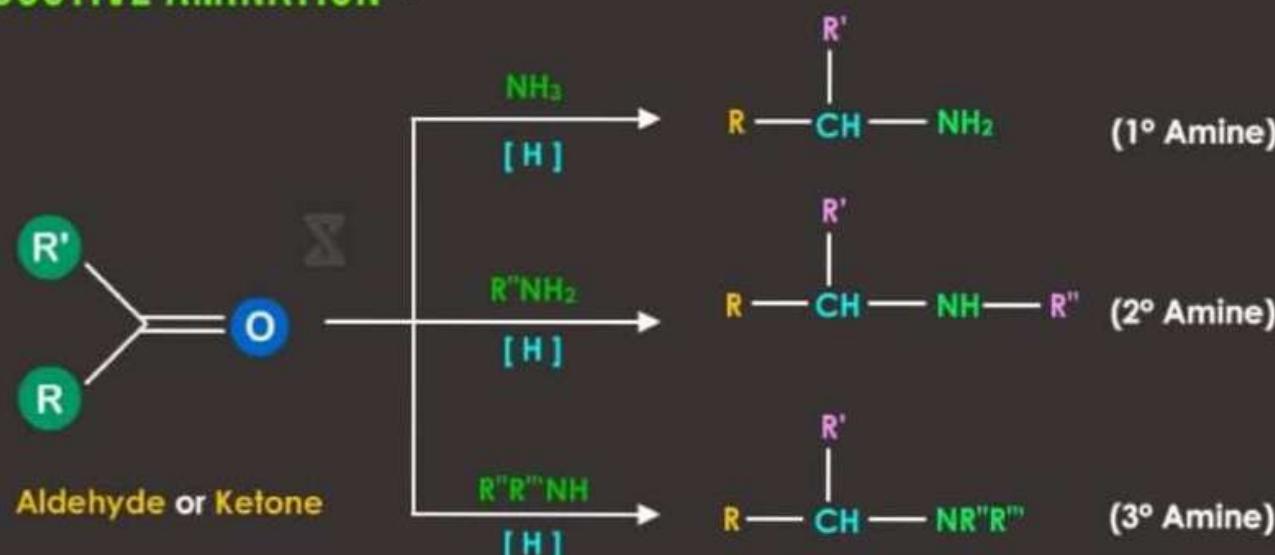
## PROPERTIES

- Water Soluble
- Gaseous at room temperature
- Foul-smelling compounds
- Colourless
- High boiling point
- Burns with a yellow flame

## USES OF AMINES

- Corrosion inhibitors in boilers
- Lubricating oils (morpholine)
- Stabilizers for cellulose
- Nitrate explosives(diphenylamine)
- Protectants against damage from gamma radiation (diarylamines)

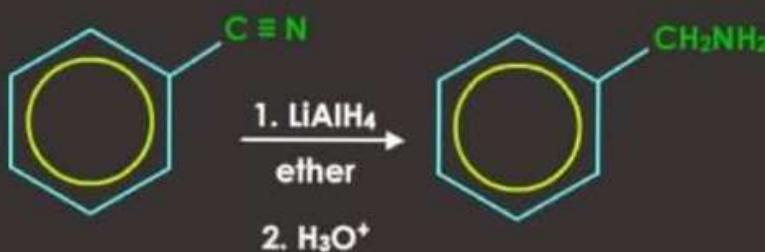
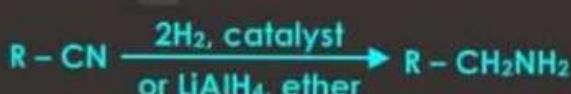
## REDUCTIVE AMINATION



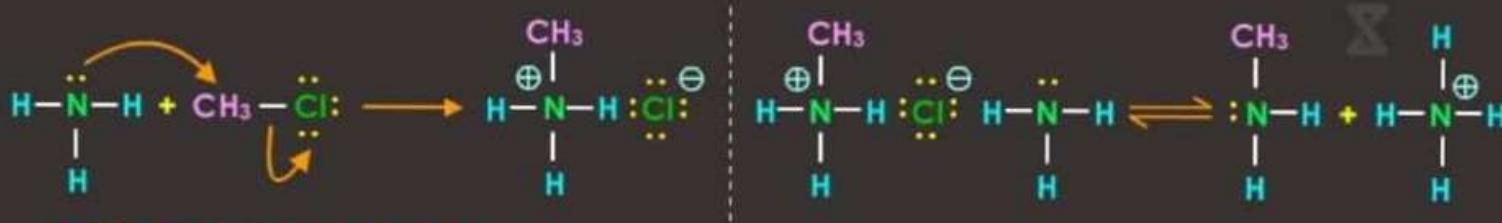
## REDUCTION OF NITRILES

Nitriles can be reduced by strong reducing agent like  $\text{H}_2$  with catalyst (example Ni or  $\text{LiAlH}_4$ ) to yield primary amines via nucleophilic addition reaction.

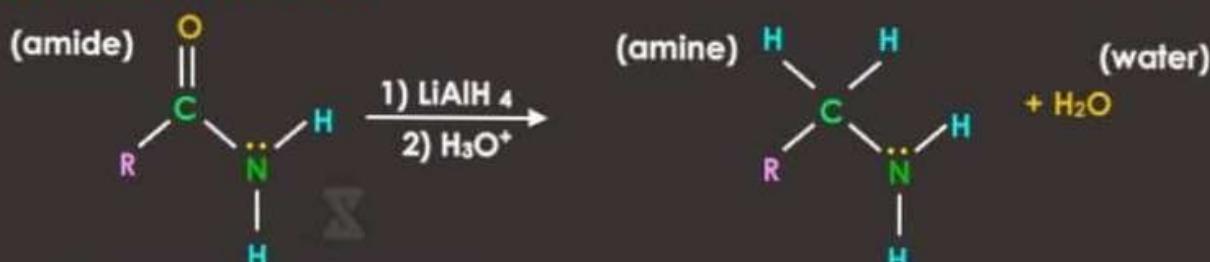
Example :



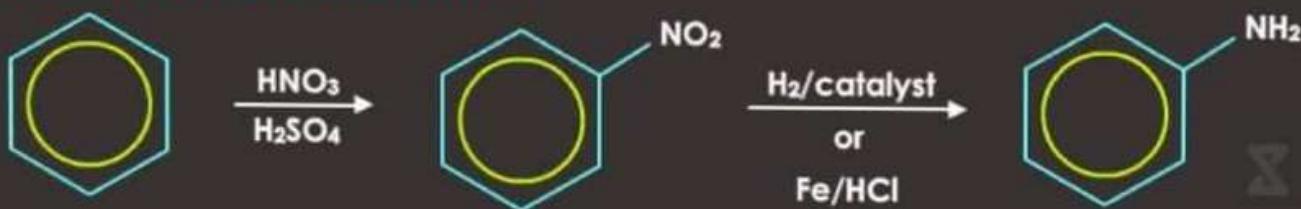
## REACTION OF AMMONIA WITH ALKYL HALIDES

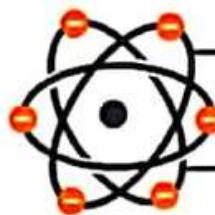


## REDUCTION OF AMIDES



## REDUCTION OF NITRO GROUPS





# HISTORY OF ATOMIC MODEL

**1885**

Johann Balmer derived a formula for mathematically predicting hydrogen spectrum.

J J Thomson discovered Electron



**1897**

Rutherford proposed a model where positive charge is at the center, and electron moves around in a spiral path and loses energy.

J J Thomson proposed plum pudding model



**1904**

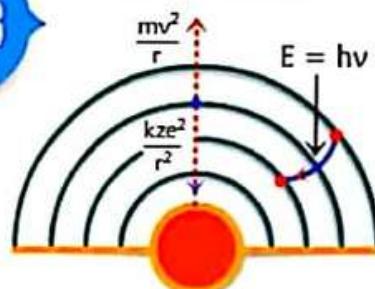
**1911**

## Bohr's Atomic Model

$$r = 0.529 \times \frac{n^2}{Z} \text{ Å}$$

$$\frac{kze^2}{r^2} = \frac{mv^2}{r}$$

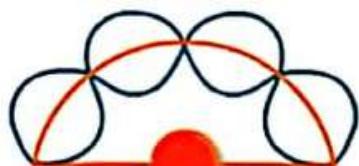
**1913**



- Worked with J J Thomson and found flaws in his theory.
- He proposed electron revolves around nucleus in orbits.
- Electron is stabilized by centripetal and electrostatic forces.
- Electrons don't lose energy in an orbit.
- Electron loses or gains energy by moving across orbits.
- He proved Balmer was right by deriving his formula theoretically.
- Only applicable for one electron systems.
- Failed to predict dual nature of electron.

**1923**

De Broglie introduced the concept of dual nature in electrons. He used Einstein's  $E = mc^2$  and proposed any moving particle or object has an associated wave.



Erwin Schrodinger developed electron cloud model using de Broglie and Bohr's atomic model. He and Heisenberg determined the regions in which electron would be likely found. He introduced one concept of orbitals.

**1925**



# HYDROGEN SPECTRUM

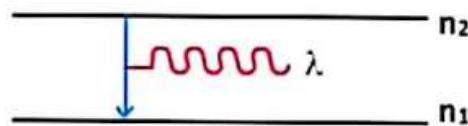
## Bohr's model

Niels Bohr proposed a model for the hydrogen atom that explained the spectrum of the hydrogen atom. The Bohr model was based on the following assumptions.

- The electron in a hydrogen atom travels around the nucleus in a circular orbit.
- The energy of the electron in an orbit is proportional to its distance from the nucleus. The further the electron is from the nucleus, the more energy it has.
- Only a limited number of orbits with certain energies are allowed. In other words, the orbits are quantized.
- The only orbits that are allowed are those for which the angular momentum of the electron is an integral multiple of Planck's constant divided by  $2\pi$ .

$$L = \frac{nh}{2\pi} \quad (\text{where } h = \text{Planck's constant})$$

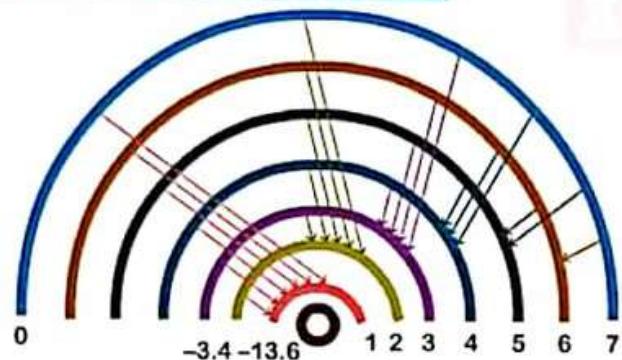
- Light is absorbed when an electron jumps to a higher energy orbit and emitted when an electron falls into a lower energy orbit.
- The energy of the light emitted or absorbed is exactly equal to the difference between the energies of the orbits.
- When electron in an excited atom comes back from higher energy level ( $n_2$ ) to lower energy level ( $n_1$ ) then it emits a photon, having energy equal to difference in energy levels.
- $h\nu = \Delta E = E_{n_2} - E_{n_1}$



Wavelength or wave no. of any line of any one electron species can be calculated as

$$\frac{1}{\lambda} = R_H Z^2 \left[ \frac{1}{n_1^2} - \frac{1}{n_2^2} \right], \quad \frac{hc}{\lambda} = \Delta E$$

## Different series



## Successes

- Combining successfully Rutherford's solar system's model, with the Planck hypothesis on the quantified energy states at atomic level and Einstein's photons
- Explaining the atomic emission and absorption spectra
- Explaining the general features of the periodic table
- First working model for the atom

### LYMAN SERIES

$n_f = 1$

$n_i = 2, 3, 4, 5, \dots$

ULTRAVIOLET

### BALMER SERIES

$n_f = 2$

$n_i = 3, 4, 5, 6, \dots$

VISIBLE

### PASCHEN SERIES

$n_f = 3$

$n_i = 4, 5, 6, 7, \dots$

INFRARED

### BRACKETT SERIES

$n_f = 4$

$n_i = 5, 6, 7, \dots$

INFRARED

### PFUND SERIES

$n_f = 5$

$n_i = 6, 7, \dots$

FAR INFRARED

### HUMPHREY SERIES

$n_f = 6$

$n_i = 7, 8, \dots$

FAR INFRARED

# QUANTUM NUMBER

## THE ELECTRON'S ADDRESS



GPS is used to track anyone at any place on the earth.

$n, \ell, m$

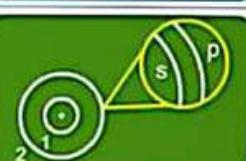
Similarly Quantum Numbers are used to identify the position of an electron in an atom.

### QUANTUM NUMBER



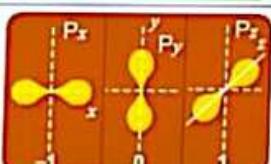
#### Principal Quantum Number ( $n$ )

Represents the orbit number in an atom.  
It is denoted by letter ' $n$ '.



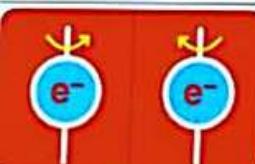
#### Azimuthal Quantum Number ( $\ell$ )

Represents the shape of an orbital in atom.  
It is denoted by letter ' $\ell$ ' and its value vary from 0 to ' $n$ '.



#### Magnetic Quantum Number( $m_\ell$ )

Represents the orientation of an orbital in the space. It is denoted by letter ' $m_\ell$ ' and its value vary from  $\ell$  to  $-\ell$ .



#### Spin Quantum Number( $m_s$ )

Represents the spin of an electron.  
It is denoted by  $m_s$  and each electron has an orbital either  $\frac{1}{2}$  or  $-\frac{1}{2}$ .

### DIFFERENCE BETWEEN BOTH ATOMIC MODELS

Bohr's model is a 2-Dimensional model.  
Therefore he used only Principal quantum number ( $n$ ) to identify the position of an electron in an atom.



Schrodinger's model is a 3-Dimensional model. Therefore he used  $n, \ell, m$  to identify the position of an electron in an atom.



### Hide Something at $n = 1, \ell = 1, m_\ell = 0, m_s = \frac{1}{2}$

Quantum numbers have some restrictions. It's not possible to find an electron at every possible combination of  $n, \ell, m, s$ . So you will never find an electron at above point.

No two electrons in an atom have same Quantum Number.

$n = 2$        $\ell = 1$   
 $m = 0$        $s = \frac{-1}{2}$

$2P_x$   
-1 ↓ →

$n = 2$        $\ell = 1$   
 $m = 0$        $s = \frac{1}{2}$

# CARBOHYDRATES



Carbohydrates are the **sugars**, **starches** and **fibers** found in **fruits**, **grains**, **vegetables** and **milk** products. They are called carbohydrates because at the chemical level, they contain carbon, hydrogen and oxygen.

## NUTRITION FACTS

Serving size 1 Large Apple

Amount Per Serving

Calories 130 Calories from Fat 0

Total Fat 0g

Saturated Fat 0g

Trans Fat 0g

Cholesterol 0g

Sodium 0g

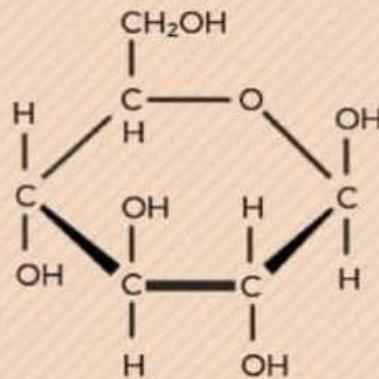
Total Carbohydrate 34g

Dietary Fiber 5g

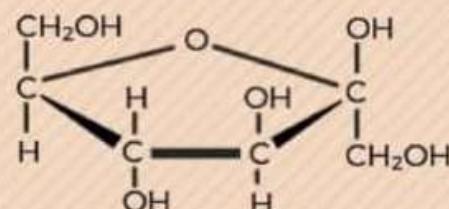
Sugars 5g

Protein 1g

### GLUCOSE



### FRUCTOSE



## SIMPLE CARBOHYDRATES

### Sources of Carbohydrates

- Fruits
- Candy
- Milk
- Sugary Beverages

## CARBOHYDRATES BENEFITS

- Mental health
- Weight loss
- Good source of nutrients
- Heart health

## COMPLEX CARBOHYDRATES

**Grains:** Grains are good source of fiber, as well as **potassium**, **magnesium** and **selenium**. Choose less processed, whole grains such as quinoa, buckwheat, and whole-wheat pasta.

**Fiber-Rich Fruits:** Such as **apples**, **berries**, and **bananas** (avoid canned fruit, as they usually contain added syrup).

**Fiber-Rich Vegetables:** Eat more of all your veggies, including **broccoli**, **leafy greens**, and **carrots**.

**Beans:** Aside from **fiber**, these are good sources of folate, iron, and potassium.

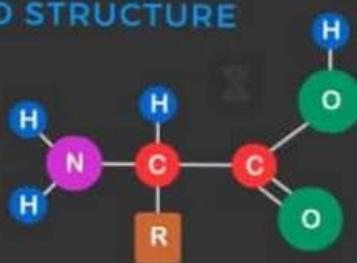
## FUNCTION OF CARBOHYDRATES

Carbohydrates provide fuel for the central nervous system and energy for working muscles. They also prevent protein from being used as an energy source and enable fat metabolism.

# Amino Acids

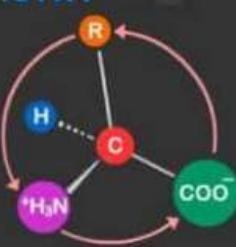
## GENERAL AMINO ACID STRUCTURE

At **physiological** condition, the head group is positively charged and the tail group is negatively charged.



## AMINO ACID STEREOCHEMISTRY

Most natural amino acids have the S or L stereochemistry about the  $\alpha$  carbon. Notice the direction of the arrows from the highest atomic number atoms to the lowest. This is the same direction as when you would write the top part of the letter S or the direction that you would write an L.

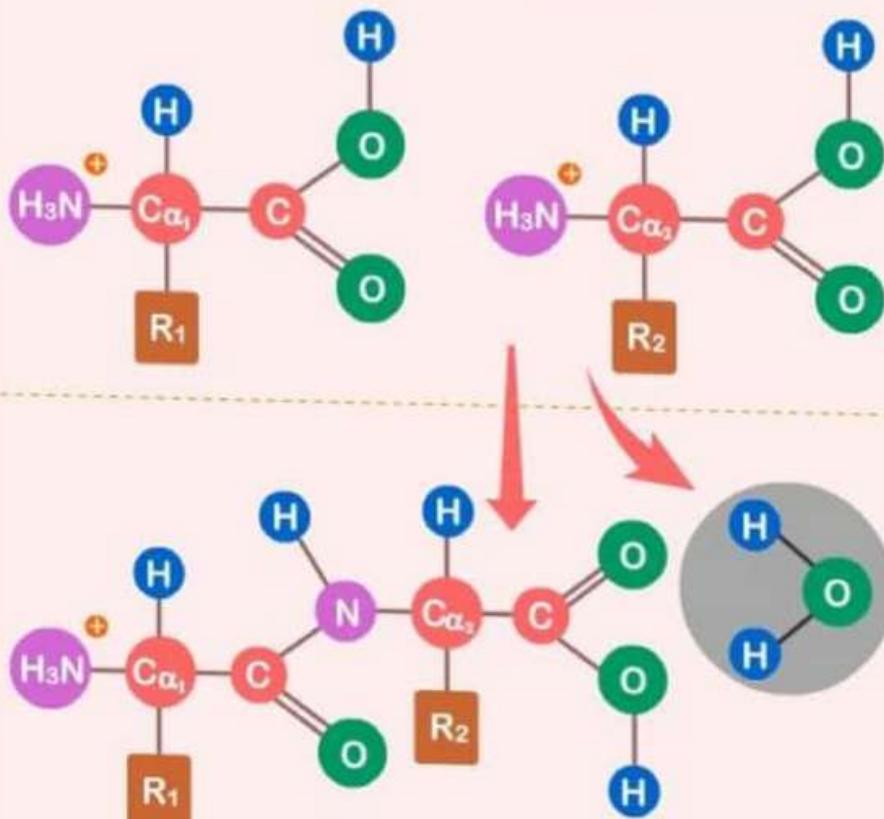


## PERIODIC CHART OF AMINO ACIDS

	Basic	Non-Polar (hydrophobic)	Polar, Uncharged	Acidic
His 155.16 <chem>C#CcN2C=CN=C2</chem> Histidine				
Arg 174.20 <chem>C#CcN2C=NN=C2</chem> Arginine				
Lys 136.19 <chem>C#CcN2CCCC=C2</chem> Lysine				
Ile 113.16 <chem>C#CcN2CCCC=C2</chem> Isoleucine				
F 165.19 <chem>C#CcN2CCCC=C2</chem> Tryptophan				
Phe 147.18 <chem>C#CcN2CCCC=C2</chem> Phenylalanine				
A 89.09 <chem>C#CcN2CCCC=C2</chem> Alanine				
M 149.21 <chem>C#CcN2CCCC=C2</chem> Methionine				
W 204.23 <chem>C#CcN2CCCC=C2</chem> Proline				
Trp 186.21 <chem>C#CcN2CCCC=C2</chem> Valine				
C 121.16 <chem>C#CcN2CCCC=C2</chem> Cysteine				
N 132.12 <chem>C#CcN2CCCC=C2</chem> Asparagine				
V 117.15 <chem>C#CcN2CCCC=C2</chem> Valine				
Gly 57.07 <chem>C#CcN2CCCC=C2</chem> Glycine				
Ser 87.08 <chem>C#CcN2CCCC=C2</chem> Serine				
Tyr 163.17 <chem>C#CcN2CCCC=C2</chem> Tyrosine				
Asn 114.10 <chem>C#CcN2CCCC=C2</chem> Aspartic Acid				
Glut 146.15 <chem>C#CcN2CCCC=C2</chem> Glutamine				
E 147.13 <chem>C#CcN2CCCC=C2</chem> Glutamic Acid				
D 133.10 <chem>C#CcN2CCCC=C2</chem> Aspartic Acid				
Glut 129.11 <chem>C#CcN2CCCC=C2</chem> Threonine				
Thr 101.10 <chem>C#CcN2CCCC=C2</chem> Threonine				

Legend:  
 ↓ 1-letter amino acid code  
 ← Relative molecular mass  
 → Molecular formula  
 ← Ser → 3-letter Amino acid code  
 ← 101.10 → MW-H<sub>2</sub>O Molecular weight in water  
 ← C<sub>4</sub>H<sub>9</sub>NO<sub>2</sub> → Chemical structure  
 ← 87.08 → Chemical name

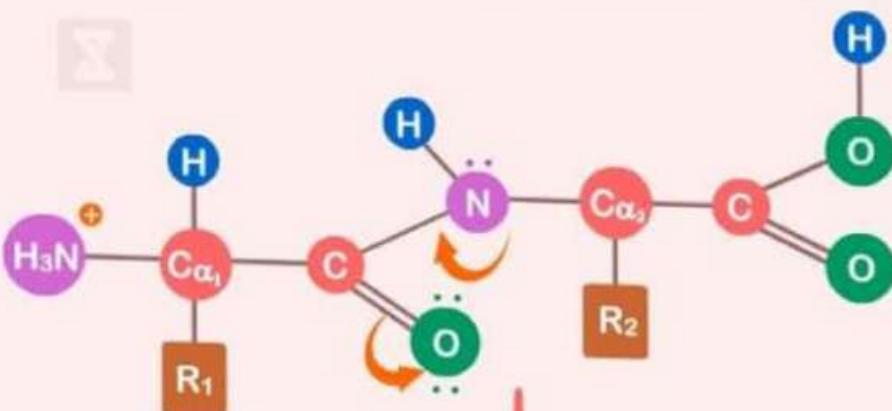
# THE PEPTIDE BOND

Amino acid  $\alpha_1$ Amino acid  $\alpha_2$ 

When two amino acids come together, a reaction can occur between the carboxylic tail of the leading end with the amine head of the trailing end.

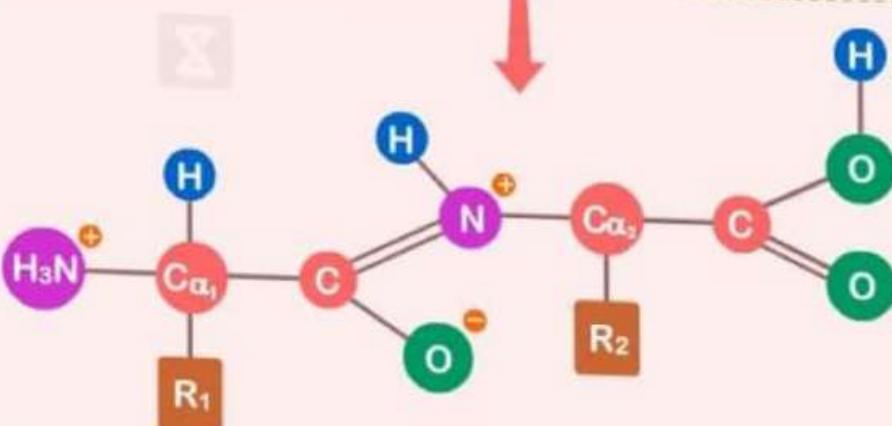
Each amino acid gives up a part of itself in a dehydration reaction and the product of their interaction is the peptide bond.

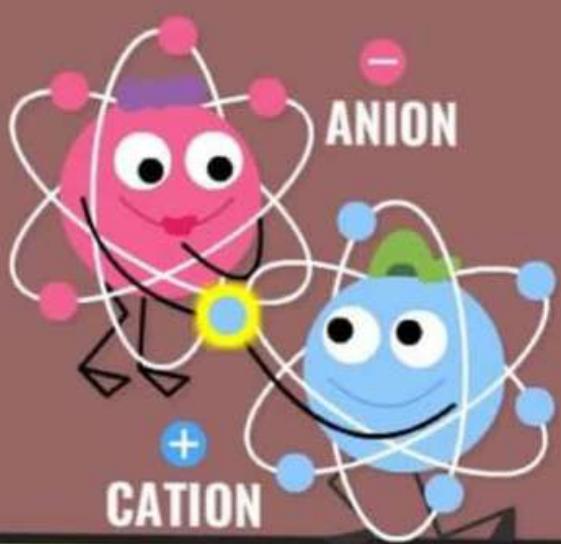
The new bond enjoys a type of resonance that strengthens it as the electrons about the nitrogen and oxygen delocalize producing a partial double bond.



The result of this resonance makes this bond difficult to rotate since the newly formed electron clouds are stabilized and do not like to bump into things.

Peptide bonds form a rigid backbone for the many proteins it is a part of.





# IONIC COMPOUNDS

## DEFINITION

Ionic Compound is formed due to creation of an ionic bond which is the electrostatic attraction between a **cation (+ charge)** and an **anion (- charge)** generally involving a metal and a non-metal.

## NOMENCLATURE

Charges are written because ions are either positive or negative.

- Name the **cation first**, followed by the anion
- Anion must end in **ide** (drop the last few letters)
- Roman Numerals must be used for metals with more than one charge (e.g. transition metals)

Ex :  $\text{NaCl}$  = Sodium chloride

Ex :  $\text{CuCl}_2$  = Copper (II) chloride

## EXAMPLES

Some examples of Ionic compounds are **Sodium Chloride** , **Lithium Iodide**, **Potassium Iodide** and **Sodium Fluoride**.

### SODIUM CHLORIDE ( $\text{NaCl}$ )

Some of sodium chloride's use includes consumption, production and is **naturally occurring**.



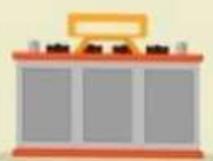
### POTASSIUM IODIDE (KI)

Potassium iodide tablets are given to people exposed to high level of radiation.



### LITHIUM IODIDE (LiI)

Lithium iodide is commonly used in batteries, pacemakers and solar power generator.



### SODIUM FLUORIDE (NaF)

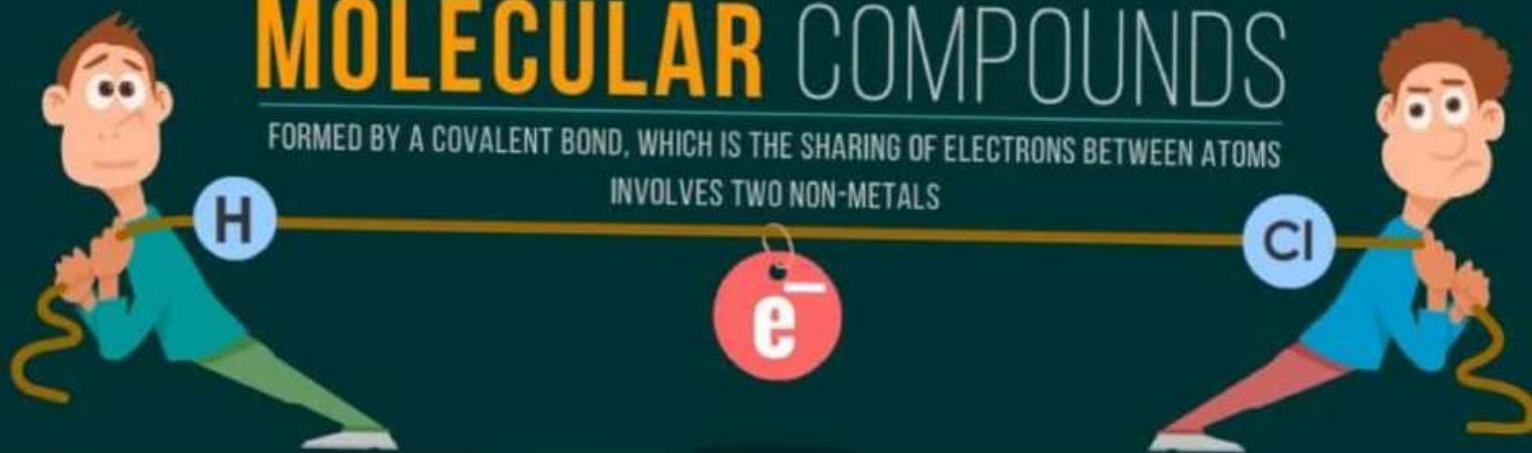
Sodium fluoride is used in medical treatment, water purification and cleaning solutions.



# MOLECULAR COMPOUNDS

FORMED BY A COVALENT BOND, WHICH IS THE SHARING OF ELECTRONS BETWEEN ATOMS

INVOLVES TWO NON-METALS



## NOMENCLATURE

- Ionic charges cannot be written because it is composed of molecules, not ions.
- Prefix :- mono, di, tri, tetra, penta, hexa, hepta, octa, nona, deca.
- Name the elements in the order listed.
- Use prefixes to indicate the number of each atom of each element (mono can only be used on the second non-metal).
- The first element includes prefix + element name.
- The second element includes the prefix + the element name + ide ending (drop the last few letters).

Eg : hydrogen chloride = HCl

Eg : phosphorus pentachloride = PCl<sub>5</sub>

## PROPERTIES



LOW  
MELTING  
POINTS



MORE  
FLAMMABLE



NOT  
SOLUBLE  
IN WATER



SOFTER  
AND  
SQUISHIER

## SOME EXAMPLES OF MOLECULAR COMPOUNDS



### DIHYDROGEN MONOXIDE (H<sub>2</sub>O)

Dihydrogen monoxide or water is vital for our survival, used in our daily needs.



### SILICON DIOXIDE (SiO<sub>2</sub>)

Silicon dioxide is used for construction and is found naturally in sand and quartz.



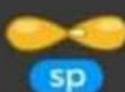
### CARBON DIOXIDE (CO<sub>2</sub>)

Some uses of carbon dioxide are carbonation of liquids and green house effect.



### SULPHUR DIOXIDE (SO<sub>2</sub>)

Sulphur dioxide is used for food preservation and acts as a disinfectant.



# HYBRIDISATION

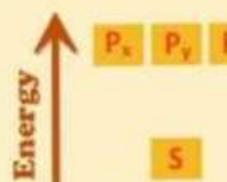


sp<sup>3</sup>

## ANALOGY FOR HYBRIDISATION



Combines



Combines

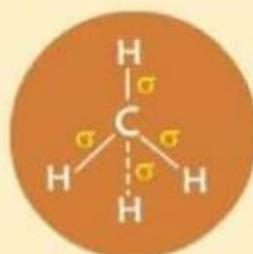


Four different sized mud balls combine to from equal shaped balls.

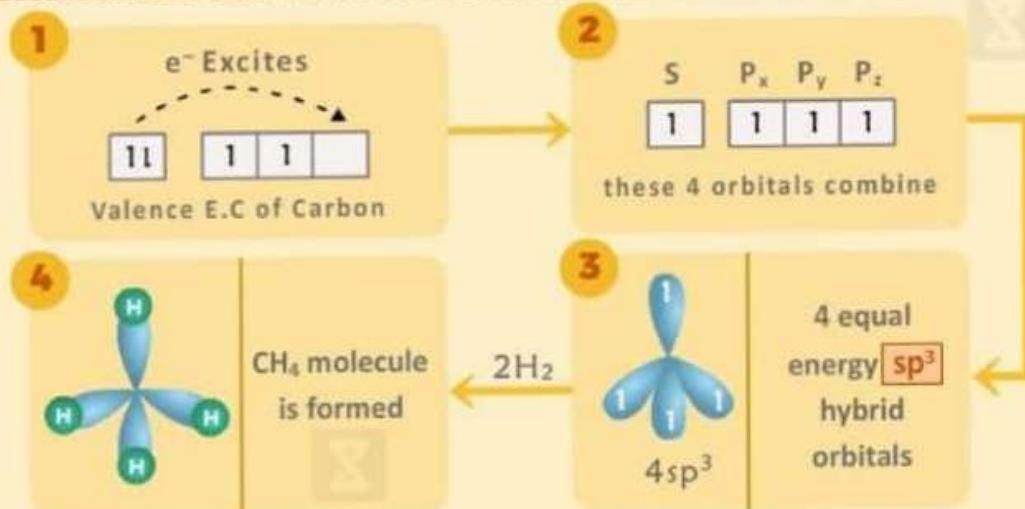
Similarly, orbitals of different energy combineto form equal energy orbitals.

## HYBRID ORBITALS ARE USED IN FORMING SIGMA BONDS

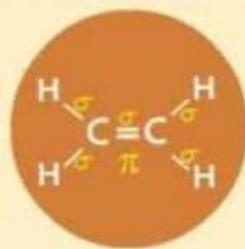
### Formation of CH<sub>4</sub>



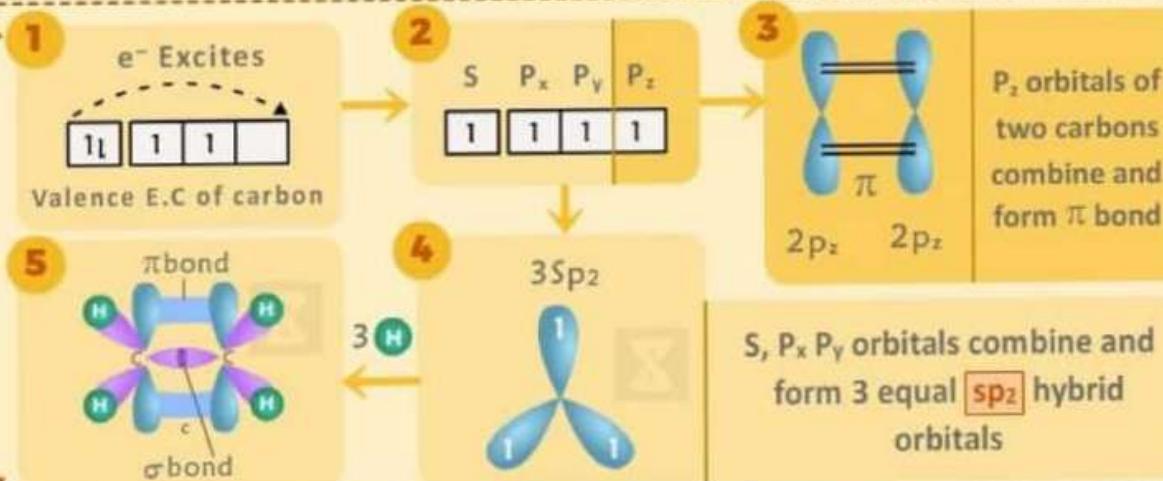
Here carbon needs to form 4 sigma Bonds.



### Formation of C<sub>2</sub>H<sub>4</sub>



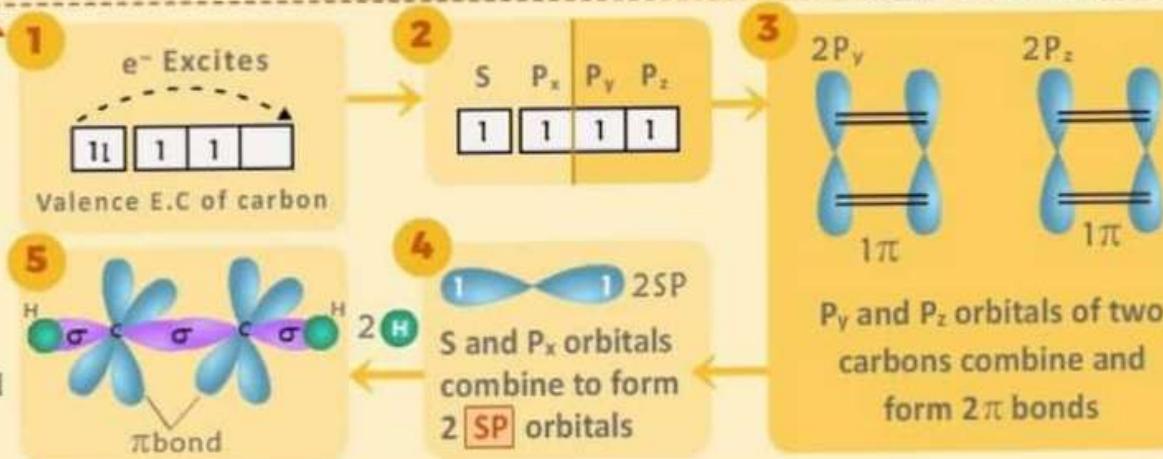
Here each carbon needs to form 3 sigma and 1 pi Bonds.



### Formation of C<sub>2</sub>H<sub>2</sub>



Each carbon needs to form 2 sigma and 2pi Bonds.

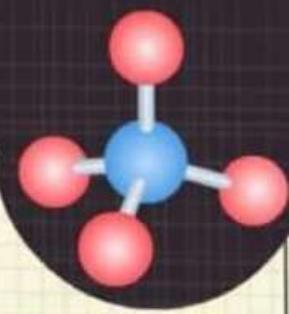


# VSEPR & SHAPES OF MOLECULES

## Bonding Pairs & Lone Pairs

Lone pairs in a molecule lie closer to the central atom, hence they repel more than a bonded pair. The order of strengths of repulsion is :

LONE PAIR/LONE PAIR > BONDED PAIR/LONE PAIR > BONDED PAIR/BONDED PAIR



### Shapes with different electron pair : (ep)

**2**  
ep :

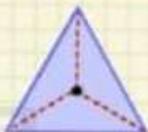
#### Linear



$\text{AX}_2$   
2 bond pairs  
0 lone pairs

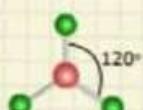
**3**  
ep :

#### Trigonal-Planar



$\text{AX}_3$   
3 bond pairs  
0 lone pairs

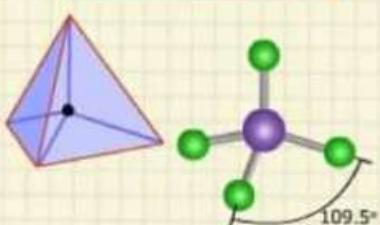
#### Bent



$\text{SnCl}_2$   
2 bond pairs  
1 lone pairs

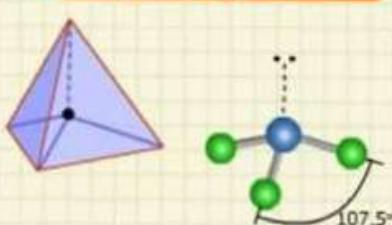
**4**  
ep :

#### Tetrahedral



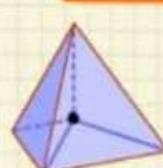
Methane ( $\text{CH}_4$ )  
4 bond pairs  
0 lone pairs

#### Trigonal pyramidal



Ammonia ( $\text{NH}_3$ )  
3 bond pairs  
1 lone pairs

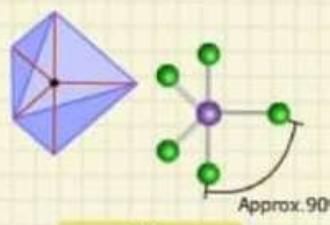
#### Bent



Water ( $\text{H}_2\text{O}$ )  
2 bond pairs  
2 lone pairs

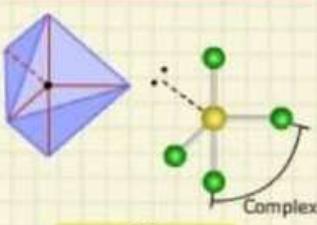
**5**  
ep :

#### Trigonal Bipyramidal



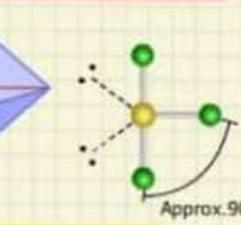
$\text{PF}_5$   
5 bond pairs  
No lone pairs

#### See Saw



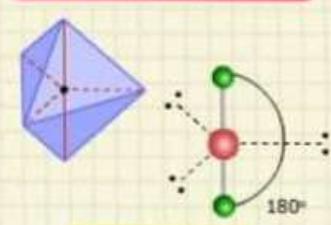
$\text{SF}_4$   
4 bond pairs  
1 lone pairs

#### T-Shaped



$\text{ICl}_3$   
3 bond pairs  
2 lone pairs

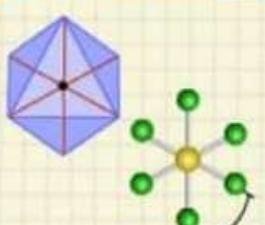
#### Linear



$\text{BrF}_2^-$   
2 bond pairs  
3 lone pairs

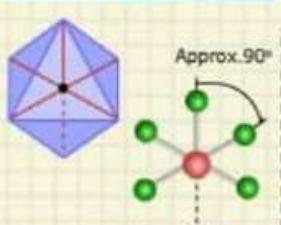
**6**  
ep :

#### Octahedral



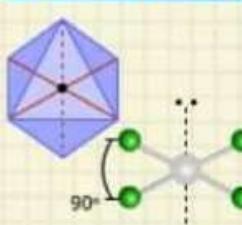
$\text{SF}_6$   
6 bond pairs  
No lone pairs

#### Square-pyramidal



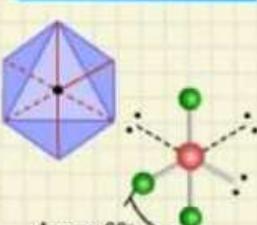
$\text{BrF}_5$   
5 bond pairs  
1 lone pairs

#### Square-planar



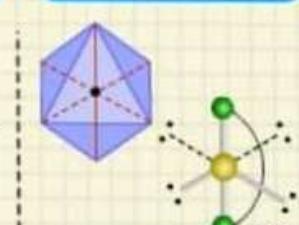
$\text{XeF}_4$   
4 bond pairs  
2 lone pairs

#### T-Shaped



$\text{ClF}_3$   
3 bond pairs  
3 lone pairs

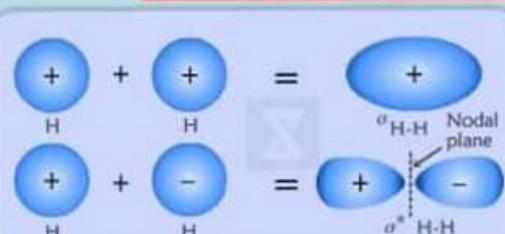
#### Linear



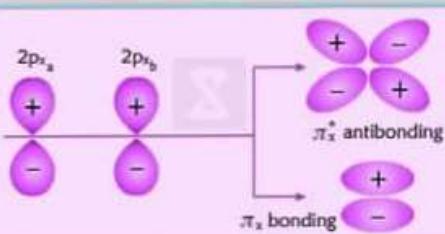
$\text{XeF}_2$   
2 bond pairs  
4 lone pairs

# MOLECULAR ORBITAL THEORY

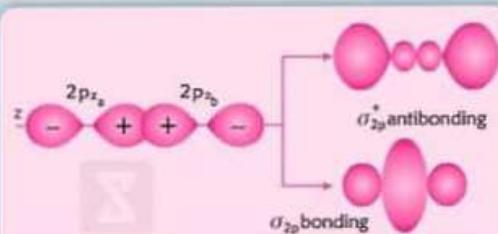
MOT explains the bonding and stability of Molecules by forming Molecular orbitals



S-orbital of one atom combines with s-orbital of another atom constructively and destructively to form  $\sigma$  and  $\sigma^*$  molecular orbitals.

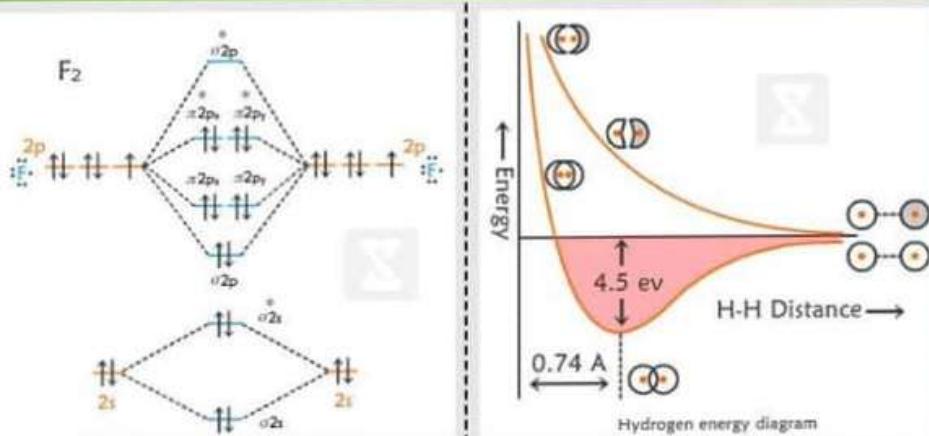


$p_x$  orbital of one atoms combines with  $p_x$  of another atom to form  $\sigma$  and  $\sigma^*$  orbitals.



$p_y$  and  $p_z$  orbitals combine and forms  $\pi$  and  $\pi^*$  orbitals.

Energy Diagram of Molecular Orbitals



Bond Order

$$\text{Bond order} = \frac{1}{2} \left[ \begin{array}{l} \text{Number of} \\ \text{Bond of} \\ \text{electron in} \\ \text{bonding} \\ \text{orbitals} \end{array} - \begin{array}{l} \text{Number of} \\ \text{Bond of} \\ \text{electrons} \\ \text{in anti-bonding} \\ \text{orbitals} \end{array} \right]$$

Bond	$H_2^+$	$H_2$	$He_2^+$	$He_2$
Bond Order	$\frac{1}{2}$	1	$\frac{1}{2}$	0

The bond order must be **positive non-zero** for a bond to be stable.  $He_2$  has a bond order of zero and that is why the  $He_2$  molecule is not observed.

# CHEMICAL EQUILIBRIUM



## EQUILIBRIUM CONSTANT 'K'

For a General Reaction  $aA + bB \rightleftharpoons pP + qQ$

The equilibrium constant expression is

$$K_c = \frac{[P]^p [Q]^q}{[A]^a [B]^b}$$

where  $K_c$  is the Equilibrium Constant (or  $K_p$  if they are all gases)

## RELATION BETWEEN $K_p$ AND $K_c$

For the Reaction  $aA + bB \rightleftharpoons cC + dD$

$$K_p = \frac{[p_C]^c \times [p_D]^d}{[p_A]^a \times [p_B]^b} = \frac{[C]^c [D]^d}{[A]^a [B]^b} \frac{(RT)^{c+d}}{(RT)^{a+b}}$$

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

$$\text{if } \Delta n_g = 0 \Rightarrow K_p = K_c$$

Where,  $\Delta n_g = (c+d) - (a+b)$

= no. of moles of gaseous products - no. of moles of gaseous Reactants

## WHAT DOES THE VALUE OF 'K' MEAN ?

(a)  $K \gg 1$

Reactants

Products

If  $K \gg 1$ , the reaction is product-favoured; product predominates at Equilibrium.

(a)  $K \ll 1$

Reactants

Products

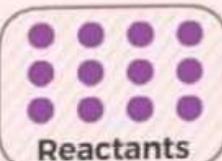
If  $K \ll 1$ , the reaction is reactant-favoured; reactant predominates at Equilibrium.

(a)  $K = 1$

The reaction lies in the middle (mix of reactants and products)

## MAGNITUDE OF 'K'

Small ( $K < 10^{-3}$ )



Mostly Reactants

Intermediate ( $10^{-3} \leq K \leq 10^3$ )



Significant amounts of reactants and products



Large ( $K > 10^3$ )



Mostly Products

# It's Le Chatelier's Principle



If a dynamic equilibrium is disturbed by changing the conditions, the position of equilibrium moves to counteract the change.



i will  
destroy your  
equilibrium



i will  
re-establish  
it

Change	Reactants	Products	Counteract
I will increase reactant concentration	$a A + b B \rightleftharpoons$	c C + d D	Then I will shift the reaction forward
I will steal products			I will shift the reaction forward
I will increase pressure			I will reduce number of moles
I will decrease pressure			Then I'll increase number of moles
I will heat up your exothermic reaction			I'll shift the reaction backward
I will put your endothermic reaction in ice			I'll warm it up by forward reaction
I will catalyze your reaction			Hahaha.... It won't disturb my equilibrium
I will add noble gases to your reaction			Hahaha.... It won't disturb my equilibrium
How did you bypass my tricks ?			It's Le Chatelier's principle dear !

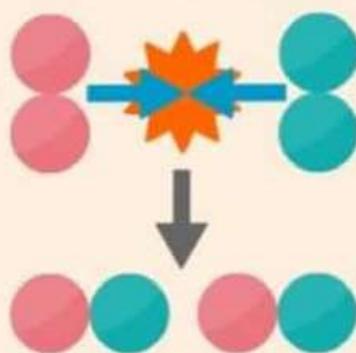
# CHEMICAL KINETICS



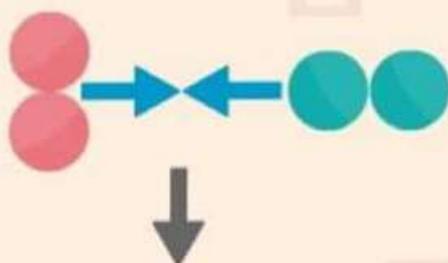
## MAKING CHEMICAL REACTION HAPPEN FASTER

There are a number of different things that we can change to make a chemical reaction faster. Here, we explain the concept of collision theory, and how it can be used to explain the effects of five different factors on the rate of a chemical reaction.

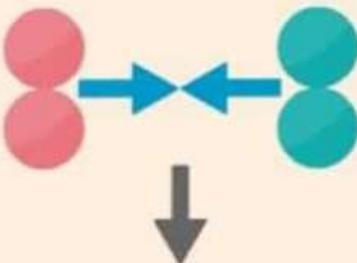
### COLLISION THEORY



Correct Orientation  
Sufficient Energy



NO REACTION



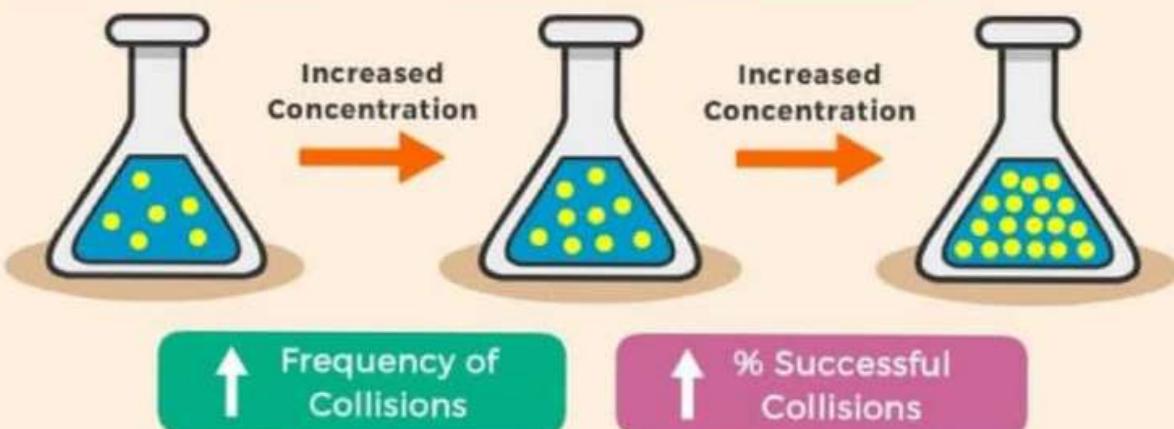
NO REACTION

Wrong Orientation

Insufficient Energy

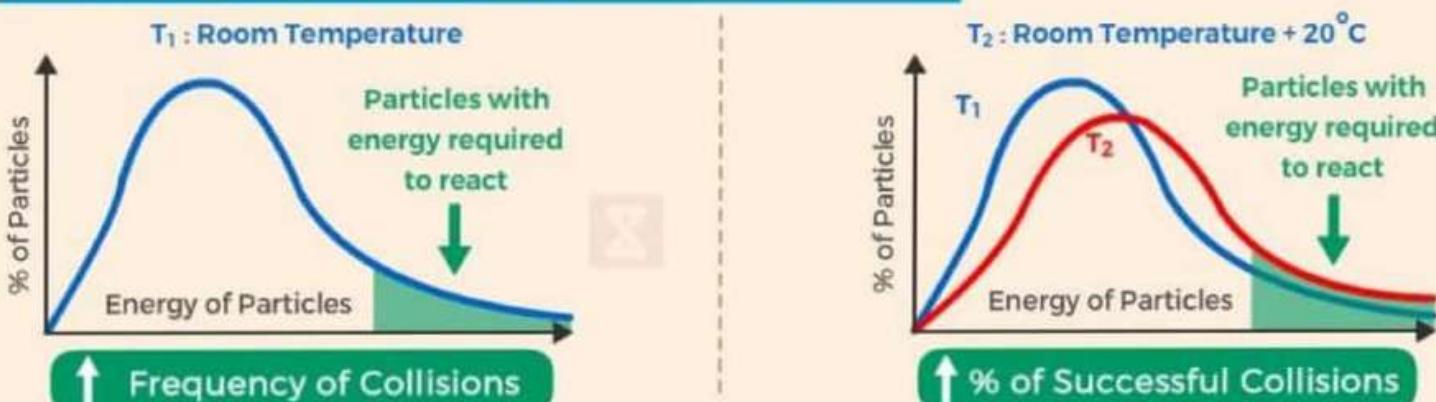
Collision theory states that for a reaction to occur, particles must collide with the **correct orientation** and with **sufficient energy** for a reaction to occur. Different factors affect the rate of the reaction by affecting the frequency of particle collisions, and the proportion of collisions that have enough energy to react.

### 01 INCREASE CONCENTRATION OF REACTANTS



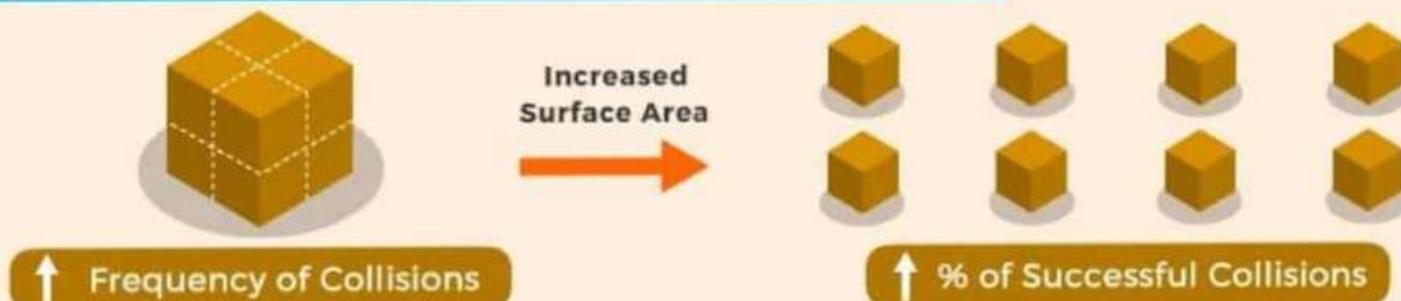
Increasing the concentration of reactants in solution increases the rate of reaction as there are a greater number of particles to react. This increases the frequency of collision between particles.

## 02 INCREASE TEMPERATURE OF REACTION



Increasing the temperature increases the kinetic energy of particles. This increases the frequency of particle collisions and a greater proportion of collisions will have the sufficient energy required to react.

## 03 INCREASE SURFACE AREA OF REACTANTS



Increasing the surface area of solid reactants increases the number of particles that are exposed and available to react and as a consequence this increases the frequency of particle collisions, thus increasing the rate.

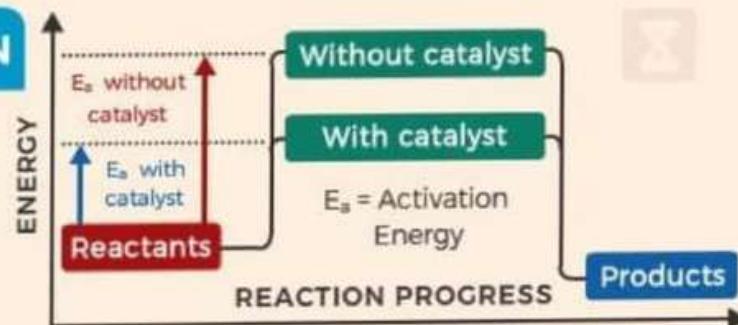
## 04 INCREASES PRESSURE OF REACTION



Increasing the pressure of a reaction involving gases, forces the gas particles closer together. This will increase the frequency of particle collisions and therefore increases the rate of reaction.

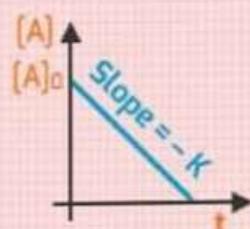
## 05 USE A CATALYST IN A REACTION

A catalyst provides an alternative route for the reaction with a lower activation energy. This means that particle collisions need less energy in order for a reaction to occur, thus increasing the rate of the reaction.



# ORDER OF REACTION

## Zero Order Reactions



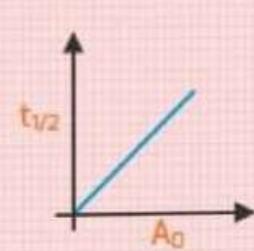
A zero order reaction has a constant rate that is independent of the concentration of the reactant(s); the rate law is simply.

$$\text{Rate} = k$$

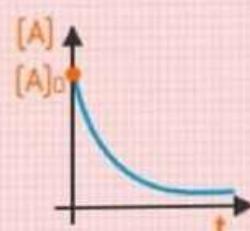
### HALF LIFE ( $t_{1/2}$ )

Time in which half of initial amount is left.

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



## First Order Reactions

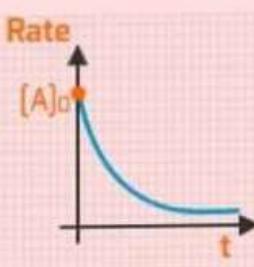


A first-order reaction is a reaction that proceeds at a rate that depends linearly on only one reactant concentration.

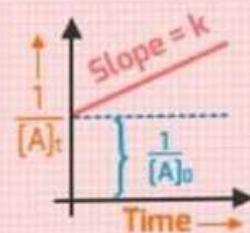
$$k = \frac{2.303}{t} \log \frac{[A]_0}{[A]}$$

### HALF LIFE ( $t_{1/2}$ )

$$t_{1/2} = \frac{0.693}{k} \quad [A] = \frac{[A]_0}{2^n}$$



## Second Order Reactions

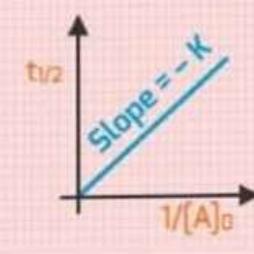


A chemical reaction in which the rate of the reaction is determined by the concentration of two chemical reactants involved or the square of the concentration of one chemical reactant.

$$k = \frac{1/[A] - 1/[A]_0}{t}$$

### HALF LIFE ( $t_{1/2}$ )

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

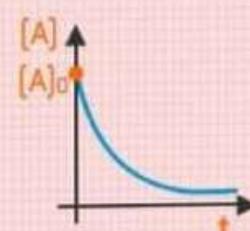


## Pseudo first order reactions

If the **concentration** of a reactant remains constant (because it is a catalyst or it is in great excess with respect to the other reactants), its concentration can be included in the rate constant, obtaining a pseudo-first-order (or occasionally **pseudo-second-order**) rate equation.

For example, the hydrolysis of sucrose in acid solution rate  $r = k[\text{sucrose}]$ . The true rate equation is third-order,  $r = k[\text{sucrose}][\text{H}^+][\text{H}_2\text{O}]$ ; however, the **concentrations** of both the catalyst  $\text{H}^+$  and the solvent  $\text{H}_2\text{O}$  are normally constant, so that the reaction is pseudo-first-order.

## $N^{\text{th}}$ order reactions

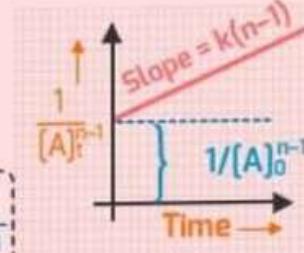


$N^{\text{th}}$  order reaction is one which proceeds at the rate that depends on concentration of multiple reactants or on multiple steps.

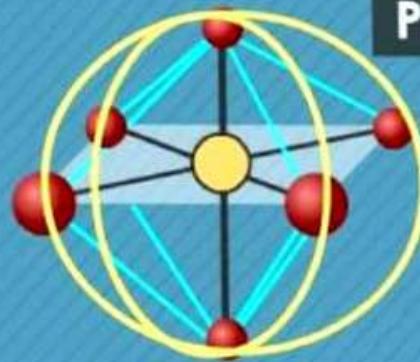
$$\Rightarrow k = \frac{1}{(n-1)t} \left[ \frac{1}{[A]_t^{n-1}} - \frac{1}{[A]_0^{n-1}} \right]$$

### HALF LIFE ( $t_{1/2}$ )

$$t_{1/2} = \lim_{x \rightarrow n} \frac{2^{x-1}-1}{(x-1)k[A]_0^{x-1}}$$



# ISOMERISM IN COORDINATION COMPOUND



## STRUCTURAL ISOMERISM

### 1 LINKAGE ISOMERISM



This type of isomerism is shown by the coordination compounds having ambidentate ligands.

$[\text{Co}(\text{NH}_3)_5(\text{NO}_2)]\text{Cl}$  and  $[\text{Co}(\text{NH}_3)_5(\text{ONO})]\text{Cl}$  or pentammine nitrito - N Cobalt (III) chloride and pentaammine nitrito - O' Cobalt (III) chloride.

### 2 COORDINATION ISOMERISM



This type of isomerism arises from the interchange of ligands between cationic and anionic complexes of different metal ions present in a complex.



$[\text{Cr}(\text{NH}_3)_6]$   $[\text{CO}(\text{CN})_6]$  and  $[\text{CO}(\text{NH}_3)_6]$   $[\text{Cr}(\text{CN})_6]$

### 3 IONISATION ISOMERISM

This isomerism arises due to the exchange of ionisable anion with anionic ligand.

$[\text{Co}(\text{NH}_3)_5]\text{SO}_4\text{Br}$  and  $[\text{Co}(\text{NH}_3)_5\text{Br}]\text{SO}_4$

### 4 SOLVATE ISOMERISM



This is also known as hydrate isomerism. In this isomerism, water is taken as solvent. It has different number of water molecules in the coordination sphere and outside it.



$[\text{Co}(\text{H}_2\text{O})_6]\text{Cl}_3$ ,  $[\text{Co}(\text{H}_2\text{O})_4\text{Cl}_2]\text{Cl} \cdot 2\text{H}_2\text{O}$ ,  $[\text{Co}(\text{H}_2\text{O})_3\text{Cl}_3] \cdot 3\text{H}_2\text{O}$

### 5 POLYMERIZATION ISOMERISM



Polymerization isomerism, in which  $n$  varies in the complex  $[\text{ML}_m]_n$ , it represents an additional way in which an empirical formula may give incomplete information about the nature of complex.

$[\text{Co}(\text{NH}_3)_3(\text{NO}_2)_3]_n$

$[\text{Co}(\text{NH}_3)_3(\text{NO}_2)_3]$

$n = 1$

$[\text{Co}(\text{NH}_3)_6][\text{Co}(\text{NO}_2)_6]$

$n = 2$

$[\text{Co}(\text{NH}_3)_5(\text{NO}_2)][\text{Co}(\text{NH}_3)_2(\text{NO}_2)_4]_2$

$n = 2$

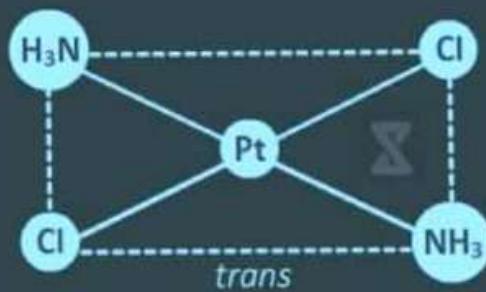
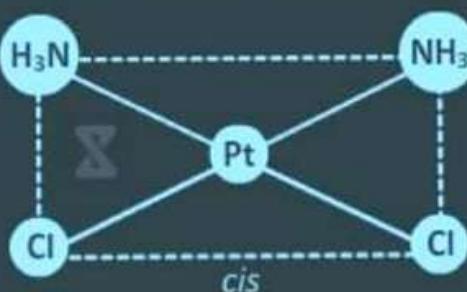
# STEREOISOMERISM

## 1 GEOMETRICAL ISOMERISM

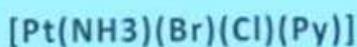
Geometrical isomers are of two types i.e., cis and trans isomers. This isomerism is common in complexes with coordination number 4 and 6.

### COMPLEXES WITH COORDINATION NUMBER 4

- Tetrahedral complexes do not show geometrical isomerism.
- Square planar complexes of formula  $[MX_2L_2]$  ( $X$  and  $L$  are unidentate) show geometrical isomerism. The two  $X$  ligands may be arranged adjacent to each other in a cis isomer or opposite to each other in a trans isomer.

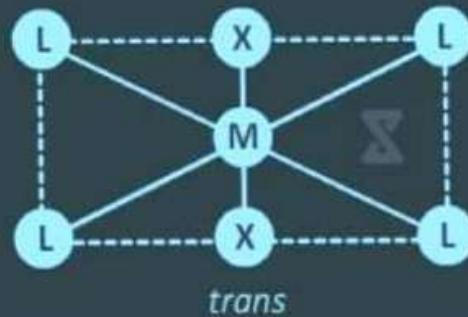
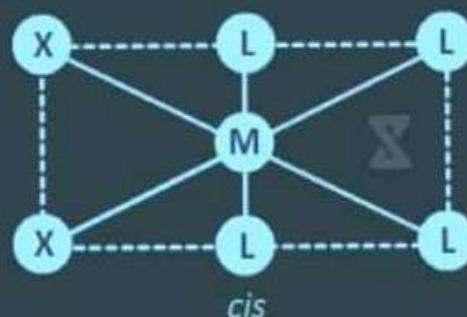


- Square planar complex of the type  $[MABXL]$  (where A, B, X, L, are unidentate ligands) shows three isomers, two cis and one trans.



### COMPLEXES WITH COORDINATION NUMBER 6

- Octahedral complexes of formula  $[MX_2L_4]$ , in which the two  $X$  ligands may be oriented cis or trans to each other



## 2 OPTICAL ISOMERISM

These are the complexes which have chiral structures. It arises when mirror images cannot be superimposed on one another. These mirror images are called enantiomers. The two forms are called dextro (d) and laevo (l) forms.

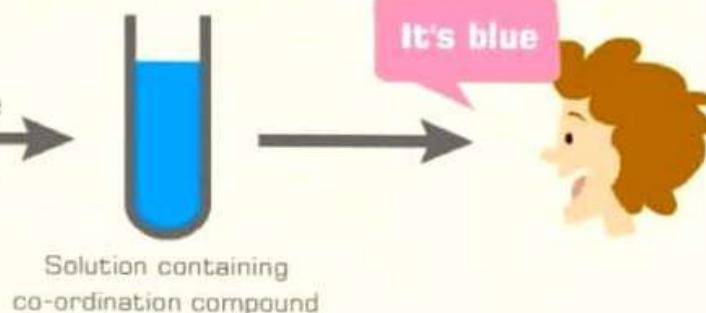
Tetrahedral complexes with formula  $[M(AB)_2]$  show optical isomers and octahedral complexes (cis form) exhibit optical isomerism.

# Colour of Co-ordination Compounds



## What is Colour Wheel ?

Generally white light is a mix of two opposite colors on colour wheel. These two colour are called **component colours**.

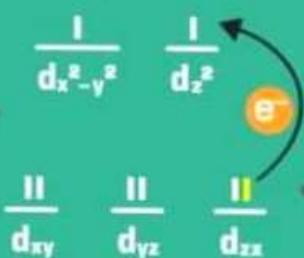


## Why we are seeing Blue, Why Not Red or Green ?

Let's see what happens inside the solution containing co-ordination compound when we cast a white light on it

White light of energy  $E$  and wavelength  $\lambda$  is passed through the solution

In presence of ligands, d-orbitals splits



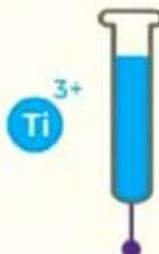
This electron absorbs the energy of wavelength  $\lambda$  and gets excited to  $d_z^2$  orbital.



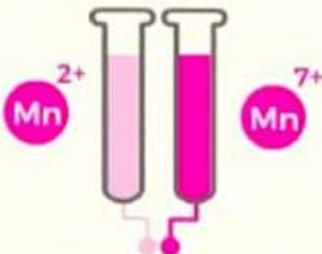
If the wavelength, that got absorbed by solution represents the **orange** colour in colour wheel, then its complimentary colour, **blue** will be seen by viewer

**Colours shown by Metals in various oxidation states**

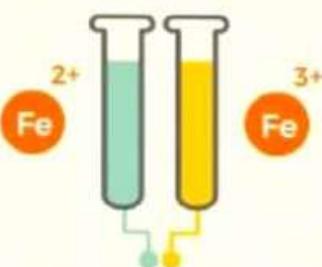
### TITANIUM (Ti)



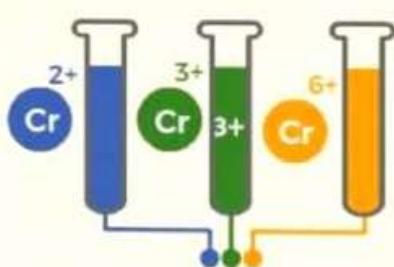
### MANGANESE (Mn)



### IRON (Fe)



### CHROMIUM (Cr)



### COBALT

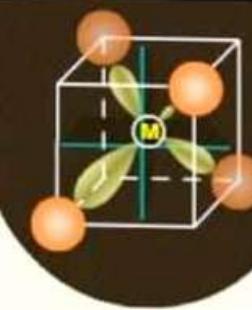


### NICKEL COPPER

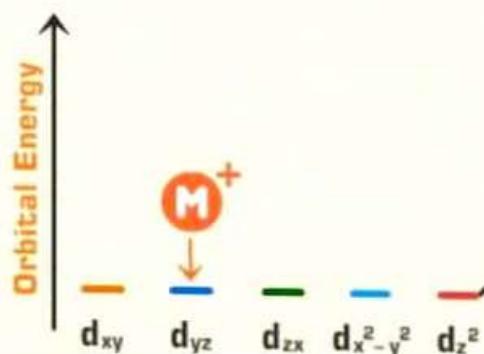


# CRYSTAL FIELD THEORY

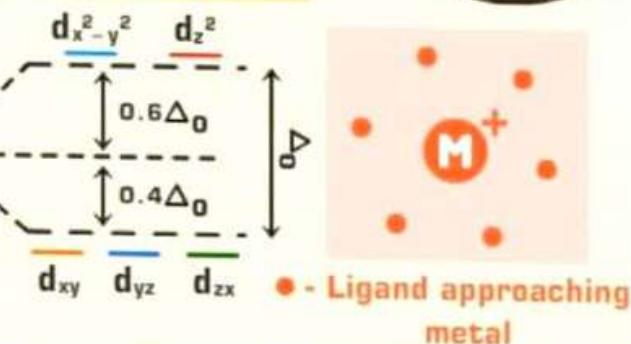
In crystal field theory, bonding between metal and ligands is purely electrostatic. Ligands are considered as negative point charges.



## WHAT HAPPENS WHEN LIGANDS APPROACH A METAL

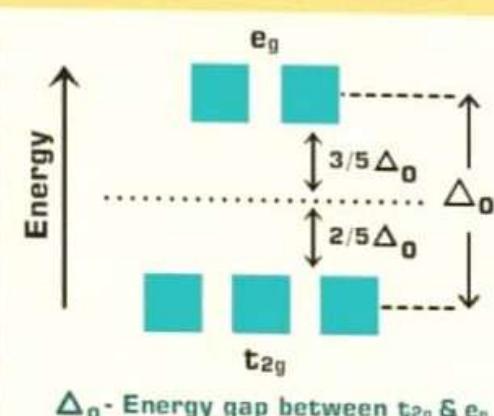
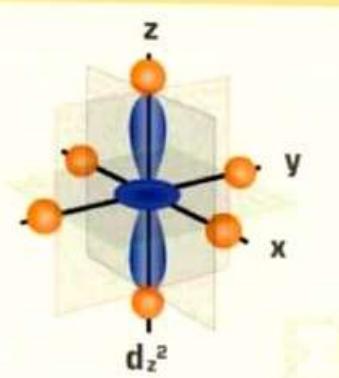
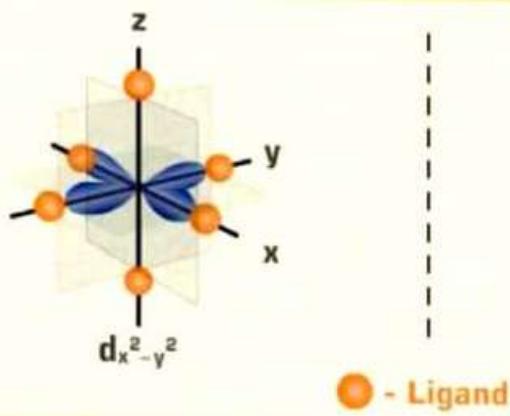


D-orbitals of metal ions when there are no-surrounding ligands



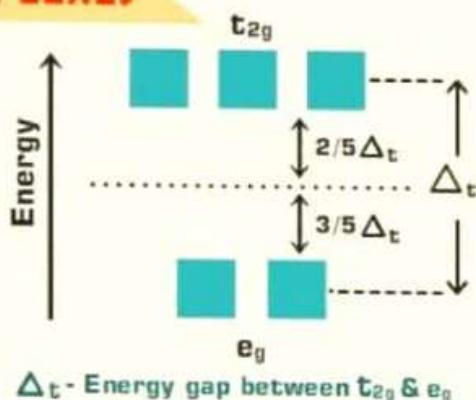
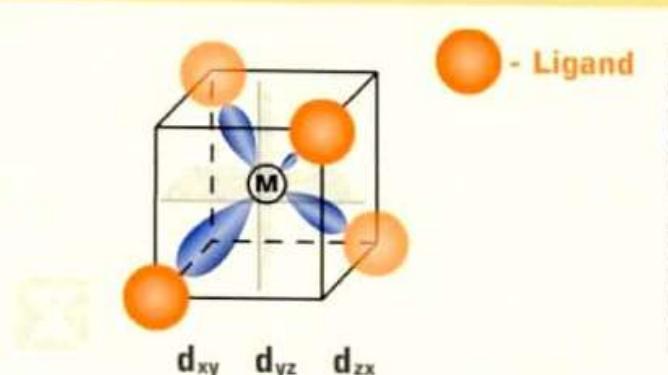
When Ligand approaches the metal ions, there will be a change in energy of electrons in d-orbitals of Metal ions.

## ORBITAL SPLITTING IN OCTAHEDRAL COMPLEXES



In Octahedral complex, Ligands approach along x,y,z axis.  $d_{x^2-y^2}$  and  $d_{z^2}$  orbitals align along the axis. So the **repulsion between Orbitals and Ligands** leads to increase in energy.

## ORBITAL SPLITTING IN TETRAHEDRAL COMPLEXES



In tetrahedral complexes, Ligands approach between the x,y and z axis ,therefore  $d_{xy}$ ,  $d_{yz}$  and  $d_{zx}$  has more energy than  $d_{x^2-y^2}$  and  $d_{z^2}$

### Strength of ligands

$\text{CO} \approx \text{CN}^- > \text{PPh}_3 > \text{NO}_2^- > \text{NH}_3 >$  pyridine  $> \text{CH}_3\text{CN} > \text{NCS}^- > \text{H}_2\text{O} \approx \text{C}_2\text{O}_4^{2-} > \text{OH}^- > \text{NCO}^- > \text{F}^-$   
 $> \text{Cl}^- > \text{SCN}^- > \text{S}^{2-} > \text{Br}^- > \text{I}^- > \text{O}_2^{2-}$

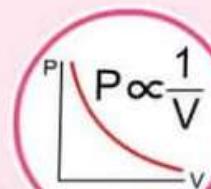
# P V T GAS LAWS



Boyle's law



As water bubble rises its size increases because pressure decreases.

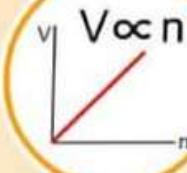


$$PV = nRT$$

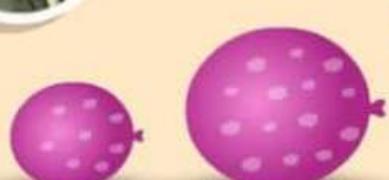
Charle's Law



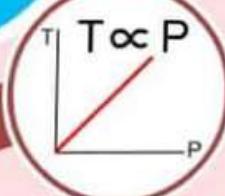
As temperature increases, volume increases



Avogadro's Law



As number of moles increase, volume increases



Gay Lussac's law



As temperature increases pressure inside the container increases and it explodes

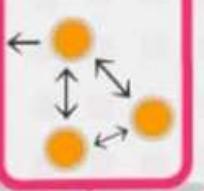
# WHAT MAKES GASES REAL

## DEVIATION FROM IDEAL GAS

Pressure is one force applied by an ideal gas on one container. In real gas, molecules have attraction between them, thus reducing the force applied on container.

$$P_{\text{real}} = P_{\text{ideal}} - \frac{an^2}{V^2}$$

### Pressure Correction



### Volume Correction



For ideal gas,  $V$  is equal to volume of container. However in real gases molecules occupy considerable volume.

$$V_{\text{real}} = V_{\text{ideal}} + nb$$

$$\left( P + \frac{an^2}{V^2} \right) (V - nb) = nRT$$

Vander Waal Equation

## IS Z A REAL DETECTOR?

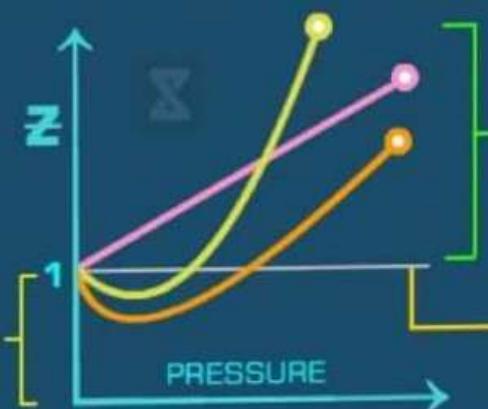
$$Z < 1$$

- Deviates from ideal gas behaviour
- Attractive forces dominate repulsive forces

$$Z > 1$$

- Deviates from ideal gas behaviour
- Repulsive forces dominate attractive forces

$$Z = 1 \Rightarrow \text{ideal gas}$$



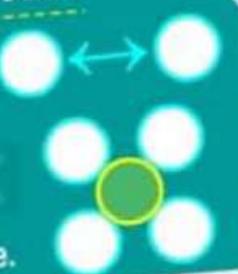
AT LOW PRESSURE & HIGH TEMPERATURE real gas acts as ideal gas

### HELIUM & HYDROGEN

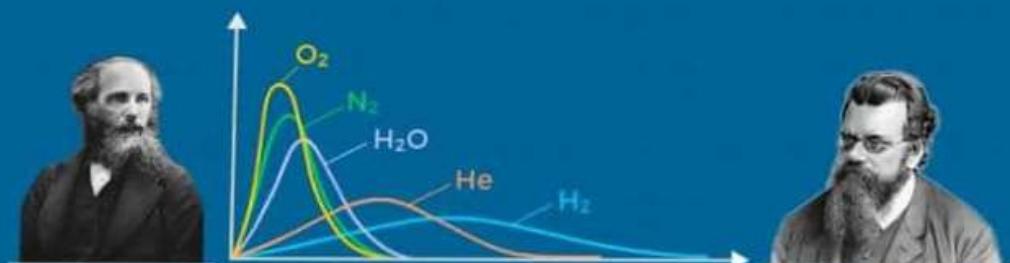
They are lighter gases. So force of attraction is less. therefore they have always  $Z > 1$

### VANDER WAAL'S CONSTANT

a - measure of average attraction of gas molecules  
 b - proper volume of gas molecules . It is actually 4 times volume of single molecule.



# DISTRIBUTION OF MOLECULAR VELOCITIES



Maxwell Boltzmann stated, all molecules don't have similar velocity. Each molecule moves with different velocity.

## AVERAGE VELOCITY

Average of all the velocities of gas molecules

$$A.V. = \sqrt{\frac{8RT}{\pi M}}$$

## AREA

Area under these graphs gives total kinetic energy of gas molecules

$$\Delta = \int F \cdot dv$$

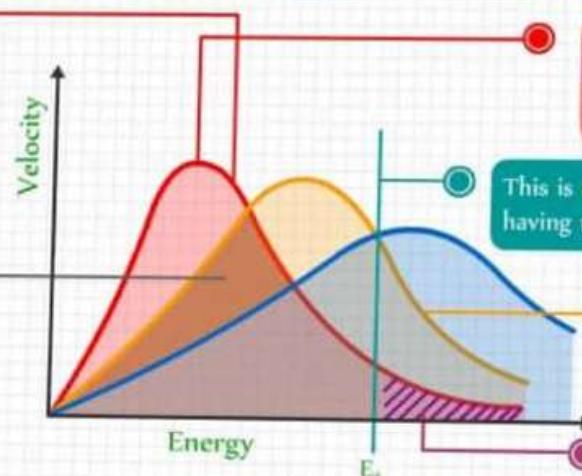
$F$  = fraction of molecules

## MOST PROBABLE VELOCITY

Velocity of Maximum number of molecules

$$M.P.V. = \sqrt{\frac{2RT}{M}}$$

This is activation energy ( $E_a$ ) barrier. Molecules having more energy than this participate in reaction.



As temperature increases, fraction of molecules having more energy than Activation energy ( $E_a$ ) increases.

Fraction of molecules having more Kinetic energy than Activation energy ( $E_a$ ).

## ROOT MEAN SQUARE VELOCITY

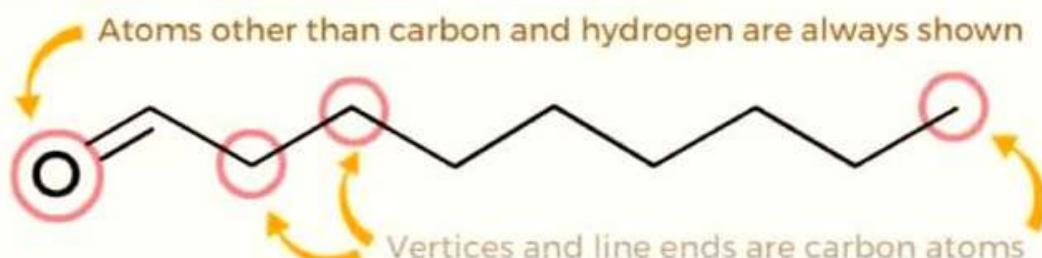
Average velocity may be zero, because velocity is vector,  $RMS = \sqrt{\frac{3RT}{M}}$  so we use root mean square velocity.

# NOMENCLATURE

## A BASIC GUIDE TO DECODING ORGANIC COMPOUNDS NAME

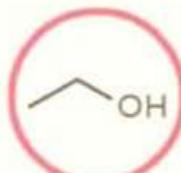
Name of an organic molecule can be long and look like a confusing mix of words and numbers. However, it follows a particular set of rules which allow its structure to be decoded from its name.

### ORGANIC COMPOUND REPRESENTATION



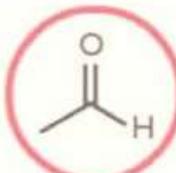
Organic molecules are usually represented using a skeletal formula. The line ends and vertices represent carbon atoms. Hydrogen atoms are implied. Atoms other than carbon and hydrogen are always shown.

### FUNCTIONAL GROUPS



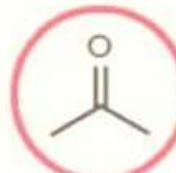
**ALCOHOL**

Suffix:- ol  
e.g.-ethanol



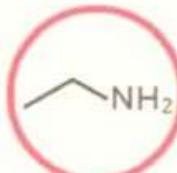
**ALDEHYDE**

Suffix:-al  
e.g.-ethanal



**KETONE**

Suffix:-one  
e.g.-propanone



**AMINE**

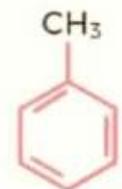
Suffix:-amine  
e.g.-ethanamine

A molecule's functional group is the group of atoms that give its chemical properties and reactivity. It's usually indicated by a suffix at the end of the name, with a number indicating its position.

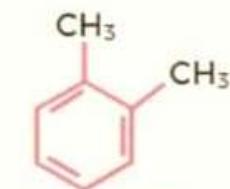
### AROMATIC COMPOUNDS



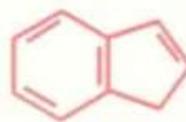
**BENZENE**



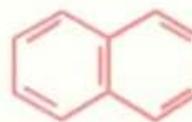
**TOLUENE**



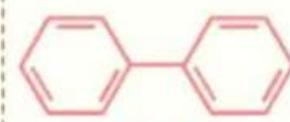
**o-XYLENE**



**INDENE**



**NAPHTHALENE**



**BIPHENYL**

Aromatic compounds also known as **arenes** or **aromatics**, are chemical compounds that contain **conjugated** planar ring systems with delocalized **pi-electron**. They should satisfy **Hückel's rule**.

# NOMENCLATURE

## BOND TYPES

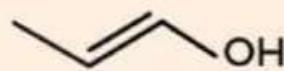
Carbon atoms can be linked by single bond, double bond or even triple bond. The name of the molecule reflects the type of bond present.



BUTANE



BUT-1-ENE



PROP-1-EN-1-OL



BUT-2-ENE



BUT-2-YNE



PROP-2-EN-1-OL

**-an-** present in name  $\Rightarrow$  molecule contains only **single bonds**

**-en-** present in the name  $\Rightarrow$  molecules contains **at least 1 double bond**

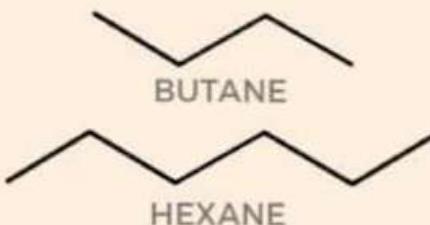
**-yn-** present in name  $\Rightarrow$  molecules contains **at least 1 triple bond**

For double and triple bond, number indicates the position of bond.

## PARENT CHAIN

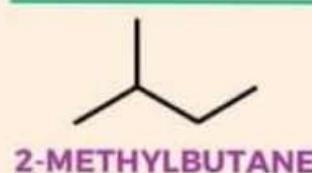
### NUMBER OF CARBON IS DENOTED BY PREFIX

- |         |         |
|---------|---------|
| 1 METH- | 6 HEX-  |
| 2 ETH-  | 7 HEPT- |
| 3 PROP- | 8 OCT-  |
| 4 BUT-  | 9 NON-  |
| 5 PENT- | 10 DEC- |

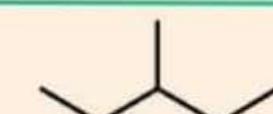


Prefix is part of the organic molecule's name that denotes how many carbons make up its '**parent chain**'. This is defined as the longest continuous connected chain of carbon atoms including the functional groups in the molecule.

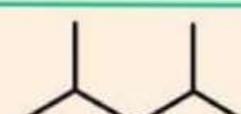
## SIDE CHAINS



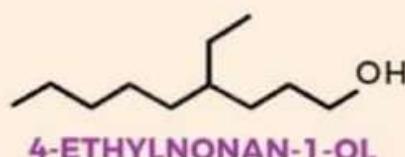
2-METHYLBUTANE



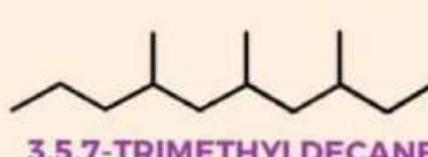
3-METHYLPHENTANE



2,4-DIMETHYLPENTANE



4-ETHYLNONAN-1-OL

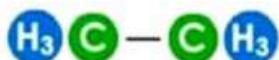


3,5,7-TRIMETHYLDECANE

Molecules can have one or more carbons that aren't part of the **parent chain**, referred to as '**side chains**'. A number is added to show the location of the side chain on the parent chain.

# FUNCTIONAL GROUPS IN ORGANIC CHEMISTRY

## ALKANE



Name:- ane  
e.g.ethane

## ALKENE



Name:- ene  
e.g.ethene

## ALKYNE



Name:- yne  
e.g.ethyne

## ALCOHOL



Name:- ol  
e.g.ethanol

## ETHER



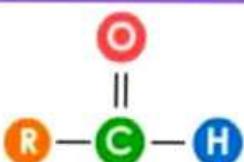
Name:- oxy-ane  
e.g.methoxyethane

## HALOALKANE



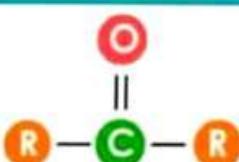
Name:- halo-  
e.g.chloroethane

## ALDEHYDE



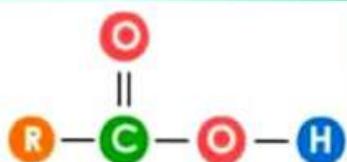
Name:- -al  
e.g.ethanal

## KETONE



Name:- -ane  
e.g.propanone

## CARBOXYLIC ACID



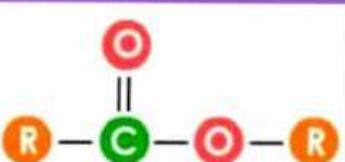
Name:- oic acid  
e.g.ethanoic acid

## ACID ANHYDRIDE



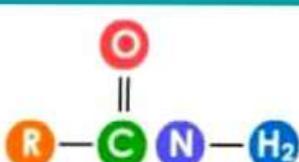
Name:- thiol  
e.g.methanethiol

## ESTER



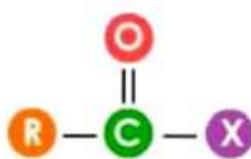
Name:- -yl -oate  
e.g.ethyl ethanoate

## AMIDE



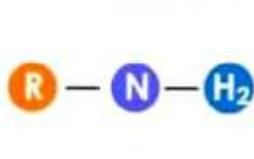
Name:- amide  
e.g.ethanamide

## ACYL HALIDE



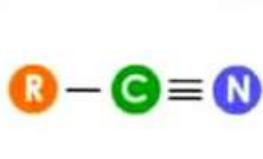
Name:- -oyl halide  
e.g.ethanoyl chloride

## AMINE



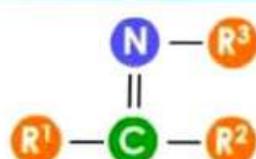
Name:- -amine  
e.g.ethanamine

## NITRILE



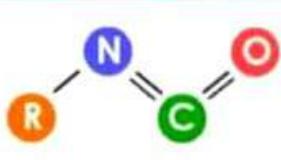
Name:- -nitrile  
e.g.ethanenitrile

## IMINE



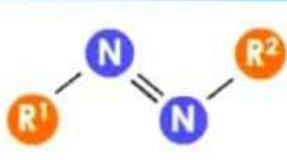
Name:- -imine  
e.g.ethanimine

## ISOCYANATE



Name:- -yl isocyanate  
e.g.ethyl isocyanate

## AZO COMPOUND



Name:- -azo-  
e.g.azoethane

## ARENES



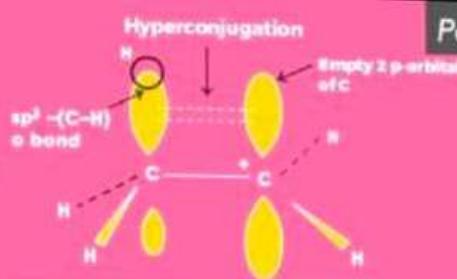
Name:- -yl benzene  
e.g. ethyl benzene

## THIOL



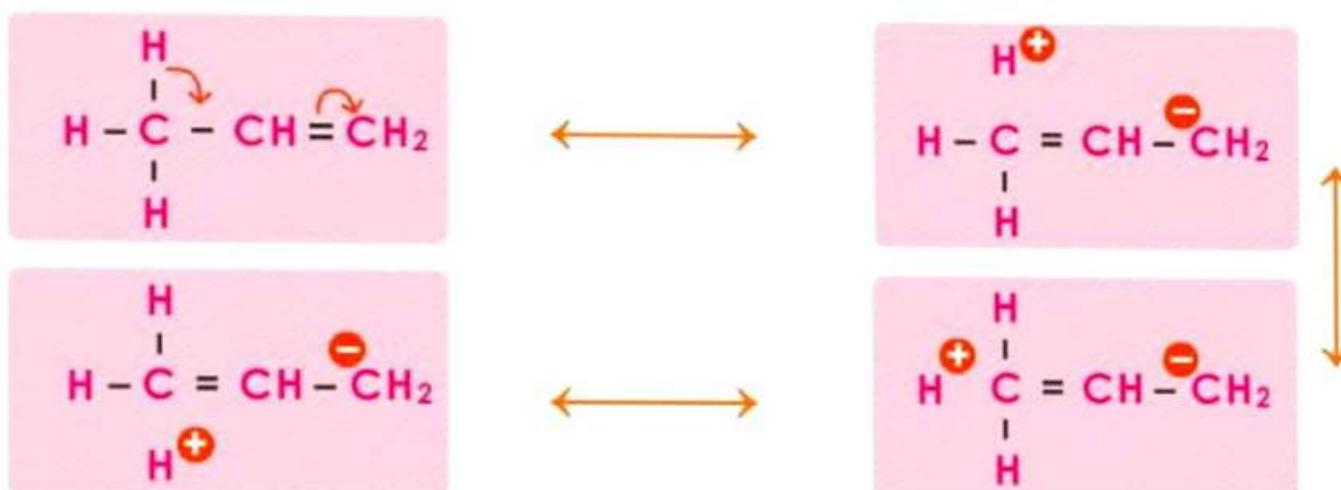
Name:- thiol  
e.g.methanethiol

# ELECTRON DISPLACEMENT



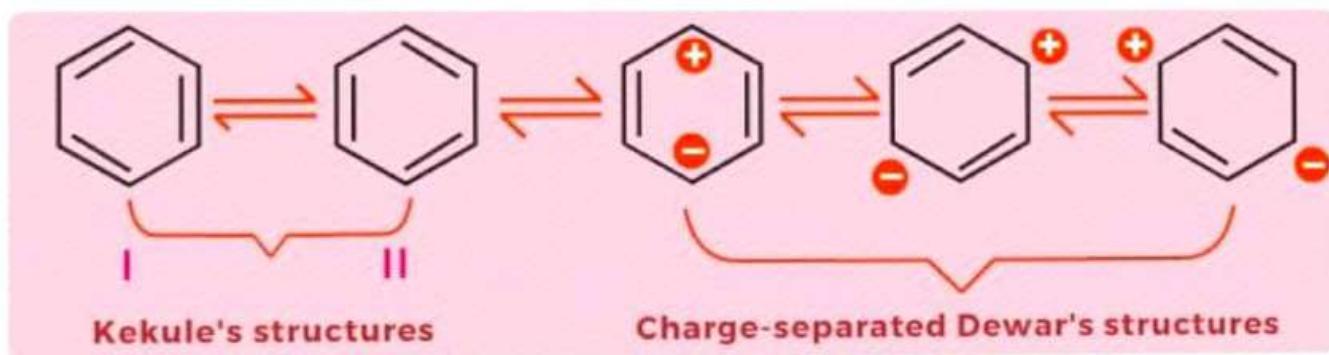
## HYPER CONJUGATION

The mechanism of electron release by an alkyl group when it is attached to an unsaturated system is called Hyper conjugation. Hyper conjugation effect takes place through the interaction of  $\sigma$ -electrons of C-H bond with  $\pi$ -electrons of double bond.



## MESOMERIC/ RESONANCE EFFECT

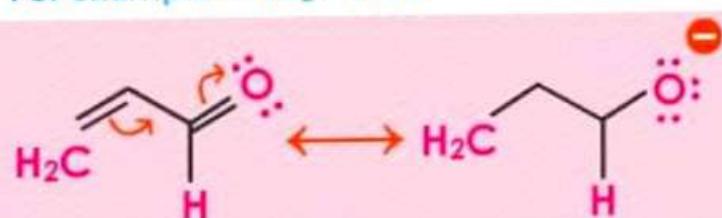
The flow of electrons from one part of a conjugated system to the other caused by phenomenon of resonance is called **resonance effect** or **mesomeric effect**.



### -M or -R effect

When the electron displacement is towards the group.

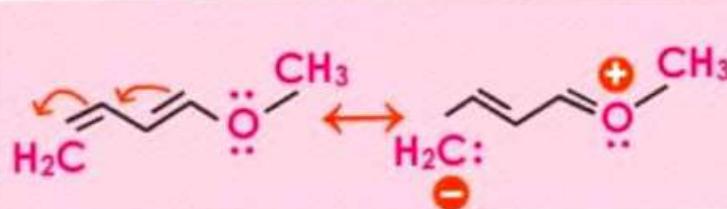
For example :-  $\text{NO}_2$ ,  $-\text{CHO}$ .



### +M or +R effect

When the electron displacement is away from the group.

For example :-  $\text{OH}^-$ ,  $-\text{OR}$ ,  $-\text{Cl}$



# ELECTROMERIC EFFECT

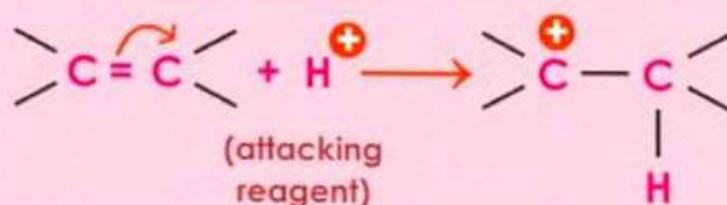
Electromeric effect is defined as the complete transfer of electrons of a multiple bond towards one of the bonded atoms at the demand of an attacking reagent.

## TYPES OF ELECTROMERIC EFFECT

### +E effect

When displacement of electrons is away from the atom or group.

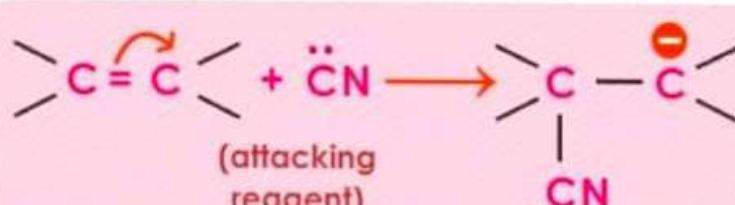
e.g : addition of H<sup>+</sup> to alkene.



### -E effect

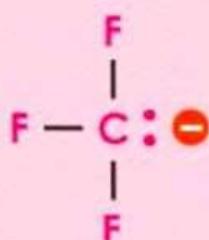
When displacement of electrons is towards the atom or group.

e.g : addition of cyanide ion (CN<sup>-</sup>) to the carbonyl group.



## INDUCTIVE EFFECT

Inductive effect is defined as permanent displacement of shared electron pair in a carbon chain towards more electronegative atom or group.



electron withdrawal  
stabilizes  
carbocation (make less-)



electron withdrawal  
destabilizes  
carbanion (make less+)



electron release  
destabilizes  
carbanion (make more-)



electron release  
stabilizes  
carbocation (make more+)

## TYPES OF INDUCTIVE EFFECT

### Negative Inductive Effect

(-I effect, Electron withdrawing effect)

When an electronegative atom or group (more electronegative than hydrogen) is attached to the terminal of the carbon chain in a compound, the electrons are displaced in the direction of the attached atom or group.

$\text{-NO}_2 > \text{-CN} > \text{-COOH} > \text{F} > \text{Cl} > \text{Br} > \text{I} > \text{OH} > \text{C}_6\text{H}_5 > \text{H}$

### Positive Inductive Effect

(+I effect, Electron releasing effect)

When an electropositive atom or group (more electropositive than hydrogen) is attached to the terminal of the carbon chain in a compound, the electrons are displaced away from the attached atom or group.

$(\text{CH}_3)_3\text{C}^- > (\text{CH}_3)_2\text{CH}^- > \text{-C}_2\text{H}_5 > \text{-CH}_3$

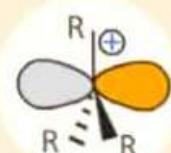
# CARBOCATION & CARBANION

## CARBOCATION

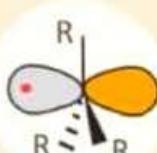
Ionic species with **positively** charged carbon atom.



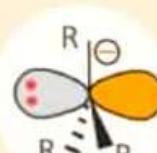
- sp<sub>2</sub> Hybridized
- Trigonal planar
- Incomplete octet



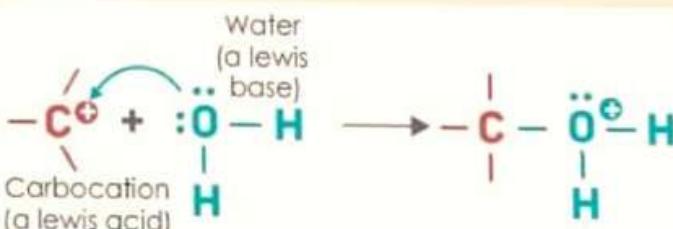
Carbocation



Carbon radical

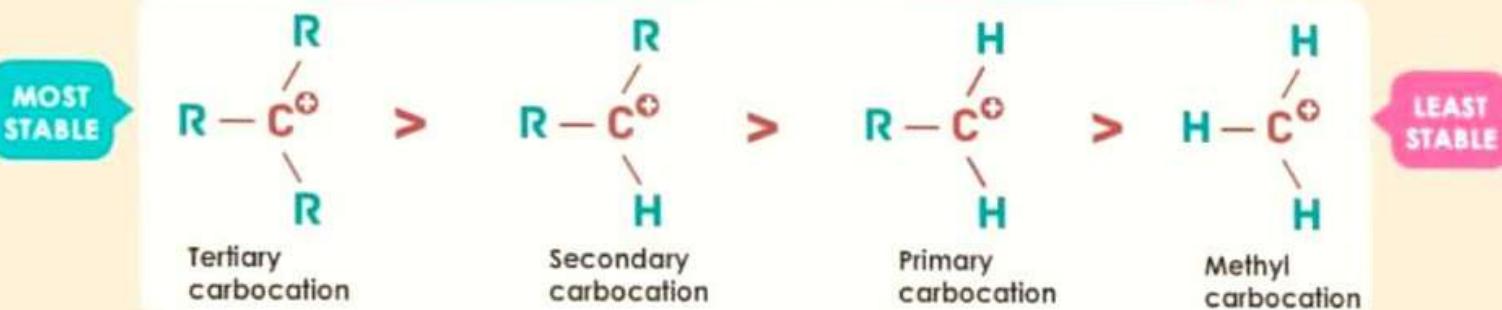


Carbanion



Carbocations are strong Lewis acids.

## RELATIVE STABILITIES OF CARBOCATIONS



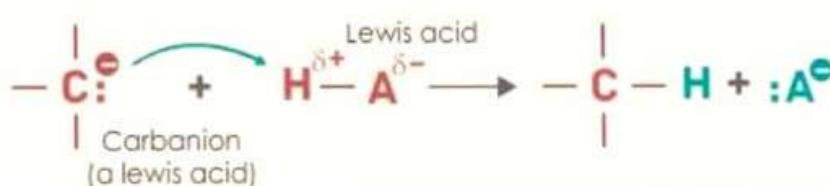
## CARBANION

Ionic species with **negatively** charged carbon atom.

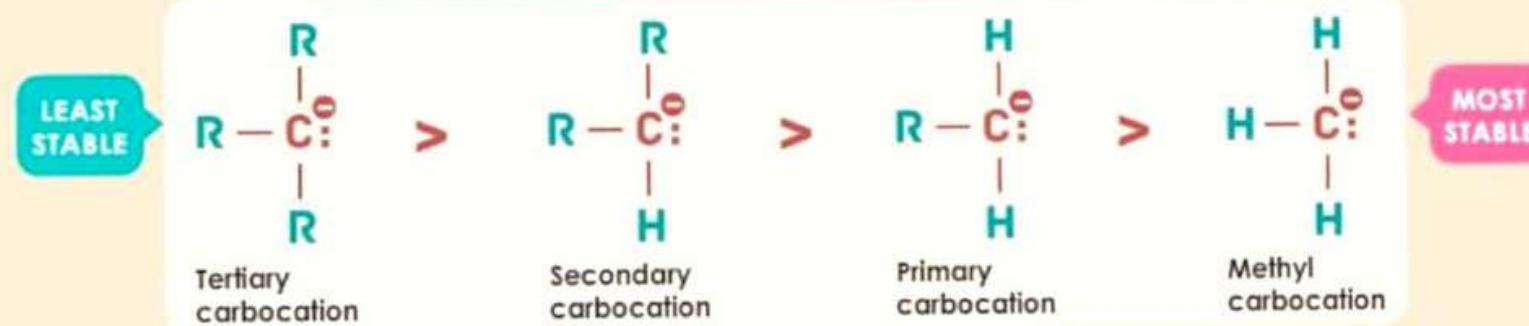


- sp<sub>3</sub> Hybridized
- Pyramidal
- Complete octet

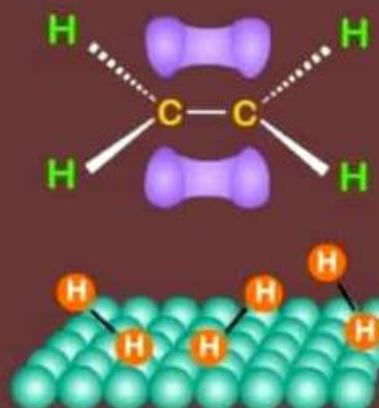
Carbanions are **strong** Lewis bases and Bronsted bases.



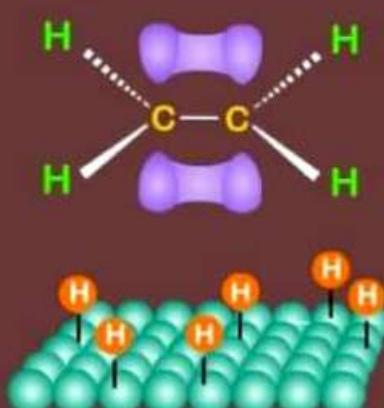
## RELATIVE STABILITIES OF CARBOCATIONS



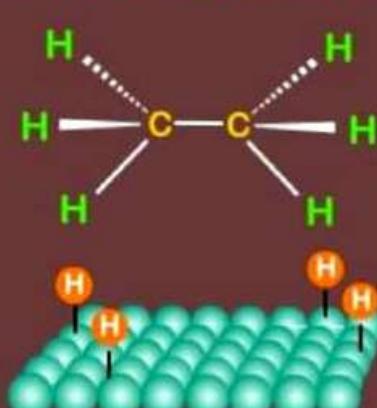
# HEAT OF HYDROGENATION



Hydrogen molecules settle on the surface of the catalyst and react with metal atoms



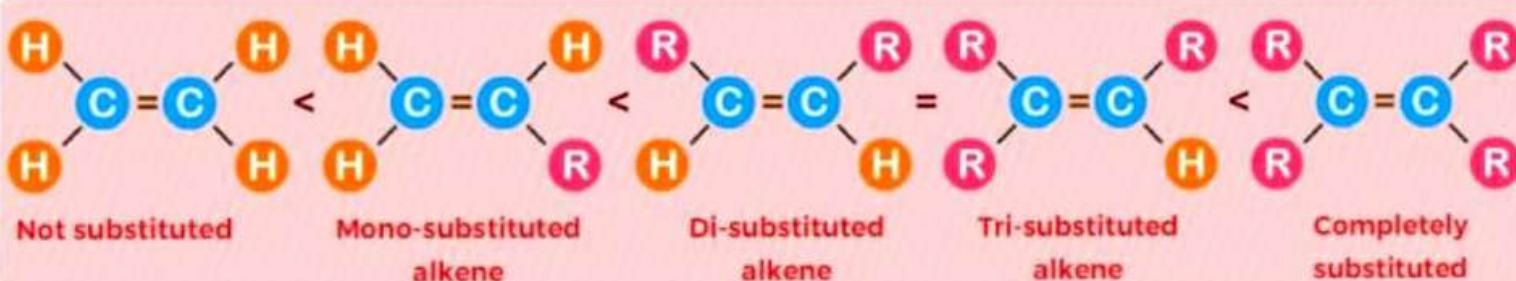
The alkene approaches the surface of the catalyst



The  $\pi$  bond between the two carbons is replaced by two C-H  $\sigma$  bonds

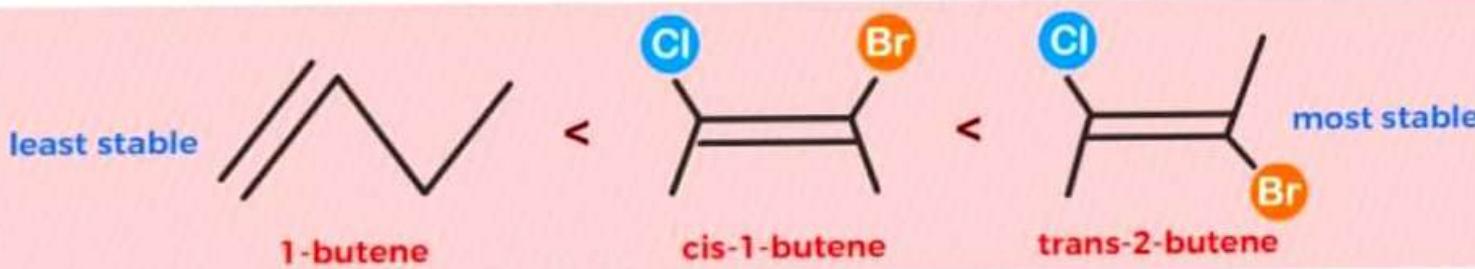
Heat of hydrogenation (symbol:  $\Delta H_{\text{hydro}}$ ,  $\Delta H^\circ$ ) of an alkene is the standard enthalpy of catalytic hydrogenation of an alkene. Catalytic hydrogenation of an alkene is always exothermic. Therefore, heat of hydrogenation of alkenes is always negative.

**least stable (higher  $\Delta H^\circ$ ).....most stable (lower  $\Delta H^\circ$ )**



**least substituted.....most substituted**

In disubstituted alkenes, **trans-isomers** are more stable than **cis-isomers** due to steric hindrance. Also, internal alkenes are more stable than terminal ones. See the following isomers of butene:



$$\text{HOH} \propto \text{no. of } \pi\text{-bond in compound}$$

If no. of  $\pi$ -bond is same then

$$\text{HOH} \propto \frac{1}{\text{Stability of compound}}$$

In case of alkene

$$\text{HOH} \propto \frac{1}{\text{Stability of compound}} \propto \frac{1}{\text{No. of } \alpha\text{ H}}$$

# ACIDITY & BASICITY



$$K_a = \frac{[\text{H}^+][\text{A}^-]}{[\text{HA}]}$$

$$\text{pK}_a = -\log_{10} K_a$$

## Key factors that affect the acidity



**Electronegativity** - The more electronegative the anionic atom in the conjugate base, the better it is at accepting the negative charge.

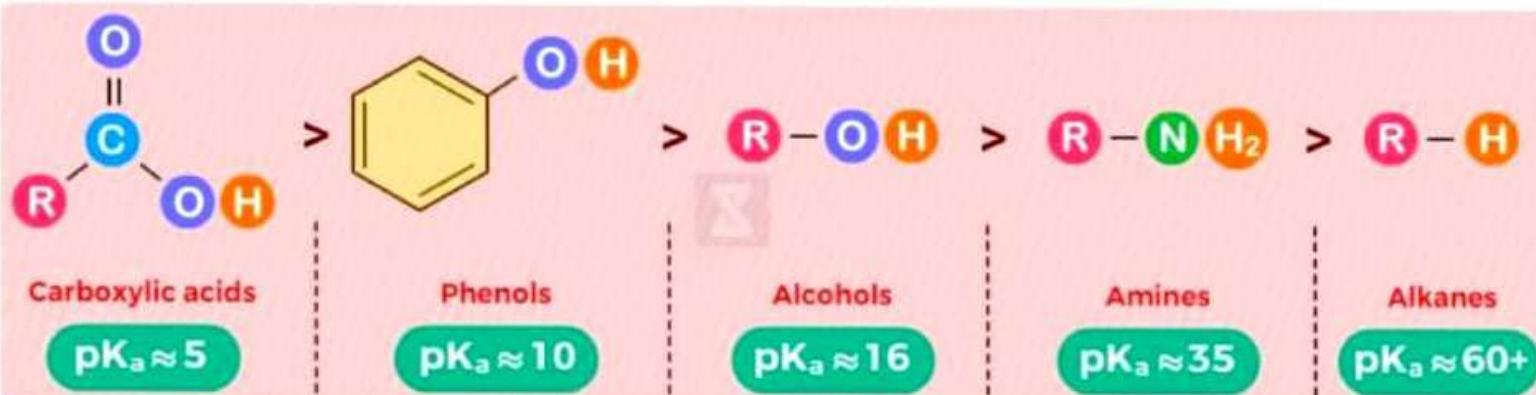


**Size** - The easier it is for the conjugate base to accommodate negative charge (lower charge density). The size of the group also weakens the bond H-X.



**Resonance** - In the carboxylate ion ( $\text{RCOO}^-$ ) the negative charge is delocalised across 2 electronegative oxygen atoms which makes it more stable than being localised on a specific atom as in alkoxide ( $\text{RO}^-$ ).

## General acidity trend of common organic acids



## Key factors that affect the basicity

**Electronegativity** - The more electronegative the atom donating the electrons is, the less willing it is to share those electrons with a proton, so the weaker the base.



**Size** - The larger the atom the weaker the H-X bond and the lower the electron density making it a weaker base.



**Resonance** - In the carboxylate ion ( $\text{RCOO}^-$ ) the negative charge is delocalised across 2 electronegative atoms which makes it the electrons less available than when they localised on a specific atom as in the alkoxide ( $\text{RO}^-$ ).

## General basicity trend of some common organic bases



# SUBSTITUTION REACTION ( $SN_1$ )



Black cat waits for the brown cat to leave and then takes the pod. Similarly in  $SN_1$  reaction one nucleophile waits for other nucleophile to move from substrate.

## WHAT IS $SN_1$ REACTION ?

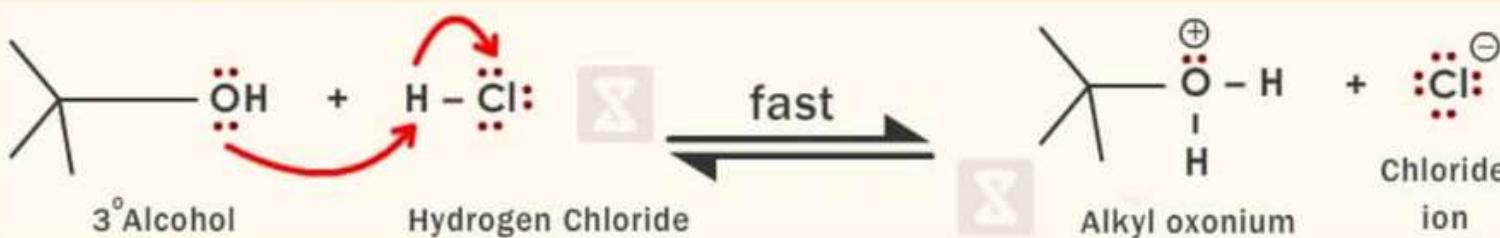


$SN_1$  indicates the unimolecular nucleophilic substitution reaction in organic chemistry. Their rate determining step of the mechanism depends on the decomposition of a single molecular species. So that, the rate of a  $SN_1$  reaction can be expressed as  $\text{rate} = k [R-\text{LG}]$ . Furthermore,  $SN_1$  is a multi-step reaction, which forms an intermediate and several transition states during the reaction. This intermediate is a more stable carbocation and the reactivity of the molecule depends on the R-group.



## $SN_1$ MECHANISM ( $R-\text{OH} \rightarrow R-\text{X}$ )

### PROTON TRANSFER



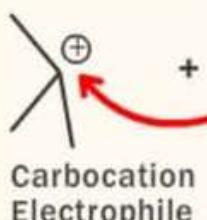
### DISSOCIATION OF WATER



#### RATE - DETERMINING STEP

- Unimolecular
- Nucleophilic reaction
- " $SN_1$ " mechanism

### CAPTURE OF CARBOCATION



- |                 |                                     |
|-----------------|-------------------------------------|
| Protic solvent  | <input checked="" type="checkbox"/> |
| 3° or 2° carbon | <input checked="" type="checkbox"/> |
| 1° carbon       | <input type="checkbox"/>            |

# SUBSTITUTION REACTION ( $SN_2$ )



Black cat forces the brown cat out from the pod. Similarly in  $SN_2$ , strong nucleophile kicks out the weaker nucleophile.

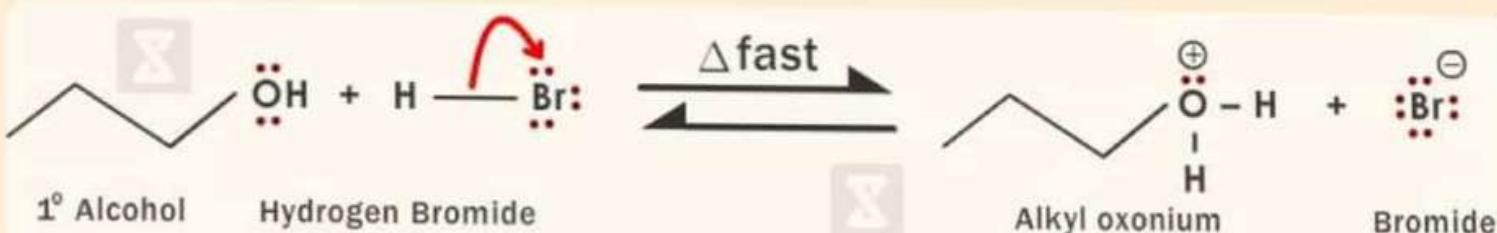
## WHAT IS $SN_2$ REACTION?



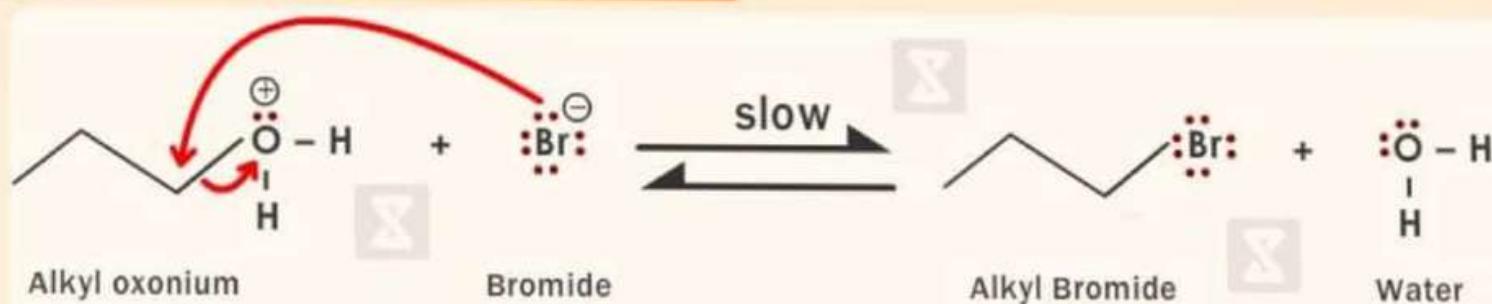
$SN_2$  indicates the **bimolecular nucleophilic substitution** reaction in organic chemistry. In this mechanism, separation of leaving group and formation of new bond happen synchronously. Therefore, two molecular species are involve in the rate determining step and this leads to the term bimolecular nucleophilic substitution reaction or  $SN_2$ . The rate of the  $SN_2$  reaction can be expressed as **rate =  $K [R-LG] [Nu-]$** . In inorganic chemistry, this reaction is also called **associative substitution** or **interchange mechanism**.

## $SN_2$ MECHANISM ( $R-OH \rightarrow R-X$ )

### PROTONATE ALCOHOL



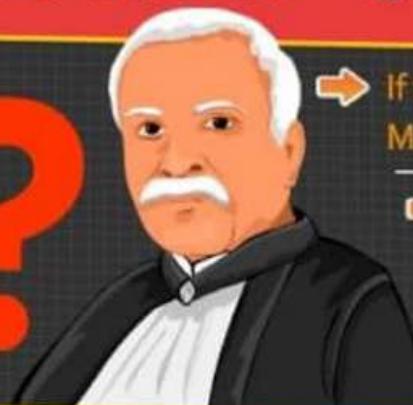
### NUCLEOPHILE (HALIDE) SEPARATES WATER



Here, nucleophile attacks from the opposite direction of the leaving group. Thus,  $SN_2$  reaction always leads to an **inversion of stereochemistry**. This reaction works best **with methyl and primary halides** because bulky alkyl groups block the backside attack of the nucleophile. In addition, the stability of the leaving group as an anion and the strength of its bond to the carbon atom both affect the rate of reaction.

# GRIGNARD REAGENT

## WHAT IS GRIGNARD REAGENT?



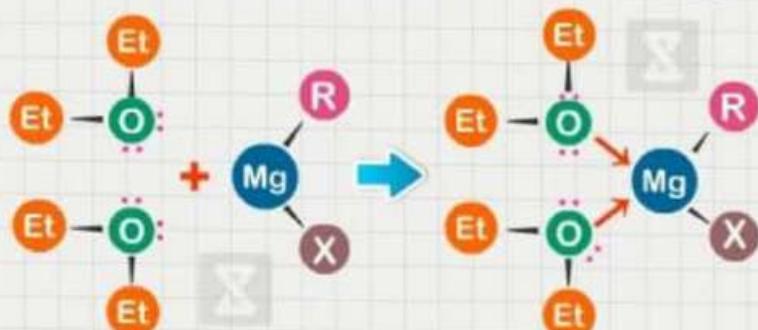
→ If the metal attached to the carbon is Magnesium, then it is called Grignard Reagent.

→ Victor Grignard first synthesized this compound.



## WHY GRIGNARD REAGENT IS PLACED IN DRY ETHER ?

Ether provides stability to Grignard reagent by completing the octet on Mg.



## WHAT ARE ORGANO METALLICS ?

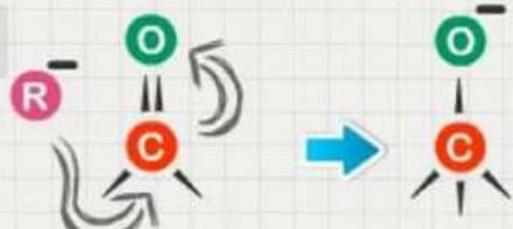
Organic metallic compounds are organic compounds in which metal atom is directly attached to Carbon atom

M — C

## CHEMICAL REACTIVITY OF GRIGNARD REAGENT

Grignard reagent produces nucleophile therefore it attacks at electrophilic centers

### ATTACK ON ALDEHYDES



### ATTACK ON ALKYNES



### REACTIVITY

Carbon has high electronegativity than Mg.  
So on breaking this bond Produces a -C<sup>-</sup> nucleophile

$\delta - \delta +$   
 $C - Mg$

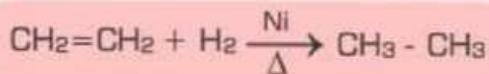


# 8

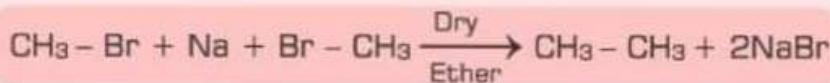
# FACTS ABOUT ALKANES

## Preparation of Alkanes

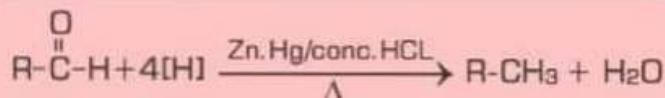
- From unsaturated Hydrocarbons in the presence of catalyst 'Ni' or 'Pt'



- By Wurtz Reaction:



- By the Reduction of Aldehydes and Ketones



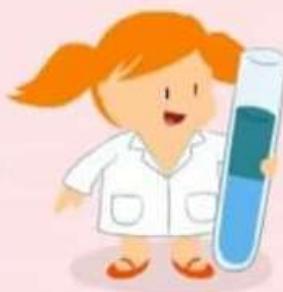
- Grignard's Reagent



Density of alkanes is less than water therefore they float over it.

## Solubility

Alkanes do not dissolve in water. They form a layer on top of water. However alkanes dissolve in non-polar organic solvents like Toluene, Benzene



## Example of Alkanes

Methane



Ethane

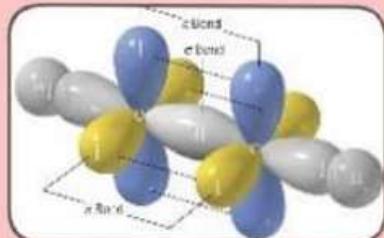


Propane



Physical State	
Carbon Count	State
1 – 4	Gases
5 – 15	Liquid
15 – more	Solid

C – in  $\text{sp}^3$  Hybridisation



General Formula :-  $\text{C}_n\text{H}_{2n+2}$

## Uses

Lighter alkanes are used in natural gas.

Propane and Butane are used in LPG cylinders



## Boiling

Boiling point depends on Vander waal forces.



More Carbon atoms



High Vander waal forces

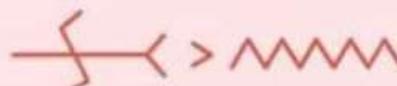


High boiling point



## Melting

Melting point depends on packing of compound.



More branching

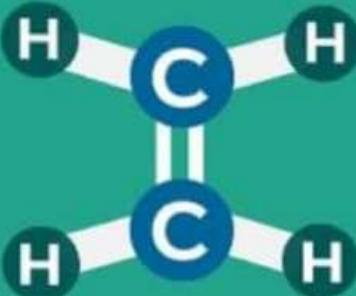


Close packing



High melting point





# ALKENES

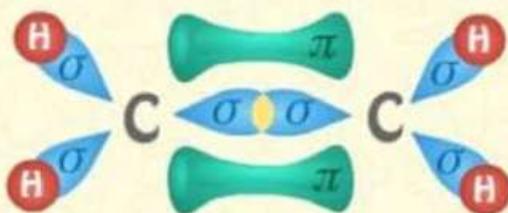
## Physical State

Carbon Count	State
1 - 3	Gases
4 - 20	Liquid
> 20	Solid

### **Acts as a Nucleophile**

In organic chemistry,  $\pi$ - bond is considered as a nucleophile. Therefore alkenes participate in addition reactions.

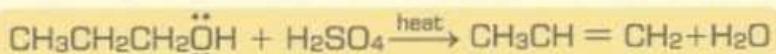
### **SP<sup>2</sup> hybridisation**



## **Preparation**

## 1. Dehydration of alcohols

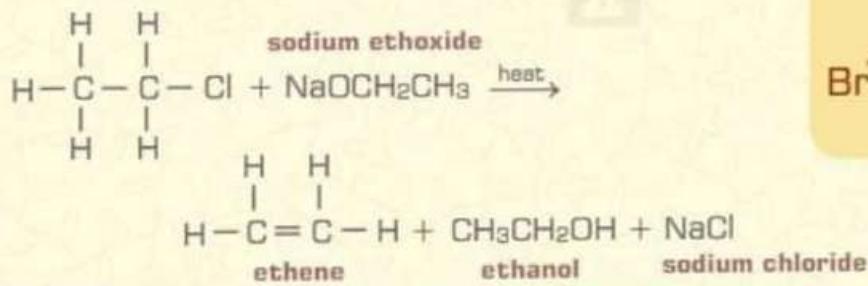
A molecule of water is eliminated from an alcohol molecule by heating the alcohol in the presence of a strong mineral acid.



## **2. Dehydrohalogenation of alkyl halides**

The **dehydrohalogenation** of alkyl halides, another  $\beta$  elimination reaction, involves the loss of a hydrogen and a halide from an alkyl halide ( $RX$ ).

### **ethyl chloride**



## Dipole Moments

$$\text{cis} > 0, \quad \text{trans} = 0$$

### Melting Point

**trans > cis**

## Boiling Point

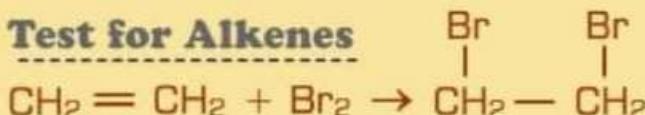
cis > trans

## Polymerisation

Ethene undergoes polymerisation and forms products like polyethene

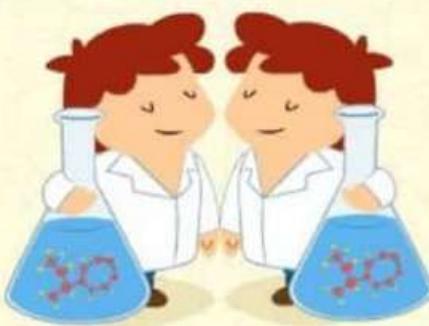
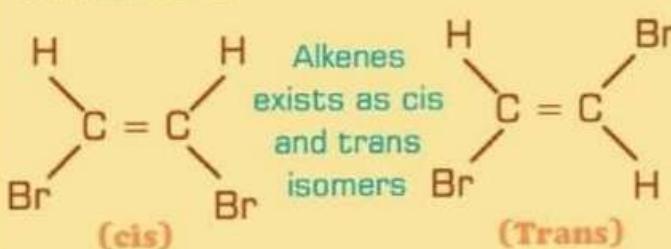


### Test for Alkenes



If you add bromine water to alkene, it decolourises the liquid because bromine reacts with alkene, whereas with alkanes it cannot react.

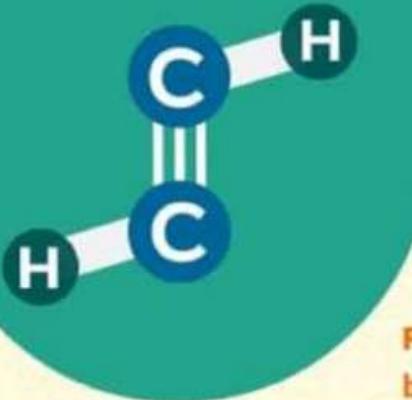
## Isomerism



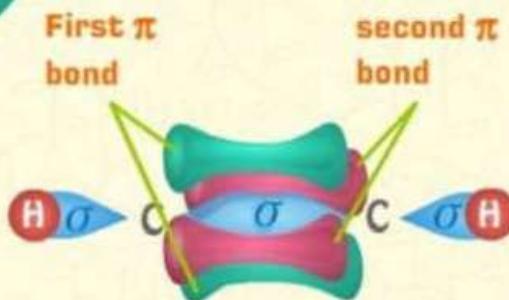
More dipole moment → More polarity → More solubility in polar solvents

More polarity → More interaction between compounds → Higher boiling point

# ALKYNES



SP hybridisation

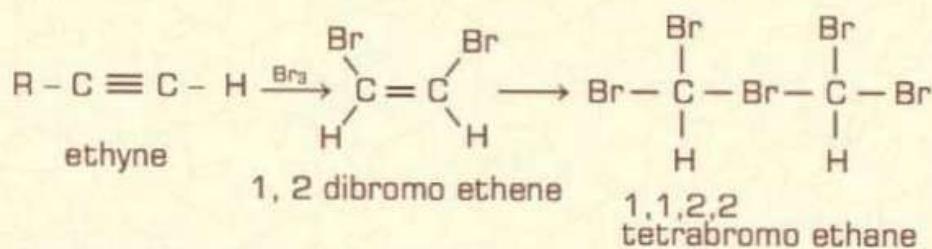


## Test for Alkynes

### Reaction with Bromine

The alkynes react slowly with bromine water to decolourise it, and this reaction can be used to distinguish between alkenes and alkynes.

Alkenes decolourise bromine water very rapidly, but alkynes take several minutes.



### For Terminal Alkynes

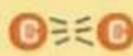
Terminal alkynes have acidic hydrogen, therefore by reacting with CuCl in NH<sub>4</sub>OH, acidic hydrogen is replaced with Cu giving red colour.



## Physical Properties



Alkynes are gases at room temperature.



192 kcal/mol energy is required to break the triple bond.

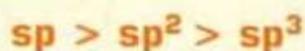


Shortest bond length is 120 Å.

## Acidic Hydrogen



Order of electronegativity is



Due to large electronegativity of sp carbon, terminal hydrogen becomes acidic and reacts with bases and undergoes neutralization.



## Uses

Alkynes don't have any commercial use. Acetylene is used in oxy-acetylene flame.

**Nucleophile:** Like alkenes, they also act as nucleophiles, due to presence of  $2\pi$  bonds

**Preparation:** Alkynes are prepared by hydrolysing carbides.





# IONIC EQUILIBRIUM



## IONIC CONDUCTORS OR ELECTROLYTES

Conductors in which the current passes through them due to the presence of free ions are called **Ionic Conductors** or **Electrolytes** or **Electrolytic conductors**. Ionic conductors are further divided into two types on the basis of their strengths :-

### STRONG ELECTROLYTES

- Those substance which almost completely ionize into ions in their aqueous solution are called **strong electrolytes**.
- Degree of ionisation ( $\alpha$ ) for strong electrolyte is equal to 1.



### WEAK ELECTROLYTES

- Those substance which ionize to a small extent in their aqueous solution are known **weak electrolytes**.
- Degree of ionization ( $\alpha$ ) for weak electrolytes is less than 1.



## CONCEPT OF ELECTROLYTE

STRONG ELECTROLYTE	WEAK ELECTROLYTE
$A^+ B^- \rightarrow A^+ + B^-$	$AB \rightleftharpoons A^+ + B^-$
a      0      0	a      0      0
0      a      a	$a(1-\alpha)$ $a\alpha$ $a\alpha$
$\alpha = 1$	$\alpha < 1$
No equilibrium	Equilibrium
Irreversible	Reversible

## OSTWALD'S DILUTION LAW

According to Ostwald, the degree of dissociation ( $\alpha$ ) of a weak electrolyte is inversely proportional to the square root of the molar concentration of the solution.

$$K = \frac{C\alpha^2}{1-\alpha} \quad \text{If } \alpha \text{ is very small} \\ 1-\alpha \approx 1 \Rightarrow K_\alpha = C\alpha^2$$

$$\text{or } \alpha = \sqrt{\frac{K_\alpha}{C}} \Rightarrow \alpha \propto \frac{1}{\sqrt{C}}$$

Here  $K_\alpha$  is dissociation constant and  $C$  is molar concentration of the solution.

## DEGREE OF IONISATION OR DEGREE OF DISSOCIATION ( $\alpha$ )

- It is the fraction of the total number of molecules which ionise (dissociate) into constituent ions.
- $\alpha = \frac{\text{number of molecules ionised or dissociated}}{\text{total numbers of molecules taken}}$
- Values of the degree of dissociation ( $\alpha$ ) depends upon the following factors

Nature of solute

Nature of solvent

Concentration

Temperature

# SALT HYDROLYSIS

Hydrolysis is defined as the process in which a salt reacts with water to give back the acid and the base. It is reverse of neutralisation.



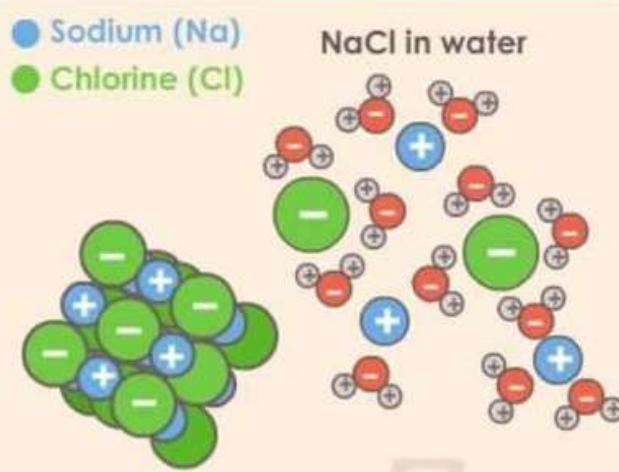
Salt hydrolysis is an endothermic reaction therefore on increasing the temperature, the extent of hydrolysis increases.

## Hydrolysis at a glance

SALT	NATURE	DEGREE	HYDROLYSIS CONSTANT	pH
Strong acid + Strong Base (NaCl)	Neutral	No Hydrolysis	-	-
Weak acid + Strong base (CH <sub>3</sub> COONa)	Base	$h = \sqrt{\frac{K_w}{CK_a}}$	$K_h = \frac{K_w}{K_a}$	$pH = \frac{1}{2}[pK_w + pK_a + \log C]$
Strong acid + Weak base (NH <sub>4</sub> Cl)	Acidic	$h = \sqrt{\frac{K_w}{CK_b}}$	$K_h = \frac{K_w}{K_b}$	$pH = \frac{1}{2}[pK_w - pK_b - \log C]$
Weak acid + Weak base (CH <sub>3</sub> COONH <sub>4</sub> )	-	$h = \sqrt{\frac{K_w}{(K_a + K_b)}}$	$K_h = \frac{K_w}{K_a \cdot K_b}$	$pH = \frac{1}{2}[pK_w + pK_a - pK_b]$

## Solution

Basic solution (Na <sub>2</sub> CO <sub>3</sub> )	Neutral solution (Na <sub>2</sub> SO <sub>4</sub> )	Acidic solution (NH <sub>4</sub> NO <sub>3</sub> )			
NaOH strong base	H <sub>2</sub> CO <sub>3</sub> weak acid	NaOH strong base	H <sub>2</sub> SO <sub>4</sub> strong acid	NH <sub>3</sub> weak base	HNO <sub>3</sub> strong acid



## Use of Hydrolysis in the "Real World"

### NaCl crystal structure

Life processes requires energy for processes like **respiration**, **muscle contraction**, **distribution of hormone** etc. The energy that is converted from food, is stored into **ATP molecules (Adenosine Triphosphate)**. To release the energy stored in the bonds of ATP molecules, hydrolysis must occur to break a phosphate group off of an ATP molecule, thus releasing energy from the bonds. ATP now becomes **ADP (Adenosine Diphosphate)** by losing a phosphate group through hydrolysis.

# ACID-BASE INDICATORS



Acid-Base indicators are organic substances which have one colour in acid solution while an altogether different colour in alkaline solution.

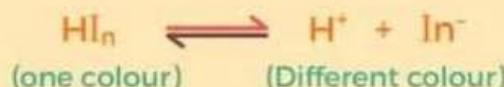
## THEORIES OF ACID-BASE INDICATORS

### OSTWALD'S THEORY (1891)



According to this theory:

- Acid-base indicators are weak organic acids or bases.
- They have different colours in ionised and non-ionised states.
- The colour of the indicator depends on the relative proportion of the unionised indicator molecules and its ions.

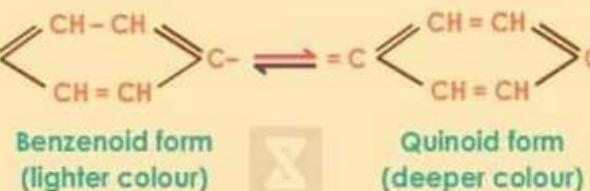


### MODERN QUINOID THEORY



Main postulates of this theory are:

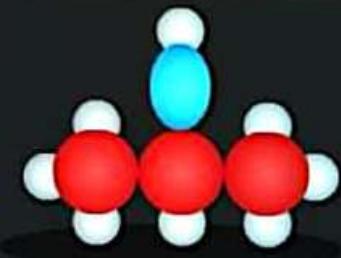
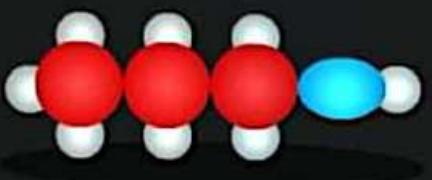
- The indicators used in acid-alkali titrations are aromatic organic compounds which are equilibrium mixtures of at least two tautomeric forms, ordinarily one form is benzenoid while the other is quinoid.
- The two forms have different colours. The quinoid form is usually deeper in colour than the benzenoid form. Out of these one form exists in acidic solution while other in alkaline solution.
- Change in pH causes the transition of benzenoid form to quinoid form and vice versa and consequently a change in colour. This theory explains the action of phenolphthalein, methyl orange and other acid base indicators.



### CHOICE OF INDICATORS

Nature of Titration	pH Jump at the Equivalence point	Suitable Indicator
Strong acid and strong base	4-10	Any Indicator (Methyl orange, Methyl red, Phenolphthalein, Bromothymol blue etc.)
Weak acid and strong base	6.5-10	Phenolphthalein, thymol blue, thymolphthalein
Strong acid and Weak base	4-7.5	Methyl orange, Methyl red, Bromocresol green
Weak acid and Weak base	6.5-7.5	No Indicator is suitable

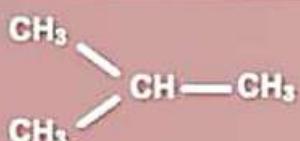
# TYPES OF STRUCTURAL ISOMERISM



## CHAIN ISOMERISM



Butane



Isobutane

Same molecular formula, difference in arrangement. Chain of minimum 4 carbons is necessary.

## RING CHAIN ISOMERISM



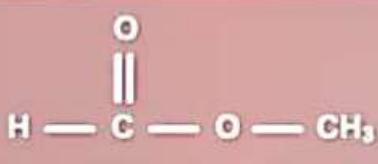
Propene



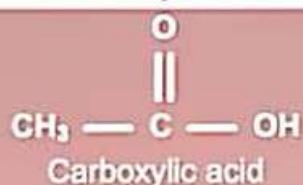
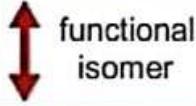
Cyclopropane

Mode of chain formation differs in open and close chain formation.

## FUNCTIONAL ISOMERISM



Ester



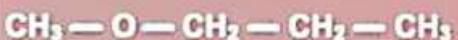
Carboxylic acid

Same molecular formula but different in functional group. Other two functional group Isomers

Alcohol & Ether.

- Aldehydes & Ketones.

## METAMERISM



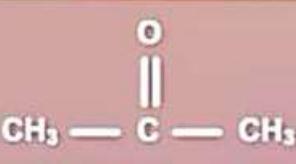
Methyl propyl ether



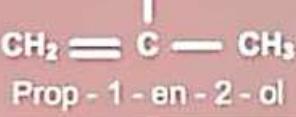
Diethyl ether

Compound having same molecular formula but differ from the nature of alkyl group directly attached with polyvalent atom or polyvalent functional group.

## TAUTOMERISM



Dimethyl ketone

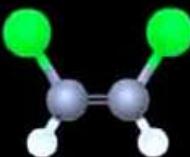


Prop-1-en-2-ol

Compound having same molecular formula but different due to oscillation of an atom (usually H<sup>+</sup>) are known as tautomers.

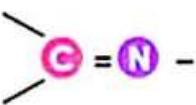
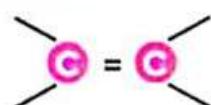
# GEOMETRICAL ISOMERISM

Isomers which possess the same molecular and structural formula but differ in the arrangement of atoms or groups in space due to restricted rotation are known as **geometrical isomers** and the phenomenon is known as **geometrical isomerism**.



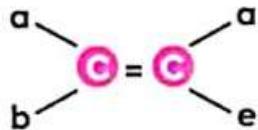
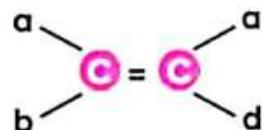
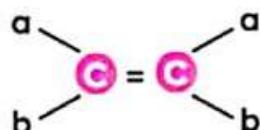
## CONDITION OF GEOMETRICAL ISOMERISM

### PRESENCE OF A DOUBLE BOND OR A RING STRUCTURE



-N=N- or ring structure

### DIFFERENT GROUPS SHOULD BE ATTACHED AT EACH DOUBLY BONDED ATOM



### CONFIGURATIONAL NOMENCLATURE IN GEOMETRICAL ISOMERISM

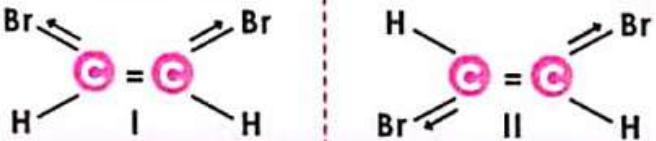
Configuration	Criteria	Remarks
cis / trans	Similarity of groups	If the two similar groups are on same side of <b>restricted bond</b> , the configuration is cis otherwise trans.
E/Z	Seniority of groups	If the two senior groups are on same side of restricted bond, the configuration is <b>Z</b> ( <b>Z = zusammen = together</b> ) otherwise <b>E</b> ( <b>E = entgegen = opposite</b> ).

### NUMBER OF GEOMETRICAL ISOMERS

Number of geometrical isomers can be found by calculating the number of **stereocentres** in the compound. **Stereocentre** is defined as an atom or bond bearing groups of such nature that an interchange of any two group will produce a **stereoisomer**.

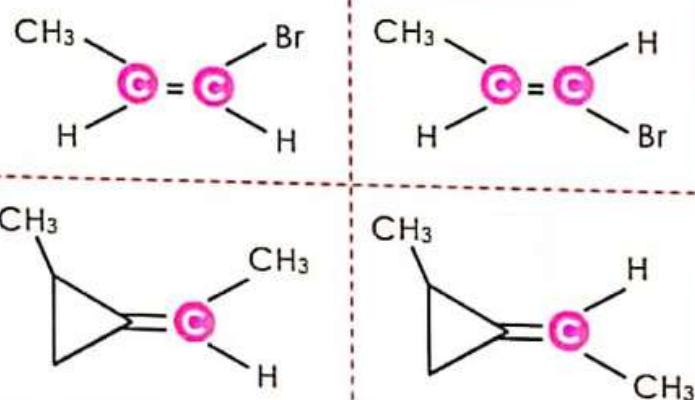
Nature of compound	No. of G.I. ( $n = \text{no. of stereocentres}$ )	Example	No. of Isomers
Compound with dissimilar ends	$2^n$	$\text{CH}_3-\text{CH}=\text{CH}-\text{CH}=\text{CH}-\text{C}_2\text{H}_5$	4
Compound with similar ends with even stereocentres	$2^{n+1} + 2^{\frac{n}{2}-1}$	$\text{CH}_3-\text{CH}=\text{CH}-\text{CH}=\text{CH}-\text{CH}_3$	3
Compound with similar ends with odd stereocentres	$2^{n-1} + 2^{\frac{n-1}{2}}$	$\text{CH}_3-\text{CH}=\text{CH}-\text{CH}=\text{CH}-\text{CH}=\text{CH}-\text{CH}_3$	6

## PHYSICAL PROPERTIES OF GEOMETRICAL ISOMERS

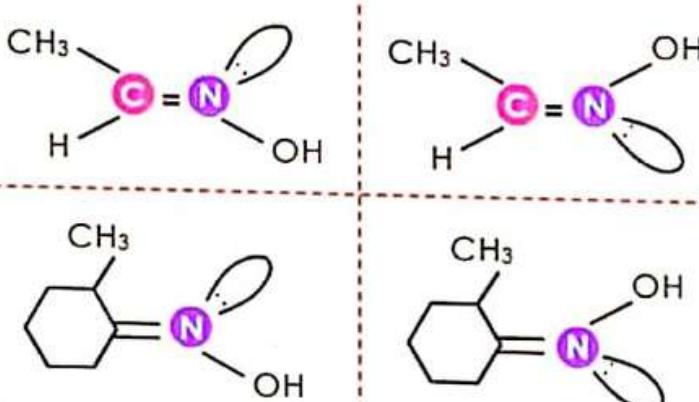
Physical properties		Example
Dipole moment	I > II	Only <b>cis - isomer</b> has dipole
Boiling point	I > II	High <b>boiling point</b> due to larger intermolecular force of attraction
Solubility (in H <sub>2</sub> O)	I > II	Polar molecules are more soluble in H <sub>2</sub> O
Melting point	I < II	More <b>symmetric isomers</b> , higher melting points
Stability	I < II	More <b>vander waal strain</b> , less stable molecule

## • EXAMPLES OF GEOMETRICAL ISOMERS •

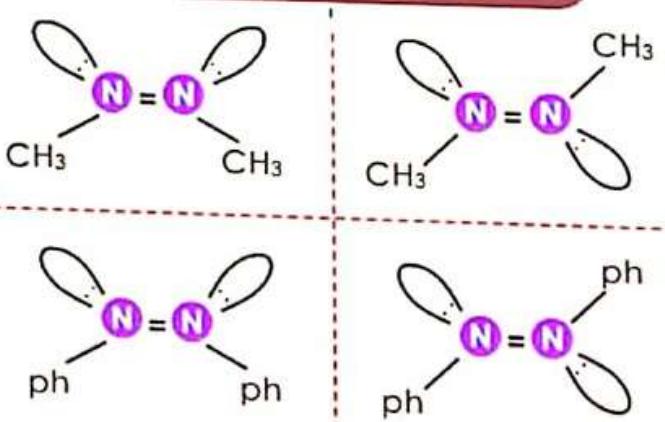
## 01 Along C = C bond



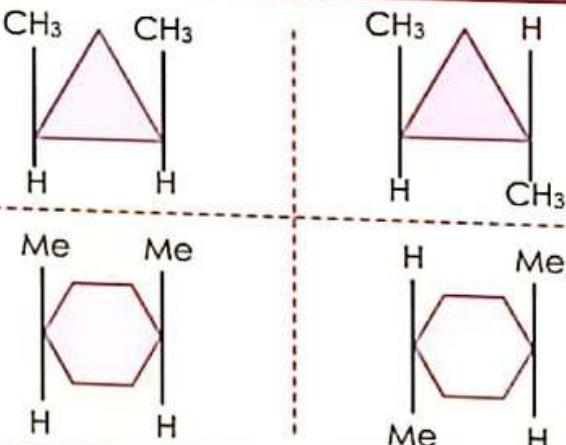
## 02 Along C = N - bond



## 03 Along - N = N - bond

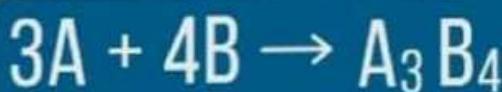


## 04 Along σ bond of cycloalkane

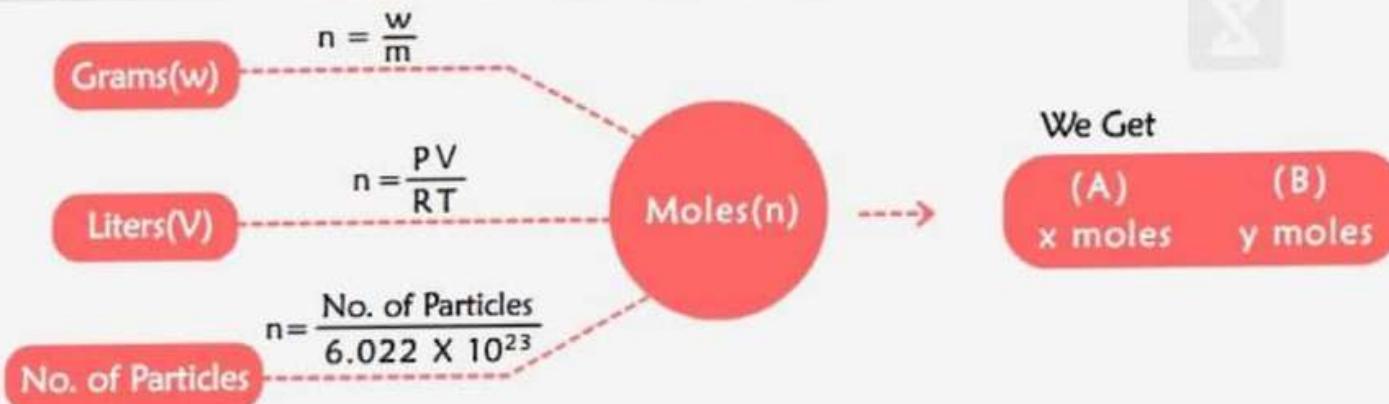


# HOW TO SOLVE ?

## STOICHIOMETRY PROBLEM

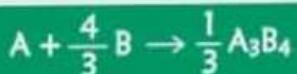


### 1 Converting reactants into moles



### 2 Finding Limiting Reagent (L.R)

Divide by Coefficient of any Reactant, in above reaction its 'A' i.e. 3



1 mole A reacts with  $\frac{4}{3}$  moles B

x mole A reacts with  $\frac{4}{3}x$  moles B

Is  $\frac{4}{3}x > y$  ...

Yes  $\rightarrow$  B is LR

No  $\rightarrow$  A is LR

### 3 Find Moles of Product using L.R (assume L.R = B)



$$n = \frac{1}{4}y$$

4 moles of 'B' gives 1 mole  $A_3B_4$

$\rightarrow$  so y moles of 'B' gives  $\frac{1}{4}(y)$  moles  $A_3B_4$

### 4 Converting Product Moles into required quantity

Product  
 $A_3B_4$   
(n)

$$w = n \times m$$

$$V = \frac{nRT}{P}$$

$$\text{No. of particle} = n \times 6.022 \times 10^{23}$$

Grams(w)

Liters(V)

Particles

$$w / \text{A.M.U}$$

$$\text{A.M.U} \\ 1.66 \times 10^{-24} \text{ gm}$$

Total no. of  
Particles

Gram Atom

# Concentration Terms



## Molarity (M)

Molarity is no. of moles of a solute per liter of solution

$$M = \frac{\text{moles of solute}}{\text{volume of solution(in liter)}}$$



## Molality (m)

Molality is the no. of moles of solute per kilogram of solvent.

$$m = \frac{\text{moles of solute}}{\text{weight of solvent (in kg.)}}$$



## Normality (N)

Normality is the gram equivalent weight per liter of solution.

$$N = \frac{\text{gram equivalents of solute}}{\text{volume of solution(in liter)}}$$



## Formality (f)

Formality is the no. of gram formula masses of the ionic solute dissolved per liter of solution.

$$f = \frac{\text{weight in gram}}{\text{formula weight} \times \text{volume of solution(liter)}}$$



## Mole Fraction

Mole Fraction is equal to the moles of one component divided by total moles in the solution or mixture.

$$X_A = \frac{n_A}{n_A + n_B}$$



## Parts per million (ppm)

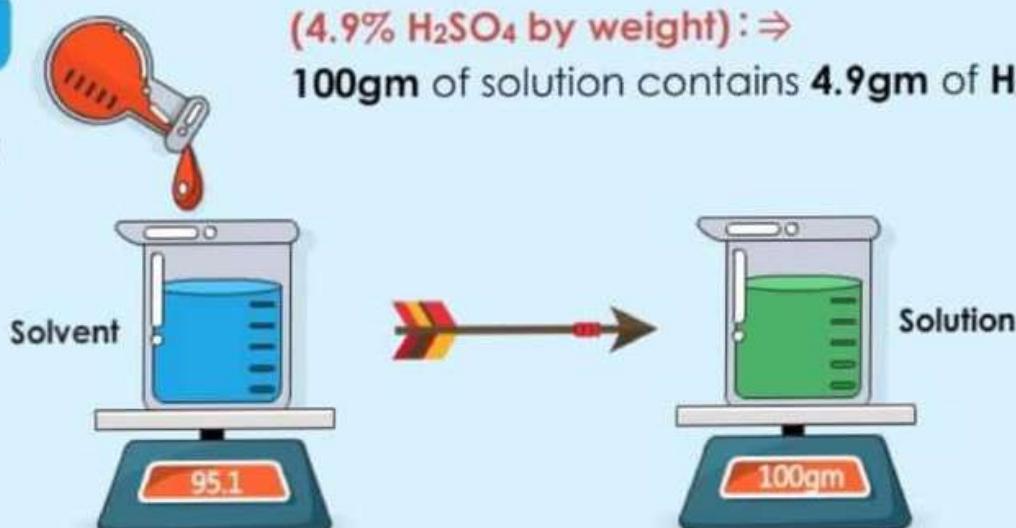
Parts per million is value that represent the part of whole no. in units of 1/1000000

$$\text{ppm} = \frac{\text{mass of solute}}{\text{mass of solvent}} \times 10^6$$

# CONCENTRATION OF SOLUTION

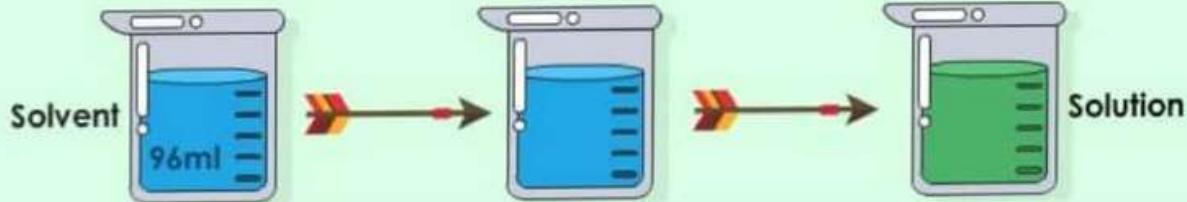
## (1) % by weight

4.9 gm  
 $\text{H}_2\text{SO}_4$



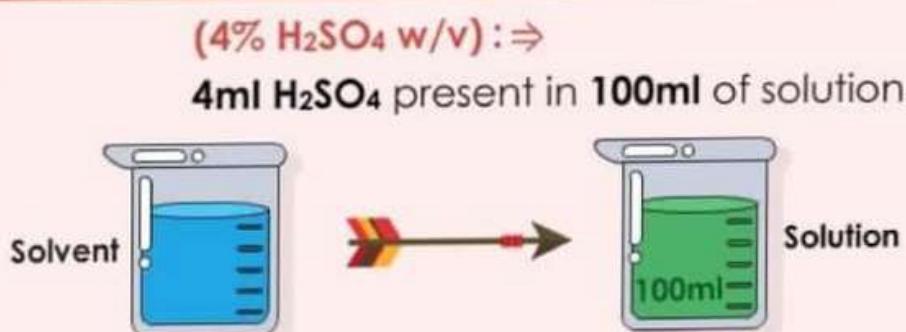
## (2) % by volume

4ml  
 $\text{H}_2\text{SO}_4$



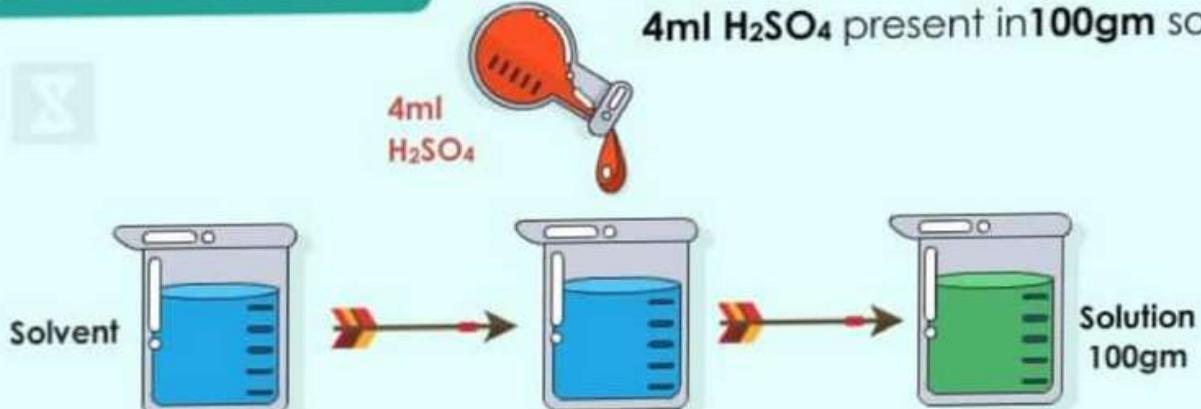
## (3) % weight by volume

4gm  $\text{H}_2\text{SO}_4$



## (4) % volume by weight

4ml  
 $\text{H}_2\text{SO}_4$



# EQUIVALENT MASS

## Definition

The mass of a substance especially in grams that combines with or is chemically equivalent to **eight grams of oxygen or one gram of hydrogen**

$$\text{Equivalent Mass} = \frac{\text{Molar Mass}}{n\text{- Factor}}$$

## EQUIVALENT MASS

Element

$$E = \frac{\text{Atomic mass of element}}{\text{Valence of element}}$$

Ion

$$E = \frac{\text{Formula mass of ion}}{\text{Charge on ion}}$$

Salt

$$E = \frac{\text{Formula mass of salt}}{\text{Total positive or negative charge on cationic or anionic part}}$$

Acid

$$E = \frac{M_{\text{acid}}}{\text{Basicity}}$$

Base

$$E = \frac{M_{\text{Base}}}{\text{Acidity}}$$

Acid Salt

$$E = \frac{M}{\text{Replaceable 'H' left in the salt}}$$

Redox Change

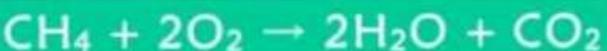
$$E = \frac{M_{\text{oxidant or reductant}}}{\text{Number of electrons lost or gained by one molecule of oxidant or reductant}}$$

# CHEMICAL REACTIONS

## COMBUSTION



**COMBUSTION** or burning is a high temperature exothermic redox chemical reaction between a fuel and an oxidant usually atmospheric oxygen.



## ADDITION

**ADDITION** reaction is a reaction in which one molecule combines with another to form a large molecule with no other product.



## DECOMPOSITION

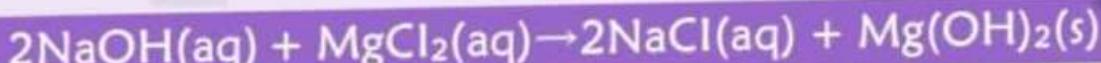


**DECOMPOSITION** reaction involves the breakdown of chemical compound into its elements or simpler compounds. These reactions often involve an energy source such as heat, light, or electricity that breaks apart the bonds of compounds.



## PRECIPITATION

**PRECIPITATION** reaction is the one in which aqueous compounds react to form an insoluble solid, called a precipitate. Whether or not a reaction will form a precipitate is dictated by solubility rules for ionic compounds.



## NEUTRALISATION



**NEUTRALISATION** reaction is the one in which an acid and a base react to form a salt and water. Neutralisation reactions do not necessarily result in a pH of 7, resultant pH is dependent on the strengths of the acid and base.



# CHEMICAL REACTIONS

## CONDENSATION



**CONDENSATION** reaction is the one in which two molecules combine to form a larger molecule with a small molecule. The small molecule lost is usually water, but not always. It can be considered to be the opposite of hydrolysis.



## HYDROLYSIS

**HYDROLYSIS** reaction involves the breaking of chemical bonds by the addition of water to a substance. In some cases, this addition can cause both the substance and the water molecule to split into two parts.



## DISPLACEMENT

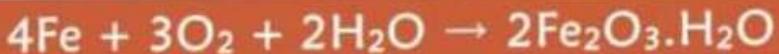
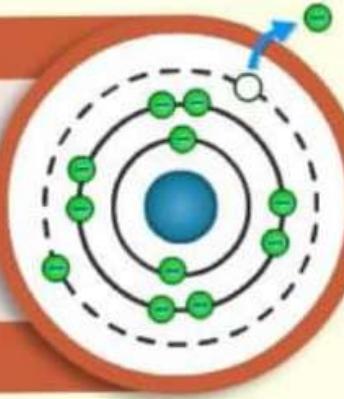


**DISPLACEMENT** reaction is chemical reaction in which a more reactive element displaces a less reactive element from its compound. Both metals and non-metals take part and more reactive displaces the less reactive.



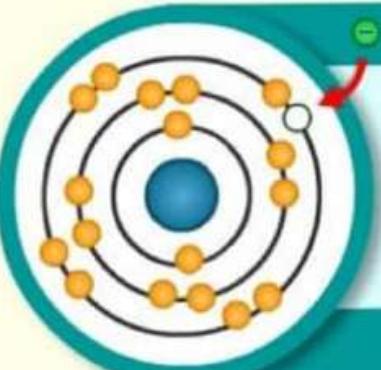
## OXIDATION

**OXIDATION** reactions are sometimes defined as the reactions in which an element forms bonds with oxygen atoms. Generally, oxidation can be defined as a reaction in which atoms of an element **lose electrons**.



## REDUCTION

**REDUCTION** reactions are sometimes defined as reactions in which other molecules lose oxygen atoms. Generally, reduction can be defined as a reaction in which atoms of an element **gain electrons**.



# BORON FAMILY



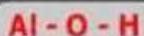
## ELECTRONIC CONFIGURATION



Gallium has the **second lowest melting point** after mercury. It remains in liquid phase even at high temperatures.

## AMPHOTERIC

$Al(OH)_3$  is amphoteric



Strength between Al - O and O - H is same.

Bond strength Al - O = Bond strength O - H



Aluminium is used in tins, aeroplanes and even in Iphone



Borax ( $Na_2B_4O_7$ ) is used for cleaning and washing purposes.



Indium is used in display screens of television and mobiles.



Aluminium was classified as precious metal during 19th century. **Napoleon III** gave aluminium cutlery to his most valuable guests, all other guests had to eat with gold cutlery.

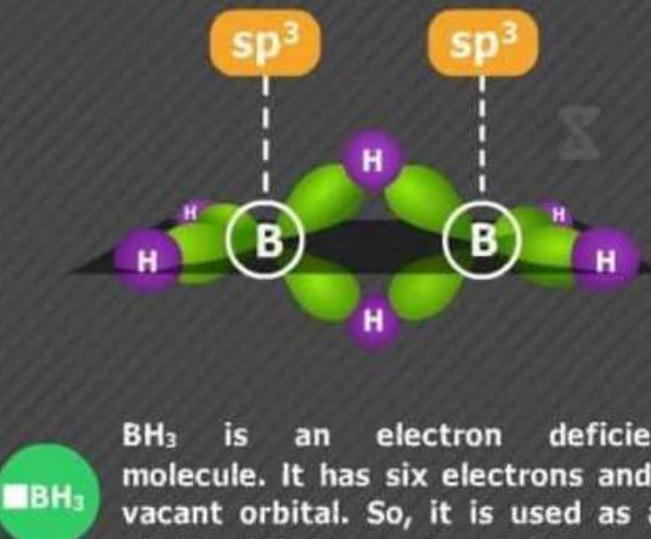


Thallium is used as rat poison.

## PHYSICAL STATE

Boron is a non metal. Aluminium, Indium, Gallium are metalloids.

## DIBORONE ( $B_2H_6$ )



$BH_3$  is an electron deficient molecule. It has six electrons and a vacant orbital. So, it is used as an electrophile in organic reactions.

# CARBON



Part-I

C	6	Si	14	Ge	32	Sn	50	Pb	82
12.0107		28.09		72.81		118.71		207.2	

## FAMILY

### DO you? KNOW?

Carbon is a non-metal

• Silicon and germanium are metalloid

• Lead and tin are metal

Carbon has three main solid state allotropes: Graphite, Diamond and Fullerenes (the most commonly known of which, buckminsterfullerene, is also known as a "bucky-ball").

### Germanium



Germanium is a rare element used in the manufacturing of **semiconductor** devices. The physical and chemical properties of germanium are very similar to those of silicon. Germanium is **grey-white** in color and forms crystal structures.

### Silicon



Silicon is the second most common element in the earth's crust (after oxygen) and it is the backbone of the mineral world. Silicon is used extensively as a semiconductor in **solid-state** devices in the computer and microelectronics industries.

### Tin



Tin is **malleable**, **ductile**, and **crystalline**. It is a superconductor at low temperatures. Tin reacts with bases, acid salts and strong acids. Tin chlorides are good reducing agents and often used to reduce iron ores. Tin fluoride is often the anticavity **"fluoride"** additive in toothpastes.

### Lead



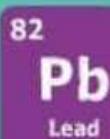
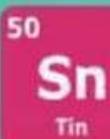
It is a soft, malleable metal with a low **melting point**. Lead is toxic to humans, especially children. Even low levels of exposure can cause nervous system damage and can prevent proper production of **haemoglobin**. Its oxides have many industrial uses as oxidizing agents, such as cathodes in lead-acid storage cells.

### Point to Remember

Carbon has the highest melting/sublimation point of the elements. The melting point of diamond is **3550°C**, with the sublimation point of carbon is around **3800°C**.

# CARBON FAMILY

Part-II



## ELECTRONIC CONFIGURATION



Valence Electrons = 4

## REACTIVITY

The carbon family elements tend to be fairly unreactive. the elements tend to form covalent compounds, though tin and lead also form ionic compounds.

## CARBIDES

Carbon combines with other elements and forms carbides  $Al_4C_3$ ,  $Be_2C$ ,  $SiC$  and  $B_4C$  are considered as the hardest compounds.



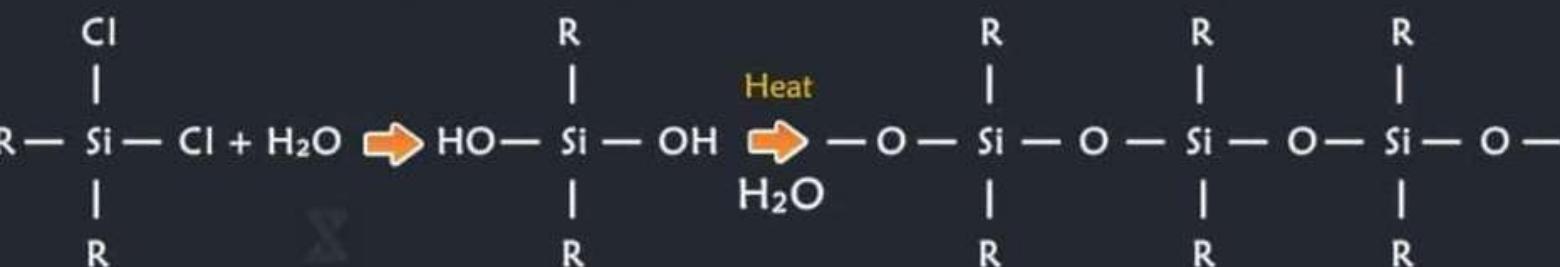
## DON'T STORE JUICES IN TIN CONTAINERS

Generally juices have metallic taste if we store them in tin containers. Juices are mostly acidic and they react with tin. Tin reduces the acid by absorbing oxygen.



## SILICONES

Silicones are organo silicon polymers and are formed by hydrolysis of  $R_2SiCl_2$



Linear Silicones

## CARBON-GODLY ELEMENT

Every human being and everything around us consists of carbon.



## TIN-CANS

Initially we used Tin in making cans, later it was replaced by Aluminium.

## LEAD PENCILS

Lead Pencils which we use do not contain Lead. It contains Graphite (an allotrope of carbon).



## SILICON

Silicon is used in semiconductor devices, which are used in modern day computers.

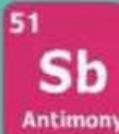
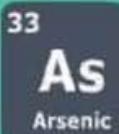


## NON STICK PAN

Nonstick pan has a Teflon layer on its surface. Teflon( $-CF_2-CF_2-$ )



# NITROGEN FAMILY



## ELECTRONIC CONFIGURATION



$ns^2 np^3$

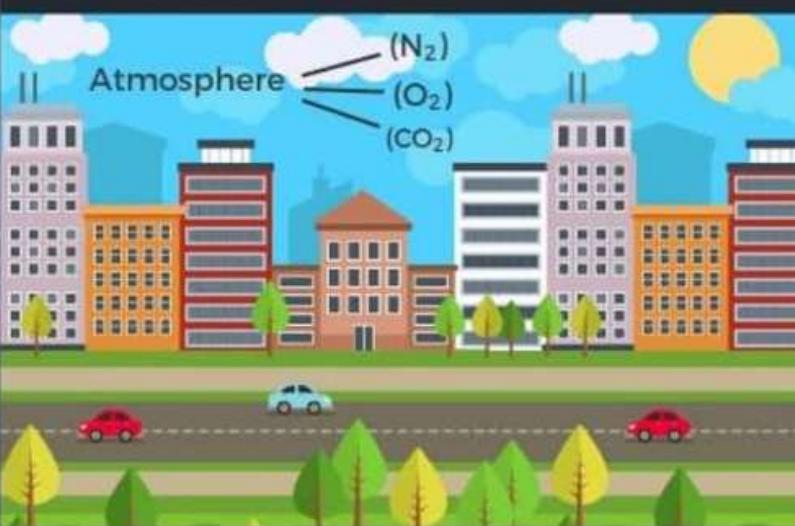
Valence Electron = 5

## BORAZONE

Borazone(cBN) has graphite like structure and it is harder than diamond. So, it is used for cutting the diamond.



## EARTH ATMOSPHERE CONTAINS 71% NITROGEN



### TNT

Tri Nitro Toluene is used in explosives.



## USES

Red phosphorus is used in matchbox.



Half life of Bismuth is very high. If 100 gm of Bismuth had been present at the beginning of universe, 14 billion years ago. About 99.9999 gm would be left today.



## INERT NATURE OF $N_2$ ( $N \equiv N$ )

Triple bond exists between Nitrogen, which is very hard to break. It reacts only when suitable conditions are met for reaction.



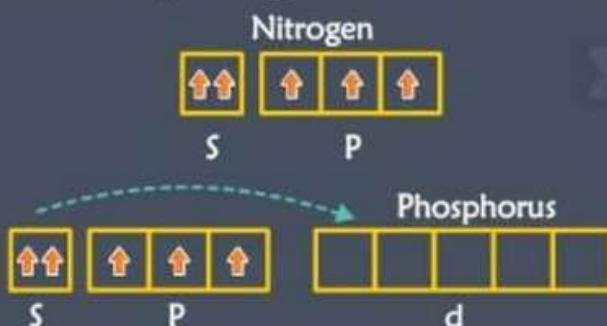
## TEST OF PROTEINS

Nitric acid attacks the protein and forms Xanthoprotein which is yellow in colour.



## PENTAHALIDES

Nitrogen does not show pentahalides because of the absence of d-orbitals. Phosphorous shows pentahalides by exciting s electrons into d-orbitals.



Arsenic is a poisonous gas therefore, it is used as pesticides for trees.

$P_2O_5$  is used as a drying agent, but it is corrosive to use outside the labs.



# CHALCOGENS

<b>8</b> <b>O</b> Oxygen	<b>16</b> <b>S</b> Sulphur	<b>34</b> <b>Se</b> Selenium	<b>52</b> <b>Te</b> Tellurium	<b>84</b> <b>Po</b> Polonium	<b>116</b> <b>Lv</b> Livermorium
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## ELECTRONIC CONFIGURATION



Valence Electrons = 6

## TAILING OF MERCURY

Mercury loses its miniscus and sticks to the glass due to formation of mercurous oxide.



## OZONE LAYER ( $O_3$ )



Ozone layer is filled with ozone molecules.

Ozone is the **BEST OXIDISING AGENT**

## POLONIUM

Radioactive and deadly. It is rumoured that Yasar Arafat died due to poisoning of Polonium.

### CAREFUL WITH H<sub>2</sub>SO<sub>4</sub>

$\text{H}_2\text{SO}_4$  is the strongest and most corrosive acid. It can cause serious burns on the skin.



## MELTING POINT

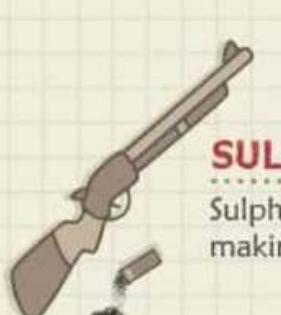
Oxygen      Selenium      Tellurium  
 $-219^{\circ}\text{C}$        $221^{\circ}\text{C}$        $450^{\circ}\text{C}$



## REACTION WITH HYDROGEN

Hydrogen with Oxygen forms water ( $H_2O$ )

Hydrogen with sulphur forms  $H_2S$  which gives foul smell.



## **SULPHUR**

Sulphur is used in making Gun powder.



## **TELLURIUM**

Tellurium is used in CD's and Blue-ray discs.



SELENIUM

Selenium is used in Glass making.



# HALOGENS

## 1 Physical State



Gas



Liquid



Solid

## 3 REACTIVITY

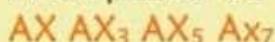
Reactivity decreases down the group as it is harder to add electrons.

F is the most reactive



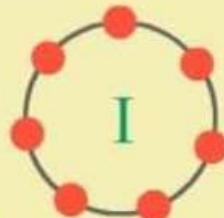
## 5 INTER HALOGEN

Halogens combine with each other to form series of compounds like



Large molecules can accommodate more halogens like in IF<sub>7</sub>

Small fluorine can't accommodate many halogens like in FCl



## 7 VARIABLE OXIDATION STATES

Halogens exhibits variable oxidation states starting from -1 to 7.

Fluorine can't show positive oxidation state.

Fluorine is used in Tooth Paste



## 9 USES

Chlorine is used as a Bleaching Agent



## 2 ELECTRONIC CONFIGURATION



They have seven valence electrons

GENERAL CONFIGURATION  
ns<sup>2</sup> np<sup>5</sup>

## 4 ACIDITY



Acidity decreases down the group

HF is the strongest acid which can dissolve glass also.

## 6 CHLORINE IN WAR FARE

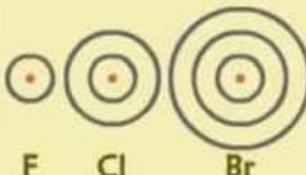


Germany used chlorine in world war- I against France.

Chlorine gas destroys respiratory organs.

## 8 ELECTRONEGATIVITY

Atomic size increases down the group, therefore electronegativity decreases down the group.



Iodine is used in Disinfectants



Bromine is used for developing Photographic films



# NOBLE GASES

2 <b>He</b> 4.0026 Helium	10 <b>Ne</b> 20.179 Neon	18 <b>Ar</b> 39.948 Argon	36 <b>Kr</b> 83.80 Krypton	54 <b>Xe</b> 131.293 Xenon	86 <b>Rn</b> 222.017 Radon
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Also known as **inert gases** as their atoms don't combine with other atoms in chemical reaction

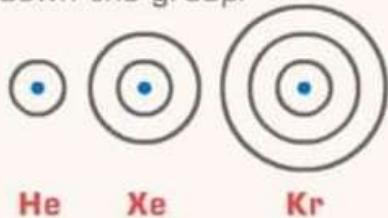
## First Noble Gas Compound - Xenon

Bartlett surprised every one by synthesising  $\text{XePtF}_6$



### Atomic Size

Size increases as you go down the group.



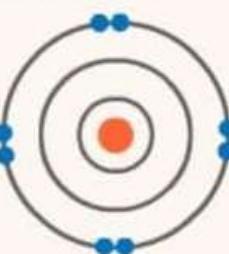
### Krypton

Light bulb containing **krypton gas** can produce a bright white light useful for photography and runaway **lights**.



### Helium

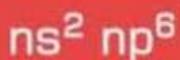
Helium is used in **balloons**. Initially hydrogen was used which is much lighter than Helium but due to its **flammability**, we shifted to **Helium**.



### Electronic Configuration

These elements have **8 electrons** in valence orbital which is considered stable.

**Exception :** Helium has two valence **electrons**  
General electronic configuration



### Neon Light

Neon Lights which we use in our streets are produced by **ionising inert gas** by applying voltage.



### Argon

#### Do you know?

There are 22 known isotopes of argon ranging from **argon-31** to **argon-51** and **argon-53**.

### Reactivity of Xenon

1 Xenon acts as fluorinating agent



2 Xenon acts as fluoride acceptor



3 Xenon acts as fluorine donor

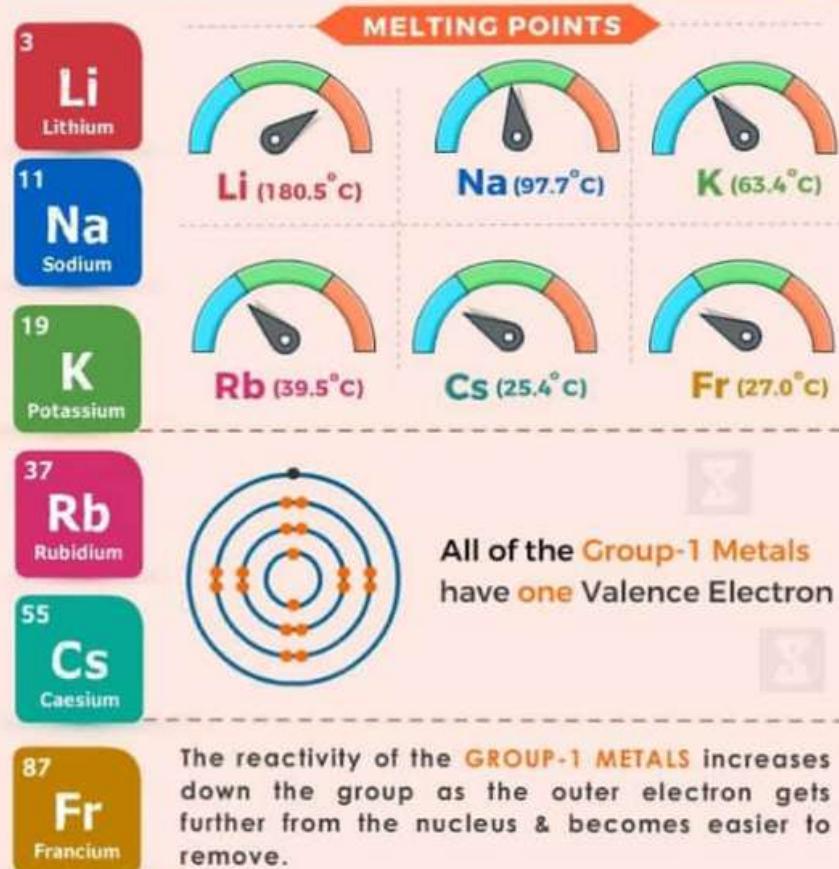


### Radon

Radon is radioactive and can enter homes through basements after **radioactive** decay of rocks below the **earth**.

# GROUP - 1 THE ALKALI METALS

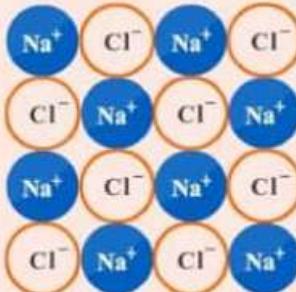
Group-1 elements are Shiny, Soft, and highly reactive metals. none of them occur as a natural free element



The alkali metals react with water to form  
**METAL HYDROXIDES**



Alkali metals react with oxygen to form  
**METAL OXIDES**



Alkali metals react with halogens to form  
**IONIC SALTS**

PROPERTIES OF ALKALI METALS	
	Silver-like lustre
	High Ductility
	Low melting point
	High malleability
	Excellent conductor of heat and electricity

# Properties of Alkali metals

## FLAME TEST COLORS

**Li<sup>3</sup>****Na<sup>11</sup>****K<sup>19</sup>****Rb<sup>37</sup>****Cs<sup>55</sup>****Fr<sup>87</sup>**

## VERY SOFT



- Alkali metals can be easily cut with a knife
- Among all alkali metals lithium is hardest.

## ATOMIC SIZE



Size increases down the group due to added extra orbit.

## STORED IN KEROSENE



Alkali metals react with air easily to form oxide layer therefore they are stored in kerosene.

## ELECTRONIC CONFIGURATION



- They have one valence shell electron.
- General valence electronic configuration

## ELECTROPOSITIVE

It is the ability to remove an electron

**Cs**

- Electropositivity increases down the group.
- Caesium** has the highest electropositive character.

## REACTS WITH WATER

**H<sub>2</sub>O**

- They reacts violently with water and form hydroxides.
- Don't even dare to go near when **caesium** reacts with water.

## USES

### LITHIUM

- Anti depressants
- Batteries



### SODIUM

- Street lamps
- Salt



### POTASSIUM

- Fertilizers



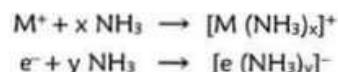
### CAESIUM

- Atomic Clocks



## REACTS WITH AMMONIA

On dissolving NH<sub>3</sub> forms Ammoniated cation and electron. Solution turns blue

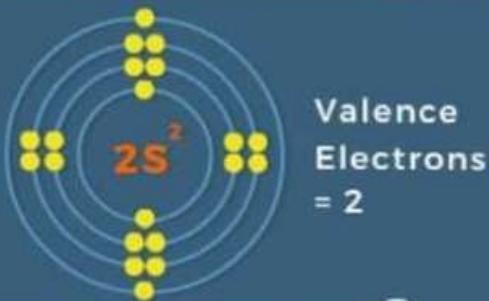


# ALKALINE EARTH METALS



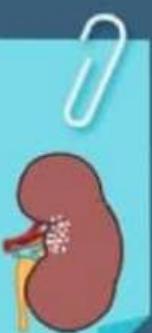
4 <b>Be</b> Beryllium	12 <b>Mg</b> Magnesium	20 <b>Ca</b> Calcium	38 <b>Sr</b> Strontium	56 <b>Ba</b> Barium	88 <b>Ra</b> Radium
-----------------------------	------------------------------	----------------------------	------------------------------	---------------------------	---------------------------

## ELECTRONIC CONFIGURATION



## DO YOU KNOW ?

Kidney stones generally consist of calcium oxalate,  $\text{CaC}_2\text{O}_4 \cdot \text{H}_2\text{O}$  which dissolves in dilute strong acids but remains insoluble in bases.



## ATOMIC SIZE

Size increases down the group due to added extra orbit.

## ELECTROPOSITIVITY

Strong electropositive elements due to large size, electropositivity increases down the group.

### BERYLLIUM

Corrosion resistant alloys

### MAGNESIUM

Present in chlorophyll, helps in photosynthesis

## USES

### CALCIUM

Hydrated  $\text{CaCl}_2$  used for melting ice on roads

### STRONTIUM

Glass for colour television cathode ray tubes

### BARIUM

Nuclear Medicine

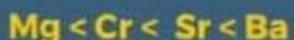
## FLAME COLOUR TEST

Group II Element	Flame Colour
Beryllium	Colourless
Magnesium	Colourless
Calcium	Brick red
Strontium	Crimson red
Barium	Apple green

They are commonly called alkaline earth metals because their oxides are alkaline in nature and are found in earth's crust.

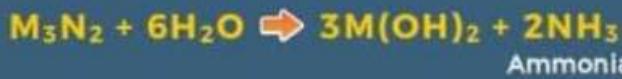
## REACTION WITH WATER

**Be** does not react even with boiling water and **Ba** react vigorously even with cold water. Thus increasing order of reactivity with water is



## REACTION WITH NITROGEN

These metals react with nitrogen to form nitrides of the types  $\text{M}_3\text{N}_2$  which are hydrolysed with water to evolve  $\text{NH}_3$ .



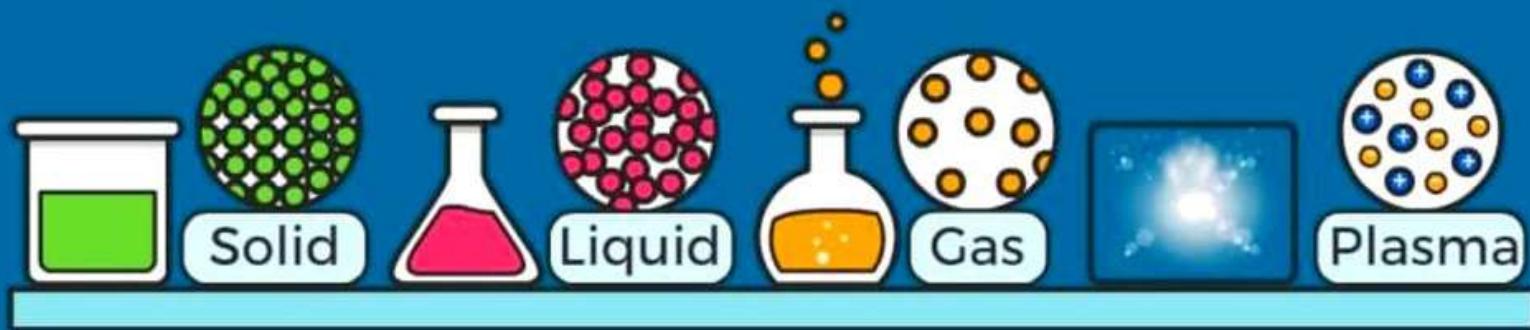
# ALKALI METALS

DIFFERENCE  
? BETWEEN

# ALKALINE EARTH METALS

PROPERTIES	ALKALI METALS	ALKALINE EARTH METALS
Physical properties	Soft, Low melting point, Paramagnetic.	Comparatively harder. High melting point, Diamagnetic
Valency	Monovalent	Bivalent
Electropositive nature	More electropositive	Less electropositive
Hydroxides	Strong base, highly soluble and stable towards heat.	Weak base, less soluble and decomposes on heating.
Bicarbonates	These are known in solid state.	These are not known in free state. Exist only in solution
Carbonates	Soluble in water. Do not decomposes on heating ( $\text{LiCO}_3$ is an exception)	Insoluble in water. Decomposes on heating.
Action of carbon	Do not directly combine with carbon	Directly combine with carbon to form carbides
Solubility of salts	Sulphates, phosphates, fluorides, chromates, oxides etc are soluble in water.	Sulphates, phosphates, fluorides, chromates, oxalates etc are insoluble in water
Reducing power	Stronger as ionization potential values are low and oxidation potential values are high	Weaker as ionization potential values are high and oxidation potential values are low.
Electronic configuration	One electron is present in the valence shell. The configuration is $\text{ns}^1$ (monovalent)	Two electrons are present in the valence shell. The configuration is $\text{ns}^2$ (bivalent)

# STATES OF MATTER



Gas molecules move around freely

Gas

Plasma

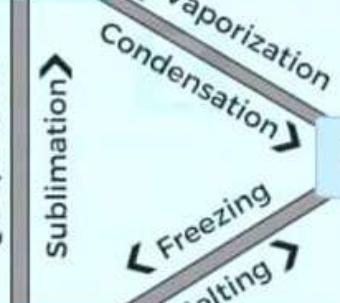
hot ionized gas consisting of charged ions.

Solid molecules are tightly packed and stay in a packed position

Solid

Liquid

Liquid molecules are close together but can move around.



## PHYSICAL STATE

### SOLID



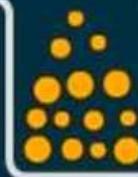
The molecules that make up a solid are arranged in regular, repeating pattern. They are held firmly in place but can vibrate within a limited area.

### LIQUID



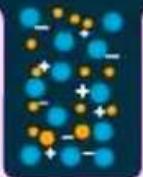
The molecules that make up a liquid flow easily around one another. They are kept from flying apart by attractive forces between them. Liquids assume the shape of their containers.

### GAS

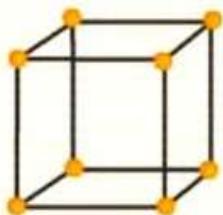


The molecules that make up a gas fly in all directions at great speeds. They are so far apart that the attractive forces between them are insignificant.

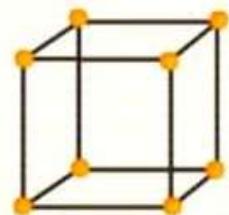
### PLASMA



At very high temperatures of stars, atoms lose their electrons. The mixture of electrons and nuclei that results is the plasma state of matter.

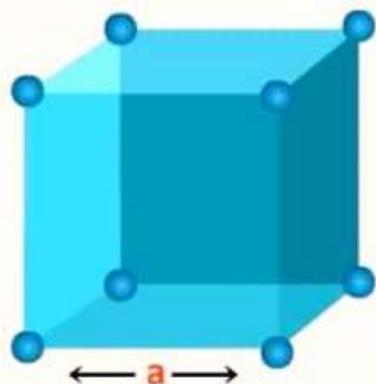


# Bravais Lattices Of Crystals

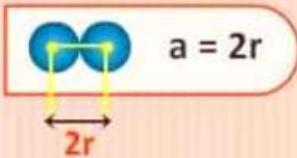


## Primitive Cube

- 8 - Corner atoms =  $8 \times \frac{1}{8} = 1$



Total Number of atoms = 1

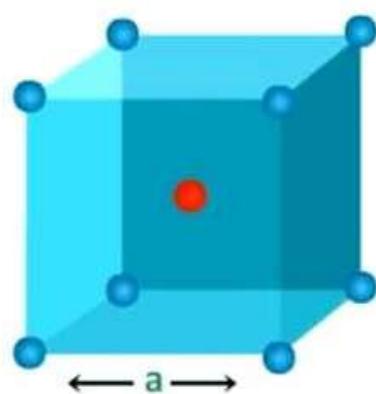


$$\text{Packing Fraction} = \frac{\text{Volume of atoms}}{\text{Volume of cube}} = 0.52$$

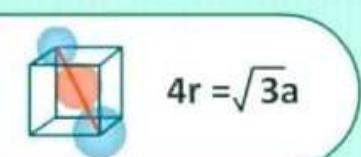
## Body Centered Cube

- 8 - Corner atoms =  $8 \times \frac{1}{8} = 1$

- 1 Center atom = 1



Total Number of atoms = 2



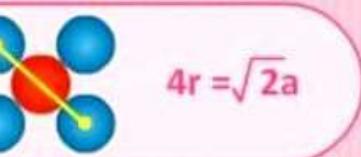
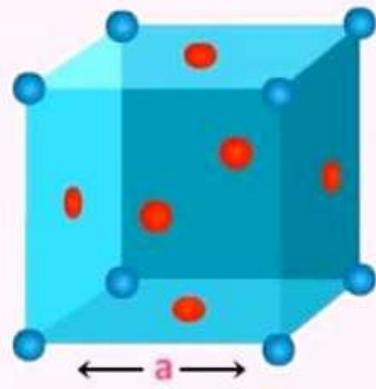
$$\text{Packing Fraction} = \frac{\text{Volume of atoms}}{\text{Volume of cube}} = 0.68$$

## Face Centered Cube

- 8 - Corner atoms =  $8 \times \frac{1}{8} = 1$

- 6 - Face atoms =  $6 \times \frac{1}{2} = 3$

Total Number of atoms = 4



$$\text{Packing Fraction} = \frac{\text{Volume of atoms}}{\text{Volume of cube}} = 0.74$$

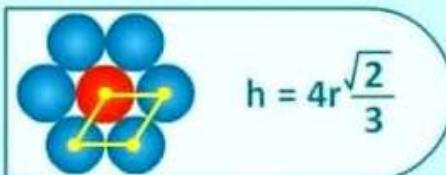
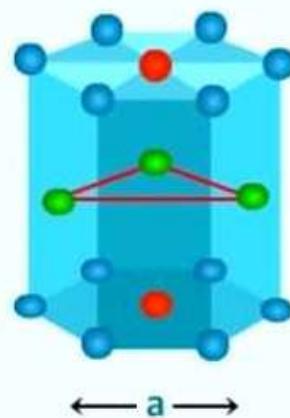
## Hexagonal Close Packed

- 12 - Side corner =  $12 \times \frac{1}{6} = 2$

- 2 - Face side atoms =  $2 \times \frac{1}{2} = 1$

- 3 - atoms inside  $3 \times 1 = 3$

Total Number of atoms = 6



$$\text{Packing Fraction} = \frac{\text{Volume of atoms}}{\text{Volume of hexagonal}} = 0.74$$

# RAOULT'S LAW

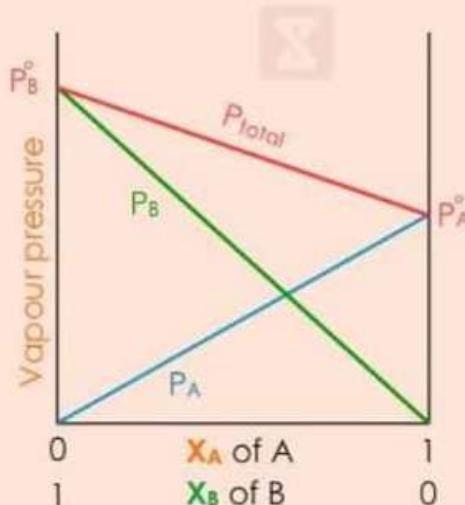
The vapour pressure of a solution of a non-volatile solute is equal to the vapour pressure of the pure solvent at that temperature multiplied by its mole fraction.

$$P_{\text{SOLN}} = X_{\text{SOLVENT}} P_{\text{SOLVENT}}^{\circ}$$

$P_{\text{SOLN}}$  = VAPOUR PRESSURE OF THE SOLUTION

$X_{\text{SOLVENT}}$  = MOLE FRACTION OF THE SOLVENT

$P_{\text{SOLVENT}}^{\circ}$  = VAPOUR PRESSURE OF THE PURE SOLVENT

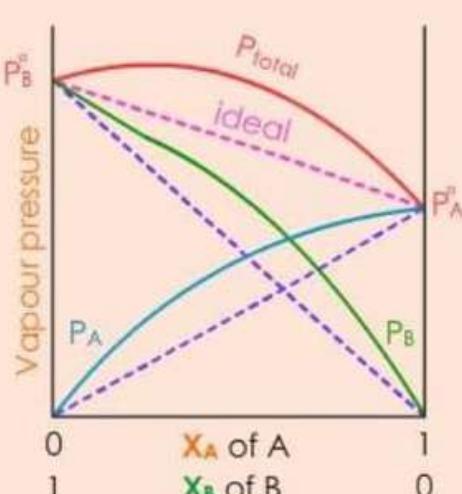


$$P_A = X_A \cdot P_A^{\circ}$$

$$P_B = X_B \cdot P_B^{\circ}$$

$$P_{\text{total}} = P_A + P_B$$

Raoult's law

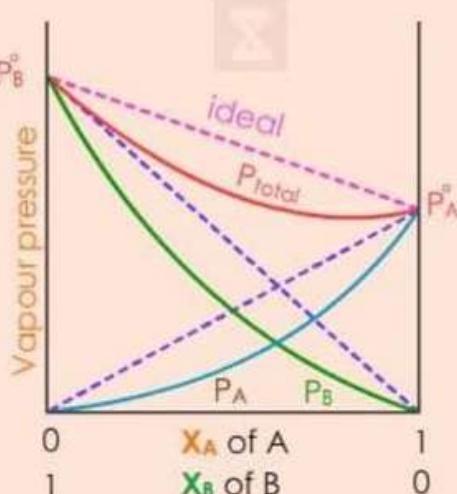


$$P_A > X_A \cdot P_A^{\circ}$$

$$P_B > X_B \cdot P_B^{\circ}$$

$$P_{\text{total}} > P_{\text{ideal}}$$

Positive deviation from  
Raoult's law



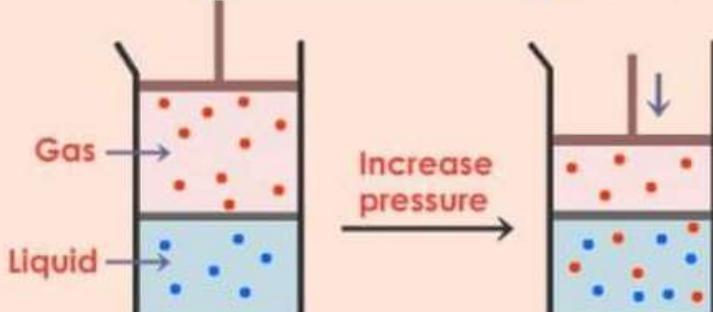
$$P_A < X_A \cdot P_A^{\circ}$$

$$P_B < X_B \cdot P_B^{\circ}$$

$$P_{\text{total}} < P_{\text{ideal}}$$

Negative deviation from  
Raoult's law

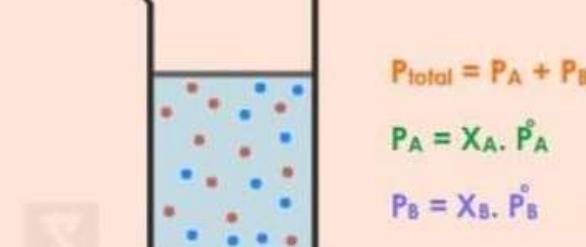
## HENRY'S LAW



$$P = K_H \cdot C$$

At a constant temperature, the amount of a given gas that dissolves in a given type and volume of liquid is directly proportional to the partial pressure of that gas in equilibrium with that liquid.

## VAPOUR PRESSURE



$$P_{\text{total}} = P_A + P_B$$

$$P_A = X_A \cdot P_A^{\circ}$$

$$P_B = X_B \cdot P_B^{\circ}$$

Each substance has a lower vapour pressure from that of a pure substance!

Even though it looks like the mix may be "50/50", "A" particles have a higher vapour pressure (evaporate more easily) than the "B" substance.

# COLLIGATIVE PROPERTY



A property that depends on the concentration of solute particles but not on the identity of the solute

## Colligative properties include:

- Vapour pressure lowering
- Boiling point elevation
- Freezing point depression



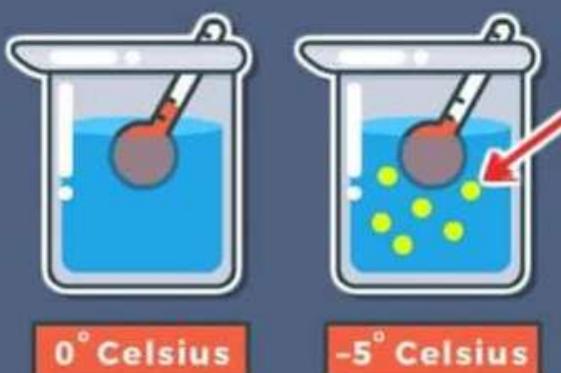
### VAPOUR PRESSURE

- Vapour pressure is the pressure of the vapour over a liquid at equilibrium.
- A non-volatile solute will lower the vapour pressure of a solvent

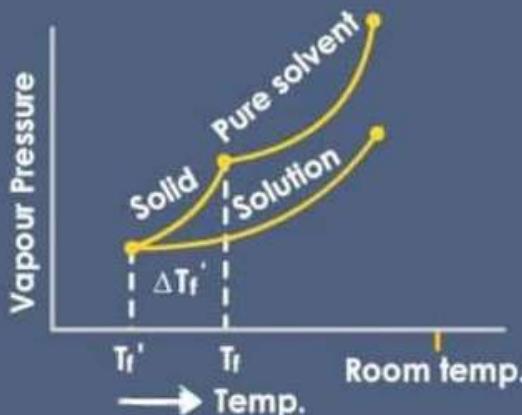


### FREEZING POINT DEPRESSION

Freezing Point Depression is the decrease in the freezing point of a solvent due to the presence of solute particles.

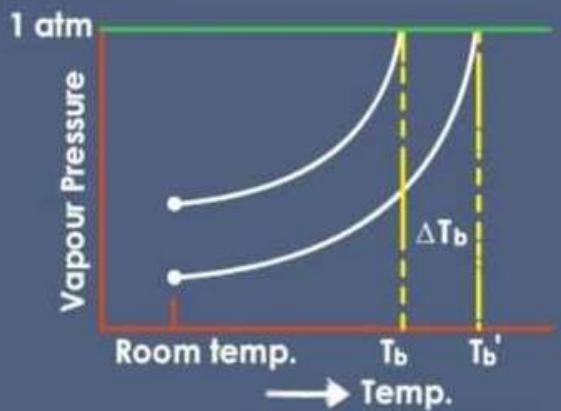


$$\Delta T_f = K_f \cdot m$$



### BOILING POINT ELEVATION

Boiling Point elevation is the increase in the boiling point of a solvent due to the presence of solute particles.



$$\Delta T_b = K_b \cdot m$$

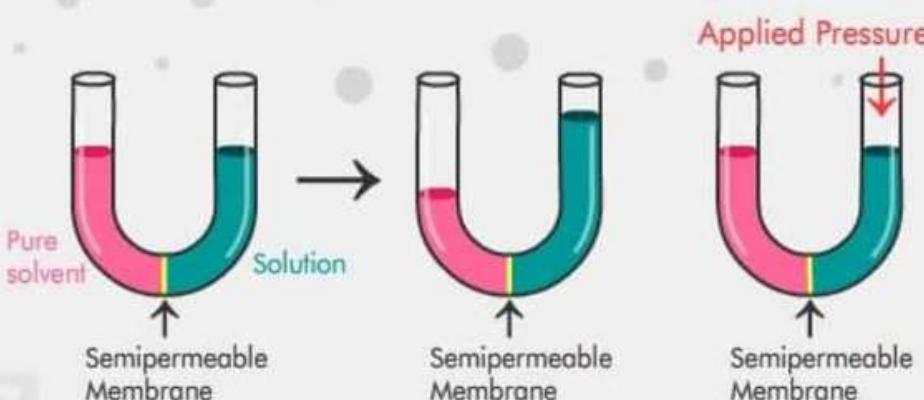


# OSMOTIC PRESSURE

# & VANT HOFF' FACTOR

## WHAT IS? OSMOTIC PRESSURE

The minimum pressure that stops the osmosis is equal to the osmotic pressure of the solution.



$$\pi = i MRT$$

$\pi$  = Osmotic pressure

$i$  = Van't Hoff factor

M = Molar concentration of solution (mol/L)

R = Ideal gas constant (0.08206 L atm Mol<sup>-1</sup> K<sup>-1</sup>)

T = Temperature in Kelvin (K)

## VAN'T HOFF' FACTOR

Colligative properties are directly proportional to the number of mole of solute, dissociation or association may cause some abnormal increase or decrease in the measured values of colligative properties. Van't Hoff factor is a factor that takes into account this abnormal behaviour and can be defined as,

$$i = \frac{\text{Observed magnitude of any colligative property}}{\text{Normal magnitude of the same colligative property}}$$

Since, colligative properties are inversely related to the molar mass of the solute, hence, one can write,

$$i = \frac{\text{Normal molar mass}}{\text{Observed molar mass (obtained from a colligative property)}}$$

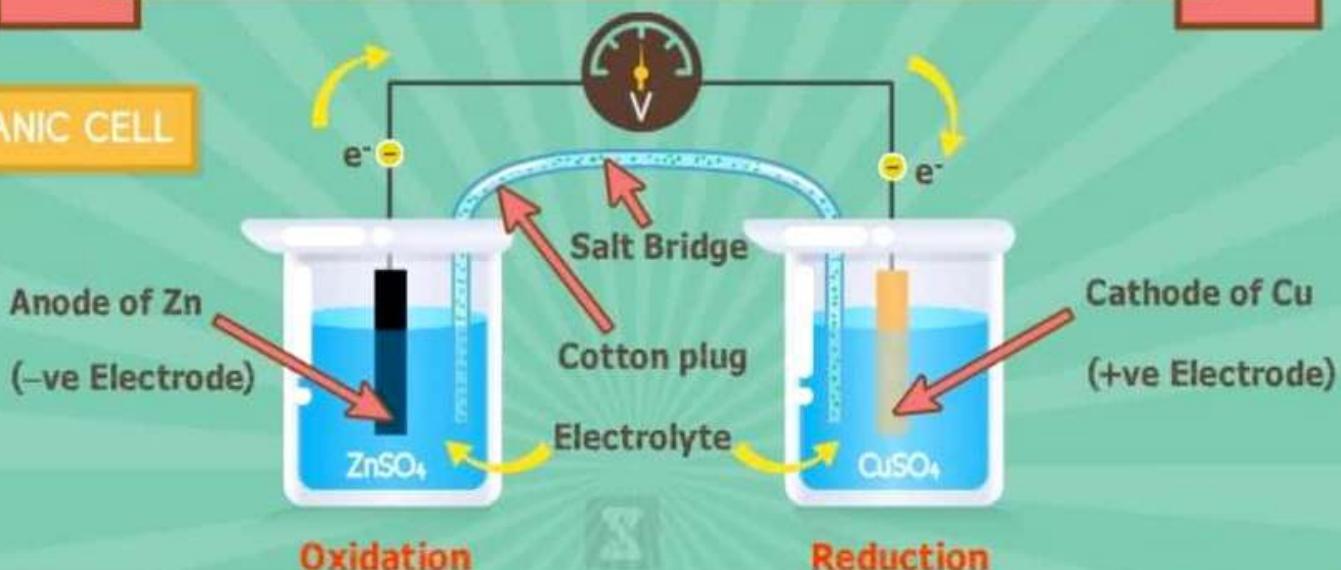
Thus, the value of  $i$  depends upon the state of solute in the solution. Following cases are possible:

- When,  $i = 1$  then the solute remains unaffected (i.e., normal) in solution.
- When,  $i > 1$  then the solute undergo dissociation in solution.
- When,  $i < 1$  then the solute undergo association in solution.

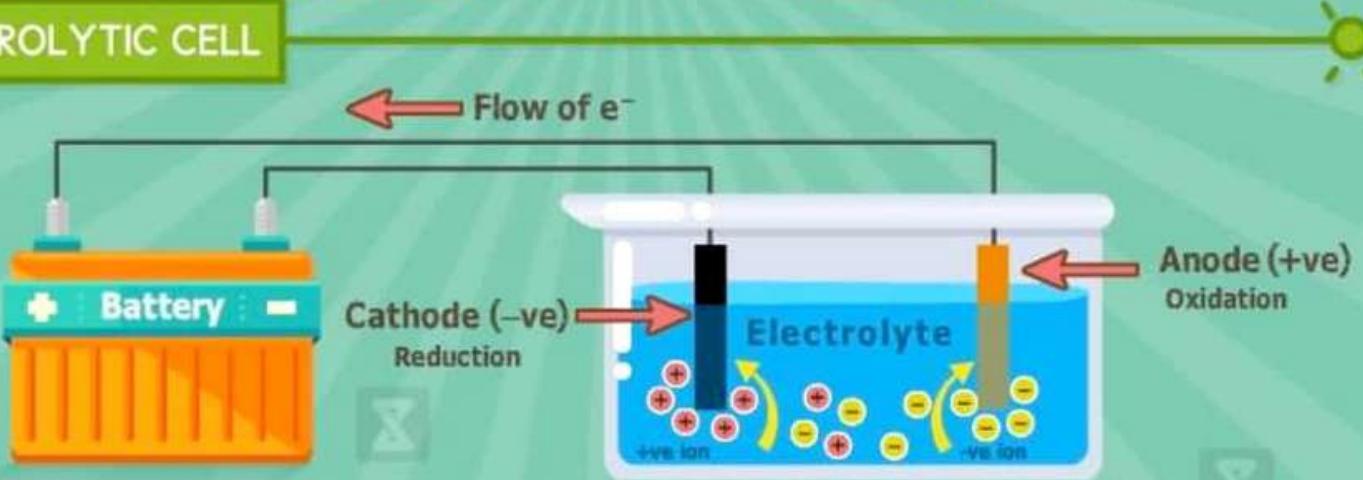
# ELECTROCHEMISTRY

## COMPARING GALVANIC AND ELECTROLYTIC CELL

GALVANIC CELL



ELECTROLYTIC CELL

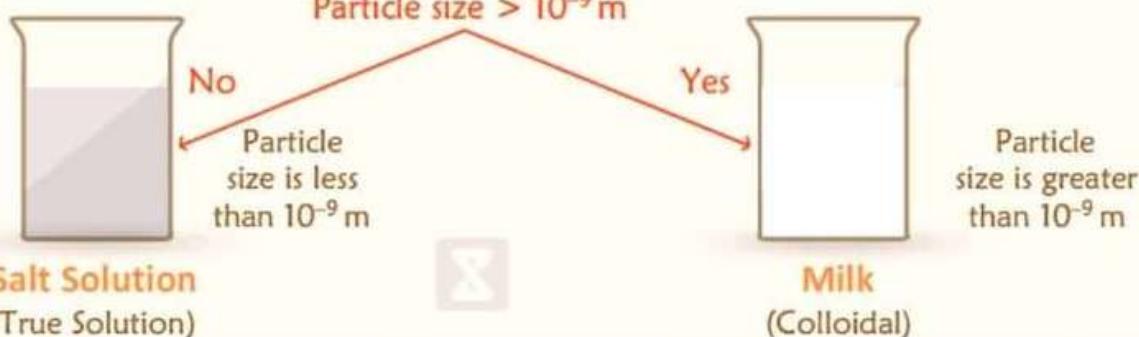


PROPERTY	ELECTROLYTIC CELL	GALVANIC CELL
Basic structure	Two half cells connected by salt bridge.	Both electrodes placed in same container
Energy conversion	Electrical energy $\rightarrow$ Chemical energy	Chemical energy $\rightarrow$ Electrical energy
Transfer of electrons on the electrode	Positive(anode) $\rightarrow$ Negative(Cathode)	Negative(anode) $\rightarrow$ Positive(Cathode)
Anode	Positively charged electrode	Negative terminal cell
Cathode	Negatively charged electrode	Positive terminal cell

# WHAT ARE COLLOIDS ?



## Is Milk a Colloidal Solution?

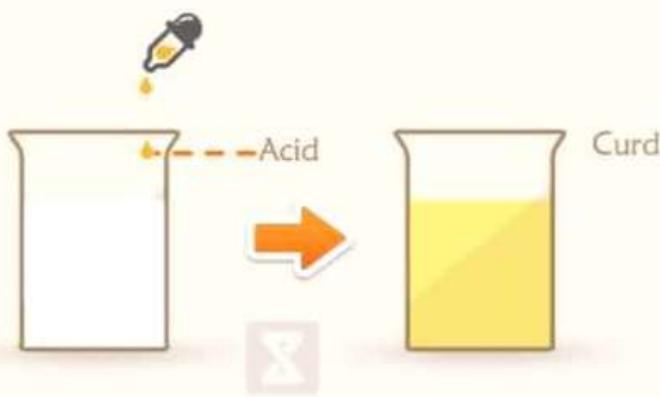


Colloids are everywhere around us

Colloid = dispersed phase + dispersed medium

## How Curd is Formed ?

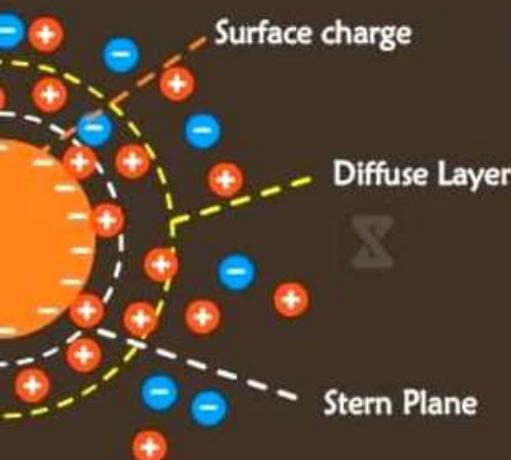
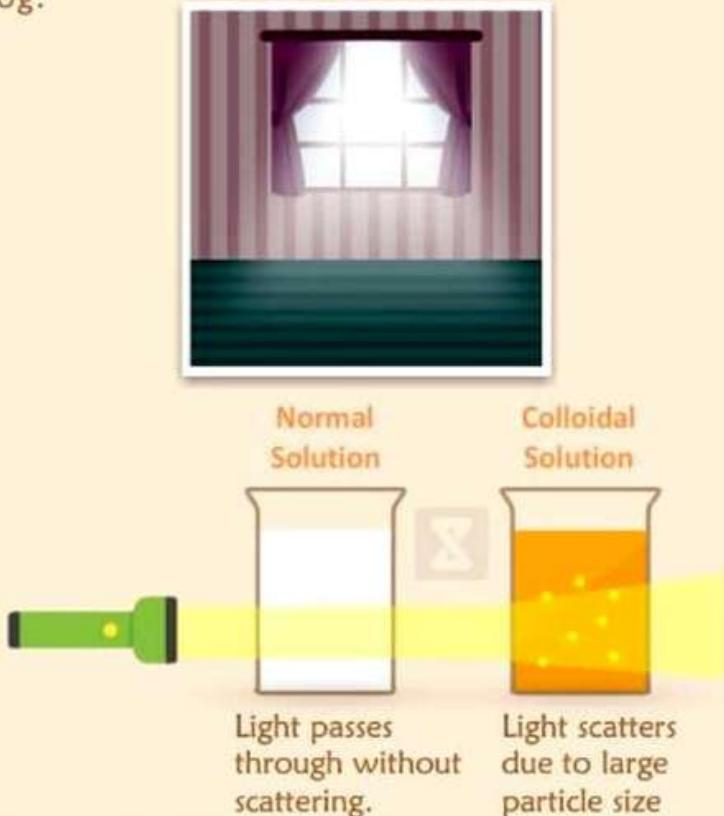
**Coagulation :** It is a process of forming precipitate by adding electrolyte to a colloidal solution.



Adding electrolytes to colloidal solution causes opposite charge to combine and form precipitate. Here acid is the electrolyte added and curd is the precipitate formed.

## Tyndall Effect

Tyndall effect is observed in morning, where sunlight scatters due to colloidal solution i.e. Fog.



## Stability of Colloids

Colloids are generally unstable. They are stabilised by forming a electric double layer.

**Surface Charge :-** Formed by absorbing charged ions on particle.

**Diffuse Layer :-** Diffuse layer consists of both the ions with higher concentration of counter ions.

**Stern Layer :-** Layer formed due to electrostatic attraction of opposite ions to the particle surface

# 12 AMAZING COLLOIDS USED IN OUR DAILY LIFE

Colloid is a homogeneous non-crystalline substance consisting of large molecules or ultra-microscopic particles of one substance dispersed through a second substance



Solid



Liquid



Gas



**Paint**



Dispersed Phase



Dispersed Medium



**Ice Cream**



Dispersed Phase



Dispersed Medium



**Tooth Paste**



Dispersed Phase



Dispersed Medium



**Smoke**



Dispersed Phase



Dispersed Medium



**Jam**



Dispersed Phase



Dispersed Medium



**Sponge**



Dispersed Phase



Dispersed Medium



**Milk**



Dispersed Phase



Dispersed Medium



**Clouds**



Dispersed Phase



Dispersed Medium



**Butter**



Dispersed Phase



Dispersed Medium



**Hair Gel**



Dispersed Phase



Dispersed Medium



**Blood**



Dispersed Phase



Dispersed Medium



**Shaving Cream**



Dispersed Phase

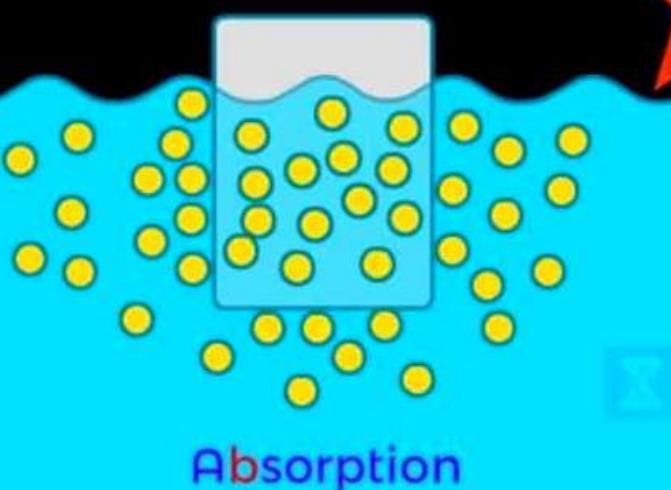


Dispersed Medium

# Absorption

# Adsorption

VS



Absorption

Adsorption

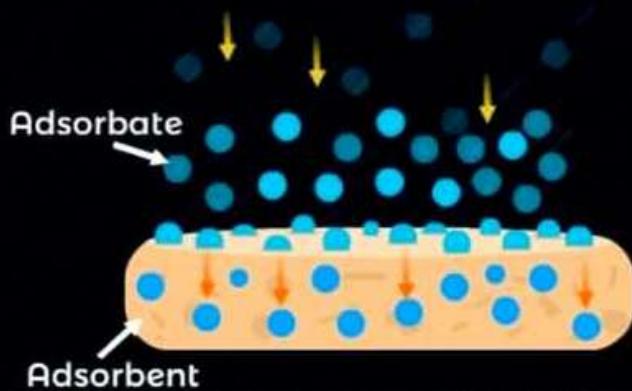
Absorption is the distribution of a certain substance through out the volume of another substrate.

Absorbed materials can be separated between different phases due to their chemical characteristics.

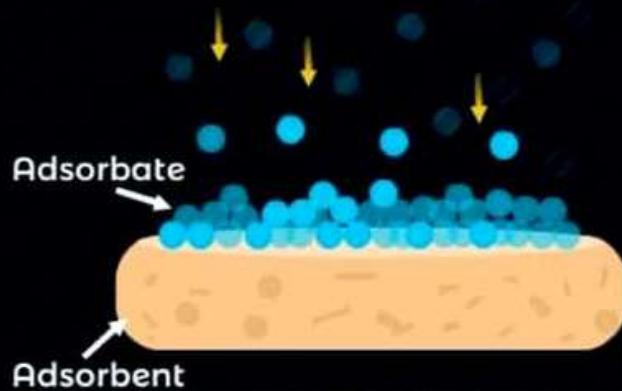
Adsorption is the attachment of a certain substance onto the surface of another substrate.

Adsorption can be used to separate out certain material by adsorbing them onto one surface.

## ILLUSTRATION



## ILLUSTRATION



Materials get absorbed into other material through the availability of space and also due to the properties of each material.

Absorbed materials remain within the space of the adsorbent without having a chemical relationship being perfectly intact as when it is free.

The vacant surface of the adsorbent has extra energy that stimulates the attachment of foreign molecules on to it.

Adsorbates bind onto the surface of the adsorbent most commonly through van der waals interactions or through covalent bonds.



# THERMODYNAMICS

Thermodynamics deals with energy interactions between two bodies & its effect on the properties of matter.

## SCOPE OF THERMODYNAMIC

- Feasibility of a process

- Extent of a process



- Efficiency of a process

### SYSTEM

The part of the universe under thermodynamical observation is called system.

### SURROUNDINGS

All the part of the universe except system is called surroundings.

### BOUNDARY

The part which separates system and surroundings is called boundary. It may be rigid or flexible.

## TYPES OF THERMODYNAMIC PROCESSES

### • QUASI-STATIC PROCESS

Arbitrarily slow process such that the system always stays arbitrarily close to thermodynamic equilibrium.



### • REVERSIBLE PROCESS

Any changes induced by the process in the universe (system + environment) can be removed by retracing its path.

Reversible processes must be quasi-static.

### • IRREVERSIBLE PROCESS

Any process in which a part or whole of process is not reversible.

E.g.: any process involving friction, free expansion of gas etc.



## BASIC THERMODYNAMIC PROCESS

### • ISOBARIC: Constant P

$$W = p\Delta V$$

### • ISOTHERMAL: Constant T

$$\Delta U = 0 \quad (\text{for ideal gases})$$

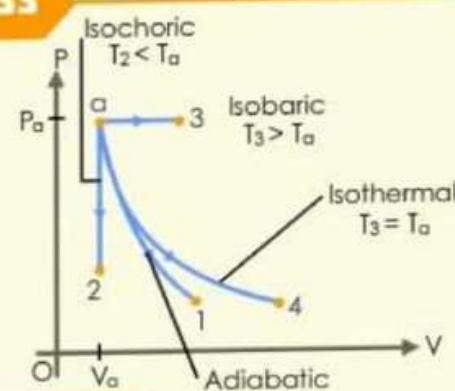
### • ISOCHORIC: Constant V

$$W = 0$$

### • ADIABATIC: No heat exchange

$$Q = 0$$

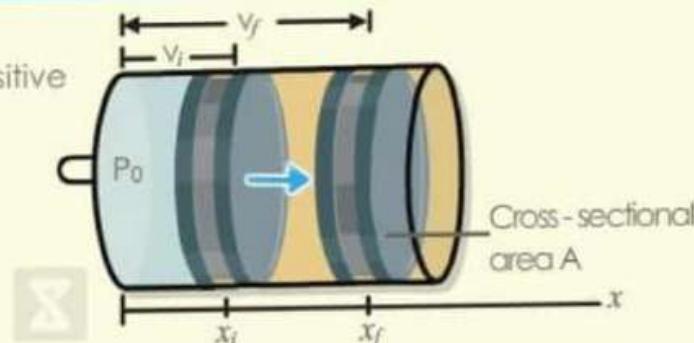
- There are an infinite number of other processes without any special name!



## WORK DONE IN THERMODYNAMIC PROCESS

Work done compressing a system is defined to be positive

$$W_{Vi \rightarrow Vf} = \int_{Vi}^{Vf} P dV = P_0 \int_{Vi}^{Vf} \frac{Vf}{Vi} dV = P_0 \cdot W_{Vi \rightarrow Vf}$$

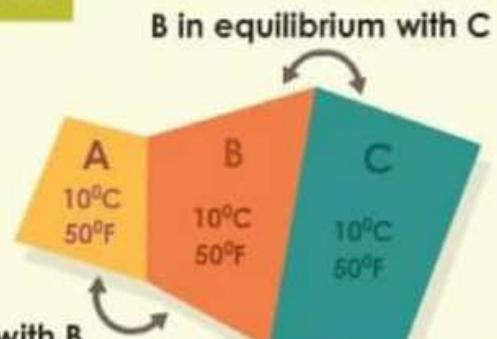


# THERMODYNAMICS LAWS

The branch of **physical science** that deals with the relations between heat and other forms of energy (such as mechanical, electrical or chemical energy) and by extension of relationship between them.

## ZEROTH LAW OF THERMODYNAMICS

If two systems are in **thermal equilibrium** with a third system, then they all are in **thermal equilibrium** with each other. This law helps define the notion of temperature.



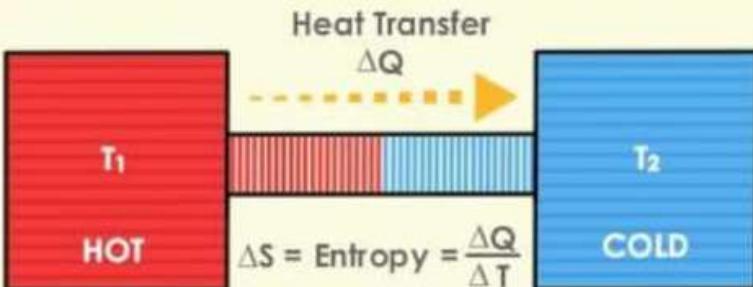
## THE FIRST LAW OF THERMODYNAMICS

The first Law of thermodynamics states that overall amount of energy is **Conserved**. Therefore, **energy cannot be created or destroyed**, only lost to an outside system.

$$\Delta U = Q - W$$



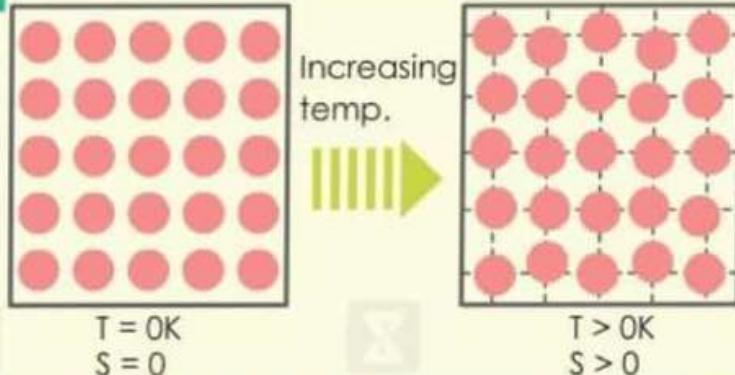
## THE SECOND LAW OF THERMODYNAMICS



This law states that **energy naturally flows** from hotter objects to cooler objects. In order for energy to flow from a cooler object to a hotter object, work must be done. When heat is converted into work, the **efficiency** or output of usable work will always be less than 100%.

## THE THIRD LAW OF THERMODYNAMICS

The **entropy** of a system approaches a constant value as the temperature approaches **absolute zero**. With the exception of non-crystalline solids (glasses), the entropy of a system at absolute zero is typically close to **zero** and is equal to the logarithm of the product of the **quantum ground states**.



# EXOTHERMIC

An exothermic reaction occurs when the temperature of a system increases due to the evolution of heat.



VS

# ENDOTHERMIC

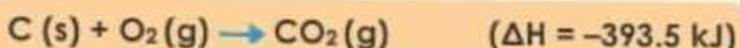
An endothermic reaction occurs when the temperature of an isolated system decreases while the surroundings of a non-isolated system gains heat.



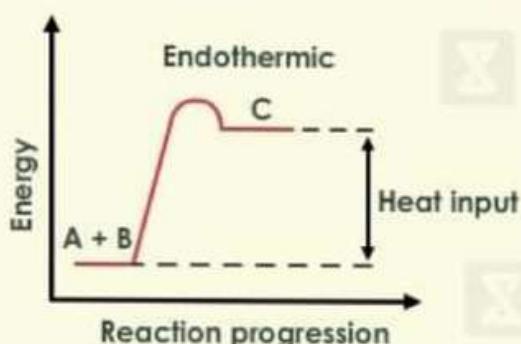
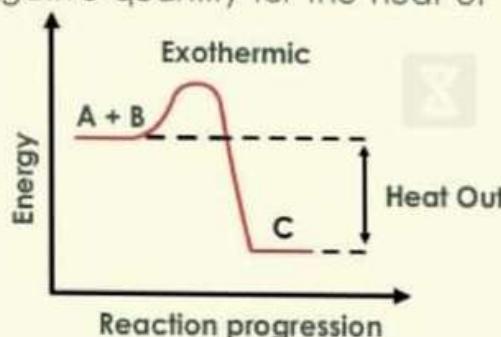
## EXOTHERMIC

Heat is released into the surroundings, resulting in an overall negative quantity for the heat of reaction.

An exothermic reaction has a negative  $\Delta H$  by convention, because the enthalpy of the products is lower than the enthalpy of the reactants of the system.



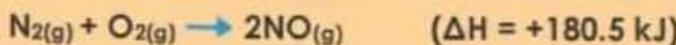
The enthalpies are less than zero.



## ENDOTHERMIC

Endothermic reactions result in an overall positive heat of reaction.

An endothermic reaction has a positive  $\Delta H$ , because the enthalpy of the products is higher than the enthalpy of the reactants of the system.



## EXOTHERMIC

Making ice cubes

Formation of snow in clouds

Condensation of rain from water vapour

A candle flame

Mixing sodium sulphite and bleach

Rusting iron

Burning sugar

Forming ion pairs

Combining atoms to make a molecule in the gas phase

Mixing water and strong acids

Mixing water with an anhydrous salt

Crystallizing liquid salts (as in sodium acetate in chemical handwarmers)

## ENDOTHERMIC

Melting ice cubes

Conversion of frost to water vapour

Evaporation of water

Forming a cation from an atom in the gas phase

Baking bread

Cooking an egg

Producing sugar by photosynthesis

Separating ion pairs

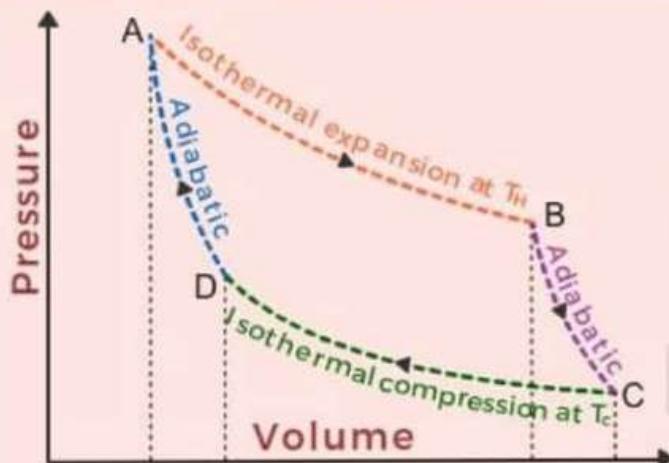
Splitting a gas molecule apart

Mixing water and ammonium nitrate

Making an anhydrous salt from a hydrate



# CARNOT CYCLE



A Carnot heat engine is an engine that operates on the **reversible Carnot cycle**. The basic model for this engine was developed by **Nicolas Léonard Sadi Carnot** in 1824.

It is an ideal **heat engine** whose efficiency is less than 100%.

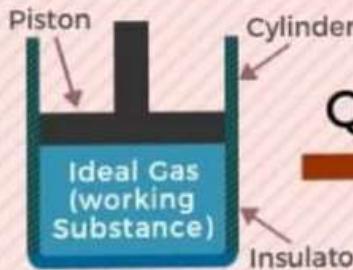
$$\text{Efficiency of Carnot Engine} = \frac{T_H - T_C}{T_H} \times 100\%$$

## PARTS OF CARNOT ENGINE

**T<sub>H</sub>**

Temp at Source

Q<sub>H</sub> →



**T<sub>C</sub>**

Temp at Sink

Carnot engine diagram shows that an amount of heat '**Q<sub>H</sub>**' flows from a **high temperature 'T<sub>H</sub>**' furnace through the fluid of the "**working body**" (ideal gas) and the remaining heat '**Q<sub>C</sub>**' flow into the cold sink '**T<sub>C</sub>**', thus forcing the working substance to do mechanical work '**W**' on the surroundings, via cycles of contractions and expansions.

## CYLINDER

It is a hollow cylinder whose walls are bad conductors of heat, and its base is a good conductor of heat.

## PISTON

It is a movable piston which is fixed in a hollow cylinder. We neglect the friction force between the piston and walls of the cylinder.

## SINK

It is a low-temperature reservoir; system rejects heat to the sink during iso-thermal compression. The thermal capacity of the sink is infinity.

## SOURCE

It is a perfect insulator in which thermal conductivity is zero. System is placed on an insulator during adiabatic expansion and adiabatic compression.

## INSULATOR

It is a high-temperature reservoir; system absorbs heat from the source during iso-thermal expansion. The thermal capacity of the source is infinity.