

11. HALO ALKANES & HALO ARENES

IMPORTANT POINTS

1. **Haloalkanes:** Halogen derivatives of alkanes are called haloalkanes or alkyl halides.

Nomenclature:

General IUPAC name	: Haloalkane
General common name	: Alkyl halide
General formula	: RX , where R =Alkyl group, $X = F, -Cl, -Br, -I$
Example	: C_2H_5Cl Chloroethane [Ethyl chloride]

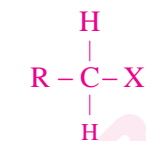
2. **Classification:**

- (i) Compounds containing $C_{sp} - X$ bond
 (ii) Compounds containing $C_{sp^2} - X$ bond
 (iii) Compounds containing $C_{sp^3} - X$ bond

3. a) **Haloalkanes:** In these, the halogen atom is bonded to sp^3 hybridised carbon atom.

These are further classified as

- i) Primary alkyl halides if the halogen atom is linked to primary carbon atom.
 ii) Secondary alkyl halide if the halogen atom is linked to secondary carbon atom
 iii) Tertiary alkyl halide if the halogen atom is linked to tertiary carbon atom.



Primary (1°)



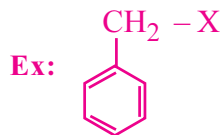
Secondary (2°)



Tertiary (3°)

- b) **Allylic halides:** In these halides, the halogen is bonded to an sp^3 hybridised carbon atom next to carbon-carbon double bond ($C=C$) i.e, to an allylic carbon. **Ex:** $H_2C = CH - CH_2 - X$

- c) **Benzylic halides:** In these halides, the halogen is bonded to an sp^3 hybridised carbon atom next to an aromatic ring.



4. **HALOARENES:** Halogen derivatives of aromatic hydrocarbons are called haloarenes.

Ex: Chlorobenzene.

The nature of C-X bond: In a haloarene, the halogen atom is bonded to the sp^2 -hybrid carbon atom of an aromatic ring. Due to this $C-X$ bond length becomes less and stronger in haloarenes.

In haloarenes, the $C-X$ bond acquires a partial double bond character and hence less reactive towards nucleophilic substitution reactions.

12.1. ALCOHOLS, PHENOLS, ETHERS

[ORGANIC COMPOUNDS CONTAINING C,H,O]

IMPORTANT POINTS

1. **ALCOHOLS:** Alcohols are hydroxyl derivatives (OH) of aliphatic hydrocarbons.

According to IUPAC, alcohols are named as **alkanols**.

General formula of Alcohols: $C_nH_{2n+1} - OH$ (or) ROH.

Alcohols containing only one $-OH$ group are **Monohydric** alcohols.

They are further classified as primary, secondary and tertiary alcohols.

In a Primary alcohol, $-OH$ group is attached to a primary carbon atom. It has $-CH_2OH$ group.

Ex: CH_3OH – Methyl alcohol; C_2H_5OH – Ethyl alcohol

In a secondary alcohol, $-OH$ group is linked to a secondary carbon atom. It has $-CHOH$ group.

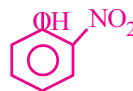
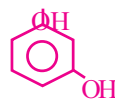
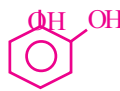
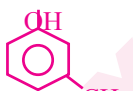
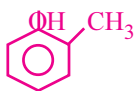
Ex: Isopropyl alcohol.

In a tertiary alcohol, $-OH$ group is linked to a tertiary carbon atom. It has $-C-OH$ group.

Ex: Tertiary butyl alcohol

2. **Phenols:** Aromatic hydroxy compounds are called phenols

Ex: Phenol, cresols, catechol, resorcinol, quinol etc.



Phenol

o-cresol

m-cresol

p-cresol

catechol

Resorcinol

Quinol

o-nitrophenol

2.1 Physical properties:

- 1) B.P of phenol is more than expected from its molecular weight due to intermolecular hydrogen bonding
- 2) Phenol is sparingly soluble in water due to its hydrogen bonding with water

2.2 Chemical properties:

Acidic nature of phenol: The acidic nature of phenol is evident from the following reactions.

- a) Phenol reacts with active metals like Na and gives H_2 gas.
- b) Phenol reacts with bases like NaOH and gives H_2O

3. **Ethers:** Ethers are functional isomers of alcohols. The IUPAC name of ether is **alkoxy alkane**.

General formula of an ether is $R-O-R'$ where R and R' are alkyl groups.

The functional group of an ether is $-O-$.

Ethers are Lewis bases because of the presence of lone pairs of electrons at oxygen.

An ether is a dialkyl derivative of $H-O-H$.

The mono alkyl derivative of H_2O is alcohol. In ether if both the alkyl groups are the same it is called a simple ether. If the alkyl groups are different it is a mixed ether.

Ex: $CH_3 - O - CH_3$ – Simple ether ; $CH_3 - O - C_2H_5$ – Mixed ether

12.2. ALDEHYDES & KETONES, CARBOXYLIC ACIDS

ORGANIC COMPOUNDS CONTAINING C, H, O

IMPORTANT POINTS

1.1 ALDEHYDES AND KETONES:

Common name : Carbonyl compounds

Common General Formula : $C_nH_{2n}O$

Common Group : $>C=O$ (carbonyl group)

General IUPAC name of Aldehyde : Alkanal

General IUPAC name of Ketone : Alkanone

General Formula of Aldehydes : $RCOOH$; General Formula of Ketones: $R-\overset{\overset{O}{\parallel}}{C}-R$

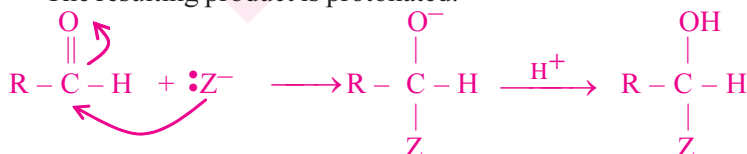
Functional group of Aldehyde : $H-\overset{\overset{O}{\parallel}}{C}-$ Functional group of Ketone : $-\overset{\overset{O}{\parallel}}{C}-$

1.2 Chemical Properties: Carbonyl compounds (aldehydes and ketones) generally undergo nucleophilic addition reactions. In carbonyl group ($>C=O$) carbon shows sp^2 hybridisation. It has polar nature since the electronegativities of carbon and oxygen are different. Being more electronegative, oxygen gets partial negative charge and carbon gets partial positive charge. So carbon is attacked by nucleophiles.

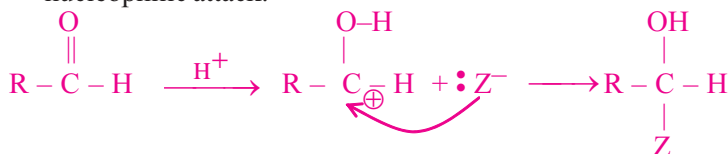


1.3 Mechanism of nucleophilic addition:

1) If the nucleophile is a strong nucleophile, it readily attacks the carbonyl carbon. The resulting product is protonated.



2) If the nucleophile is a weak nucleophile, the reaction rate is increased by an acid. Then the acid protonates the carbonyl oxygen and makes carbonyl carbon more susceptible for nucleophilic attack.



Alkyl group, being electron donating makes the $>C=O$ group, less reactive towards nucleophilic addition. $\therefore HCHO > RCHO > R-CO-R$ (in nucleophilic addition).

CHEM BEAT

AAA Reaction: $[Alcohol \xrightarrow{[O]} Aldehyde \xrightarrow{[O]} Acid]$

2.1 CARBOXYLIC ACIDS

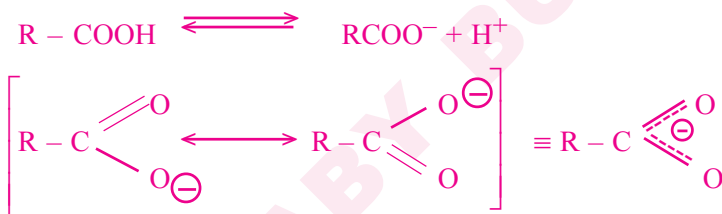
Common name : Carboxylic acid
 General IUPAC name : Alkanoic acid
 General Formula : RCOOH

Functional Group : $-\text{COOH}$ (or) $-\text{C} \begin{array}{l} \text{// O} \\ \text{\ / OH} \end{array}$

Examples:

Formula	IUPAC name	Common name	Source
HCOOH	Methanoic acid	Formic acid	Ants
CH ₃ COOH	Ethanoic acid	Acetic acid/Vinegar	Vinegar
CH ₃ CH ₂ COOH	Propanoic acid	Propionic acid	Fat
CH ₃ CH ₂ CH ₂ COOH	Butanoic acid	Butyric acid	Butter
CH ₃ (CH ₂) ₃ COOH	Pentanoic acid	Valeric acid	Valerian plant

2.2 Acidity of carboxylic acids: Carboxylic acids behave as acids since they dissociate and give H⁺ ions in aqueous solution. The dissociation is favoured because of the resonance stabilised carboxylate ions.



From the above equilibrium, $K_a = \frac{[\text{RCOO}^-][\text{H}^+]}{[\text{RCOOH}]}$.

K_a is called acid dissociation constant. Strength of an acid is given by its P^{K_a} value.

$$P^{K_a} = -\log K_a$$

2.3 Table of P^{K_a} values

P^{K_a} value	Strength of acid
Less than 1	Strong acid
between 1 and 5	Moderately strong
between 5 to 15	Weak acid
>15	Very weak acid

From the table, it is clear that the lesser the P^{K_a} value, the stronger is the acid.

Electron withdrawing groups like $-\text{NO}_2$, $-\text{Cl}$ increase the acid strength of carboxylic acids.

Similarly, electron donating groups like $-\text{R}$, $-\text{OR}$ decrease the acid strength.

2.4 Order of acid strength:



13. ORGANIC COMPOUNDS CONTAINING NITROGEN

(Amines, Diazonium Salts, Cyanides and Isocyanides)

IMPORTANT POINTS

1. **ANILINE:** The IUPAC name is Benzenamine. It is an aromatic primary amine.

Factors influencing the basic nature of amines:

- 1) **Inductive effect:** Alkyl groups are electron donating groups and thus show positive inductive effect (+I effect). Therefore, the more the number of alkyl groups on N atom, the more is its basic character.

Based on this factor, the order in the base strength is 3° amine $>$ 2° amine $>$ 1° amine $>$ NH_3

- 2) **Hydrogen bonding with solvent:** If there are more number of H atoms on N atom, then more number of H-bonds are formed with the solvent.

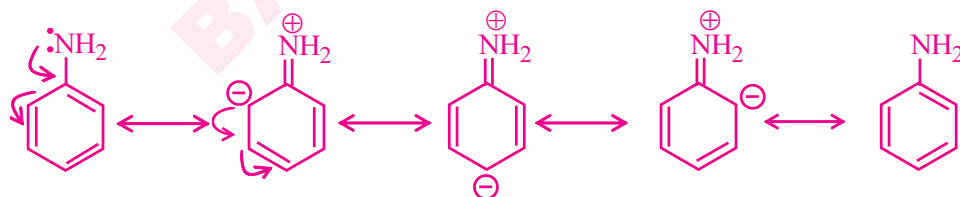
Based on this factor, the order in the base strength is $\text{NH}_3 > 1^\circ$ amine $>$ 2° amine $>$ 3° amine.

- 3) **Steric factor:** If bulky alkyl groups are present on $-\text{N}$ atom, they hinder the entering of the reactant. This is steric factor.

Based on this factor, the order in the base strength is $\text{NH}_3 > 1^\circ$ amine $>$ 2° amine $>$ 3° amine

The net (combined) effect of the above 3 factors is 2° amine $>$ 3° amine $>$ 1° amine $>$ NH_3

2. **Resonance effect:** Aniline exhibits resonance, hence availability of lone pair of electrons decreases. Therefore basic nature decreases.



3. **Diazonium Salts:**

Common name : Alkyl diazonium salt

General IUPAC name : Alkane diazonium salt

General formula : RN_2^+X^- (or) $\text{R}-\overset{\oplus}{\text{N}}\equiv\text{NX}$

where R=alkyl or aryl group

$\text{X}^- = \text{Cl}^-, \text{Br}^-, \text{HSO}_4^-, \text{BF}_4^- \dots\dots$

4. Cyanides (R-CN) and Isocyanides (R-NC) are functional isomers.