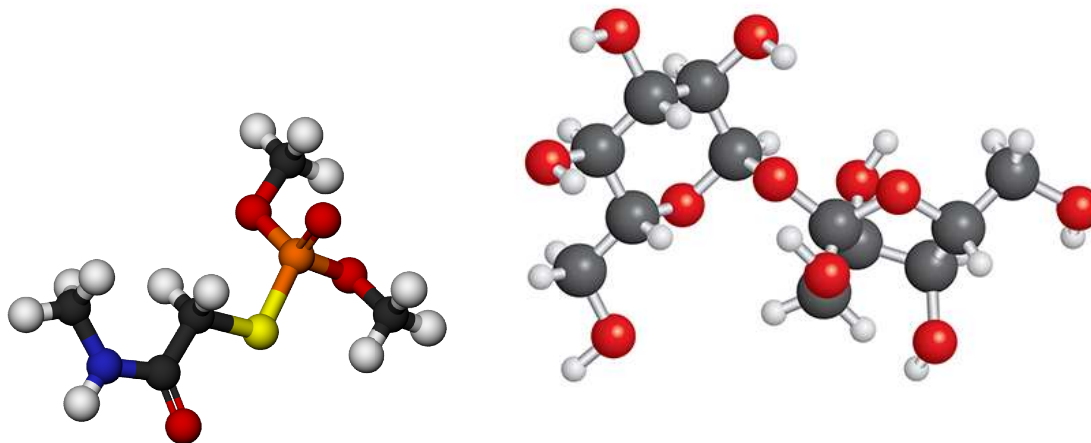


Unit 29: An Introduction to Selected Homologous Series



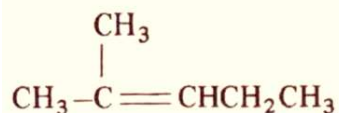
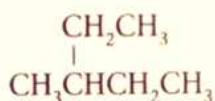
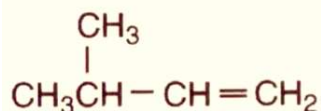
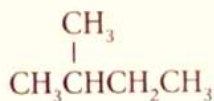
HKDSE Syllabus

a. Introduction to selected homologous series

Students should learn	Students should be able to
<input type="checkbox"/> homologous series	<input type="checkbox"/> give systematic names, general formulae, condensed formulae and structural formulae for: alkanes, alkenes, haloalkanes, alcohols, aldehydes and ketones, carboxylic acids, esters, unsubstituted amides and primary amines
<input type="checkbox"/> structural formulae and systematic naming	<input type="checkbox"/> draw the structures of the compounds based on their systematic names <input type="checkbox"/> understand the effects of functional groups and the length of carbon chains on physical properties of carbon compounds <input type="checkbox"/> identify common trivial names of some carbon compounds (e.g. formaldehyde, chloroform, acetone, isopropyl alcohol, acetic acid)

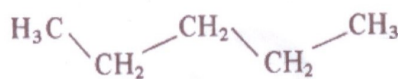
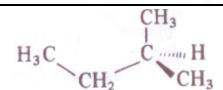
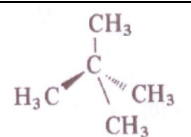
A. Alkanes and Alkenes

IUPAC name (suffix - _____, _____)(name of functional group: _____, _____)



Physical properties:
1. Boiling point (b.p.) and Melting point(m.p.)

The b.p. of alkanes, alkenes and alkynes are almost the _____ with similar molecular _____. As they are polar / non-polar, there are only weak V.D.W.F. (_____ forces) between molecules. Therefore, their m.p. and b.p. are relatively low / high.

Structure	Remarks	b.p. (°C)	m.p. (°C)
		36	-136
		28	-160
		10	-20

Important remarks:

Factors affecting the boiling point	Factors affecting the melting point
- < <	1.
- <	2. < <

2. Density

All liquid alkanes are more / less dense than water because the intermolecular forces in

Alkanes : _____

Water : _____

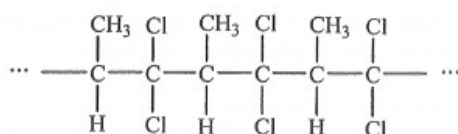
3. Solubility

They are soluble in water / non-polar organic solvents.

True / False

- The solubility of alkane in water also depends on the size of the alkane molecule. ()
- Viscosity increases with relative molecular mass. ()
- Straight-chain isomers are less viscous than branched-chain isomers. ()

14. A portion of the structure of an addition polymer X is shown below:



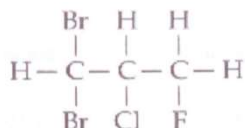
Which of the following is the systematic name of the monomer of X based on the given structure ?

- 1,1-dichloro-2-methylethene
- 1,1-dichloropropene
- 1,2-dichloropropene
- 3,3-dichloropropene

B. Haloalkanes

IUPAC name:

e.g.



Physical properties:

1. Boiling point (b.p.)

chloromethane

 With similar molecular size., which has a higher b.p.? alkane or haloalkane

 As halogens are more electronegative than C, the C-halogen bond is polar / non-polar.

There are _____ attractions between molecules.

 How is the b.p. change as the no. of C atoms increases? increase or decrease

 As molecular _____ increases, strength of **V.D.W.F.** also increases.

Class work :	Explain briefly the order of b.p. if the following compounds. $\text{CH}_4 < \text{CH}_2=\text{CH}_2 < \text{CH}_3\text{CH}_2\text{F} < \text{CH}_3\text{CH}_2\text{I}$
CH_4 :	
$\text{CH}_2=\text{CH}_2$:	
$\text{CH}_3\text{CH}_2\text{F}$:	
$\text{CH}_3\text{CH}_2\text{I}$:	

2. Solubility

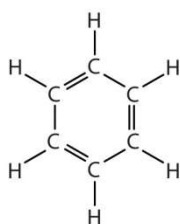
 A few lower haloalkanes are slightly soluble in water, most of them being **insoluble** because the _____ attractions are **NOT** as strong as the _____ bonds between water molecules.

 \therefore Haloalkanes are more soluble in most of the _____ solvents.

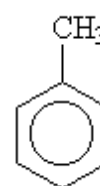
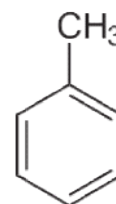
C. Benzene

Physical properties :

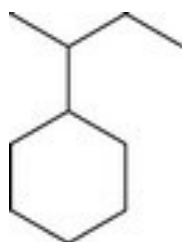
- Polar / non-polar
- Colourless liquid with aroma
- Less dense / denser than water
- Good organic solvent
- Carcinogenic
-



or



Ex.



What is the IUPAC name of the above compound?

- A 2-cyclohexylbutane
- B 3-cyclohexylbutane
- C 2-phenylbutane
- D 3-phenylbutane

D. Alkanols (Alcohols)

IUPAC name : (suffix - _____)(name of functional group: _____)

	Primary alkanol	Secondary alkanol	Tertiary alkanol
Monohydric alkanol:	$\text{CH}_3\text{CH}_2\text{OH}$	$\begin{array}{c} \text{CH}_3\text{CHCH}_3 \\ \\ \text{OH} \end{array}$	$\begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3-\text{C}-\text{OH} \\ \\ \text{CH}_3 \end{array}$

Polyhydric alkanol:	$\begin{array}{c} \text{CH}_2\text{CH}_2 \\ \quad \\ \text{OH} \quad \text{OH} \end{array}$	$\begin{array}{c} \text{CH}_2\text{CH}_2\text{CH}_2 \\ \quad \quad \\ \text{OH} \quad \text{OH} \quad \text{OH} \end{array}$
---------------------	-------------------------------------------------------------------------------------------------	------------------------------------------------------------------------------------------------------------------------------------

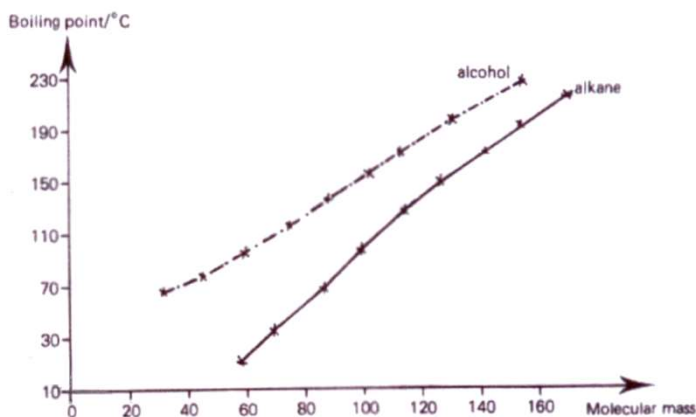
Physical properties :

1. Boiling point (b.p.)

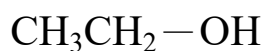
 Lower members of alkanols are liquid / gases.

 They have higher / lower b.p. than alkanes with similar molecular size due to stronger intermolecular _____ bonds.

Hydrogen bonds between ethanol molecules:



2. Solubility

 The structure of alkanol makes it a **good solvent** because it can dissolve **BOTH** _____ (e.g. water) and _____ compounds (e.g. oil).

 The _____ is **non-polar** while the _____ is **polar**.

 Alkanols with up to 3 carbon atoms (methanol, ethanol, propan-1-ol, propan-2-ol) are completely _____ with **water** as they can form hydrogen bonds with H_2O molecules.

Miscible = soluble?

- ✓ Ethanol is miscible with water. (i.e. able to mix in _____ proportions)
 - ✓ Pentan-1-ol is immiscible with water. (i.e. they do not mix in ALL proportions)

It is only slightly _____ in water.

True or False

1. B.p. of butan-1-ol is higher than that of methylpropan-2-ol. ()
2. Polyhydric alcohols have even higher b.p., viscosity and density than monohydric alcohols. ()
3. As the carbon chain of alkanols gets longer, solubility in water increases rapidly. ()

E. Aldehydes and Ketones

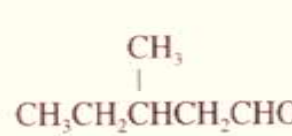
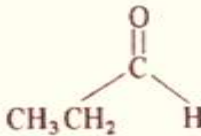
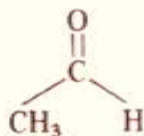
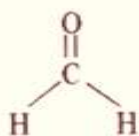
Both series of compounds contain the functional group, the carbonyl group : _____

They only differ in the **position** of the carbonyl group in the carbon chain.

Aldehydes

The **carbonyl group** must be present at the **END** of the carbon chain :

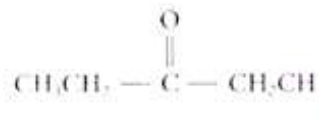
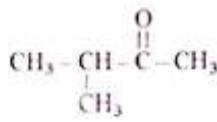
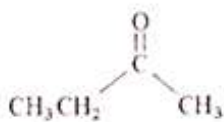
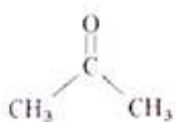
IUPAC name : (suffix - _____)(name of functional group: _____)



Ketones

The **carbonyl group** is attached to R groups (can be the same or different) :

IUPAC name : (suffix - _____)(name of functional group: _____)



True or False

- Possession of carbonyl group makes aldehydes and ketones molecules polar. ()
- Aldehydes and ketones can form hydrogen bonds between their own molecules. ()
- Aldehydes and ketones can form hydrogen bonds with water molecules. ()

Physical properties :

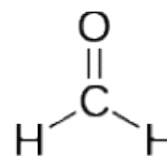
1. Boiling point (b.p.)

Lower members of aldehydes and ketones are gases and liquids at room conditions.

With similar molecular size, b.p. of

Alkanes Aldehydes and ketones Alcohols

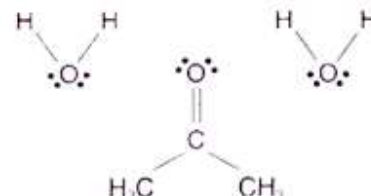
As the carbon chain gets longer, b.p. increases / decreases.



2. Solubility

Lower members of aldehydes and ketones are **miscible** with water in **ALL** proportions because they can form hydrogen bonds with H₂O molecules.

As the carbon chain gets longer, solubility increases / decreases.



Ex What is the IUPAC name of the above compound?

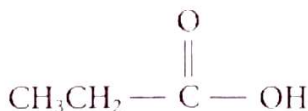


- A hexan-2-al B hexan-5-al
C hexan-2-one D hexan-5-one

F. Carboxylic acids

They contain the functional group, the carboxyl group :

IUPAC name : (suffix - _____)(name of functional group: _____)



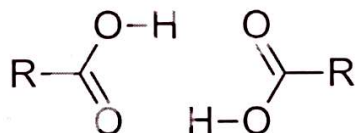
Physical properties :

1. Boiling point (b.p.)

- (a) Since both carbonyl group and hydroxyl group can involve in the formation of hydrogen bonds, carboxylic acid molecules can form MORE _____ intermolecular hydrogen bonds.



- (b) Formation of _____ \rightarrow molecular size x 2

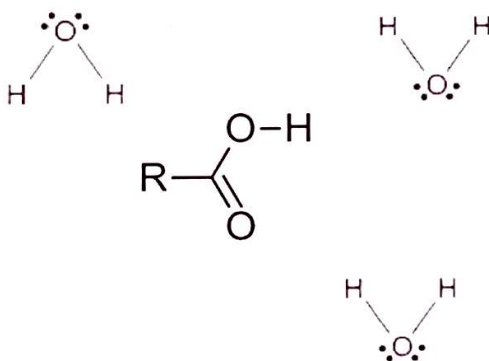


\therefore With similar molecular size, b.p. of Alkanes < Aldehydes and ketones < Alcohols

Likewise, as the carbon chain gets longer, b.p. increases / decreases.

2. Solubility

Lower members (methanoic \rightarrow butanoic acid) are miscible with water in ALL proportions because they can form hydrogen bonds with H_2O molecules.



As the carbon chain gets longer, solubility increases / decreases.

Ex. Which of the following compounds is the *least* soluble in water?

A $\text{CH}_3\text{CH}_2\text{Cl}$

B $\text{CH}_3\text{CH}_2\text{OH}$

C HCOOCH_3

D CH_3COOH

G. Esters

They contain the ester functional group :



IUPAC name : (suffix - _____)(name of functional group: _____)



True or False

1. Ester molecules are polar. ()
2. Esters can form hydrogen bonds between their own molecules. ()
3. Esters can form hydrogen bonds with water molecules. ()

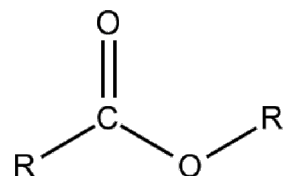
Physical properties :

1. Boiling point (b.p.)

Most ester are liquids at room temperature.

With similar M.S. , b.p. of Alkanes < Aldehydes and ketones < Alcohols < Carboxylic acids

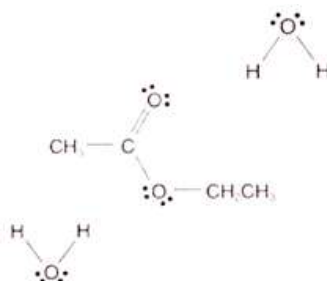
Likewise, as the carbon chain gets longer, b.p. increases / decreases.



2. Solubility

Lower members are miscible with water in ALL proportions because they can form hydrogen bonds with water molecules.

As the carbon chain gets longer, b.p. increases / decreases.



Ex $\text{CH}_3-\text{CH}(\text{CH}_3)-\text{COO}-\text{C}_2\text{H}_5$ What is the IUPAC name of the above compound?

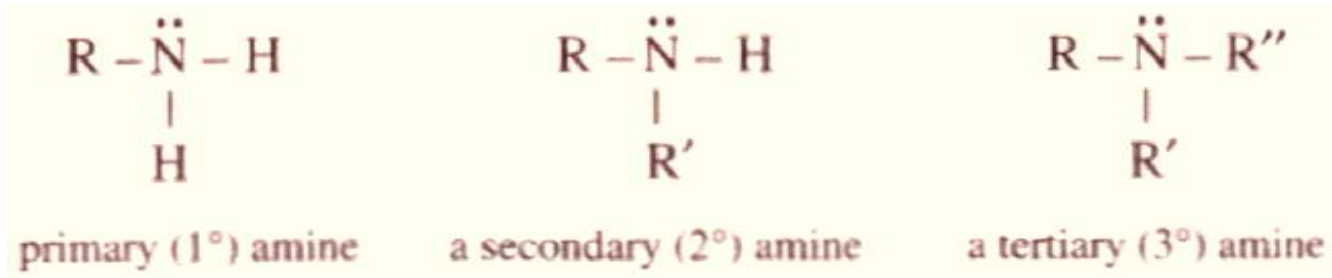


- A 3-methylhexanoic acid
- B 4-methylhexanoic acid
- C ethyl methylpropanoate
- D methylpropyl ethanoate

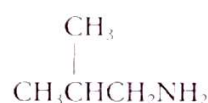
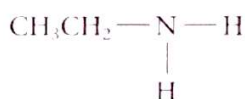
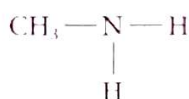
H. Amines (primary)

Amines may be considered as organic derivatives of NH_3 .

The functional group of primary amine is :



IUPAC name : (suffix - _____)(name of functional group: _____)



True or False

- Primary amine molecules are polar. ()
- Primary amine molecules are form hydrogen bonds between their own molecules. ()
- Primary amine molecules are form hydrogen bonds with water molecules. ()

Physical properties :

1. Boiling point (b.p.)

Lower members are gases while others are **liquids** at room conditions.

Compared to alcohols & carboxylic acids :

\therefore E.N._{nitrogen} E.N._{oxygen}, **N-H bond / O-N bond** is less polar.

\therefore Intermolecular hydrogen bonds are weaker in primary amines / alcohol & carboxylic acids.

\therefore With similar molecular size, b.p. of

Alkanes < Esters, Aldehydes and ketones < Alcohols < Carboxylic acids

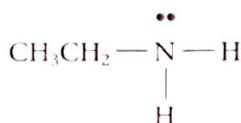
Hydrogen bonds between amine molecules

Likewise, as the carbon chain gets longer, b.p. increases / decreases.

2. Solubility

Lower members are miscible with water in ALL proportions because they can form hydrogen bonds with

As the carbon chain gets longer, b.p. increases / decreases.



Ex Which of the following compounds is the *least* soluble in water?

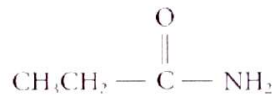
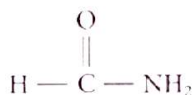
- | | | | | | | | |
|---|-----------------------------------|---|-----------------------------------|---|-------------------|---|--------------------------|
| A | $\text{CH}_3\text{CH}_2\text{Cl}$ | B | $\text{CH}_3\text{CH}_2\text{OH}$ | C | HCOOCH_3 | D | CH_3COOH |
|---|-----------------------------------|---|-----------------------------------|---|-------------------|---|--------------------------|

I. Amides (unsubstituted)

Amides are derived from carboxylic acids by dropping the $-OH$ group and replacing it with a $-NH_2$ group. So the functional group is :

(Unsubstituted means the two H atoms are NOT replaced by any other atoms or group of atoms)

IUPAC name : (suffix - _____)(name of functional group: _____)



True or False

1. Primary amide molecules are polar. ()
2. Primary amide molecules are form hydrogen bonds between their own molecules. ()
3. Primary amide molecules are form hydrogen bonds with water molecules. ()

Physical properties :

1. Boiling point (b.p.)

Except methanamide (a liquid), ALL amides are **white solids** at room temperature.

\therefore Amides can form intermolecular hydrogen bonds **MORE** extensively.

\therefore With similar molecular size, b.p. of

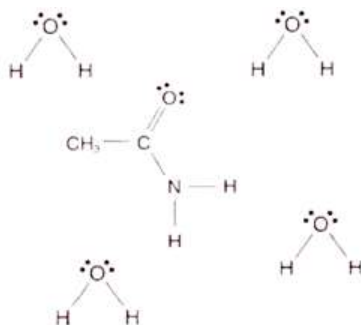
Alkanes < Esters, Aldehydes and ketones, Amine < Alcohols < Carboxylic acids

Likewise, as the carbon chain gets longer, b.p. increases / decreases.

2. Solubility

Lower members are miscible with water in ALL proportions because they can form hydrogen bonds with

As the carbon chain gets longer, b.p. increases / decreases.



Ex $\text{CH}_3\text{COCH}_2\text{COOH}$

What functional groups does the above compound contain?

- (1) Carbonyl group
- (2) Carboxyl group
- (3) Hydroxyl group

- A (1) and (2) only B (1) and (3) only
 C (2) and (3) only D (1), (2) and (3)

L. Summary

	General formula	Polar?	Forming H bonds Between its molecules	Forming H bonds with water molecules?
Alkanes				
Alkenes				
Haloalkanes				
Alkanols				
Aldehydes				
Ketones				
Carboxylic acids				
Esters				
Primary amines				
Unsubstituted amides				

M. Bond-like formula
