Name:

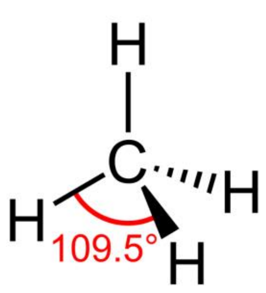
Organic Chemistry	Objectives
22. Some Families of Organic Compounds	-define tetrahedral carbon **-explain what is meant by the term alcohol** -describe the alcohols as a homologous series of organic compounds **-explain what is meant by the term chloroalkane** -name the **chloroalkanes** and alcohols (primary and secondary alcohols only) up to C4 **-discuss the use of chloroalkanes as solvents** -draw the structural formulas of **chloroalkanes** and alcohols (primary and secondary alcohols only) up to C4 -account for the physical properties [physical state, solubility (qualitative only) in water and in non-polar solvents]of the alkanes and **chloroalkanes** and alcohols up to C4 -relate the physical properties of alcohols and water through comparison of their structures -account for the solubility of (a) methanol (methyl alcohol) and (b) butan-1-ol in (i) cyclohexane and (ii) water. -discuss the use of ethanol (ethyl alcohol) as a solvent -outline the use of methanol (methyl alcohol) as a denaturing agent -recall that fermentation is a source of ethanol (ethyl alcohol) -discuss the use of fermentation in the brewing and distilling industries -define planar carbon -define carbonyl compound -describe the bonding in the carbonyl group -describe aldehydes as a homologous series of compounds -construct models to illustrate the structure of aldehydes -name the aldehydes to C4 -draw the structural formulas of the aldehydes up to C4 -account for the physical properties [physical state, solubility (qualitative only) in water and in non-polar solvents]of the aldehydes up to C4 -account for the solubility of ethanal (acetaldehyde)in (i) cyclohexane and in (ii) water **-recall that benzaldehyde is a constituent of almond kernels (structure of benzaldehyde not required)** **-describe ketones as a homologous series of compounds** **-construct models to illustrate the structure of ketones** **-name the ketones to C4** **-draw the structural formulas of the ketones to C4** **-account for the physical properties [physical state, solubility (qualitative only) in water and in non-polar solvents]of the ketones up to C4** **-account for the solubility of propanone (acetone) in (i) cyclohexane and in (ii) water** **-give an example of the use of propanone (acetone) as a solvent e.g. in nail varnish remover** -describe carboxylic acids as a homologous series of compounds -construct models to illustrate the structure of carboxylic acids -name the carboxylic acids to C4 -draw the structural formulas of the carboxylic acids to C4 -describe the bonding in the carbonyl group of carboxylic acids -account for the solubility of ethanoic (acetic) acid in (i) cyclohexane and in (ii) water

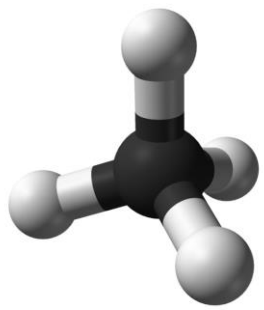
	-account for the physical properties [physical state, solubility (qualitative only) in water and in non-polar solvents] of the carboxylic acids up to C4 -give examples of carboxylic acids in everyday life e.g. methanoic acid (formic acid) in - nettles and ants, ethanoic acid (acetic acid) in vinegar **-recall the use of ethanoic acid (acetic acid) in the manufacture of cellulose acetate (structure of cellulose acetate not required)** **-recall the use of propanoic and benzoic acid and their salts as food preservatives (structure of benzoic acid not required)** **-describe esters as a homologous series of compounds** **-construct models to illustrate the structure of esters** **-name the esters to C4** **-draw the structural formulas of the esters to C4** **-account for the physical properties of esters [physical state, solubility (qualitative only) in water and in non-polar solvents]** **-account for the solubility of ethyl ethanoate (ethyl acetate) in (i) cyclohexane and in (ii) water** **-recall that fats are natural esters** **-appreciate that esters have a characteristic aroma** **-recall the use of ethyl ethanoate (ethyl acetate) as a solvent** -explain what is meant by an aromatic compound -explain in simple terms the use of the circle to represent the identical bonds in benzene, intermediate between double and single **-describe the bonding in benzene with reference to sigma and pi bonds** -account for the solubility of methylbenzene in (i) cyclohexane and in (ii) water -discuss the use of methylbenzene as an industrial solvent -give an indication of the range and scope of aromatic chemistry (Structures not required) -identify the benzene ring in the structural formulas of a range of consumer products -give one example in each case of: aromatic compounds as the basis of dyestuffs, detergents, herbicides and many pharmaceutical compounds (structures not required) -aromatic acid-base indicators: phenolphthalein, methyl orange (structures not required) -recognise the carcinogenic nature of some aromatic compounds e.g. benzene -recognise that not all aromatic compounds are carcinogenic, e.g. aspirin (structure of aspirin not required)

IMPORTANT: YOU NEED TO BE ABLE TO NAME AND DRAW THE STRUCTURAL FORMULAE OF EACH TYPE OF COMPOUND COVERED IN THIS SECTION

<u>Tetrahedral Carbons:</u>

A tetrahedral carbon is a carbon atom which has tetrahedral geometry. This geometry happens only when the carbon atom has 4 single bonds (saturated).





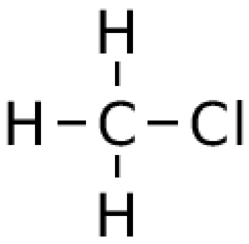
We will look at 2 types of compounds which contain only tetrahedral carbons:

1. Chloroalkanes
2. Alcohols

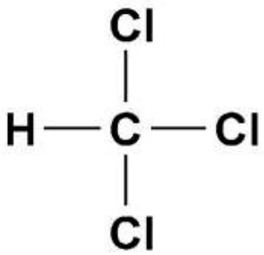
1. Chloroalkanes

Defⁿ: A **Chloroalkane** is a compound in which one or more of the hydrogen atoms in an alkane have been replaced by chlorine atoms.

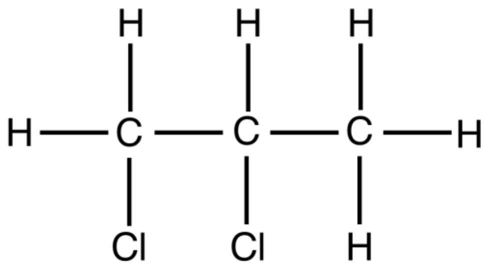
Examples: (Chlorine group is named using the prefix "chloro")



chloromethane



trichloromethane



1,2-dichloropropane

Uses: Chloroalkanes are used as industrial solvents, e.g. in dry cleaning.

Physical Properties:

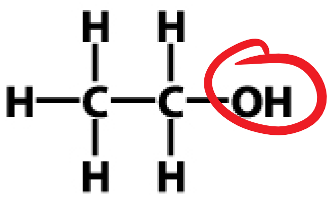
1. Chloroalkanes are weakly polar. They are not soluble in water. They are soluble in non-polar solvents (cyclohexane).
2. Liquids at room temperature.

2. Alcohols

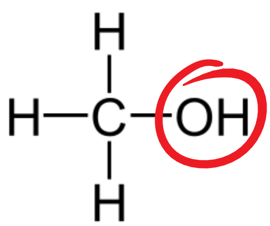
Defⁿ: A **functional group** is an atom or a group of atoms which are responsible for the characteristic properties of an organic compound or a series of organic compounds.

Functional Group: **-OH** Name ends in "-ol"

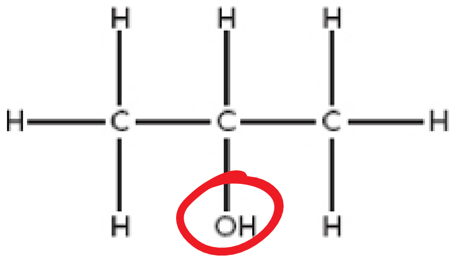
Examples:



ethanol



methanol



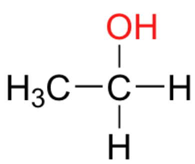
propan-2-ol

Types of Alcohols:

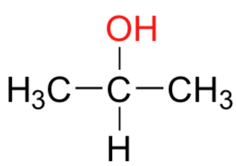
Primary Alcohols: An alcohol where the carbon atom bonded to the OH group is bonded to only 1 other carbon.

Secondary Alcohol: An alcohol where the carbon atom bonded to the OH group is bonded to 2 other carbons.

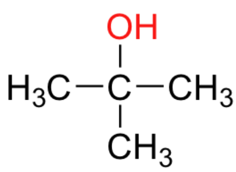
Tertiary Alcohol: An alcohol where the carbon atom bonded to the OH group is bonded to 3 other carbons.



a primary alcohol



a secondary alcohol



a tertiary alcohol

Ethanol:

Ethanol (C_2H_5OH) is the most common and best known alcohol. It is found in alcoholic drinks.

It is made by fermenting glucose using yeast: $\mathbf{C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2}$

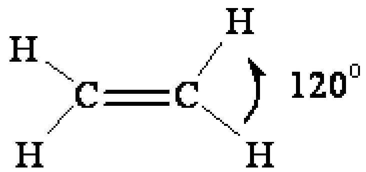
To prevent people from drinking industrial ethanol, methanol is added, as it is particularly toxic. This ethanol is now denatured and is called methylated spirits.

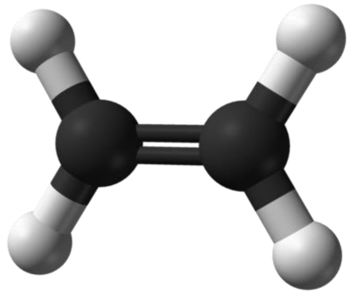
Physical Properties:

1) Alcohols have higher boiling points than their corresponding alkanes. This is due to hydrogen bonding between the alcohol molecules.
2) Small alcohol molecules are soluble in water due to the hydrogen bonding between the molecules. Larger alcohol molecules (e.g. butanol) are not soluble in water as the effect of the hydrogen bonding decreases as the molecule gets bigger. These larger alcohols are soluble in non-polar solvents like cyclohexane.

Planar Carbons:

A planar carbon is a carbon atom which has planar geometry. This geometry happens only when the carbon atom is unsaturated (contains a double- or triple-bond)





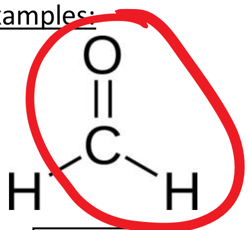
We will look at 5 types of planar compounds:

1. Aldehydes
2. Ketones
3. Carboxylic Acids
4. Esters
5. Benzene and Natural Compounds Containing Benzene Rings

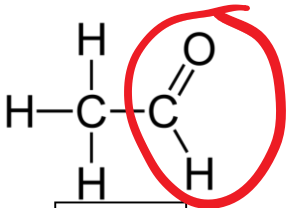
1. Aldehydes:

Functional Group: **-CHO** Name ends in "-al".

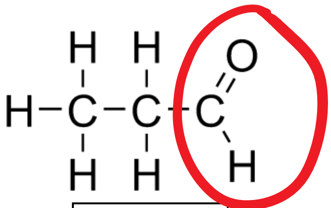
Examples:



methanal



ethanal



propanal

Carbonyl Group: The highly polar **C=O** carbonyl group is always located at the end of the carbon chain in an aldehyde.

Physical Properties:

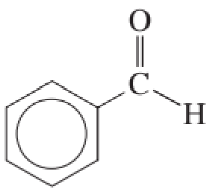
The polar carbonyl group in aldehydes mean that aldehyde molecules have dipole-dipole intermolecular forces.

1. Boiling points of aldehydes are higher than their respective alkanes due to the dipole-dipole forces between the aldehyde molecules being stronger than the weak Van-der-Waals forces between the alkane molecules.

2. The boiling points of aldehydes are lower than their corresponding alcohols due to the dipole-dipole forces between aldehyde molecules being weaker than the hydrogen bonding that occurs between alcohol molecules.
3. Small aldehyde molecules are soluble in water due to the polar carbonyl group. The larger the aldehyde molecule becomes, the less soluble the aldehyde is in water, as the effect of the polar carbonyl group decreases.

Aromatic Aldehyde: (aromatic = a compound containing a benzene ring)

Benzaldehyde smells like almonds as it is found in almond kernels. It is used as a flavouring agent.

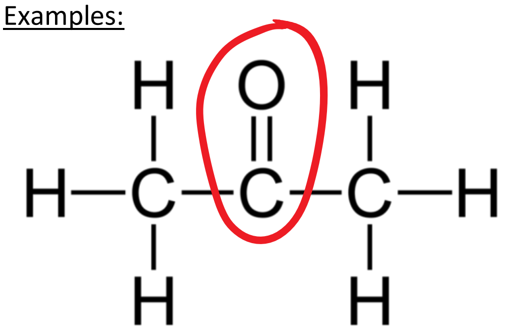


benzaldehyde

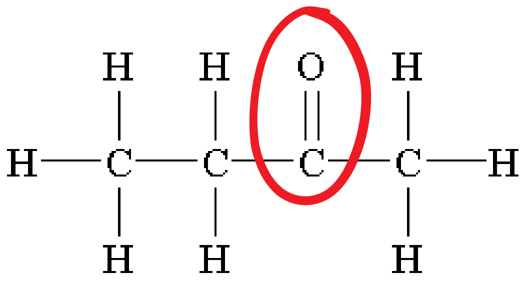
2. Ketones:

Functional Group: **-CO-** Name ends in "-one".

Examples:



Propanone



Butan-2-one

Uses: Propanone (also called acetone) is used in nail polish remover.

Carbonyl Group: The highly polar C=O carbonyl group is always located on one of the central carbons, and never at the end of the carbon chain in a ketone.

Physical Properties:

The polar carbonyl group in ketones mean that ketone molecules have dipole-dipole intermolecular forces.

1. Boiling points of ketones are higher than their respective alkanes due to the dipole-dipole forces between the ketone molecules being stronger than the weak Van-der-Waals forces between the alkane molecules.
2. The boiling points of ketones are lower than their corresponding alcohols due to the dipole-dipole forces between ketone molecules being weaker than the hydrogen bonding that occurs between alcohol molecules.

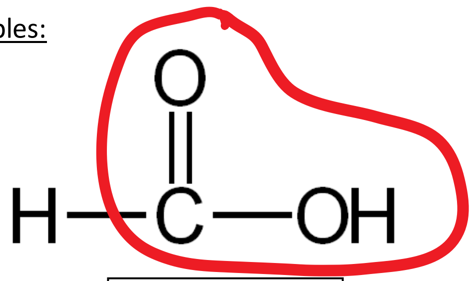
Small ketone molecules are soluble in water due to the polar carbonyl group. The larger the ketone molecule becomes, the less soluble the ketone is in water, as the effect of the polar carbonyl group decreases.

Note: Corresponding aldehydes and ketones are structural isomers e.g. propanal and propanone. (Draw both structures to see if this is true.)

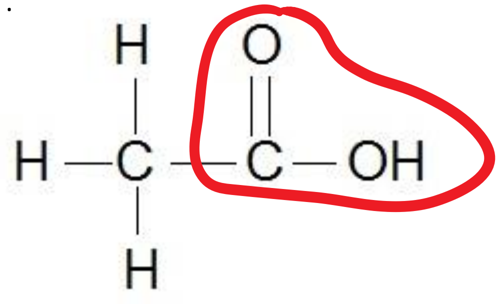
3. Carboxylic Acids:

Functional Group: **-COOH** Name ends in "-oic acid".

Examples:



Methanoic acid



Ethanoic acid

Uses: Methanoic acid is found in ant and nettle stings.

Ethanoic acid is used as a flavouring agent in vinegar. Also used to make **cellulose acetate** (camera film).

Propanoic acid, Benzoic acid (and its salt, Sodium Benzoate) are used as preservatives in food.

Carbonyl Group: The highly polar **C=O** carbonyl group is always located at the end of the carbon chain in a carboxylic acid.

Physical Properties:

The polar O-H bond located off the carbonyl group in carboxylic acids means that carboxylic acid molecules have Hydrogen Bonding intermolecular forces.

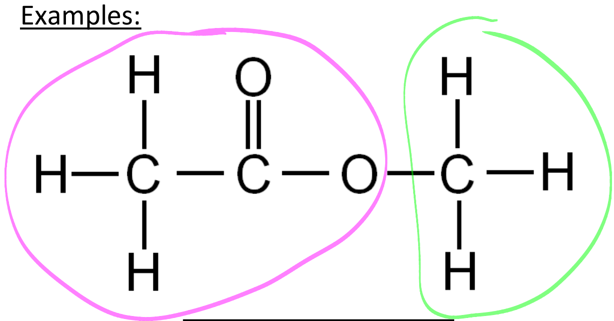
1. Boiling points of carboxylic acids are higher than their respective alkanes, aldehydes, alcohols and ketones due to the relatively strong hydrogen bonds between the carboxylic acid molecules being stronger than the weaker Van-der-Waals and Dipole-Dipole forces between the other respective molecules.

Small carboxylic acid molecules are soluble in water due to the Hydrogen Bonding. The longer the carbon chain becomes, the less soluble the carboxylic acid is in water, as the effect of the polar **-OH** group decreases.

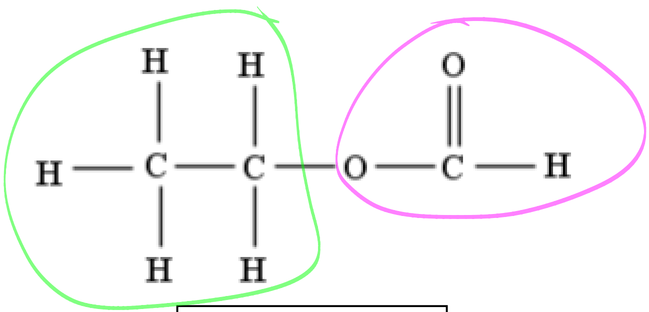
4. Esters:

Functional Group: **-COOC-** Name ends in "-yl -oate".

Examples:



Methyl Ethanoate



Ethyl Methanoate

Formation: Esters are formed by reacting an **alcohol** with a **carboxylic acid**, with **sulphuric acid** being used as a catalyst. This reaction is called a **condensation reaction** because it results in the loss of a water molecule.

Naming:

1. Divide the structure by identifying the part derived from the carboxylic acid (seen in purple, above), and the part derived from the alcohol (seen in green, above)
2. Name the alcohol-derived section first e.g. methyl, ethyl, propyl, etc.
3. Identify the carboxylic acid which the purple sections are derived from. Remove "-oic acid" from the name and replace it with "-oate" e.g. "ethanoic acid" becomes "ethanoate"
4. Combine the name from step 2 with the name from step 3. (always in the order "-yl –oate", NEVER "-oate –yl")

Uses: Used as flavourings and fragrances as they have sweet, fruity scents.

Fats and oils are naturally occurring esters.

Physical Properties:

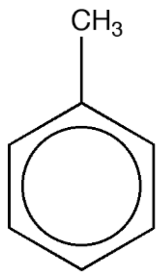
The polar carbonyl group (C=O) means that ester molecules have Dipole-Dipole intermolecular forces.

Small ester molecules are soluble in water due to the Dipole-Dipole intermolecular forces. The longer the carbon chain becomes, the less soluble the ester is in water, as the effect of the polar **C=O** group decreases. Fats and oils are large esters and are insoluble in water.

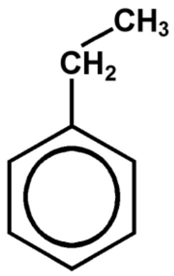
5. Aromatic Compounds:

Structure: Contains a **Benzene Ring**.

Examples:



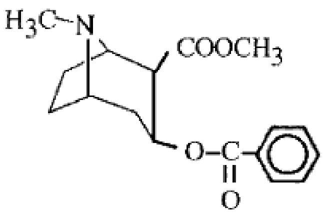
Methylbenzene



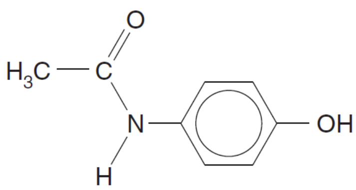
Ethylbenzene

Structure/Bonding in Benzene: 4 valence electrons on each carbon in the benzene ring. 3 of these electrons are used to form sigma bonds with the 2 carbon atoms on either side and the H atom. Each remaining valence electron (6 in total) is shared between all 6 carbons. This is a very stable structure and is represented as a ring in the structural formula. Evidence for this is that the bond lengths between all carbon atoms is identical. (Structure is NOT alternating single and double bonds).

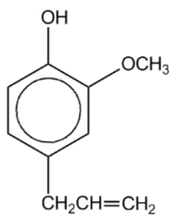
Organic Natural Products: Many compounds made in nature contain benzene rings. Examples are:



Cocaine
(Lab Made)



Paracetamol
(Lab Made)



Eugenol (Clove Oil)
(Natural)