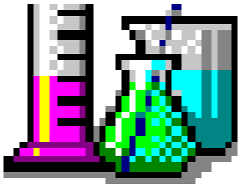

# ORGANIC CHEMISTRY

a students guide

**Click on the topic you wish to look at:**
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**Introduction to organic chemistry....**Click Here

**Basic glossary of chemistry related terms....**Click Here

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# BASIC TERMS & DEFINITIONS

This glossary is useful for reference on basic concepts of chemistry. The organic related definitions are available in more detail either on their own page or in the advanced glossary................

Click here   to return to the contents page................Click here for the advanced glossary

AbsoluteTemperature:
A scale for measuring temperature that is obtained by adding algebraically 273 to degrees centigrade.

Absolute Zero:
The temperature,273 degrees below the zero of the centigrade scale,at which all molecular motion ceases.

Acid:
A compound which yields hydrogen ions in aqueous solution;a proton donor.

Addition reaction:
A reaction in which a reagent adds to a carbon-carbon double or triple bond.

Adsorption:
A process in which molecules or ions adhere to the surface of a solid.

Alkali:
A water soluble base that yields hydroxyl ions in aqueous solution.

Allotropism:
The property of certain elements of existing in more than one form,such as oxygen and ozone.

Alpha particle:
The positively charged nucleus of the helium atom.

Anhydrous:
Without water.

Anion:
A negatively charged ion.

Anode:
The positively charged electrode of an electrolytic cell.

Atom:
The smallest unit of an element that participates in chemical change.

Atomic number:
A number,characteristic of an atom,that represents the number of protons in the nucleus of the atom.It indicates the location of an element in the periodic table.

Atomic weight:
The relative weight of an atom referred to carbon,whose weight has been arbitrarily set at 12.01115.

Avogadro's law:
The law which states that equal volumes of all gases,at the same temperature
and pressure,contain the same number of molecules.

Base:
A compound which yields hydroxide ions in aqueous solution;a proton acceptor.

Beta particle:
A negative electron given off by a radioactive substance.

Binary compound:
A compound composed of two elements per molecule.

Boiling point:
The temperature at which the vapor pressure in a liquid equals the atmospheric pressure.

Brownian movement:
The rapid oscillatory movement of small particles when suspended in water or other liquids.

BTU:
British Thermal Unit,the quantity of heat required to raise the temperature of one pound of water one degree Fahrenheit.It is equal to 0.252 calorie.

Buffer:
A substance that keeps the pH of a solution relatively constant in spite of the addition of considerable amounts of acid or base.

Calorie:
A small calorie(cal.) is the amount of heat required to raise the temperature of 1 gram of water by one degree Celsius.A large calorie(Cal.)equals 1000

calories.

Carboxyl group:
A univalent organic radical (-COOH) which is the functional group of all the carbolic acids.

Catalyst:
A substance which speeds up,or less frequently retards,a chemical reaction, without being changed itself.

Cathode:
The negatively charged electrode of an electrolytic cell.

Cation:
A positively charged ion.

Chemical change:
A change in which the chemical structure of a substance is changed.

Chemistry:
The science which deals with the composition and properties of substances and their transformation from one form to another.

Colloids:
Particles which are intermediate in size between crystalloids that form true solutions and suspensions that eventually settle.

Combining weight:
The weight of an element which will combine with 8 grams of oxygen,or 1.008 grams of hydrogen.

Combustion:
Rapid oxidation accompanied by evolution of heat and usually light.

Compound:
A substance composed of two or more elements united chemically in definite proportions by weight.

Covalence:
The combining of atoms by means of the sharing of electrons.

Crystalloids:
Substances which,when dissolved in liquid,will diffuse through a semipermeable membrane.

Dehydration:

The removal of water from a substance.

Deliquescence:
The process whereby certain substances absorb sufficient water from the atmos- phere to dissolve themselves.

Denaturation:
The process of altering the structure of a protein by physical or chemical means.

Density:
Mass per unit volume.

Deoxygenation:
The process of removing water from a compound.

Deuterium:
An isotope of hydrogen having twice the mass of ordinary hydrogen.

Diffusion:
The process by which one substance distributes itself uniformly through water.

Dispersion:
Colloidal particles suspended in a liquid medium.

Distillation:
The evaporation of a liquid and the condensation of it's vapor.

Efflorescence:
The spontaneous loss of water by a substance when exposed to air.

Electrolysis:
The decomposition of a chemical compound by an electrical current.

Electrolyte:
A substance which will conduct an electrical current when in solution or melted

Electron:
An atomic particle carrying a unit charge of negative electricity,having a mass of 1/1837 of that of a proton.

Electrophoresis:
The migration of colloidal particles dispersed in a fluid,under the influence of an electric field.

Electrovalence:
The valence as determined by the electrons lost or gained by the elements reacting to form a compound.

Element:
One of the basic fundamental forms of matter that cannot be separated into simpler substances by ordinary chemical means.

Emulsion:
A colloidal dispersion of a liquid in another liquid.

Endothermic reaction:
A chemical change in which heat is absorbed.

Energy:
The ability to do work.

Equilibrium:
A state existing in a reversable reaction when the rates of the forward and reverse reactions are equal and the concentrations of the reactants and products are equal.

Ester:
An organic compound formed by the reaction between an acid and an alcohol.

Exothermic reaction:
A chemical change in which heat is liberated.

Filtration:
The process of separating suspended particles from a liquid by means of a porous medium.

Fission:
The disintegration of the nucleus of a heavy atom with the liberation of large amounts of energy.

Formula:
An expression of the constituents of a compound by symbols.

Gamma ray:
Similar to X-rays,forming part of the radiation of a radioactive substance.

Gel:
A semi-rigid colloid.

Gram-atomic weight:
One atomic weight of an element expressed in grams.

Gram-molecular weight:
One molecular weight of a compound expressed in grams.

Half-life:
The length of time required for one-half of a radioactive substance to disintegrate.

Halide:
A compound composed of two elements,one of which is a halogen.

Halogens:
A family of elements consisting of flourine,chlorine,bromine and iodine.

Heterocyclic compounds:
Cyclic compounds in which the ring system of the molecule contains other elements than carbon.

Hydrate:
A compound containing water of crystallization.

Hydride:
A compound containing a negatively charged hydrogen,as in sodium hydride(Na-H).

Hydrocarbons:
Organic compounds containing hydrogen and carbon only.

Hydrogenation:
A chemical reaction in which hydrogen is added to a compound.

Hydrolysis:
Chemical decomposition by which a compound is resolved into other compounds by taking up the elements of hydrogen.

Hypertonic solution:
A solution of higher osmotic pressure than another with which it is compared.

Immiscible:
Incapable of being mixed,as oil and water.

Indicator:
A compound which changes color with changes in the hydrogen ion

concentration (pH)of a solution.

Iodine number:
The number of grams of iodine required to saturate 100 grams of fat.

Ion:
An electrically charged atom or radical.

Ionization:
The separation of an electrolyte into charged ions in solution.

Isoelectric point:
The pH at which a substance is electrically neutral or at it's minimum ionizaation.

Isomers:
Compounds which have the same molecular formula but different structural formulas.

Isotonic solution:
A solution having the same osmotic pressure as another with which it is compared.

Isotopes:
Atoms of the same element having the same atomic number but having different atomic weights.

Ketone:
An organic compound containing the carbonyl group attached to two organic radicals.

Kindling temperature:
The lowest temperature at which a substance bursts into flame.

Kinetic energy:
Energy in motion.

Latent heat:
The heat absorbed in the changing of a substance from solid to liquid,or from a liquid to a gas.

Matter:
Anything which occupies space and has mass.

Miscible:
Capable of being mixed.

Mixture:
An aggregate of two or more substances which are not chemically combined and which exist in no fixed proportion to one another.

Molal solution:
A solution containing one mole of a solute in 1,000 grams of solute.

Molar solution:
A solution which contains 1 gram-molecular weight of solute in one liter of solution.

Mole:
The molecular weight of a substance expressed in grams.

Molecular weight:
The sum of the atomic weights of all the atoms in a molecule.

Molecule:
The smallest particle of a compound that can exist independently.

Nascent:
The condition of an element that has just been released in the monatomic state in a chemical reaction.

Neutron:
A neutral particle existing in the nucleus of an atom.

Noble gases:
A family of elements consisting of helium,neon,argon,krypton,xenon and radon.

Nonelectrolyte:
A compound whose water solution does not conduct an electric current.

Normal solution:
A solution which contains 1 gram-equivalent weight of a solute in 21 liters of solution.

Nucleic acid:
An organic compound composed of phosphoric acid,ribose or deoxyribose,and
purine and pyride bases.

Nucleus:
The positively charged center of the atom containing protons and neutrons.

Osmosis:
The passage of fluid from a less concentrated solution to a more concentrated solution through a semipermeable membrane.

Oxidation:
Combination of a substance with oxygen;the increase in valence toward the positive;the loss of electrons.

Oxide:
A compound of oxygen and some other element.

Periodic law:
The law that the properties of the elements are periodic functions of their atomic numbers.

Periodic table:
A table illustrating the periodic system in which the chemical elements arranged in the order of their atomic numbers are shown in related groups.

pH:
A symbol denoting the algorithm of the reciprocal of hydrogen ion concentration

Physical change:
A change in the condition or state of a substance;it's composition is not altered.

Potential energy:
Energy that is due to position and not of motion;stored energy.

Precipitate:
An insoluble liquid that separates from solution.

Protein:
A substance of high molecular weight composed of carbon,hydrogen,nitrogen,and sometimes sulphur or iodine,that yields upon hydrolysis amino acids or their derivatives.

Proton:
A subatomic particle carrying a unit of positive charge.

Radical:
A group of atoms that behave as a unit in a chemical reaction.

Radioactivity:

The spontaneous disintegration of an atom,with the emission of alpha.beta,and gamma rays.

Radioisotope:
A radioactive isotope,often used as a tracer in scientific research.

Reduction:
The removal of oxygen from a compound;the gain of electrons by a substance or a decrease in it's valence.

Salt:
A compound consisting of a positive ion other than hydrogen and a negative ion other than the hydroxyle ion;the product of an acid with a base.

Saturated solution:
A solution that contains all the solute that it can hold at a given temperature and pressure.

Semipermeable membrane:
A membrane that allows water and crystalloids to pass through but holds back colloids.

Solute:
A substance dissolved in a solvent.

Solution:
A homogeneous mixture of two or more substances.

Solvent:
A substance in which a solute is dissolved.

Specific gravity:
The ratio of the weight of a given volume of a substance to the weight of an equal volume of water.

Specific heat:
The quantity of heat in calories required to raise the temperature of one gram of a substance one degree Celsius.

Spontaneous combustion:
The ignition of a substance as the result of the accumulated heat of slow oxidation.

Structural formula:
A formula which shows the arrangement of the atoms in a molecule.

Substitution reaction:
A chemical reaction in which one or more elements or radicals in a compound are replaced by other elements or radicals.

Suspension:
A system consisting of small particles dispersed in a liquid.The particles will settle out slowly upon standing.

Synersis:
The shrinking of a gel,with the expulsion of water or other liquid from it.

Synthesis:
The construction of a compound by the union of elements or simple compounds.

Tincture:
A solution of a medicinal substance in alcohol.

Titration:
The process of determining the quantity of a substance in a solution by adding
a measured volume of a standard solution until the desired reaction has been affected.

Transmutation:
The conversion of one element into another in a nuclear reaction.

Tyndall effect:
The reflection of a beam of light by the dispersed particles of a colloidal solution,making visible the path of the light.

Unsaturated compounds:
Organic compounds containing double or triple bonds and are capable of forming addition products.

Unsaturated solution:
A solution containing less solute than the amount needed to make a saturated solution.

Valence:
A number that represents the combining power of an element or radical.

Valence electrons:
The electrons located in the outermost shell of an atom.

Water of crystallization:

Water present in the crystal of a hydrate.

Zwitterion:
A dipolar ion carrying both a positive and a negative charge.

# TYPES OF REACTION

There are three different types of organic reaction, and all reactions fall into one of the catagories of addition, substitution or elimination.

## Classes of Organic Reaction...........

1. Addition A-B + X-Y -------> X-A-B-Y
2 Elimination X-A-B-Y ---------> A-B + X-Y
3 Substitution A-X + Y ---------> A-Y + X
These catagories can be split into different types however:

## Electrophilic addition

An electrophilic addition is an addition reaction where the first step of the reaction is the attachment of an electrophile to a nucleophilic centre. Alkenes undergo electrophilic addition because the first step of the reaction, is the attack of the electron rich area by an electrophile.
The addition across the double follows Markovnikov's rule.

## Electrophilic substitution

An electrophilic substitution is a substitution in which the attacking (and leaving) group is an electrophile. Benzene undergoes electrophilic substitution. It's electron rich ring is attacked by an electrophile and then this substitutes for one of the H atoms bonded to it.

## Nucleophilic addition

A nucleophilic addition occurs when the first step of a reaction is the attachment of a nucleophile to an electrophilic centre.
Carbonyl compounds undergo nucleophilic addition reactions. The C atom of the carbonyl acts as an electrophile and is vulnerable to nucleophilic attack.

## Nucleophilic substitution

A nucleophilic substitution reaction is one where the attacking (and leaving) group is a nucleophile.
Haloalkanes and alcohols undergo nucleophilic substitution.
There are two types of nucleophilic substitution reaction:

### SN1

An SN1 reaction is a unimolecular nucleophilic substitution. The SN1 reaction is charactorized by:
1. First order kinetics
2. Racemization
3. Rearrangement
4. The reactivity sequence 3'>2'>1'>$CH_3W$

### SN2

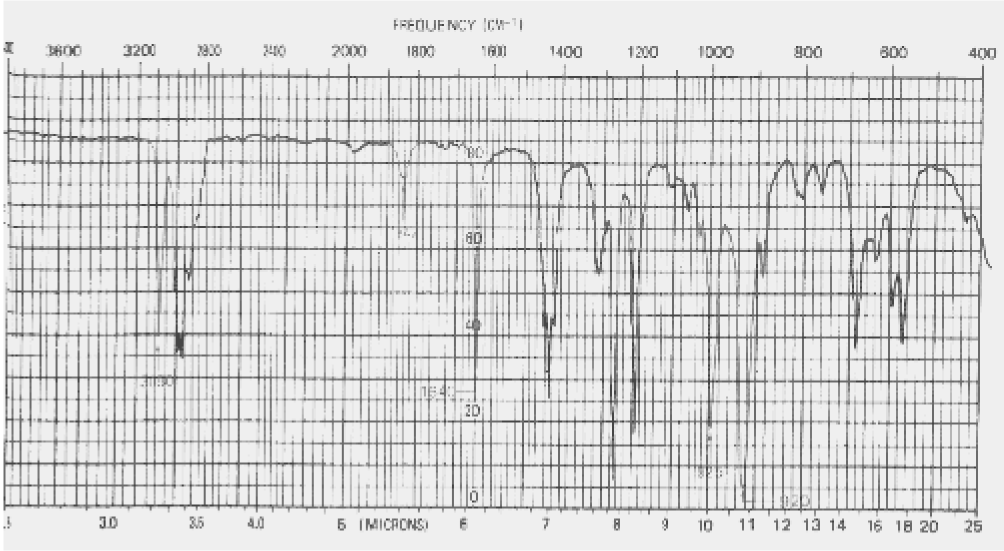
An SN2 reaction is a bimolecular nucleophilic substitution reaction. The SN2 reaction is charactorized by:
1. Second order kinetics
2. Complete stereochemical inversion
3. Absence of rearrangement
4. The reactivity sequence $CH_3W$>1'>2'>3'

## Elimination

An elimination reaction is one where an atom or group is removed from a molecule.
Dehydration of an Alcohol to an alkene can be regarded as an elimination, in which the

elements of water are eliminated.

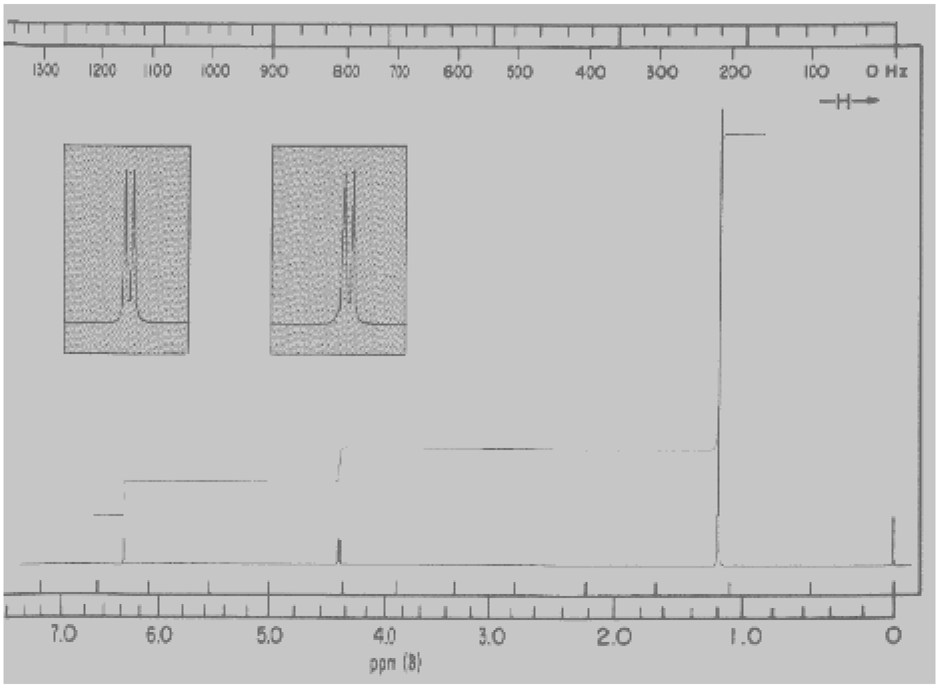
A condensation reaction may be regarded as an addition reaction followed an elimination reaction.



This is an example of an I/R spectrum. The x-axis is in wavenumbers 1/cm.

## TABLE 1.Characteristic Infrared Group Frequencies

| **Class** | **Group** | **Wavenumber** |
|---|---|---|
| alkane | C-H | 2850-3000 |
| alkene | C-H | 3080-3140 |
| | C=C | 1630-1670 |
| alkyne | C-H | 3300-3320 |
| | C=-C | 2100-2140 |
| alcohol | 0-H | 3400-3600 |
| | C-O | 1070-1150 |
| ether | C-O | 1070-1150 |
| aldehyde | C=0 | 1725 |
| ketone | C=O | 1700-1780 |



This is an example of a proton NMR. The x-axis gives shifts in PPM and reads right to left.

## Table 2 Characteristic Shifts of Organic Compounds in H-NMR

| Compound | Shift/ppm |
|---|---|
| Br-C-H (bromoalkane) | 2.5-4.0 |
| I-C--H (iodoalkane) | 2.0-4.0 |
| -O-C-H (ether) | 3.3-4.0 |
| C=C--H (alkene) | 5.0-6.5 |
| Ar-H (aromatic) | 6.5-8.0 |
| -CH=O (aldehyde) | 9.7-10.0 |

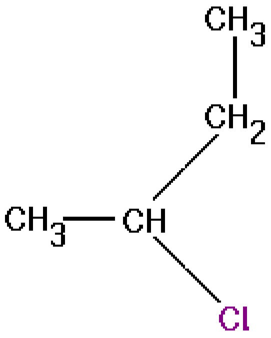
# ALKYL HALIDES

## Alkyl Halides   (the Haloalkanes)

Haloalkanes or alkyl halides are compounds formed by the substitution a halogen atom for a hydrogen atom in an alkane. Haloalkanes differ from each other in three different ways:

1. The type of halogen substituted on it.
2. The number of hologens substituted on it.
3. The nature of the carbon chain. (No. of atoms, Branching etc)

Haloalkanes are named firstly by a number indicating the position of the halogen, then by the name of the halogen i.e Cl = chloro Br = Bromo I = Iodo , then by the longest carbon chain.



This compound would be called 2-chlorobutane

## Physical properties

The melting points and boiling points of the haloalkanes are higher than their corresponding alkanes this is due to dipole-dipole interactions between the molecules.

## Chemical properties

The haloalkanes undergo nucleophilic substitution and/or elimination reactions depending upon the strength and polarity of the carbon-halogen bond, the structure of the alkyl group and the nucleophiles strength as a proton acceptor (base). The carbon attached to the halogen has a slightly +ve charge due to the dipole set up between it and the more electronegative halogen. It is this positive centre that is attractive to nucleophilic attack.

## Reactions of the haloalkanes

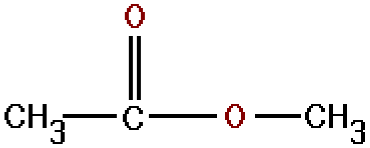
$C_4H_9Br + NaOH$ ------------> $C_4H_9OH + NaBr$ **Nucleophilic substitution**

$C_4H_9Br + KOH$ -------------> $C_2H_5CH{=}CH_2 + H_2O$ (alcoholic conditions)
**Elimination**

# ESTERS

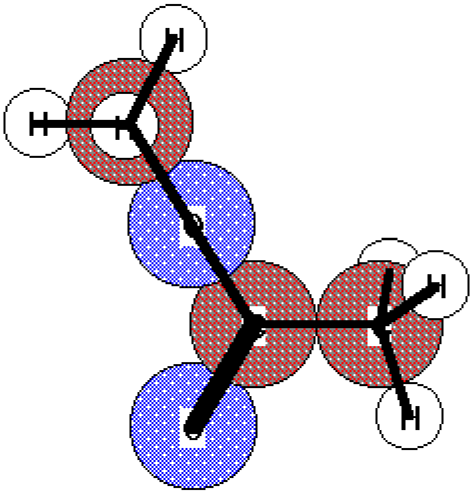
## Esters, Esterification

Esters are usually volatile liquids which are insoluble in water. They are identifyable by their fruity smell, many perfumes have naturally occuring esters in them.



$CH_3-\overset{\overset{\displaystyle O}{\|}}{C}-O-CH_3$

A simple ester (methyl ethanoate)



A 3D view of methyl ethanoate

Esters are made by the reaction of an acid with an alcohol in the presence of an acid (sulphuric). This reaction is known as an **esterification** reaction.
$CH_3CH_2COOH + CH_3CH_2OH$ ------(H+)--------> $CH_3CH_2COOCH_2CH_3$
This reaction has an equilibrium point; it does not proceed to completion, therefore a 100% will never be achieved.

# INTERMOLECULAR FORCES

Intermolecular forces are the forces of attraction between liquid molecules.
Order of strength:

Covalent bond >> H-bond >> Dipole-dipole attraction >> Vand der Waals attraction

## Van der Waals Forces

The boiling point of hydrocarbons depend upon weak Van der Waals forces between molecules, it is these forces that prevent the molecules escaping into the vapour phase. Two things affect Van der Waals forces:

a. the length of the carbon chain.
b. the branching of the chain.

The longer the carbon chain, the higher the boiling point of the substance. This is due to the larger surface area having more attractive forces and hence more energy is needed to break them.

The more branched a hydrocarbon is, the less surface area it has for Van der Waals forces to act on.This means that the more branched a hydrocarbon is, the lower the boiling point, compared to a straight vhain hydrocarbon.

## Dipole-Dipole attractions

The electronegativity of an atom is the measure of how strongly it attracts electron charge when in a covalent bond.

Electronegativity increases as you tend to the top right of the periodic table (i.e F and O are very elctronegative atoms).

In a bond which is polar (i.e atoms of different electronegativity) such as C-Cl a dipole is set up due to the fact that Cl pulls electron charge onto itself, and causes the C and Cl to have different charges (slightly +ve and slightly -ve respectively).

The dipole-dipole attractions are the attractive forces between the C of one molecule and the Cl of another molecule, using the example above.

## Hydrogen Bonding

Hydrogen bonding is a type of dipole-dipole attraction which occurs between a hydrogen atom attached to a highly electronegative atom (nitrogen, oxygen, halogen etc) and a second highly electronegative atom with a lone pair of electrons e.g the oxygen in a water molecule.

If we take the example of water; the electronegative oxygen attracts electron charge in the O-H bond and hence leaves the H electron deficient. This electron deficient H then approaches an electron rich area of another molecule, i.e the O of water, electrostatic forces forces of attraction takes between these two molecules. It is the small size of the H which allows the O the approach it very closely and therefore give a very strong electrostatic attraction.

# ORGANIC NITROGEN COMPOUNDS

## Amines, Amides, Nitliles, Amino acids, Proteins

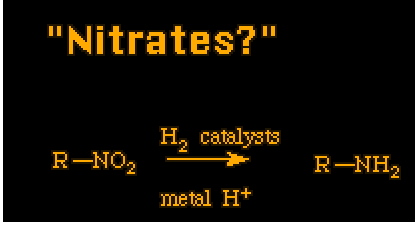
Organic compounds which contain nitrogen are very important and include amines, amides, amino acids and proteins. Nitriles, also known as cyanides are also importand nitrogen containing organic compounds.

## Amines

$$CH_3—CH_2—CH_2—NH_2$$

A Primary amine (propylamine)

Amines are organic compounds which contain the NR3 group (R = Hydrogen or alkyl group). Amines are derived from ammonia and have base character.
Amines are classed as primary, secondary and tertiary according to the number of hydrogen atoms in an ammonia molecule that have been replaced by an alkyl group.
e.g $CH_3NH_2$ = methylamine (primary)
$(CH_3)_2NH$ = dimethylamine (seconary)
$(CH_3)_3N$ = trimethylamine (tertary)
Amines can be prepared in the laboratory by the reduction of a nitrate:



## Physical properties

Amines have a very unpleasant smell; methylamine smells like rotting fish. The electronegative N atom forms a dipole and hence dipole-dipole attractions are present in liquid amines. Primary and secondary amines are also able to hydrogen bond, which causes the boiling point of amines to be quite high in comparison to organic compounds of similar RMM. The H-bonding also accounts for the solubility of amines in water.

## Chemical properties

Many amines are toxic and are hazardous to health. They are flammable and form $CO_2$ $H_2O$ and $N_2$ when burned in excess air.Most amines are weak bases in aqueous solution, primary amines are the strongest then secondary and tertiary respectively. The N atom in the amine functional group acts as a Lewis base by donating its lone electron pair.
The lone pair on the N atom is also a nucleophilic centre and therefore amines undergo reactions with haloalkanes, acyl chlorides and acid anhydrides.
e.g The reaction of a primary amine and an acid chloride:
$R\text{-}NH_2 + CH_3\text{-}C{=}OCl$ -------------------> $CH_3\text{-}C{=}ONHR$

## Diazotisation of primary Amines

Diazotisation is the reaction of ice cold aqueous nitrous acid with an aromatic amine to form an aqueous diazonium ion. The diazonium ion is a cation with the general formula $R\text{-}N_2+$. The nitrous acid must be formed in situ as it is unstable, it is formed by the reaction of hydrochloric acid with aqueous sodium nitrite. Diazotisation can be carried out on aliphatic primary amines but the product decays immediately on reaction where nitrogen is liberated.
$C_6H_5NH_2$ (aq) + N=O (aq) ------> $C_6H_5N_2+$ (aq) + $H_2O$ (l)

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## Amino acids and proteins

An amino acid is a compound which contains an amino group (-NH2), a carboxyl group (-COOH), a hydrogen atom (-H) and a side chain (R) all atached to the same carbon atom.
Amino acids can be neutral, basic, or acidic depending upon the number of -COOH and -NH2 groups they have in their structure.
There are about 20 different alpha amino acids in existance which are the building block of polypeptides and proteins.
Amino acids are white crystaline, water soluble solids which melt or decompose at temperatures above 200'c because they exist as **Zwitterions**. Zwitterions are ions which have +ve and -ve charges on the same molecule, proton transfer from the acid group to the base group in amino acids causes these Zwitterions to be ste up and hence cause the melting point of th crystals to be very high.
e.g in the case of Glycine (aminoethanoic acid) the Zwitterion would be $^{+}NH_3CH_2COO^{-}$
Proteins are naturally occuring polyamides, and often contain up to 25 different amino acids in their structure, the RMM of a typical protein is about 500000 g/mol.

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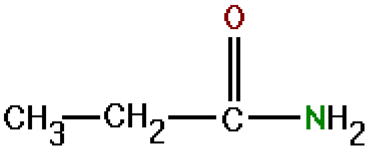
## Amides

Amides are derivatives of carboxylic acids. Their functional group is -C=ONH2. They are made by reacting acid chlorides with ammonia.



$$CH_3-CH_2-\overset{O}{\overset{\|}{C}}-NH_2$$

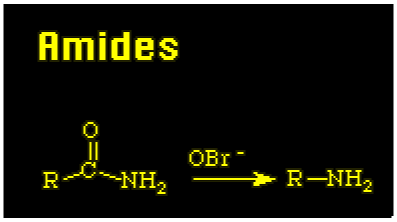
Propanamide

### Physical properties

Amides, apart from methanamide, are white crystaline solids. Amides are able to H-bond which makes them soluble in water and also increases their boiling point. As amides do not predominantly H-bond in dimers when in solution, they have higher boiling points than their parent carboxylic acids.

### Chemical properties

Amides are less reactive than amines due to the fact that the delocaliozed electrons of the C=O bond extends ove the NH2 group.
Amides can be reduced to amines by a powerful reducing agent i.e LiAlH4 followed by hydrolysis in H2O.
Amides can also have the C=O bond taken out by a solution of aqueous alkali. This reaction (shown below) is known as the **Hofmann degardation** and be used to precisely shorten a carbon chain.



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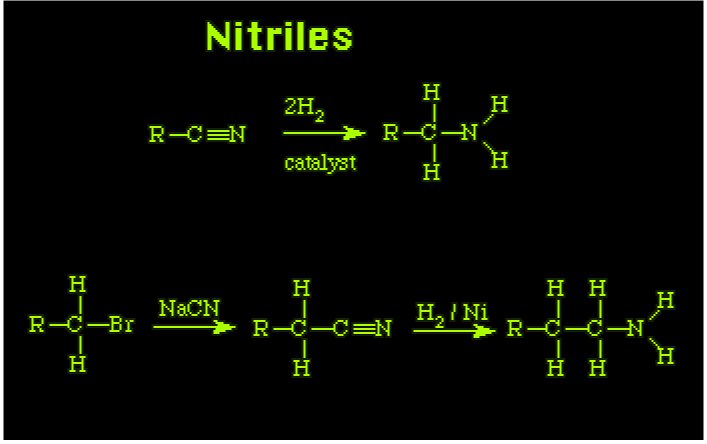
# Nitriles (the organic cyanides)

Nitriles are organic compounds containing the functional group -CN. These compounds are highly toxic and are known as cyanides. The are also dangerously flammable and can often explode when ignited. Nitrlies are synthesized by heating alcoholic pottasium cyanide with a haloalkane. This is a simple nucleophilic substitution reaction which is also important chemically in order to extend a carbon chain.

Nitriles are important intermediates in organic sytheses. They can be hydrolysed to carboxillic acids and also reduced to primary amines.

The diagram below shows the reduction of a nitrile and the prearation of a nitrile followed again by reduction.



# ISOMERIZM

## Stereo isomerizm

Stereo isomerizm is exhibited by isomers having the same atoms attached to each other, but different spatial arrangments.

There are two types of stereo isomerizm:

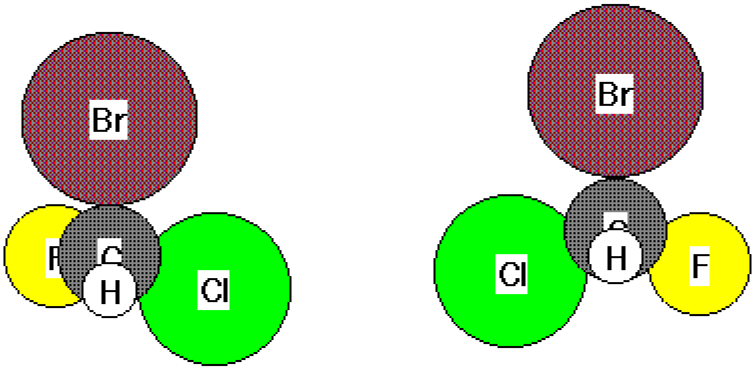
a. Optical

b. Geometrical

## Optical isomerizm

Optical isomerizm is found widely in organic chemistry and occurs with compounds whose molecules do not have a plane of symmetry. If a beam of light is passed through an optical isomer the emergent light vibrates in a single plane, it is said to be plane polarized. A substance which is able to do this is said to be optically active. If the plane of polarization rotates in a clockwise direction the substance is said to be **dextrorotatory** or has a prefix (+). If the plane of polarization is rotated in an anti clockwise direction then the substance is said to be **laevorotatory** or has a prefix (-).

Optically active compounds are **chiral**, meaning that they have an asymetrically distributed carbon atom, that is, a carbon with 4 different groups attatched to it. These types of compounds exist in pairs known as **enantiomers** which are non super-imposable mirror images of each other:



The picture above shows a pair of enatiomers which are mirror images of each other. They have the same molecular formula and only differ in there spatial arrangement. Although the compounds may seem identical, the enantiomers often have different chemical properties, in medicine it is often only one enantiomer which has pharmaceutical properties whilst the other may have no use at all. An example of this is the drug thalidomide, one enantiomer had pain relieving properties whilst the other was a potent teratogen which caused deformaties amongst new born babies. This drug was developed before the known effects of different optical isomers.

If there are equal amounts of both (+) and (-) enantiomers in a mixture then the compound would be optically inactive; this type of compound is known as a **racemic mixture**.

Lactic acid has a chiral centre and therefore is optically active. It is found naturally in three forms: in it's racemic mixture it is found in sour milk, in it's (+) form it is found in muscle tissue it is not naturally occuring in its (-) form.

## The Cahn-Ingold Prelog sequence

The Cahn Ingold Prelog sequence is a way of naming optical isomers according to their configuration. A prefix of R or S is given to a compound which simplifies matters in that the compound does not have to be drawn all the time to fully give the structure. There are two steps involved in applying the prefix to a compound.

1. Following a sequence rule we assign each of the 4 groups of the chiral centre a priority.

This sequence rule is simply the atomic mass of the atom attached to the chiral carbon. If this is the same in two or more cases then the molecular mass of the next atom in line is taken into account.

2. We visualize the molecule orientated so that the ligand of lowest priority is directed away from us, and observe the arrangment or the remainding groups. The 3 remaining groups or atoms are then viewed in order of priority, highest first. If the obseved rotation of decreasing priority is clockwise then the compound has the prefix R-. If the obseved rotation is anticlockwise then the prefix is S-.

## Resolution

Resolutionis a term which describes the process of separating a racemic mixture into it's two enantiomeric forms. Racemic mixtures cannot usually be separated by physical methods as the enantiomers have identical physical properties. There are several methods by which a racemic mixture could be separated if one wanted just one pure enantiomer:

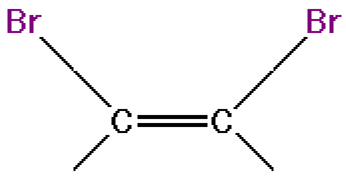
a. Destroying one of the enantiomers with bacteria.

b. Pasteurs method :- crystallization and separated by hand due to different coloured crystals. (v. rare)

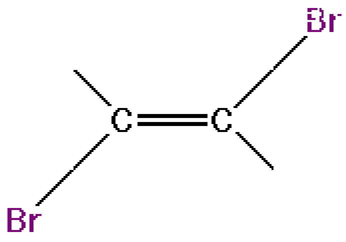
c. Reaction with another optically active reagent to give two products with different physical properties which can be separated by physical methods i.e fractional crystalization.

## Geometrical isomerizm

Geometrical isomerizm is a special form of stereo isomerizm which occurs because two atoms joined by a double bond cannot rotate about the bond as an axis. The prefixes cis- ,now known as Z-, (on the same side) and trans-, now known as E-, (on opposite sides) are used to name geometric isomers with the same group on each of two doubly bonded carbon atoms - For example:



z-1,2-dibromo ethane



E-1,2-dibromoethane

# INTRODUCTION

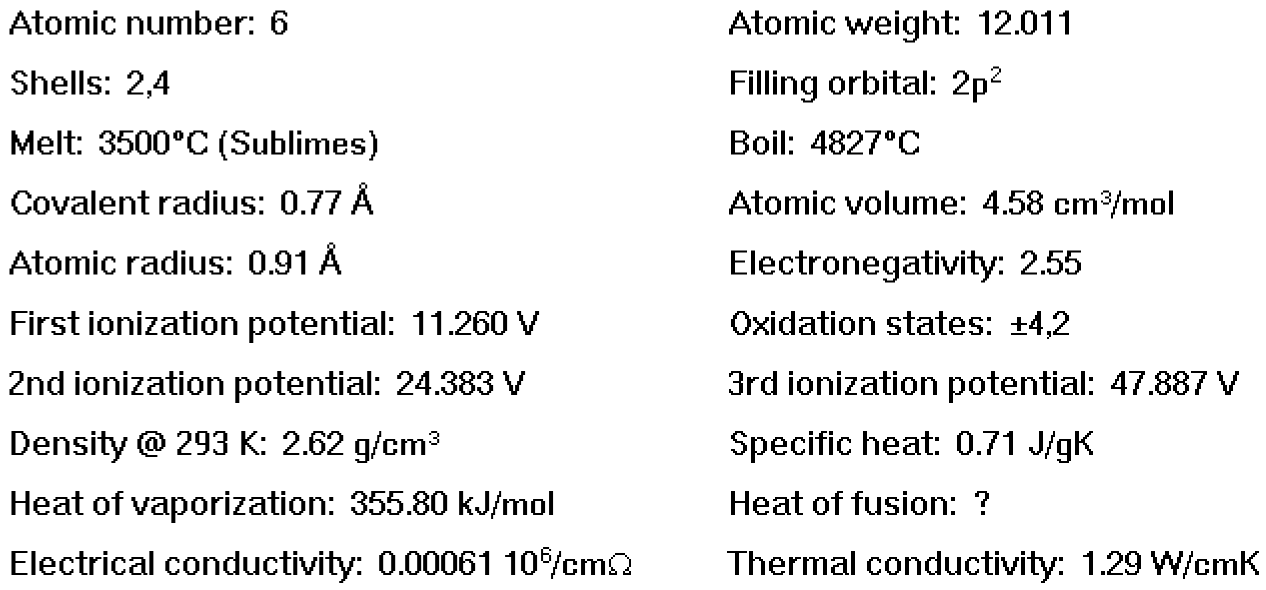
## Carbon Chemistry

Organic chemistry is the branch of chemistry in which carbon compounds and their reactions are studied. A wide variety of classes of substances such as drugs, vitamins, plastics, natural and synthetic fibers, as well as carbohydrates, proteins, and fats consist of organic molecules. Organic chemists determine the structures of organic molecules, study their various reactions, and develop procedures for the synthesis of organic compounds. Organic chemistry has had a profound effect on life in the 20th century: It has improved natural materials and it has synthesized natural and artificial ma terials that have, in turn, improved health, increased comfort, and added to the convenience of nearly every product manufactured today.

The advent of organic chemistry is often associated with the discovery in 1828 by the German chemist Friedrich Wöhler that the inorganic, or mineral, substance called ammonium cyanate could be converted in the laboratory to urea, an organic substance found in the urine of many animals. Before th is discovery, chemists thought that intervention by a so-called life force was necessary for the synthesis of organic substances. Wöhler's experiment broke down the barrier between inorganic and organic substances. Modern chemists consider organic compounds to be those containing carbon and one or more other elements, most often hydrogen, oxygen, nitrogen, sulfur, or the halogens, but sometimes others as well.

Carbon is unique amoungst the elements in that it can form an enormous number of compounds, and a variety of different structures. It can form single, double and triple bonds; rings, branched chains, branched and interlocked rings. An example of the unique behavior of carbon in forming compounds is the fact that thousands of hydrocarbons exist (compounds of carbon and hydrogen only) wereas only two compounds of, for example, hydrogen and oxygen exist (water and hydrogen peroxide).

### The properties of carbon.....



Atomic number: 6
Shells: 2,4
Melt: 3500°C (Sublimes)
Covalent radius: 0.77 Å
Atomic radius: 0.91 Å
First ionization potential: 11.260 V
2nd ionization potential: 24.383 V
Density @ 293 K: 2.62 g/cm$^3$
Heat of vaporization: 355.80 kJ/mol
Electrical conductivity: 0.00061 10$^6$/cmΩ
Atomic weight: 12.011
Filling orbital: 2p$^2$
Boil: 4827°C
Atomic volume: 4.58 cm$^3$/mol
Electronegativity: 2.55
Oxidation states: ±4,2
3rd ionization potential: 47.887 V
Specific heat: 0.71 J/gK
Heat of fusion: ?
Thermal conductivity: 1.29 W/cmK

Carbon is able to form 4 single bonds, all homogenous. This is due to carbon forming hybrid orbitals:

**Electronic Structure of Carbon** = $1S_2$ $2S_2$ $2P_2$ . The 2S and 2P orbitals combine and form hybrid orbitals known as SP3 orbitals (1S + 3P orbitals) this makes 4 equivalent orbitals which are able to bond singley. In the case of double bonds 1 S orbital and 2 P orbitals combine to form a hybrid known as an SP2 hybrid. Triple bonds form by way of SP hybridization.

The study of compounds of carbon forms the discipline known as organic chemistry. This is not strictly correct though, as there are compounds of carbon in inorganic chemicals. Organic chemistry was first given its name derived from the Greek Organon - part of the body ; this is because it was first believed that organic compounds could only be produced from living organisms. Today there are over 6 million organic chemicals known, a figure which is rises day by day.

Organic compounds are divided into classes according to their molecular structure, and their properties are interpreted in terms of the chemistry of their functional groups.

Organic compounds each fall into catagories known as a homologous series:

The homologous series has 4 major criteria by which aorganic compounds are catagorized:

1. Have the same general formula e.g Alkanes have $C_nH_{2n+2}$
2. Thet have a molecular mass 14 ($CH_2$) greater than the preceding member i.e $C_4H_{10}$ and $C_5H_{12}$
3. They have similar chemical properties.
4. Thet have physical properties showing steady graduation e.g B.P will increase with RMM.

Organic compounds are named systematically by using nomenclature. All organic compounds can be named by the guidlines set by IUPAC. This includes the naming of the functional group and also the carbon chain:

1 carbon = meth
2 carbons = eth
3 carbons = prop
4 carbons = but
5 carbons = pent
6 carbons = hex
7 carbons = hept
etc........

Organic chemistry concerns itself with both the physical and chemical properties of organic compounds. Physical properties include size and shapes of molecules and how the behave under certain conditions ; chemical properties deals with how the compounds react, both with other organic compounds and also inorganic reagants. There are three main ways by which organic compounds react:

## Classes of Organic Reaction...........

1. Addition A-B + X-Y -------> X-A-B-Y
2 Elimination X-A-B-Y ---------> A-B + X-Y
3 Substitution A-X + Y ---------> A-Y + X

All classes of organic reaction fall into one of these catagories.

# HYDROCARBONS

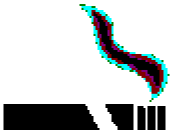
## Hydrocarbons............. Alkanes, Alkenes and Alkynes

As the name sugests, hydrocarbons are compounds containing carbon and hydrogen only. They are mainly derived from coal, natural gas, petroleum and plants. They may be saturated or unsaturated, they may be aliphatic or aromatic. Saturation is the amount of substituents around carbon, in the case of alkanes each carbon has 4 substituents, the maximum allowed by valency, therefore they arer known as saturated compounds. Alkenes and alkynes have double and triple bonds respectively therefore do not have the maximum 4 valency, these types of compounds are therefore unsaturated compounds.

$CH_3{-}CH_3$ Alkanes (Cn H2n+2)

$CH_2{=}CH_2$ Alkenes (Cn H2n)

$CH{\equiv}CH$ Alkynes (Cn H2n-2)



Hydrocarbons are very flammable and combust to form $CO_2$ and $H_2O$ Hydrocarbons are the basis of many fuels: such as butane for gas cookers etc, Acetylene (ethyne) for weilding equipment, and the mixtures of hydrocarbons for motor fuel.

## Naming Hydrocarbons.......

**1.** Find the longest possible continuous chain of carbon atoms in the molecule. The molecule will be named as a derivative of this alkane.

i.e

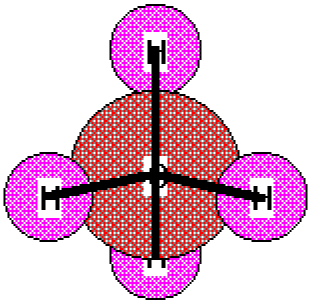
| Chain | Name |
|---|---|
| 1 | meth- |
| 2 | eth- |
| 3 | prop- |
| 4 | but- |
| 5 | pent- |
| 6 | hex- |
| 7 | hept- |
| 8 | oct- |
| 9 | non- |
| 10 | dec- |

**2.** Determine the names of the hydrocarbon groups attached to this chain. These side chains are called alkyl groups. There names are obtained by dropping the ending -ane from the corresponding alkane and replacing it with -yl i.e a side chain with 3 carbons would by propyl-.

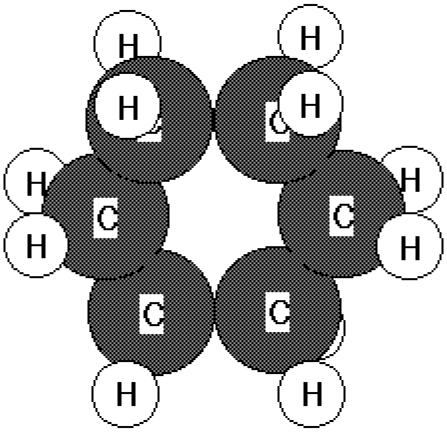
**3.** Number the carbon atoms along the chain. Identify the alkyl groups by the number of the carbon atom that they are attached to.
**4.** If more than one alkyl group of the same type is attached to the molecule then use the prefix di- (two) tri- (three) tetra- (four) in front of the hydrocarbon name.
**5.** If several types of alkyl groups are attached, namer them in alphabetical order.
**6.** If the hydrocarbon contains unsaturation then find the number of the carbon with the double or triple bond on it and prefix this number in fron of the ending -ene (alkenes) and -yne (alkynes)

## Alkanes

Alkanes are saturated hydrocarbons. The simplest hydrogen is methane (CH4) which is tetrahedral in structure.



There are also more complicated alkanes, such as branched chain alkanes and cycloalkanes. A common occuring cycloalkane is cycloheaxane:



Alkanes are very unreactive apart from cracking and burning in air with a non-luminous flame.
The only react by substituting radicals for hydrogen atoms:
Free radical substitution of Alkanes
At 20'c and in the dark Chlorine and methane do not react. If the mixture is heated above 200'c or is irradiated by ultra violet light a rapid **chain reaction** takes place.
This chain reaction takes place in three steps:
1 **INITIATION** :- the $Cl_2$ undergoes homolytic fission and splits into two Cl' radicals.
2 **PROPAGATION** :- a radical combines with a stable molecule to give a different radical and molecule.

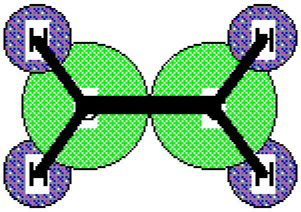
e.g $CH_4$ + Cl' ------------> $CH_3$' + HCl
A chain reaction is then set up when the radicals are combining with stable molecules.
This continues until no more product can be formed i.e $CCl_4$ or the

reaction is terminated.

3 **TERMINATION** :- the reaction can be terminated in three ways: (all involve the combination of 2 radicals)

i) Cl' + Cl' -----------> $Cl_2$
ii) $CH_3$' Cl' --------------> $CH_3Cl$
iii) $CH_3$' + $CH_3$' -----------------> $CH_3CH_3$

## Alkenes

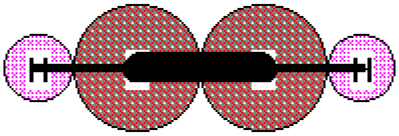


This is ethene. The smallest alkene.There is a sigma and a pi bond between the C=C. This means that the bond is shorter and stronger than a single bond.

Alkenes are unsaturated hydrocarbons containing one or more double bonds. Alkenes are prepared by the dehydration of alcohols or by the dehydrobromination of bromoalkanes. Alkenes are named by the name of the straight chain alkane with a number representing the position of the double bond. The prefixes cis- and trans- (now Z- and E-) are also used to name the simple geometric isomers (see page on isomerizm).

Alkenes undergo electrophilic addition reactions which follow **Markovnikovs rule**. Alkenes react with halogens such as Br-Br or hydrogen halides such as H-Br. They also react with bromine water and sulphuric acid. All these reagents are able to react with alkenes because they have an electrophilic part on there molecule i.e H-Br has an electrophilic (electron deficient) H which is attracted to the electron rich area of a double bond. The electrophilic part attatches itself to the carbon with the most hydrogens already attached to it, and then the nucleophilic part of the molecule bonds to the carbocation intermediate.

## Alkynes



This is ethyne. The smallest alkyne. The C=C triple bond is shorter and stronger than that of an alkane or an alkene.

Alkynes are unsaturated hydrocarbons with one or more triple bonds. They are formed by the hydrolysis of calcium dicarbide or by the dehydrohalogenation of 1,2-dibromoethane using hot alcoholic potassium hydroxide. Alkynes do not undergo many reactions, but are used industrially in cutting and weilding equipment.

# POLYMERS

## Polymers, Polymerization (addition&condensation), Zeigler-Natta,

## Polymers

Carbon atoms are able to string together in chains of almost unlimited length. Such chains form the backbone of truly huge molecules, or macromolecules, these can be hundreds of thousands of atoms in length.The links in these chains do not however have to carbon atoms, other atoms or functional groups can replace the carbon atoms and the macromolecule is still known as a polymer, made up of monomers, i.e several repeating units.

Carbon based polymers with various functional groups, either included in it or as side chains are prominent in synthetic and biological aplications that are hugely important in everyday life.

Properties of polymers and in particular plastics that are of great importance include:

i) Mouldability - highly complex parts may be made in one operation
ii) Colour can be uniform (not just surface paint)
iii) Good thermal insulators
iv) Wide range of strengths
v) Range of solvent resistances
vi) Low density
vii) Low energy requirements for manufacture
viii)Some plastics have elastic properties (known as elastomers)
ix) Some plastics may be drawn into fibres (e.g nylon)
x) Polymers may be constructed to have stress/strain properties ideal for a particular application.

## Making polymers

### Addition polymers

An addition polymer is formed by a large number of small molecules combining to form a large molecule. Addition polymers combine to form a chain without a net loss of atoms. The combining species are usually alkenes which undergo homolytic fission across the double bond to form free radicals; hence a chain reaction is set up. This chain reaction has initiation, propagation and termination steps in it. The initiation step is started by a small trace of oxygen in the reacting vessel (200 'c & 1,500 atm) for the case of branched chain stereo irregular (atactic) polymers. For high density polymers, in particular polyethene a catalyst known as a Ziegler-Natter catalyst is used, the conditions employed are less vigorous in this case (60'c and 2 atm)

### Condenstaion polymers

Condensation polymerization is the combining of molecules to form larger molecules with the elimination of some smaller molecule. The two reacting molecules usually have functional groups at either end of there carbon chains e.g the formation of a Nylon ( a polyamide ) combines a Di-acid and a Di-amino group:

Nylon 6,6 = 1,6-diaminohexane + hexane-1,6-dioic acid

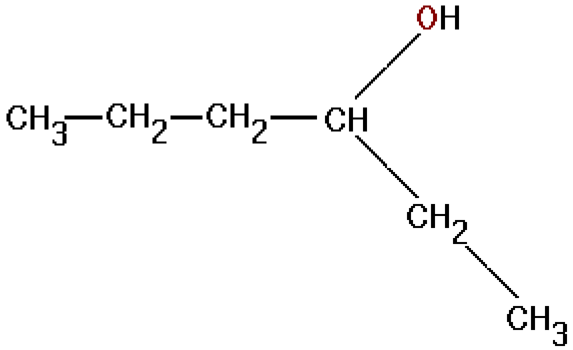
These long chain condensation polymers are extremily tough due to the inter-chain hydrogen bonding between CO and neighbouring NH groups. Nylon cord is twice as strong as steel, this strength gives it many applications such as the strengthening of car tyres or the moving parts of machinery.

# ALCOHOLS

## Alcohols and Phenols

### Alcohols

Alcohols contain the hydroxyl functional group in their structure. They are named systematically by the number of carbons in the chain and a number representing the position of the O-H group.

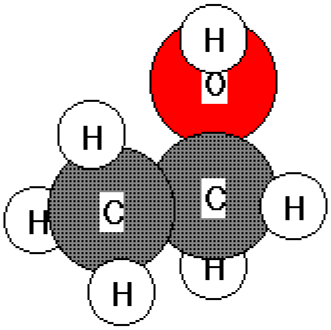


This compound is known as 3-hexanol (or hexan-2-ol)
Alcohols containing more than one O-H group are known as diols (2 x O-H) and triols (3 x O-H).

### Physical properties

Alcohols are typical covalent compounds; yet they have a high melting and boiling point, this is owing to the presence of hydrogen bonding and permanent Dipole-Dipole forces between the molecules. The -OH group is also able to interact with water which accounts for the solubility of the lower RMM alcohols. Alcohols have a wide variety of uses; for example, ethanol in alcoholic beverages, ethan-diol in anti-freeze, and cetyl alcohol (hexadecan-1-ol) which is used to reduce the surface tension of water in order to lessen evaporation of reservoirs etc

Below is a picture of ethanol in 3D. Note that all the bonds are single and each points to the corners of a tetrahedron. (bond angle = 109')

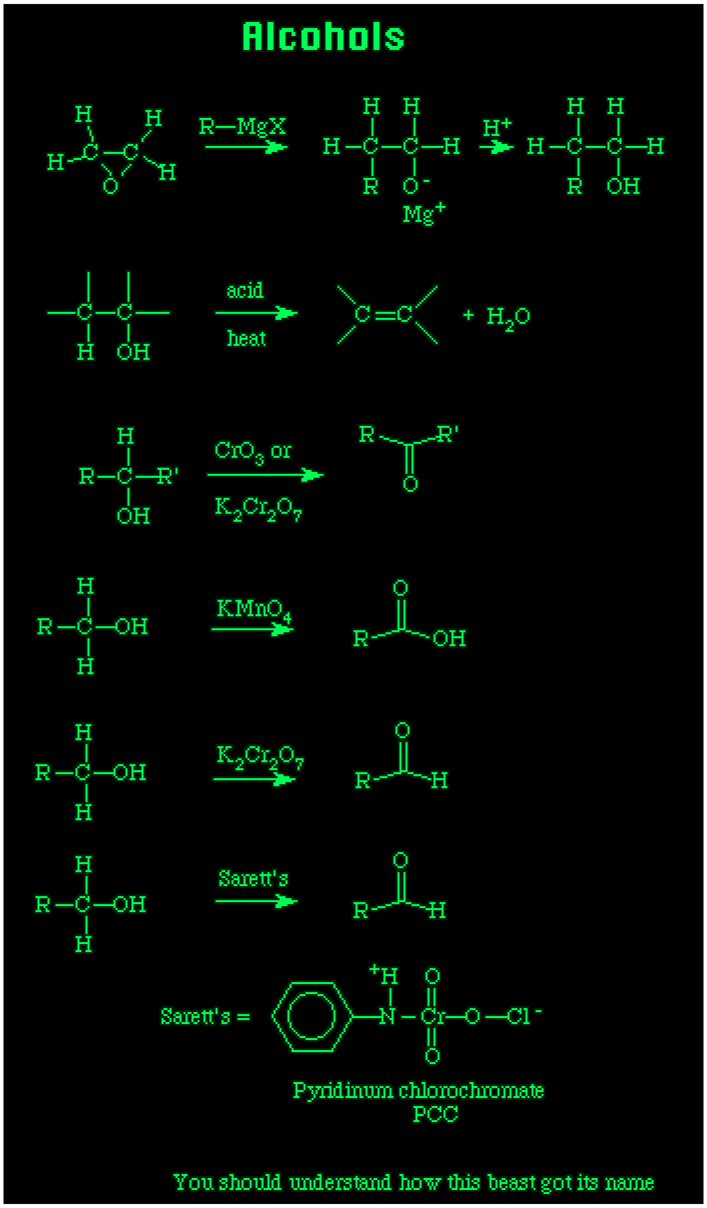


**Ethanol**

### Chemical properties

Alcohols burn readiliy in air to produce water and carbon dioxide. Primary and secondary alcohols are oxidized by hot acidified sodium dichromate (VI) to produce aldehydes and ketones respectively. Primary alcohols are easily oxidized to carboxylic acids, and it is the acid that is the major product when an alcohol is refluxed with oxidizing agent.

## Important reactions of the alcohols...........

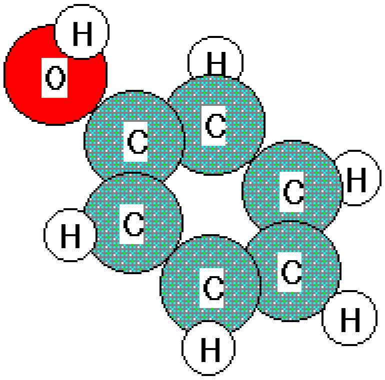

Alcohols

You should understand how this beast got its name

## Phenols

Phenols are classes of aromatic compounds compounds with one or more -OH groups attached directly to a benzene ring. Phenols are very reactive compared to aromatic hydrocarbons due to the activating charactor of the hydroxyl group.

The simlest phenol is called Phenol. It consists of a benzene ring with one OH group attached to one of the carbons.



Phenol ($C_6H_5$-OH)

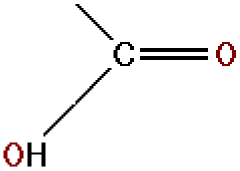
Phenol is a white crystaline solid. It is very toxic and a strong skin irritant. The solid is not very soluble in water although it will absorb water from the atmosphere over time. Phenol is a weak acid which contrasts it to the aliphatic alcohols.

Phenol undergos rapid electrophilic substitutions in the ortho/para (2,4,6) positions because the -OH group activates the benzene ring. For example, phenol would react with aqueous bromine water to give a white precipitate of 2,4,6 tribromophenol.

# CARBOXYLIC ACIDS

## Carboxylic acids, Acid chlorides and Acid anhydrides

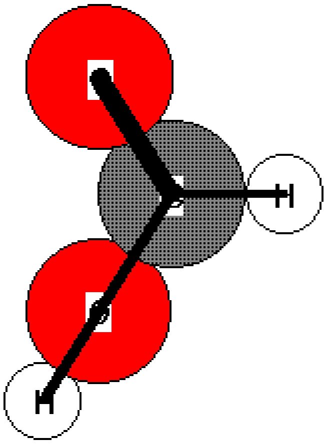
### Carboxylic acids



Carboxylic acids are organic acids that have the functional group
Despite having the same functional groups as both a carbonyl and an alcohol, the carboxylic acid shows few similarities to that of aldehydes and ketones or primary alcohols.
Carboxylic acids have the suffix -anoic after there name.For example an acid with 3 carbons in it's chain would be called propanoic acid. Traditional name are often used for the common acids ;
e.g Methanoic acid is commonly known as formic acid
Ethanoic acid is known as acetic acid (major ingrediant of vinegar)

### Physical properties

Carboxylic acids are able to hydrogen bond between molecules and also to water, making them very soluble. Although the boiling point of the acids is high compared to hydrocarbons of similar RMM it is not as high as expected as the acids are able to form dimers; that is they form in pairs resembling a six pointed ring.Carboxylic acids have a very unpleasant smell which is in contrast to the sweet, fruity smell of the esters which they are isometric with.

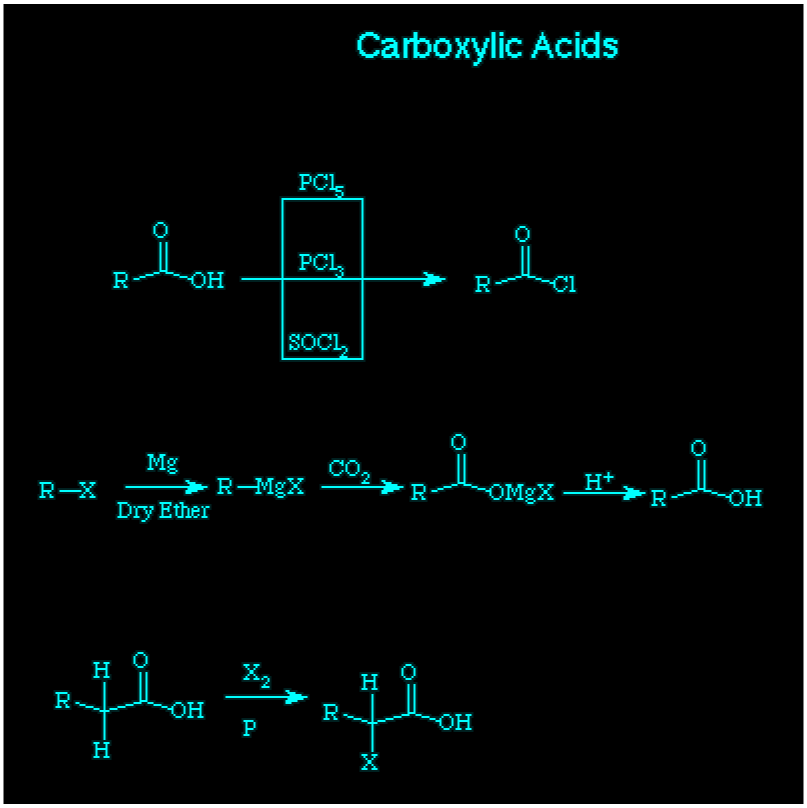


This is picture of Methanoic acid, the smallest carboxyllic acid.

### Chemical properties

Carboxylic acids are formed by the oxidation of primary alcohols or aldehydes.They will not oxidize further chemically, but will burn in air to form $CO_2$ and $H_2O$.Most acids are weak compared to mineral acids such hydrochloric acid.The strength of an organic acid depends on the constituents near the crboxyl group. For example if an electron withdrawing group such as a chloride group was attatched to a carbon near the carboxyl group then this would 'pull' electron charge away from the O-H group and hence reduce the hold on the H of the O-H group (it is the ability to lose this proton that makes for the acidity of a solution of the compound).
Carboxylic acids can be reduced to primary alcohols by a strong reducing agent such as $LiAlH_4$ in dry ethoxyethane.

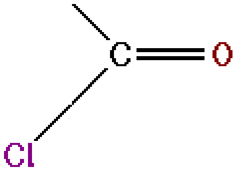
## Some of the more important reactions of Carboxylic acids:



One of the most important reactions of carboxylic acids is the conversion to an acid halide.

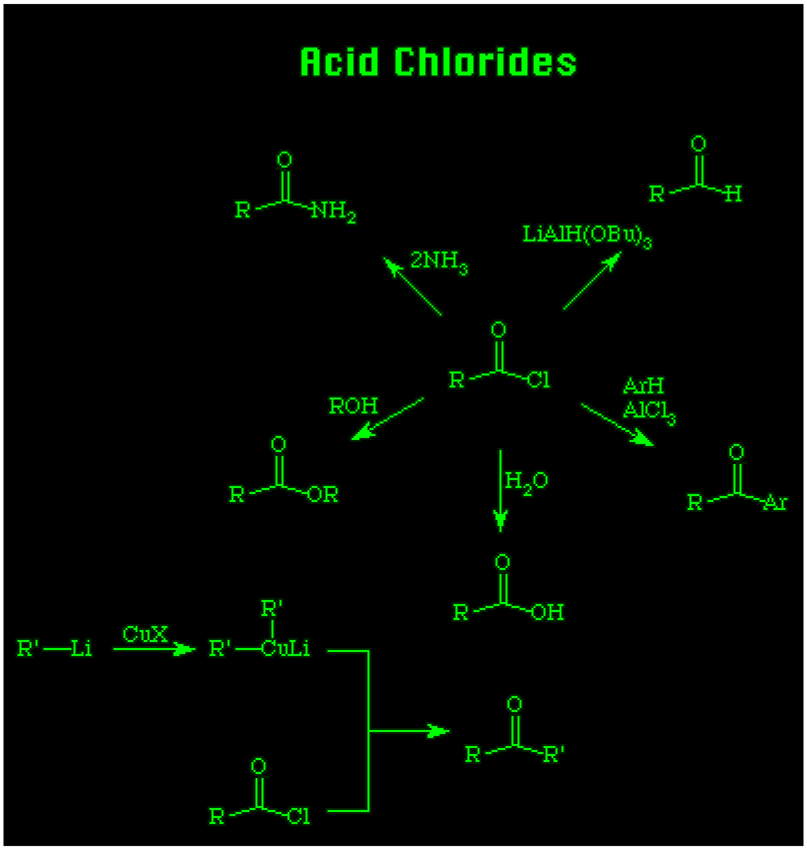
## Acid Halides

Acid chlorides are prepared from the corresponding carboxylic acids by thionyl chloride,phosphorus trichloride or phosphorus pentachloride.They have the same structure as carboxylic acids but the O-H of the acid is replaced by a halide.



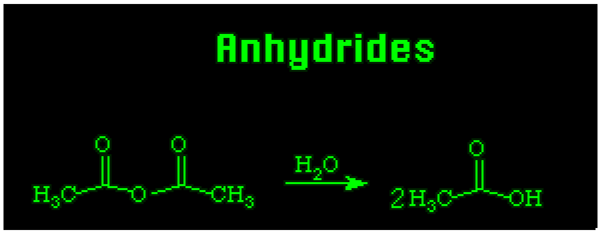
Acid chlorides are the most reactive of the carboxylic acid derivatives.
Acid chlorides are very unstable in moist conditions and give off HCl gas on reaction with water.

## Some of the important reactions of acid chlorides:



## Acid anhydrides

Organic anhydrides are colourless liquids regarded as being formed from from two molecules of carboxylic acid by the removal of a water molecule.
They are usually prepared by distilling a mixture of the acid chloride and the sodium salt of the carboxylic acid in a dry apparatus and collecting the anhydride as the distillate.
Acid anhydrides are less reactive than acid chlorides and are used to prepare amides and esters, especially of phenols where direct esterification is not possible. Acid anhydrides are hydrolyzed to there parent carboxylic acids with water (as shown below).



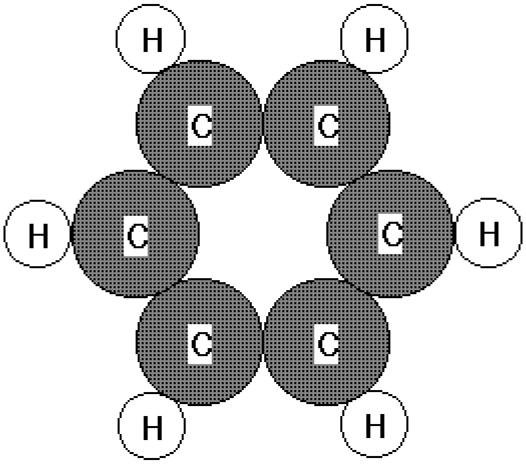
This section does not have it's own page. Please look at the relavent section in the glossary for further information.

Glossary

# AROMATIC COMPOUNDS

## Aromatic compounds, Arenes, Benzene

Aromatic refers to a major class of organic cyclic compounds. The most commonly encountered and by far the most important of these is Benzene.
**Aromatic compounds are defined in many ways:**
i) They have a distinctive odour. (hence the name aromatic)
ii)They are more commonly, and more accurately recognised because of their inability to undergo addition reactions. i.e Br in water will not add to a benzene compound like it does to an unsaturated alkene.

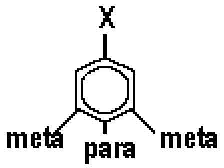


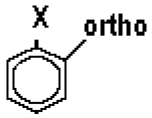
## Benzene

Benzene is a clear, colourless, flammable liquid that is insoluble in water. It is made synthetically from petroleum.
It was first isolated in 1825 by Michael Faraday but its structure remained a mystery for years. In modern chemistry, benmzene is commonly regarded as having 6 carbon-carbon bonds each alternating between a single and double bond.The carbon electrons are delocalized and exist as a cloud around the hexagon ring structure.
Benzene is an excellent solvent; its main use however ,is in the preparation of other compounds e.g styrenes for polymerization,phenol,detergents and many different pharmaceuticals.
Benzene does not compare to other unsaturated compounds as its de-localized structure differs from the double bonds of alkenes.Benzene undergoes electrophilic substitution reactions:

## Positions in a benzene ring

There are three positions that you can have in a benzene ring with respect to a substituent already being present.
Ortho
Meta
Para
The position a reagent takes up is determined by the activating or deactivating nature of the original substituent. If an **activating** species is attached to a ring then reagents will bond either in an ortho or para position. If the species is **deactivating** then the reagent will take up a position meta to the original substituent.
**Activating groups** = -NH2, -NHR, -NR2, -OH, -OCH3
**Deactivating groups** = -NO2, -C=-N, -CF3, -CCL3, -RC=O, -COOH





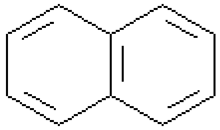
This diagram shoes the positions with respect to a group X already attached to the ring.

## Reactions of Benzene

Benzene undergoes many of its reactions with a halogen carrier usually $AlCl_3$.These reactions are known as the Freidel-Crafts reactions.Other common reactions of benzene are nitration and sulphonation.

## Arenes

Arenes are hydrocarbons containing one or more benzene rings. These hydrocarbons are also known as aromatic compounds. Benzene is the simplest arene, others may just have side chain aliphatic hydrocarbon groups although benzene rings may combine to form such compounds as naphthalene.



This an example of naphthalene, it is a arene resembleing two benzene rings.

This dictionary was written by Ian McGuinness. All the information is correct to the best of my knowlege, but I do not accept responsibility for errors or spelling mistakes.
If you received this product for free, do not hesitate to send me a small donation as I am very poor!!

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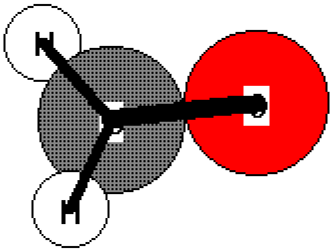
# CARBONYL COMPOUNDS

## Carbonyl compounds      Aldehydes and ketones..

Organic carbonyl compounds are aldehydes and ketones which contain the C=O functional group. These two types of compounds are isometric and show similararities but also differerences in chemical and physical properties.In aldehydes the carbonyl group is always connected to a H atom which defines it's functional group.Ketones have alkyl groups connected to the carbonyl group which differentiates them from ketones.The reactions of the C=O may be compared to that of the C=C i.e electrophillic addition.

## Aldehydes



This is methenal, it is the smallest aldehyde. The diagram shows the C=O double bond and the 2x C-H bond all in the ame plane.

Aldehydes take the suffix -al after there name if they are aliphatic and -aldehyde if the are the functional group of an aromatic compound.

i.e $CH_3CH_2CHO$ = proponal

$C_6H_5CHO$ = benzene carbaldehyde ($C_6H_5$ = benzene ring)

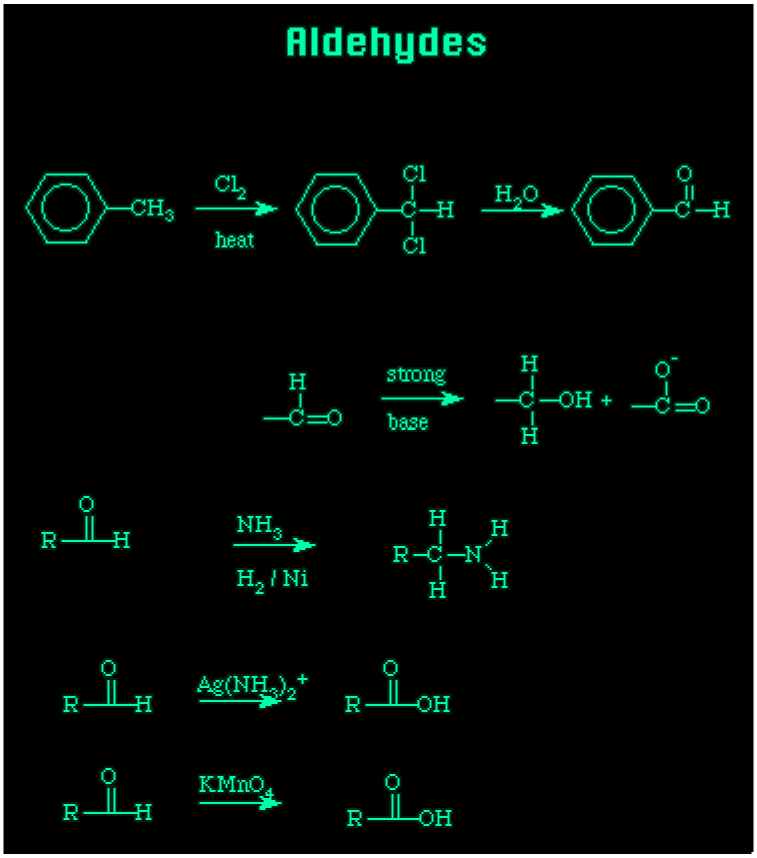
## Physical properties

Aldehydes have a distinctive infra red absorption band of approximately 1760/cm. The C=O bond is polar with a slightly +ve charge on the carbon and -ve on the electronegative O atom. It is this feature which contributes to its intermolecular forces of attraction Known as Dipole-Dipole interactions. (a dipole is the setup between two atoms of differing electronegativity). Aldehydes are also able to form hydrogen bonds with water and carboxylic acids although they do not form H-Bonds with each other. This ability to hydrogen bond makes them slightly solubility in water but as the number of carbons in the chain increases this solubility decreases.

## Chemical properties

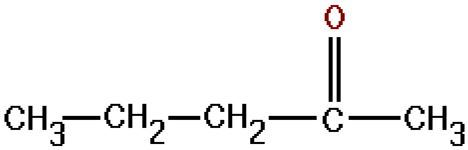
Aldehydes are flammable and will burn in air (or sometimes explode) to form $CO_2$ and $H_2O$. They undergo oxidation to carboxyllic acids in the presence of strong oxidizing agents; the most common being sodium dichromate(VI) in a warm acidic solution.
A typical test for the presence of an aldehyde group in an unknown compound is the Fehlings solution test.
Fehlings solution is a copper (I) solution which is reduced to a copper orange-red precipitate.

The most important reactions of the aldehydes are diplayed below:



## Ketones

Ketones take the suffix -one after their name. They also have a number which shows the position of the carbonyl group in the carbon chain.



$$CH_3-CH_2-CH_2-\overset{\overset{\Large O}{\|}}{C}-CH_3$$

This would be 2-Pentanone or Pentan-2-one.

The number given is always the lowest i.e The example compound would not be 4-Pentanone.

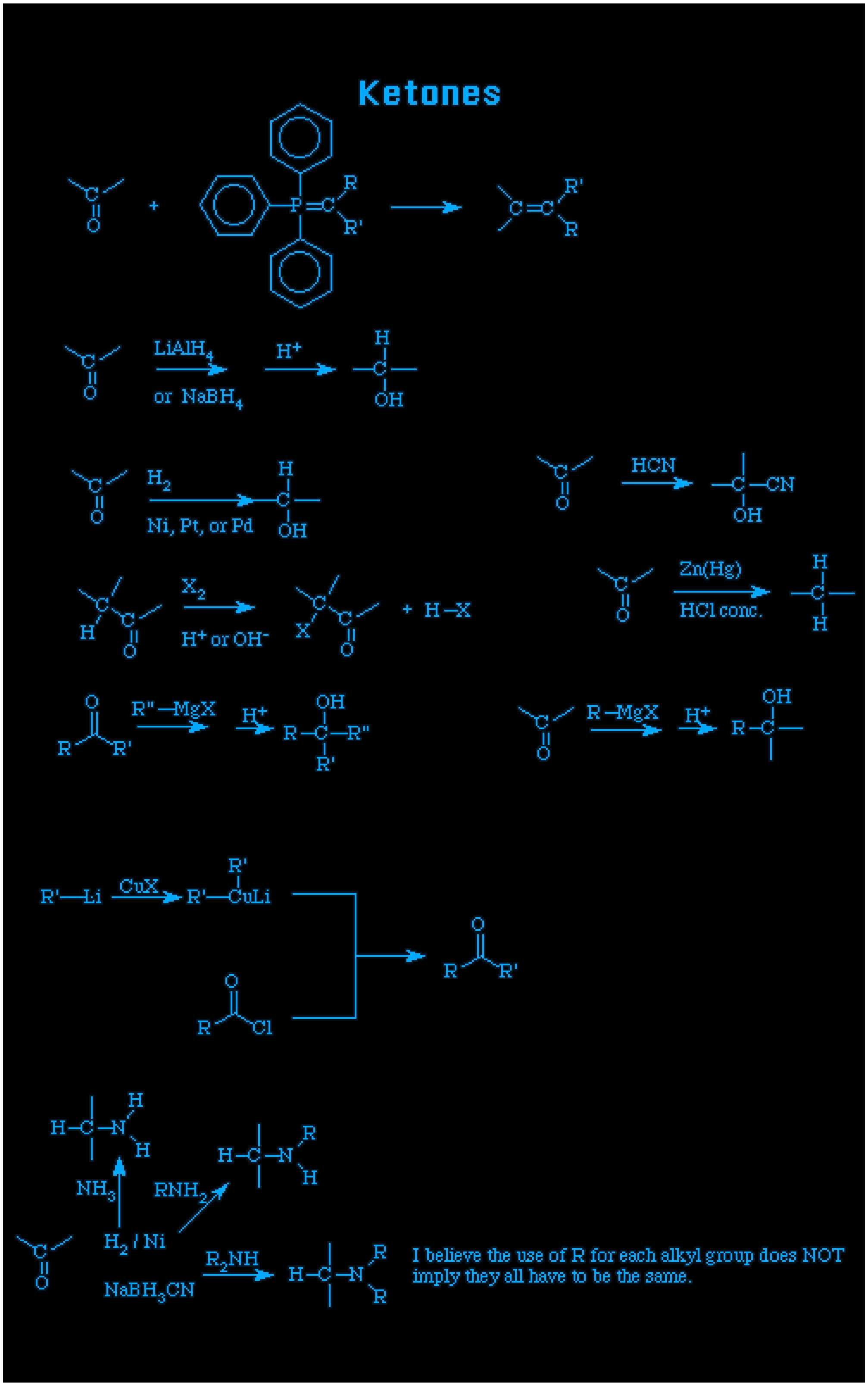
## Physical properties

Ketones of low RMM are usually polar covalent liquids with a similar IR absorbtion band as the aldehydes (about 1690-1760 /cm). Intermolecular Dipole-dipole attractions exist which makes their melting and boiling points higher than aliphatic hydrocarbons.Propanone (the lowest member of the ketone family) is able to form H-bonds with water this makes it a very good solvent as it will absorb ionic and covalent substances.

## Chemical properties

Ketones are highly flammable in air and can form explosive mixtures with oxygen.
They are NOT oxidized by acidified sodium dichromate and do not reduce fehlings solution.
Fehlings therefore is a good reagent to distinguish between aldehydes and ketones.

Some of the more useful reactions of ketones:



I believe the use of R for each alkyl group does NOT imply they all have to be the same.

# ORGANIC GLOSSARY..

## /cm ................

This is the units for wave numbers.

## Activating group.........

An activating group is one that enhances the reactivity of a benzene ring. These are substituents that increase the ability of a benzene ring to undergo electrophilic substitution.
The groups include:
$-NH_2$ ($-NHR$, $-NR_2$) $-OH$ << $-OCH_3$ $-NHCOCH_3$ <<$-CH_3$ $-R$
Activating groups direct the reactants onto the ortho/para positions of a benzene ring.

## Aliphatic.........

aliphatic compounds are ones which there is a straight C chain

## Aromatic.........

Aromatic compounds have a ring of carbons in their structure, inparticular those compounds of benzene.

## Azo dye............

Azo dyes contain the group N=N that gives the compounds their colour.Azo dyes are made synthetically by diazotation of an aliphatic compound in the presence of a coupling reagent.

## Carbanion..........

A carbanion is an organic anion (a carbon with a -ve charge on it).Carbanions are usually short lived species formed by the hetrolytic fission of a C-H bond. The carbanion acts as a nucleophile by attacking an elecrophilic centre in order to neutralize its charge. An example of reaction involving the formation of a carbanion is the aldol condensation:

## Carbocation.........

A carbocation is an organic cation (a carbon with a +ve charge).It is formed when a covalent bond breaks hetrolytically where the leaving group takes both electrons. The carbocation is a short lived electrophile. The carbocation is a very important intermediate in a wide range of organic reaction mechanisms.

## Deactivating group.......

A deactivating group is one that reduces the ability of a benzene ring to undergo electrophilic substitution reactions.
These groups include:
$-NO_2$ $-N(CH_3)_3+$ -CN -COOH $-SO_3H$ -CHO -COR -X (X=halogen)
Deactivating groups direct reactants onto the meta position of the benzene ring.

## Dehydrogenation........

This is a method of removing gaseous hydrogen from a gaseous compound by the use of a heterogeneous catalyst. For example an alkene could be formed from the dehydrogenation of an alkene.
E.g. $CH_3CH_2CH_2CH_3$ ------------------------> $CH_2=CHCH=CH_2$ + $2H_2$ (catalyst = $Al_2O_3/Cr_2O_3$)

## Detergent.........

A detergent is a substance which lowers the surface tension of water and aids cleaning by the emulsification of dirt and grease. Detergents are also known as surfactants (surface-active agent) due to its effect on the surface of water. Grease and dirt are emulsified in

water due to the hydrophobic and hydrophilic properties of a detergent, this means that it has one end that is soluble in water (i.e. hydrophilic) and on end that is insoluble in water (hydrophobic). It is the hydrophobic end that attaches itself to the grease or dirt, whilst the hydrophilic end is happy in the water; the dirt is therefore surrounded by the detergent molecules that emulsifies because of the hydrophilic end being in contact with the water. Soap is an example of a detergent because it has a hydrophobic tail (i.e. an alkyl chain) but has a hydrophilic head (i.e. a sodium salt).
Soap = $CH_3\,(CH_2)_{16}\,CO_2$-Na+
Dipole-Dipole.............

## Distillation...........

This is a method whereby a volatile substance is separated from a less volatile substance by heating. It can be a purification technique such as in the heating of water to remove dissolved salts or can also

## Double bond.............

A double bond is a covalent bond formed between two atoms by the sharing of two pairs of electrons. It is stronger than a single bond and also shorter.

## Elecrophile......

An electron pair acceptor. One that will attack electron rich areas.

## Ether...........

Ethers are organic compounds that have an oxygen atom bridged between two alkyl groups.
e.g. $CH_3$-O-$CH_2CH_2CH_3$ Methoxy propane
Ethers are named firstly by the shortest alkyl chain then the suffix -oxy then the longer alkyl chain.
Ethers are structural isomers of alcohols, they differ largely in properties however. Ethers have very low melting and boiling points due to poor intermolecular forces of attraction. Ethers are rather unreactive apart from their flammability; they have a low flash point and ignite very easily and often explosively. They are used in the lab to extract organic solvents from water because of their immiscability in water, they are then separated by vacuum evaporation due to the low B/P of ether.

## Fehling's solution.........

Fehling's solution is a solution of copper (ii) sulphate (Fehlings A) and sodium 2,3-dihydroxybutanedioate (Fehlings B). This solution was first prepared by a German chemist called Fehling who designed it as a test for aldehydes. When warmed with an aldehyde, the blue solution turns from blue to green and an orange/red precipitate of copper(i) oxide is formed. The test can differentiate between aldehydes and ketones.

## Free Radical................

A free radical is an atom which has only one unpaired valence electron. It is a very reactive species that is only short-lived under normal circumstances. It is formed from the homolytic fission of a covalent bond. In the halogenation of an alkane it is the reacting halogen species that is formed in the initiation step by the splitting of the $Cl_2$ bond to 2xCl' in the presence of U. V light.

## Friedel-Crafts reactions...........

A Freidel-Craft reaction is a type of electrophilic substitution catalyzed by a halogen carrier such as aluminum chloride. The main use for the F-C reaction is to introduce an alkyl or acyl group onto a benzene ring. The reaction was discovered in 1877 in France.

## Functional group.............

A functional group is an element, or group of elements responsible for specific properties of an organic compound.
e.g. F, Cl, Br in the haloalkanes
O-H in the alcohols .......etc.

## Grignard reagent................

A Grignard reagent is an organo-magnesium halide in anhydrous ethoxyethane.They are mainly used in the formation of secondary and tertiary alcohols from aldehydes and ketones respectively. They are also highly important because the can be used to form a C-C bond which is difficult to synthesize in the lab.

## Halogen carrier...........

A halogen carrier is a catalyst, such as AlCl3 that aids in the electrophilic substitution of aromatic compounds. Halogen carriers are typically Lewis acids that react with a halogen to form an electron rich substance.
i.e. $AlCl_3$ + Cl-Cl -------> $AlCl_4$ + Cl+
It is the Cl+ that is the electrophile that undergoes the substitution. Examples of reactions involving halogen carriers include Freidel-Crafts reactions of benzene.

## Hetrolytic fission..........

Hetrolytic fission is the breaking of a single covalent bond between two atoms whereby one atom receives both of the shared electrons.
E.g. In the breaking of a Br-Br bond Br+ and:Br- would be formed with the electron pair going to only one of the bromine atoms.

## Homolytic fission.............

Homolytic fission is the breaking of a single covalent bond between two atoms so that each atom receives one each of the shared electron pair.
e.g. Br-Br ---------> Br` + Br` (Br` represents a bromine free radical)
Energy is needed in order for a compound to undergo homolytic fission often in the form of ultra-violet light. The free radicals produced are highly reactive and take part in chain reactions.

## Hydrogenation............

Hydrogenation is the addition of hydrogen to an unsaturated compound to produce a saturated one. Hydrogenation is usually carried out in the presence of a catalyst such as nickel or platinum.

## Isometric.........

Two compounds that have the same number of constituent atoms.

## Markovnikovs Rule....

When a molecule HZ undergoes an electrophilic addition across C=C double bond in an asymmetric alkene, the hydrogen adds to the C-atom with the most hydrogens already attatched.This is to make the most stable carbonium ion i.e secondary or tertiary as opposed to the unstable primary one. (see also section on alkenes)

## Optical activity............

Optical activity is the ability of a substance to rotate the plane of plane polarized light.Optical activity is found widely in organic chemistry and is demonstrated by molecules that do not have a plane of symmetry. The most common example of an asymmetric molecule is one which has a chiral centre brought about by a carbon atom with 4 different groups around it.

### Organometallic compounds............

An organometallic compound is one in which a metal atom is directly attached to a carbon atom.An example of such a compound, important to organic chemistry is a Grignard reagent.

### Phenyl group...............

The phenyl group $C_6H_5$- is a benzene ring with one hydrogen atom missing.

### Polar bond..........

a polar bond is formed when two atoms of different electronegativities share a pair of electrons unequally. For example, the bond between hydrogen and chlorine in H-Cl is polar because chlorine is very electronegative compared with hydrogen and therefore the chlorine atom 'pulls' electron charge towards itself and away from the hydrogen.

### Primary position..........

The primary position in an organic compound is on the end of a chain where the terminating carbon has only one alkyl group attached to it and three hydrogen atoms the equivalent atom (e.g. a halide).

### Reflux.............

A method in which a liquidic compound is heated to boiling with a reagent but the gas evolved is condensed and returns to the reaction vessel.

### Saturated..................

Saturated usually refers to a hydrocarbon in which all its bonds are single covalent bonds with bond angles of 109' i.e. tetrahedral.

### Secondary position.........

The secondary position in an organic compound is one where a carbon is attached to two alkyl groups and two hydrogen atoms or the equivalent atom. e.g. in the middle of a straight chain molecule.

### Substituent..........

The word substituent refers to any group attached to a carbon atom in an organic compound.The substituent on a compound has a major effect on the reactivity of a compound:
i.e the effects of the substituents of benzene when undergoing further electrophilic substitution.

### Tautomerizm..................

Tautomerizm is a special case of structural isomerism whereby two tautomers exist in dynamic equilibrium with each other.
e.g. a ketone could exist in the form of an alcohol with a C=C bond. The electrons have simply moved around the compound from the C=O bond to the C-C bond and a proton has shifted from the C-H bond to form a O-H bond.

### Tertiary position.........

The tertiary position is one where a carbon is bonded to three alkyl groups and only one hydrogen (or the equivalent)

### Triple bond..............

A triple bond is a covalent bond formed between two atoms by the sharing of three pairs of electrons. They are shorter and stronger than double and single bonds. Alkynes contain triple bonds.

## Unsaturated...........

An unsaturated hydrocarbon is a compound, of carbon and hydrogen only, in which at least two atoms share four or six valence electrons, so that the molecule contains at least one double or triple bond.