

Chapter 2

Organic chemistry introduction

Organic chemistry is the study of carbon chemistry. Carbon can form 4 covalent bonds, and whenever you draw an organic molecule each and every carbon should have 4 bonds. The reason that carbon chemistry gets its own complete branch of chemistry is that carbon can form bonds, single, double and triple, with itself. This means that long and branching chains and rings of carbon can form. Various different atoms can be bonded to carbon to provide different types of chemistry. The different atoms or groups of atoms are called **functional groups**. These functional groups affect a molecule's chemistry. As is seen in Topic 2, even very simple substitutions change the chemistry and the physical nature of compounds. We meet a variety of functional groups, the majority of them involving oxygen atoms.

Organic chemistry also involves making use of the shapes of molecules, which is why knowledge of the structures is very important. In order to make an organic molecule a chemist (that's you) needs to carefully select the conditions and understand the chemistry required to convert between functional groups. This is important as complicated molecules have many functional groups, some of which may need changing, some of which may need to be kept for the final product to have the desired chemical behaviour. Organic chemicals are used as drugs, polymers, fuels, flavourings and perfumes, they are an integral part of biochemistry which includes the chemistry of DNA, proteins, fats and sugars. It should be clear that being able to control these compounds is essential to modern life.

2.1 Naming organic compounds

Because of near-infinite variety of carbon compounds which can be made, there needs to be a systematic way of naming them. The naming of compounds becomes easier with practice.

2.1.1 Alkanes

Alkanes are the simplest homologous series of organic compounds. (An homologous series is one in which the molecules all have the same general formula.) For instance, CH_4 is methane, C_2H_6 is ethane, C_3H_8 is propane and so on. As a rule alkanes are not soluble in water. They are non-polar molecules. As the length of the carbon chain increases the state of the molecules at room temperature and pressure changes from gas to liquid. This is because there are more interactions between the molecules, although none of these interactions are very strong. The majority of organic compounds have low boiling points and are volatile. In the space below draw the displayed formulae for the above three molecules (remember that the displayed formula shows all of the bonds and atoms in a molecule).

We say that alkanes have **saturated** structures, which means that they have no carbon-carbon double or triple bonds. Try to name the compounds below which have the molecular formula C_5H_{12} . These compounds are (structural) isomers: They have the same molecular formula, but different structural formulae.

Cyclic alkane structures are prefixed with the word 'cyclo-'. Name the cyclic alkanes shown below. Note that the molecular formulae of these alkanes are *not* of the general form $\text{C}_n\text{H}_{2n+2}$.

2.1.2 Alkenes

The functional group in an alkene is a carbon-carbon double bond, C=C. They have similar physical properties to alkanes. Their boiling points are lower than for the corresponding alkanes - why? For alkenes with four or more carbons it is necessary to name the compound with the position of the double bond. Two butenes with the same molecular formula are shown below. Which is but-1-ene and which is but-2-ene?

Name the compounds below.

2.1.3 Alcohols

Alcohols have an -O-H functional group on a carbon atom. They have much higher melting and boiling points than the corresponding alkanes - why? Short chain alcohols are miscible with water, but as the length of the carbon chain increases the miscibility decreases. Their names end in '-ol'. If the carbon atom has up to one other carbon atom bonded to it, it is a primary (1°) alcohol; if it has two other carbon atoms bonded to it, it is a secondary (2°) alcohol; if it has three other carbon atoms bonded to it, it is a tertiary (3°) alcohol. Name the alcohols shown below.

2.1.4 Aldehydes

Aldehydes have a CHO functional group. Their names end in 'anal'. Name the aldehydes shown below.

How do you know that a compound is an aldehyde?

2.1.5 Ketones

Ketones have a C=O group like aldehydes, except that the carbonyl carbon is in the middle of a carbon chain, rather than at the end. Their names end in '-anone'. Name the ketones shown below.

2.1.6 Carboxylic acids

Carboxylic acids have a COOH functional group. Their names end in '-oic acid'. Name the carboxylic acids shown below.

2.2 The chemistry of alcohols

You should know the products of the following reactions of alcohols

- Reaction with sodium
- Partial oxidation
- Complete oxidation
- Burning / combustion
- Elimination (removal of a small molecule, if the molecule is water the elimination is specifically known as dehydration)

2.3 Oxidation of alcohols

If we write [O] for oxidising agent then what are the products of the following partial and further oxidations of alcohols? Remember that changing the nature of the carbon to which the -O-H group is bonded may alter the reactivity.

Partial oxidation conditions are: _____ sulphuric acid, _____
_____, heat and _____.

For further oxidation of an alcohol the following conditions are required: _____
sulphuric acid, _____, heat and _____.

2.4 Amounts of organic substances

Organic reactions have equations just like any other reaction. It may be necessary to draw a molecule, rather than write its molecular formula. This is especially true of those with complicated or cyclic structures, and is a way of demonstrating that you know what parts of the molecule are being changed and what these things look like. You should be able to calculate the molecular masses of organic compounds from their formulae. Be careful to include hydrogen atoms which are bonded to parts of the molecule other than carbon atoms (on -O-H groups in particular). Common masses which you should know are

- Carbon _____
- Hydrogen _____
- Oxygen _____
- Hydroxyl (-O-H) _____
- Nitrogen _____
- Sulphur _____

Calculations with amounts of substance should be done with moles, as always. This gives you a measure of how many molecules are involved in each part of the reaction. You should lay these calculations out as below - You get marks for the steps in these calculations. If you get a step wrong and then get the answer right if your error is carried forward you will get credit, if you simply write down a wrong answer, but your working has only involved one error, you will lose all the marks available.

For organic liquids it is possible to measure the number of moles present by volume. You will need to know its formula and density.

For instance, ethanol has a density of 0.78 g cm^{-3} . What is the volume of 0.05 moles of ethanol? (2.95 cm^3)