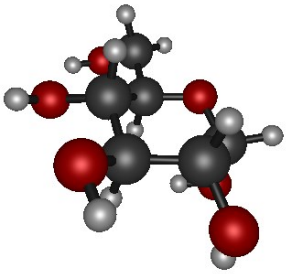
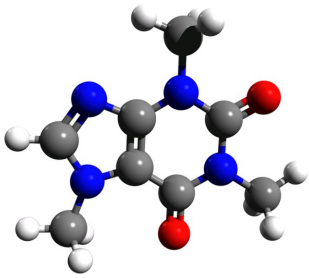
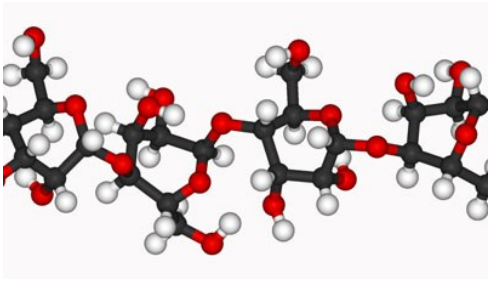
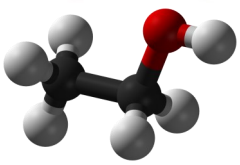
Nat 4/5 Chemistry - Topic 8

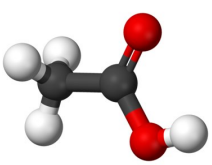


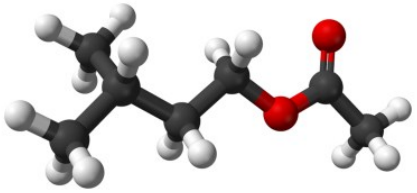


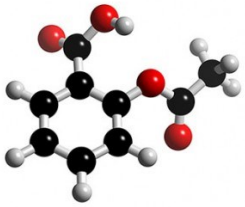


Alcohols, Carboxylic acids and Esters





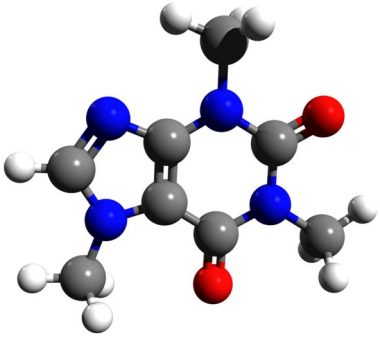


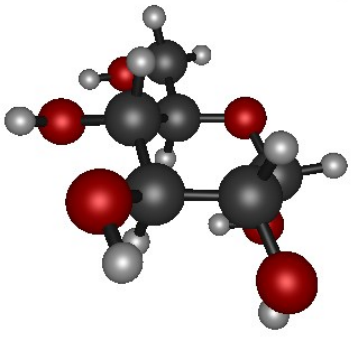


Topic 7 Kitchen Cupboard Chemicals

You may not realise it but everything is made of chemicals and therefore everything in your kitchen cupboard is a chemical. In fact some of the substances in your cupboard contain really important chemicals that have lots of uses not only as foods but also in other areas of our everyday lives.

This topic will look at six important chemicals found inside your kitchen cupboard.





Topic 7 Kitchen Cupboard Chemicals

By the end of this unit you should know the following:

- ☐ Carbohydrates are compounds which contain carbon, hydrogen and oxygen with the hydrogen and oxygen in the ratio of two to one.
- ☐ Glucose is a simple carbohydrate with the formula $C_6H_{12}O_6$. It is a good source of energy as it is easily absorbed by the human body.
- ☐ Glucose will turn hot Benedict's solution from blue to brick red.
- ☐ Plants make glucose through photosynthesis, then use a condensation reaction to join glucose molecules together to form other carbohydrates like sucrose and starch.
- ☐ Starch is a polymer made up of 1000's of glucose molecules joined together, it is also a good source of energy but needs to be broken down by enzymes in order for it to be used by our cells in respiration.
- ☐ Starch will turn orange iodine solution blue/black.
- ☐ Ethanol is produced by the fermentation of fruit juices using an enzyme present in yeast, it is found in alcoholic drinks. The amount of ethanol found in a drink is measured in units.
- O Alcohols are hydrocarbon chains containing a hydroxyl group (-OH). You should also be able to name and draw a variety of different alcohols.
- O Alcohols are effective solvents, highly flammable, and burn with very clean flames resulting in their use as a fuel.
- O Carboxylic acids contain the carboxyl group (-COOH) and you should know some of the properties and uses of these compounds. You should also be able to name and draw a variety of different carboxylic acids.
- O Vinegar is a solution of ethanoic acid. Vinegar is used in household cleaning products designed to remove limescale (a build up of insoluble carbonates on plumbing fixtures) and as a preservative in the food industry.
- O Esters are formed by the reaction of alcohols and carboxylic acids. They are responsible for many fruit flavours but are also used in a variety of other ways as solvents or plastics.
- ☐ Many plants are used by chemist in the design and manufacture of many everyday products such as pharmaceuticals, soaps, cosmetics, dyes, medicines, foods and food colourings.

1 Energy Drinks

Energy drinks need to be able to deliver a large dose of energy to the consumer. They do this by using the chemical **glucose, a carbohydrate with the chemical formula $C_6H_{12}O_6$**. Glucose is found in many everyday products particularly sweets.

When glucose burns it produces carbon dioxide and water, this is because it is **a carbohydrate, a compound containing just carbon, hydrogen and oxygen**.

DISCUSS

After discussion with your teacher and others, make sure you can write a word equation and a balanced chemical equation for the burning of glucose.

NOTES

In the space below write the word equation and the balanced chemical equation for the complete combustion of glucose.

Word Equation:

_____ + _____ → _____ _____ + _____

Balanced Chemical Equation:

_____ + _____ → _____ + _____

Glucose is a white powder and like sucrose (sugar) is used as both a sweetener and source of energy as we have already seen.

ACTIVITY 7.2 Chemical & Physical Properties of glucose & sucrose

Glucose and sucrose are quite similar both physically and chemically, but they can be identified by a chemical test.

Test 1 Half fill two test tubes with water, add ¼ of a spatula of glucose to one and the same quantity of sucrose to the other. Put in a stopper and shake. Check to see if they are soluble.

Test 2 In a dimple tile or watch glass place ½ a spatula of glucose then add a few drops of orange iodine solution and observe any changes. Repeat with sucrose.

Test 3 Half fill two test tubes with water, add a spatula of glucose to one and the same quantity of sucrose to the other. Add 10 drops of Benedict's (or Fehling's) reagent to both test tubes. Place them in a beaker of boiling water and observe any changes in colour.

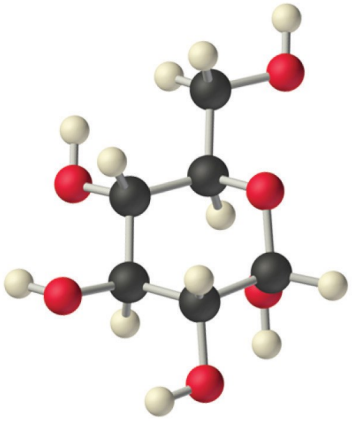
NOTES

Complete the following table by describing your results:

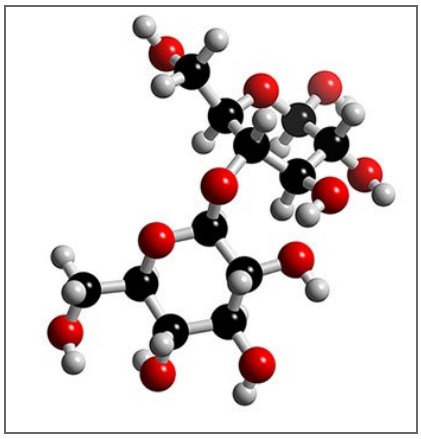
Carbohydrate	Test 1 Solubility	Test 2 Reaction with iodine	Test 3 Reaction with Benedict's reagent
Glucose			
Sucrose			

NOTES

In the space below write down how you would tell the difference between glucose and sucrose.

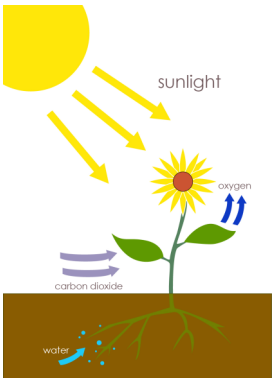


Glucose has the chemical formula $C_6H_{12}O_6$ and is known as a monosaccharide.



Sucrose has the chemical formula $C_{12}H_{22}O_{11}$ and is known as a disaccharide.

Formation and Digestion



Plants make glucose through a process called photosynthesis, where carbon dioxide and water combine, producing glucose and oxygen. Chlorophyll, the green pigment in plant leaves, helps use the energy from sunlight in the process.

carbon dioxide +water → glucose + oxygen

Some plants like sugar cane and sugar beet convert the glucose into sucrose through a reaction called condensation.

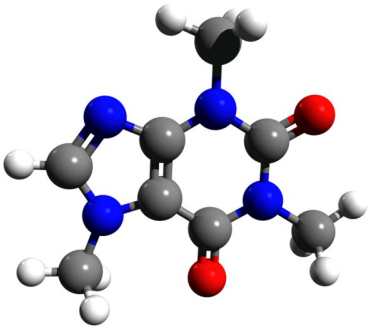
During digestion glucose molecules are able to move through the wall of the intestine into our blood stream really easily, where they get transported to cells and undergo respiration to release carbon dioxide, water and energy.

Sucrose is too big to pass directly through the intestine wall and must first be **broken down into glucose, through a reaction called hydrolysis**.

This is why glucose is used in energy drinks rather than sucrose as it is more quickly turned into energy in our bodies.

DISCUSS

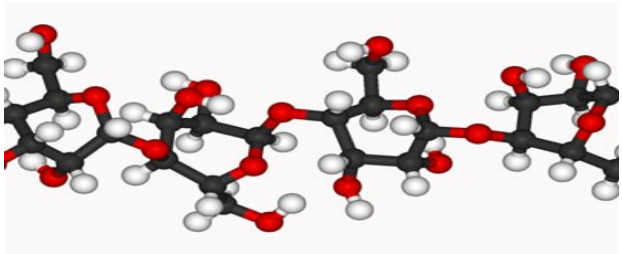
After discussion with your teacher and others, make sure you can explain why energy drinks use glucose rather than normal sugar (sucrose).



2 Bread & Pasta

Bread and pasta are two very common foodstuffs that we use as a source of energy. Like glucose and sucrose they are both made of carbohydrates, but in **bread and pasta the carbohydrate is called starch.**

Plants convert glucose, made through photosynthesis, into starch through a condensation reaction, similar to the way sucrose is made in sugarcane. Whereas sucrose is a disaccharide, starch is a polysaccharide made up of thousands of glucose molecules all joined together.



ACTIVITY 7.3 Testing for Starch

Many foods contain starch, it can be easily identified by using iodine solution.

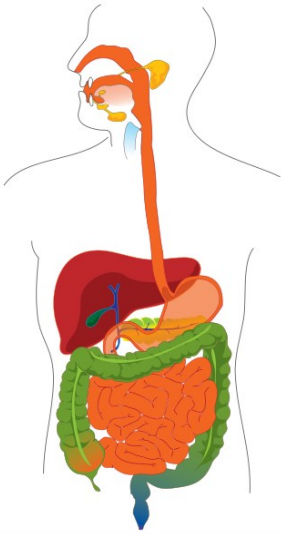
In a dimple tile or watch glass place ½ a spatula of starch then add a few drops of orange iodine solution and observe any changes. Repeat with other foodstuffs to see if they contain starch.

NOTES

Complete the following table by describing your results:

Foodstuff	starch				
Results of test with iodine solution					

Starch is made in plants by joining glucose molecules together in very long chains, several thousand long, by a condensation reaction. When we eat starch in our food it is too big a molecule for our bodies to use, so it is broken down back into glucose, by enzymes in our digestive system. The glucose molecules can then pass through our intestine into the bloodstream. **This reaction is called hydrolysis.**



ACTIVITY 7.4 Hydrolysis of Starch

1. Half fill the beaker with water and heat it until it reaches about 40°C.
2. Using a syringe add 3 cm^3 of starch solution to each of two test tubes.
3. To one of the test tubes add 1 cm^3 of water from a syringe - this will be the control. To the other test tube carefully add 1 cm^3 of amylase solution.
4. Place both test tubes in the beaker of warm water and leave them for 10 minutes. (Make sure the temperature is not above 40^0C)
5. After 5 minutes, use a syringe to add 2 cm^3 of Benedict's solution to each test tube.
6. Keep the test tubes in the beaker of water and then heat the water until it boils.
7. Observe and record what happens to the Benedict's solution in each test tube.

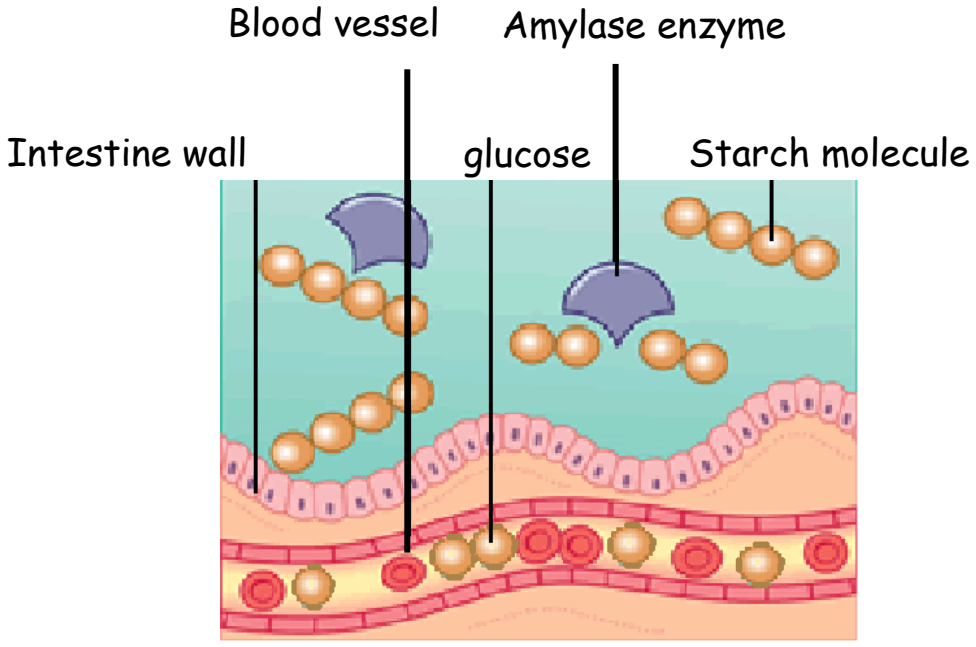
NOTES

Complete the following table by describing your results:

	Test tube 1 **Starch + water**	**Test tube 2** **Starch + amylase**
Reaction with Benedict's reagent		

DISCUSS

After discussion with your teacher and others, make sure you can explain how the body converts starch into glucose during digestion.



3 Alcoholic Drinks

There are a wide range of drinks that contain alcohol including wine, spirits, beer and cider. **They are all made using the fermentation of a carbohydrate**, whether it be grapes for wine, barley for beer and whiskey or even rice and potatoes for sake and vodka.

ACTIVITY 7.5 Fermentation

Your teacher may demonstrate or allow you to make some alcohol using the fermentation of glucose.

In order for fermentation to occur yeast is used which contains an enzyme, zymase. The process must be carried out in warm conditions but not above 50°C. Even in optimum conditions the percentage of alcohol is only 15%. **In order to produce alcoholic drinks with an alcohol percentage greater than 15%, distillation is used.**

DISCUSS

After discussion with your teacher and others make sure you can explain how fermentation is used to produce alcohol.

NOTES

Complete the table below:

Alcoholic drink	Source of carbohydrate
Beer	
Wine	
Whiskey	
Vodka	
Sake	
Cider	
Gin	

ACTIVITY 7.6 Distillation

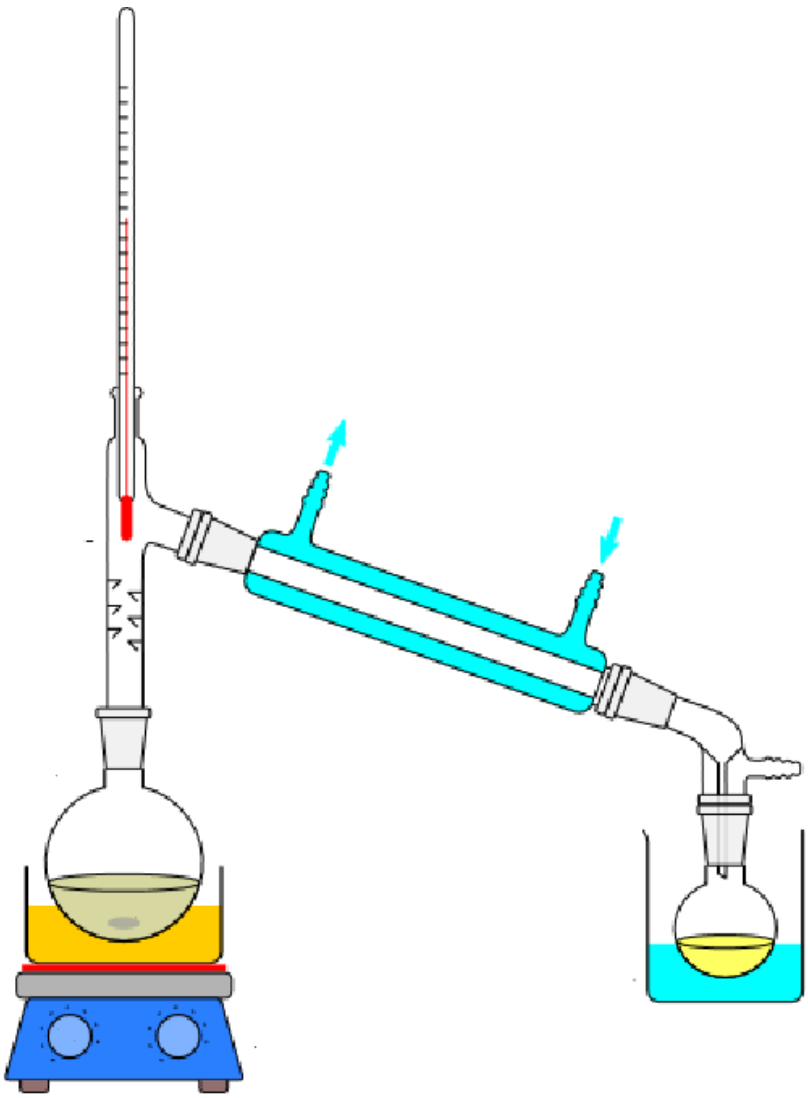
Your teacher may demonstrate or allow you to produce some pure alcohol using distillation.

DISCUSS

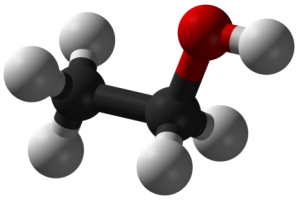
After discussion with your teacher and others make sure you can explain how distillation is used to produce pure alcohol, including the temperature used.

NOTES

Label the following diagram and use it to explain how you produce pure alcohol by distillation.



Alcohols



The alcohol found in alcoholic drinks is called ethanol. There are many types of alcohol with different structures and uses, but all have the same feature or functional group called a **hydroxyl group**. A hydroxyl group consists of an oxygen and hydrogen (-OH) attached to the carbon chain. If the **alcohol is a straight chain alkane** with a hydroxyl group along the chain it is a member of the **alkanol homologous series.**

Activity 7.7 Structure of Alcohols

If you have Molymod kits your teacher may get you to make the first four members of the alkanol homologous series.

DISCUSS

After discussion with your teacher and others make sure you can work out the correct chemical and structural formula for the first four members of the alkanol homologous series.

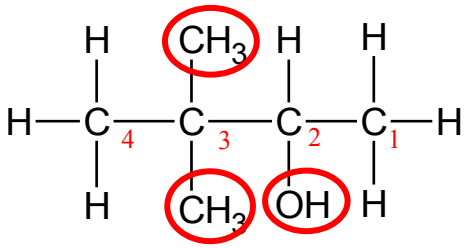
NOTES

Complete the following table.

Name	Full structural formula	Shortened structural formula	Chemical Formula
methanol			
ethanol			
propanol			
butanol			

Systematic Naming

This can be used to name branched chain hydrocarbons containing the hydroxyl functional group:



1. Identify the longest chain of carbon atoms. (4 = but)
2. Number the carbon atoms starting at the end carbon nearest the functional group or branch if there is no functional group. (right hand side)
3. Identify the type and position of any functional groups. (hydroxyl, carbon 2)
4. Identify the type and position of any branches. (2 x methyl, carbon 3 & 3)
5. Put together in the following format; position of, number of and type of branches, then the number of carbons in the longest chain and then the position of and type of functional group.

e.g. **3,3-dimethylbutan-2-ol**

DISCUSS

After discussion with your teacher and others make sure you can work out the correct systematic name of a variety of alkanols.

NOTES

Using the above example to help have a go at the questions below:

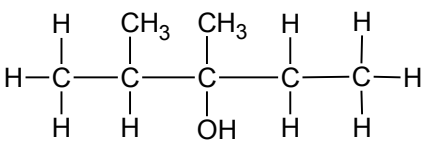
Quick Test 1

1. Draw the full structural formula of 3-methyl butan-2-ol

2. Draw the full structural formula of 2,3-dimethyl pentan-1-ol

3. Name the following alcohols:

$CH_3CH(CH_3)C(CH_3)OHCH_3$



Uses of Alcohols

The most common alcohol is ethanol which is found in alcoholic drinks, the amount of ethanol in different types of drinks can vary. Most labels show the % concentration of ethanol, but many now show how many units the drink contains. **Units are used to show the drinker how much alcohol they are consuming by the glass, can or bottle**.

The recommended maximum number of units of alcohol for a fit and healthy male adult is 21 per week, for a woman it is 14. The diagram gives you an idea of the amount of units contained in a variety of drinks.

thelivercarefoundation.org

Alcohols burn very easily and so they can be used as a fuel, ethanol can be used as a petrol replacement and methanol is used as the fuel for drag racers.

Alcohol as a Fuel

Due to the presence of the hydrocarbon chain and the hydroxyl group, **alcohols are good solvents** for many types of substances. Ethanol is used as a solvent in perfumes, aftershave and mouthwash as it is good at dissolving and evaporates easily as well.

RESEARCH TASK

After discussion with your teacher and others, find a range of household products that use ethanol as a solvent.

4 Vinegar

Vinegar's chemical name is ethanoic acid, sometimes called acetic acid. It is a member of a group of compounds called **carboxylic acids, which contain the carboxyl functional group (-COOH).** If it is a **straight chain hydrocarbon** containing the **carboxyl functional group** it is known as an **alkanoic acid.**

ACTIVITY 7.10 Structure of Carboxylic Acids

If you have Molymod kits your teacher may get you to make the first four members of the alkanoic acid homologous series.

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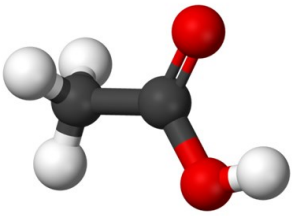
NOTES

Complete the following table:



Name	Full structural formula	Shortened structural formula	Chemical Formula
methanoic acid			
ethanoic acid			
propanoic acid			
butanoic acid			

ACTIVITY 7.11 Testing Carboxylic Acids

Your teacher will give you a selection of carboxylic acids to test for smell, pH and reactivity.

DISCUSS

After discussion with your teacher and others, can you identify any trends in smell, pH and reactivity as the length of the carbon chain in the carboxylic acid increases?

NOTES

Complete the following table and note any trends in smell, pH and reactivity as the length of the carbon chain increases.

Name	Smell	pH	Reaction with magnesium
methanoic acid			
ethanoic acid			
propanoic acid			
butanoic Acid (if available)			

Uses of Carboxylic Acids

Carboxylic acids are used for a variety of purposes including acting as solvents, descaling agents, food preservatives, cleaning products and in the manufacture of esters and plastics.

NOTES

Name some uses of carboxylic acids:

5 Flavourings

Inside most kitchen cupboards you will find flavourings used to make cakes and pastries taste and smell of various fruits and nuts such as banana, lemon or almond. **The flavouring may be natural or synthetic, but in both cases they contain a group of compounds called esters**. Esters have a wide range of uses not just as flavourings as the following experiment will show you.

ACTIVITY 7.12 Identifying Esters

Your teacher will give you a selection of esters to smell. Use the labels on the bottle to find the name and formula of the ester, then try and think where you have smelt it before.

NOTES

After completing the experiment copy and complete the table below:

Naming Esters

Esters are compounds that contain an **ester link (-COO-) or (-OCO-).**

Name of ester	Chemical Formula	Where have you smelt it before?

They are **made by reacting an alcohol with a carboxylic acid**; with the parent alcohol and carboxylic acid forming the name of the ester.

Methanol and **methanoic acid** react together to form the ester **methyl methanoate**. The alcohol forms the alkyl part and the carboxylic acid part forming the alkanoate.

ACTIVITY 7.13 Naming Esters

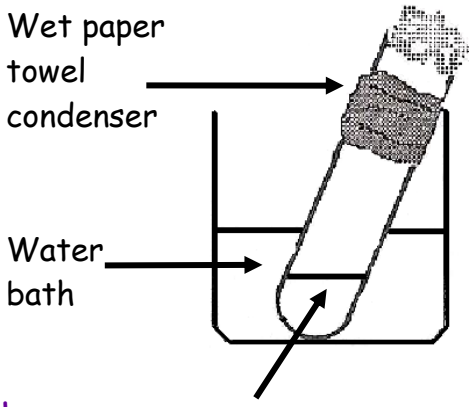
Your teacher may let you play this card game.

Making Esters

In order for the alcohol and carboxylic acid to react, they need to be gently heated in the presence of an acid catalyst.

ACTIVITY 7.14 Making Esters

Using a variety of alcohols and carboxylic acids, a wide range of esters can be produced.



Alcohol, carboxylic acid and concentrated sulfuric acid

1. Add an alcohol to a test tube to a depth of 1cm.
2. Add to this the same volume of a carboxylic acid.
3. Carefully smell the mixture by wafting.
4. Get your teacher to add 5 drops of concentrated sulfuric acid.
5. Wrap a piece of wet tissue paper around the neck of the test tube and hold it in place with an elastic band. Then place a loose plug of cotton wool in the neck of the tube, as shown above.
6. Place the test tube in a hot water bath for about 15 minutes.
7. Remove the plug of cotton wool and pour the contents of the tube into a beaker containing 50cm^3 of sodium carbonate solution, to neutralise the acid catalyst.
8. Look at the surface of the solution for an oily layer and gently waft to smell if you have produced an ester.

DISCUSS

After discussion with your teacher and others, can you describe the experimental procedure for making an ester, including the purpose of the concentrated sulfuric acid, the wet paper towel condenser and the water bath?

NOTES

From the name of the parent alcohol and carboxylic acid you used, name the ester you made in the space below:

Uses of Esters

Ester are used in a wide range of applications including food flavourings, solvents ,fragrances and plastics.

Making Esters

.

NOTES

After completing the above activities complete the table below:

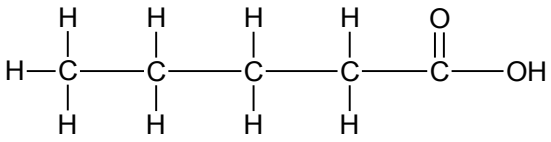
Quick Test 2

1. Name the following carboxylic acids:

a. b.

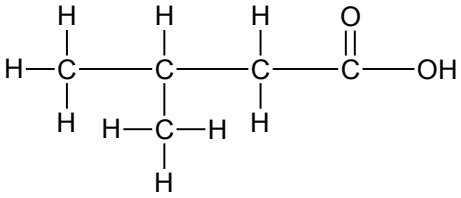
Ester	Use

2. Identify the alcohol and carboxylic acid used to make the following esters:



pentyl butanoate

A. methyl propanoate



b .

3. Identify the ester formed when the following alcohol and carboxylic acid react:

A. ethanol & propanoic acid

b. butanol & ethanoic acid

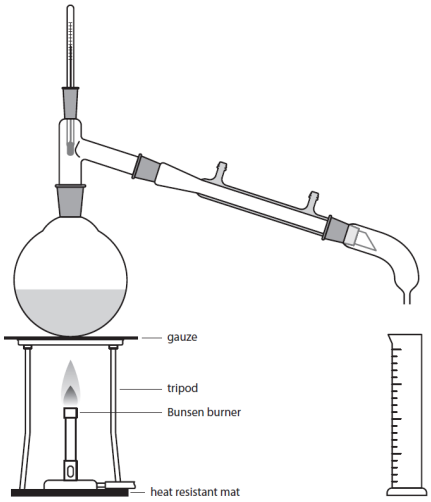
6 Medicines

We have been using medicines to relieve pain and other ailments for 1000's of years. **Until relatively recently all our medicines were derived from plants and herbs**, even today herbalists and homeopaths treat a wide variety of ailments using plant extracts.

One of the most effective ways to extract the active ingredients from plants is by steam distillation; releasing the plant's essential oils which contain many useful chemicals.

ACTIVITY 7.16 Steam Distillation

Your teacher may allow you to set up the following apparatus or something similar to extract the essential oils from different plant material.



Other methods used to extract or produce active ingredients are to dry sap or other liquids from the plant or use fermentation.

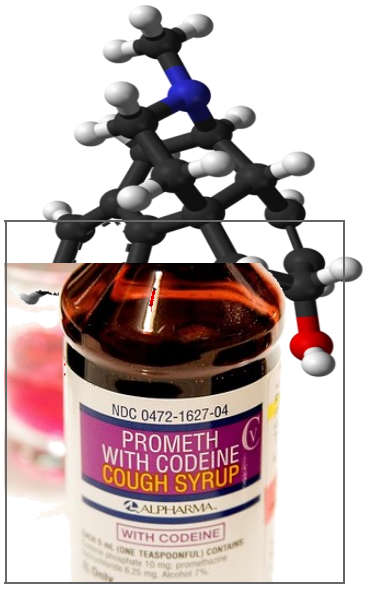
Although many people are sceptical about these remedies chemists have spent many years analysing these treatments to try and identify the active ingredient so that the medicine can be improved or synthesised from other cheaper sources.

DISCUSS

After discussion with your teacher and others, can you identify different ways to extract useful chemicals from plants?

For over 4000 years plants containing salicylic acid and related compounds, such as **willow bark, have been used to treat pain and fever**. Aspirin, was a drug created by the German pharmaceutical company, Bayer, in 1899. **Aspirin is acetylsalicylic acid, an ester made by reacting salicylic acid with ethanoic anhydride**. It is more effective than the salicylic acid found in plants and also has less unpleasant side effects.

Morphine is a drug that can be extracted from poppies. It is a very effective pain reliever, but **unfortunately it is very addictive.** In an effort to reduce the addictive properties of this plant extract chemist started to tinker with the chemical structure and initially produced heroin, which gave better pain relief but was even more addictive. Then came **codeine which wasn't addictive** but wasn't as good at relieving pain either. However it was found to be **very good at stopping people coughing**. It is now found in many cough reliefs.



RESEARCH TASK

After discussion with your teacher and others, find suitable sources of information on one of the many important chemicals that are extracted from plants. Produce an information poster on your particular plant and the important chemical it is used to produce.