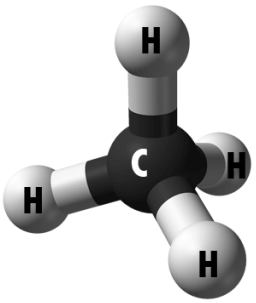
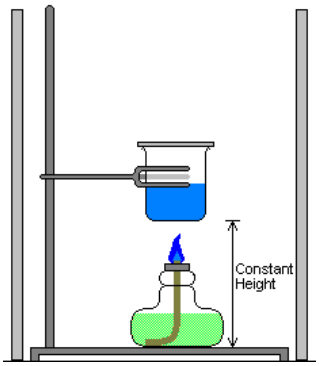
St. Ninian's High School
National 4 and 5
Chemistry





Unit 2
Nature's Chemistry
Homework Booklet

Chemistry Department

Standards Expected of Homework

- All homework must be recorded in your homework diary.
- All homework must be **dated** and have a **heading** which is **underlined.**
- A **ruler** must be used for all underlining and for diagrams.
- Diagrams must be properly **labelled.**
- Graphs should be drawn on graph paper.
- You must **attempt every question,** using your notes to help you. Ask for help if it is required.
- **Answer in sentences** when appropriate.
- **Care** and **attention** must be given to your written work at all times.
- In every report you receive, your teacher will give you a rating for your homework. This rating is based on the criteria outlined below. You should be aware of this when completing each piece of homework:

Homework grade

1	Excellent	2	Good	3	Needs improvement	4	Significant concern

Fuels and combustion 1

1. Carbon burns in an exothermic reaction to form carbon dioxide.

   (a) Explain what is meant by an *exothermic* reaction.
   (b) Write an equation, using symbols and formulae, for the combustion of carbon.
   (c) What is the test for oxygen?
   (d) What is the test for carbon dioxide?

2. Wood is a solid fuel.

   (a) What is meant by the word *fuel*?
   (b) What gas is used up when coal burns?
   (c) Name the **three** things that are required for burning to take place.

3. Carbon is an important fuel. Depending on the conditions of combustion it may burn to produce carbon monoxide or carbon dioxide.

   (a) Give the formulae for:
   (i) oxygen (ii) carbon monoxide (iii) carbon dioxide
   (b) Under what conditions will carbon burn to make carbon monoxide?
   (c) Write an equation for the reaction in which carbon burns to form carbon monoxide.
   (d) Write a balanced equation for the reaction in which carbon burns to form carbon dioxide.

4. Hydrogen is a useful fuel. It is often used to power rockets.

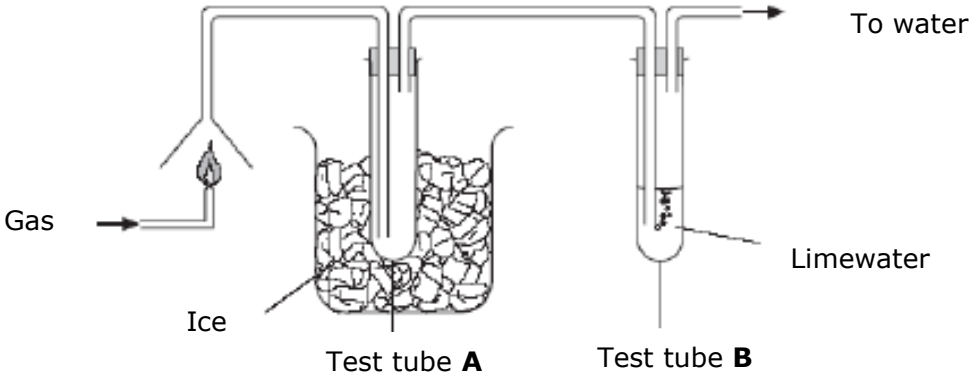
   (a) What is the test for hydrogen?
   (b) What is the formula of hydrogen?
   (b) Write an equation for hydrogen burning.

5. Different **types of coal** have different **moisture content (%)**. The **heat output (kW/kg)** depends on the type of coal.
   Anthracite coal has a moisture content of 15%. The heat output of anthracite is 9 kW/kg. Bituminous coal has a higher moisture content of 20% and gives out 7·5 kW/kg. The heat output of lignite coal is 6 kW/kg
   and it has a moisture content of 30%. Brown coal has the lowest heat output, 5 kW/kg, and at 45%, it has the highest moisture content.

   Show this information in a table with **three** suitable headings.

Products of Combustion 2

1. A pupil tries to identify the products of combustion of various gases. To do this she sets up the experiment shown below.



(a) What could be collected in test tube A? How would you test for this substance?
(b) What is the purpose of the container with lime water?
(c) What would you see at A and B if the following gases were burned at X?

(i) Hydrogen (ii) Carbon monoxide (iii) a hydrocarbon

2. Read the following passage and use the information to answer the questions.

Biomass fuel is the name given to renewable fuels obtained from living things. The most commonly used biomass fuel is wood. In many parts of the world, wood is the main fuel used for domestic heating and cooking. Charcoal and wood-alcohol are biomass fuels made from wood. Charcoal can be used in solid fuel heaters, while wood-alcohol is used as a liquid fuel. Charcoal is produced by heating wood in the absence of air. This process is called destructive distillation. The process also produces a mixture of gases which can be condensed to form an oily liquid. Wood-alcohol is obtained from this liquid.
Sugar cane can be used to produce another liquid biomass fuel called ethanol. Sugar, which is extracted from sugar cane plants, is converted to ethanol by the process of fermentation. Ethanol can be burned to produce heat energy or used in a fuel cell to produce electrical energy.

(a) What is the most commonly used biomass fuel?
(b) Describe how charcoal is produced.
(c) What happens during the process of fermentation?
(d) Name two liquid biomass fuels.

Pollution (Collect graph paper) 3

1. Petrol is a mixture of hydrocarbons. Inside the car's engine the petrol is mixed with oxygen and burned. The exhaust fumes from a car are a complex mixture of chemicals including unburnt petrol, nitrogen dioxide, nitrogen monoxide, water, carbon dioxide, carbon monoxide and soot.

   All modern cars now come equipped with catalytic converters.

   (a) Explain why nitrogen dioxide is dangerous.
   (b) Explain why the following gases are present in car exhausts:

   (i) Carbon monoxide (ii) Oxides of nitrogen

   (c) Why do cars have catalytic converters fitted?

2. The table below shows the amount of sulphur dioxide emitted by the European Union in 2010.

Source of sulphur dioxide	*Sulphur dioxide emitted(millions of tonnes)*
Homes	0.5
Heavy industry	5.8
Refineries	0.8
Power stations	2.9

   Present this information in a bar chart.

3. (a) What are the products of combustion of hydrocarbons in excess oxygen?
   (b) Combustion of hydrocarbons is an exothermic reaction which must have a plentiful supply of air to prevent possible fatal results.

   (i) Explain the meaning of the underlined words.
   (ii) Why can combustion of hydrocarbons possibly have fatal results?

4. Petrol, diesel and ethanol are all used to power motor vehicles. For the last 15 years people in the UK were encouraged to buy cars that ran on diesel rather than petrol. Diesel vehicles produce far lower CO_2 emissions (50g per kilometre) than petrol vehicles (130g per kilometre). However diesel vehicles (200g per kilometre) produce far greater quantities of other harmful gases, such as sulphur and nitrous oxides, which are polluting our cities, than petrol vehicles (70g per kilometre). Cars powered on ethanol are carbon neutral and produce very few other harmful gases (20g per kilometre)

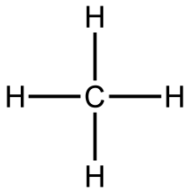
   Present this information in a table with **three** headings.

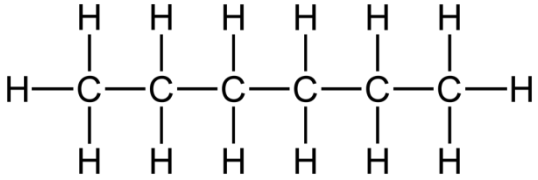
Alkanes 4

1. Give the
   i) molecular formula,
   ii) extended structural formula,
   iii) formula mass of the following hydrocarbons:

   (a) propane
   (b) pentane
   (c) ethane
   (d) heptane

2. Name the following hydrocarbons and give the molecular formula and formula mass of each.

   (a) 

   (b) 

3. From the shortened structural formulae below, name and draw extended structural formulae of the molecules.

   (a) $CH_3CH_2CH_2CH_3$
   (b) $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_3$

4. Give balanced equations for the combustion of the following hydrocarbons.

   (a) propane (b) pentane (c) butane

5. The table gives information about some members of the alkane family.

Name	*Molecular formula*	*Boiling point (°C)*
Nonane	C_9H_{20}	151
Decane	$C_{10}H_{22}$	174
Undecane	$C_{11}H_{24}$	196
Dodecane	$C_{12}H_{26}$	

   (a) Predict the boiling point of dodecane.

   (b) What term is used to describe any family of compounds, like the alkanes, which have the same general formula and similar chemical properties?

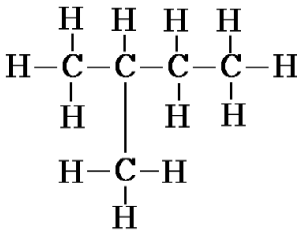
Branched alkanes 5

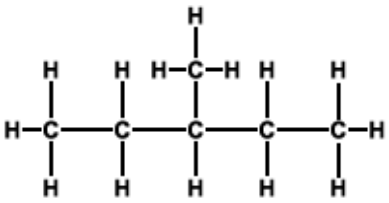
1. Draw the (i) extended and (ii) shortened structural formulae of the following hydrocarbons

(a) 2-methyl propane (b) 2-methyl pentane

2. For each of the hydrocarbons below give:

(i) the shortened structural formula (ii) the systematic name

(a) 

(b) 

3 Give the extended structural formula and systematic name of each of the compounds below.

(a) $CH_3CH_2CH_3$ (b) $CH_3CH_2CH(CH_3)CH_2CH_3$

4. Silicon combines with hydrogen to form a series of compounds called the Silanes.
The formula of the first four silanes is shown below.

SiH_4 Si_2H_6 Si_3H_8 Si_4H_{10}

(a) What is the general formula of the silanes?

(b) Draw the structural formula of Si_3H_8.

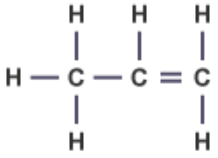
(c) The compound Si_3H_8 reacts with oxygen to form silicon dioxide and one other substance.
Suggest what this substance might be.

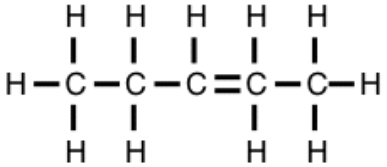
Alkenes 6

1. Give the extended and shortened structural formulae, molecular formulae and formula mass of the following hydrocarbons.

(a) ethene (b) hex-1-ene.

2. Name the following hydrocarbons and give their molecular formulae, shortened structural formulae, and molecular mass.

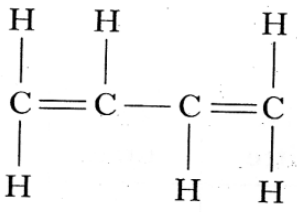
(a) 

(b) 

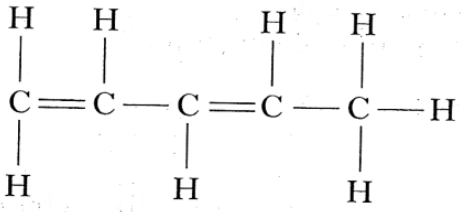
3. Draw the extended structural formula and give the name of each of the following hydrocarbons

(a) $CH_2CHCH_2CH_3$ (b) $CH_2CHCH_2CH_2CH_3$

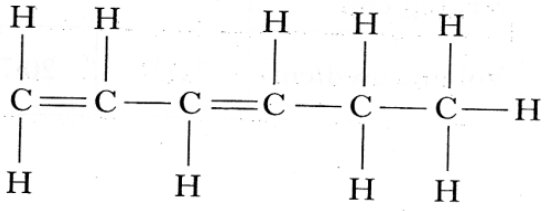
4. Dienes are a homologous series of hydrocarbons which contain two double bonds per molecule.



buta-1,3-diene



penta-1,3-diene



hexa-1,3-diene

(a) What is meant by the term "homologous series"?

(b) Suggest a general formula for the dienes.

(c) Write the **molecular formula** for the product of the complete reaction of penta-1-3-diene with bromine.

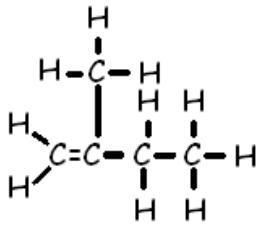
Branched alkenes 7

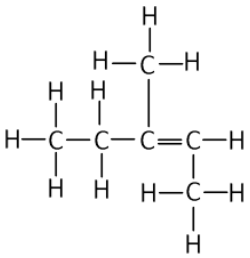
1. Draw the (i) extended and (ii) shortened structural formulae of the following hydrocarbons

(a) 3-methyl pent-1-ene (b) 2,4-dimethyl hex-3-ene.

2. For each of the hydrocarbons below give:

(i) the shortened structural formula (ii) the systematic name

(a) 

(b) 

3 Give the extended structural formula and systematic name of each of the compounds below.

(a) CH_2CHCH_3 (b) $CH_3CHCHCH(CH_3)CH_3$

4. Silicon combines with hydrogen to form a series of compounds called the Silanes.
The formula of the first four silanes is shown below.

Si_2H_2 Si_3H_4 Si_4H_6 Si_5H_8

(a) What is the general formula of the silanes?

(b) Draw the structural formula of Si_6H_{10}.

(c) The compound Si_3H_4 reacts with oxygen to form silicon dioxide and one other substance.
Suggest what this substance might be.

Cycloalkanes 8

1. Give the structural and molecular formulae of the following hydrocarbons.

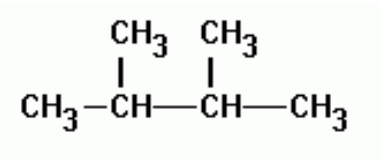
(a) Cyclobutane (b) Cyclopentane

2. (a) What is the general formula of the cycloalkanes?

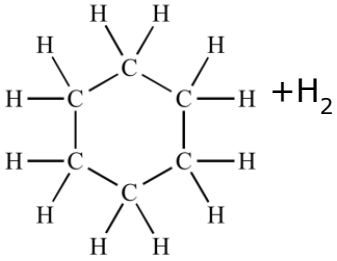
(b) Name two hydrocarbons with molecular formula C_4H_8

3. Reforming is a chemical reaction which changes straight chain hydrocarbon molecules into branched chain or cyclic molecules. Unlike cracking, reforming does not change the number of carbon atoms in a molecule.
Two examples of a reforming reaction are shown below.

Reaction One Production of a branched chain alkane

Hexane → 

Reaction Two Production of a cyclic alkane.

Hexane →  $+H_2$

(a) Draw the structural formula of a branched chain alkane which could be made by reforming pentane.

(b) Name the cyclic alkane produced in the reaction above.

4. Many different drugs are used to alter the chemistry of our bodies in different ways. Aspirin can lower our temperature when we have a fever, Ibuprofen lessens pain and Antihistamines stop allergic reactions. Bacteria are killed by penicillin and streptomycin. Patients with stomach ulcers are often treated with tagamet which lowers production of stomach acid.

Present this information in a table with **two** headings**.**

Isomers 9

1. C_5H_{12} can exist as three isomers.

(a) Define isomers.

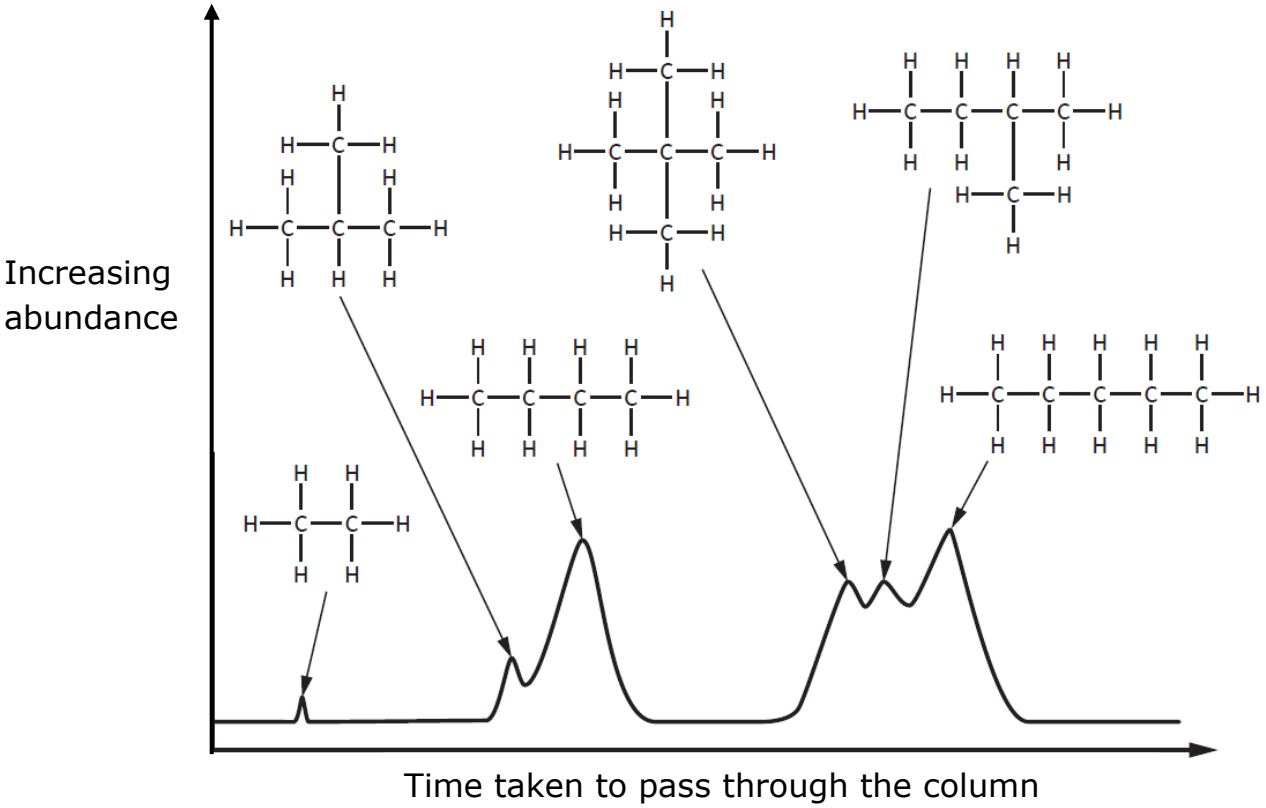
(b) Draw the extended structural formula of each isomer.

2. C_4H_8 can exist as isomers.

(a) Give the name and extended structural formula of two unsaturated isomers whose molecular formula is C_4H_8.

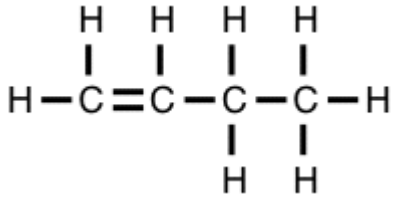
(b) Give the name and extended structural formula of a saturated isomer whose molecular formula is C_4H_8.

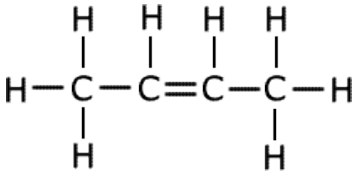
3. A mixture of gas hydrocarbons can be separated by a method called gas chromatography.
The gas mixture is passed through a special column packed with a powder.
Different hydrocarbons move through the column at different speeds.
The following result was obtained from a mixture of hydrocarbons.



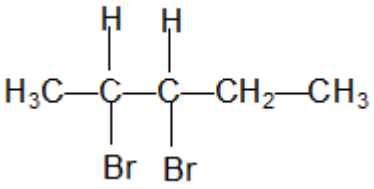
Make **two** general statements linking the structure of a hydrocarbon with the length of time taken to pass through the column.

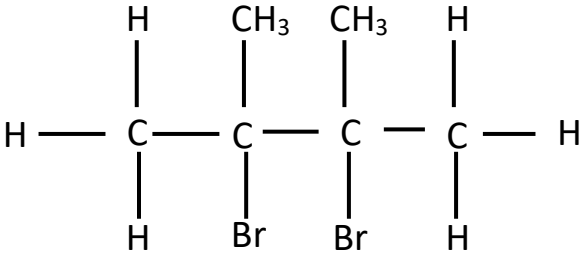
1. Draw the structural formula of the molecules produced when the molecules below react with bromine

(a) 

(b) 

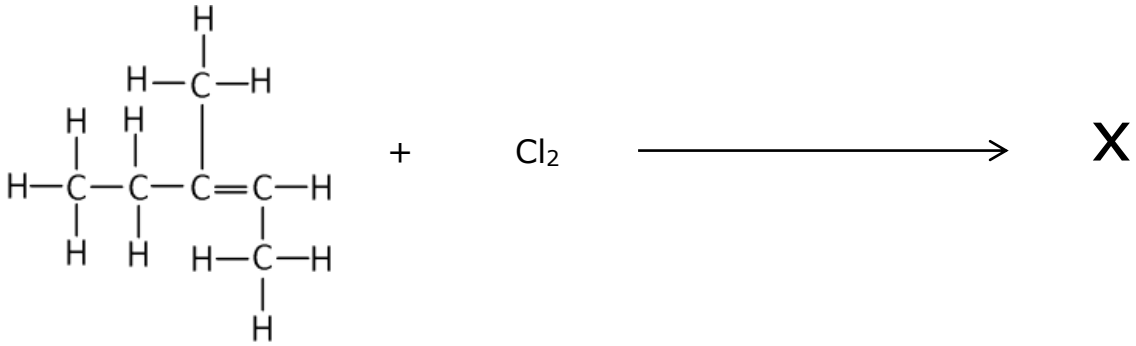
2. Draw the extended structural formula of the hydrocarbons which react with bromine to make the compounds shown below.

(a) 

(b) 

3. Chlorine is used in swimming pools as a disinfectant in the water. Another use for chlorine is to produce chlorinated compounds.

(i) What are the two possible *specific* names for this reaction?
(ii) Chlorine is added to the compound below, draw the structure of the product, x.



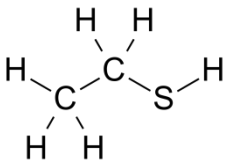
Crude oil 11

1. A sample of crude oil is fractionally distilled into a series of fractions.

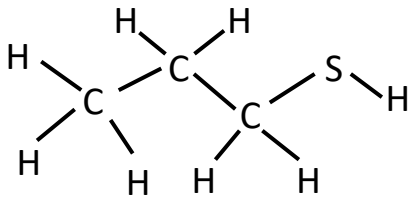
Fraction no.	No. of carbon atoms in the chain
1	1-4
2	5-6
3	7-8
4	9-15
5	15-25
6	More than 25

(a) Why can the fractions in crude oil be separated by fractional distillation?
(b) Which fraction contains the highest boiling point molecules?
(c) Which fraction is made up exclusively of gases?
(d) Which of the fractions 2,3 or 4 is easiest to ignite?
(e) Which of the fractions 2,3 or 4 is the most viscous?
(f) Which of the fractions 2,3 or 4 contains the largest molecules?

2. The chemicals with the most powerful smell are the mercaptans. Two of the most powerful are ethyl mercaptan and propyl mercaptan. The structural formulae of these compounds are shown below.



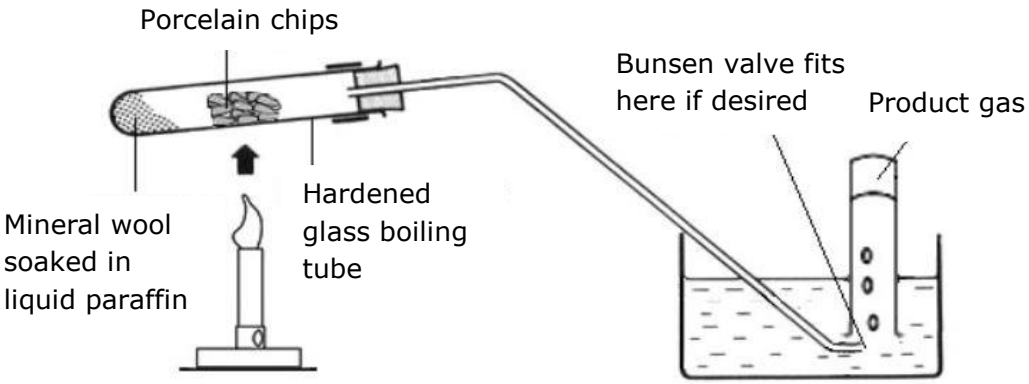
Ethyl Mercaptan



Propyl Mercaptan

(a) What is the molecular formula of ethyl mercaptan?
(b) When ethyl mercaptan is burned it produces carbon dioxide, water, and an acidic gas. What could this gas be?
(c) Draw the structural formula of butyl mercaptan.

1. The diagram below shows the laboratory set up used to crack hydrocarbons.



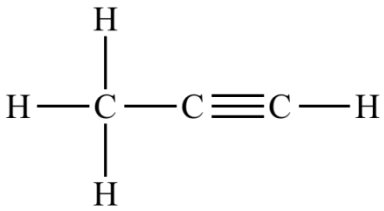
(a) What is the function of the porcelain chips in the above experiment?
(b) How would you show that the gas collected in the test tube contained alkenes?

2. When a sample of a hydrocarbon is heated it breaks down as follows

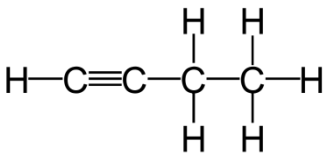
$$C_8H_{18} \rightarrow C_6H_{14} + \mathbf{X}$$

(a) What is the molecular formula of the hydrocarbon **X**?
(b) Name the hydrocarbons C_8H_{18} & C_6H_{14}.

3. The alkynes are a family of hydrocarbons which contain a carbon to carbon triple bond.



propyne



butyne

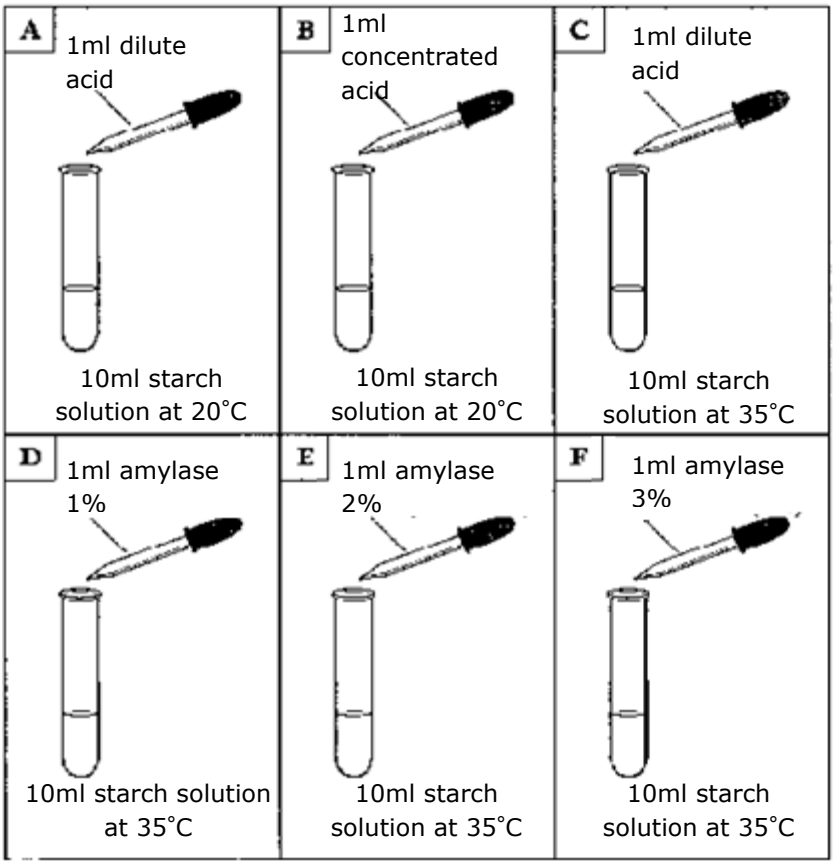
(a) Suggest a general formula for the alkynes.
(b) Draw the structural formula of pentyne.

Testing carbohydrates 13

1. Some starch was put into a test tube and saliva added. The mixture was kept at a temperature of 37°C for one hour. After this time the mixture was tested for starch and sugars. No starch was found, but glucose was present in the mixture.

(a) Explain how you would test the mixture to see if it contained starch. What would you expect if starch was present?
(b) Explain how you would test the mixture to see if it contained sugars like glucose.
What result would you expect if sugars like glucose were present?
(c) What happened to the starch in the test tube?
(d) Why was the experiment carried out at 37°C?
(e) Name the substance in the saliva which acted on the starch.

2. Carol and Jim were investigating different substances which break down starch.
They set up the following experiments.



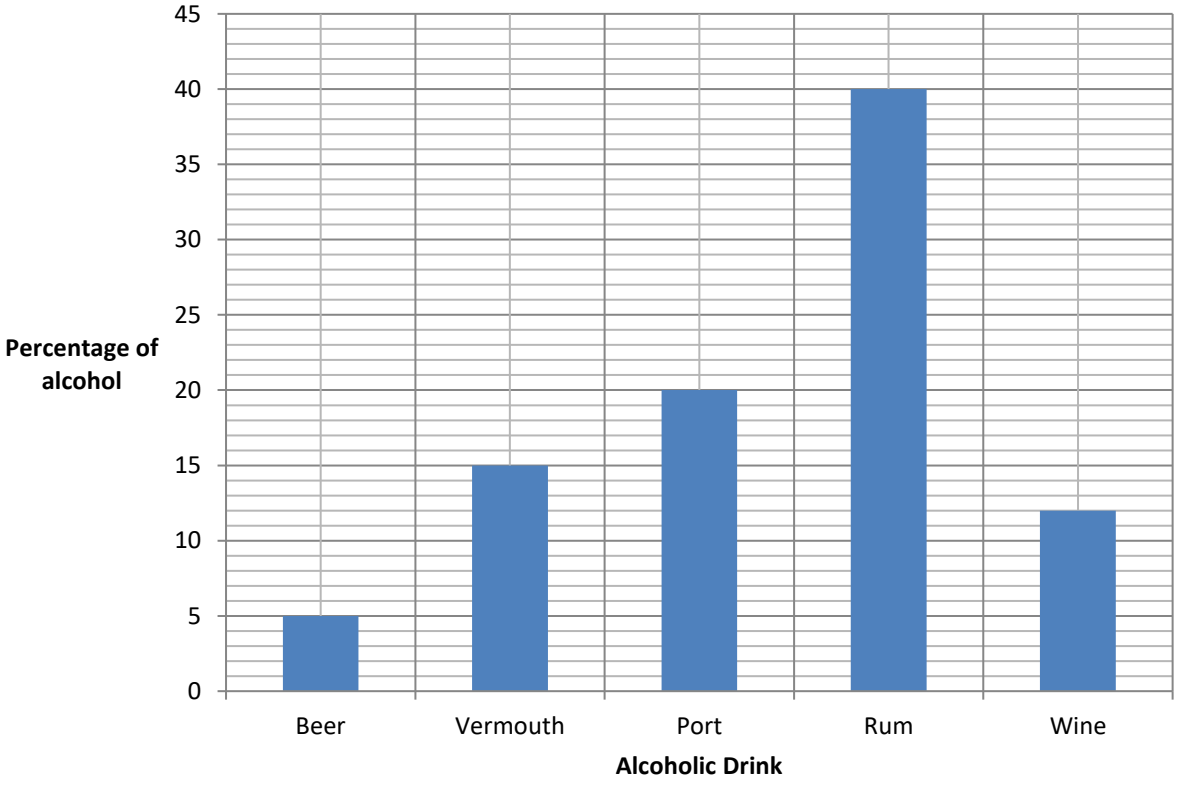
(a) Which **two** experiments would they compare to find the effect of temperature on the breakdown of starch?
(b) Carol looked at the results of experiments D and F. What was she trying to find out?

Fermentation 14

1. In Brazil sugar is changed into ethanol to produce a renewable fuel for cars. The sugar is dissolved in water and yeast added. After a few days the solution will contain about 12% ethanol. Pure ethanol can then be obtained from this solution.

(a) What name is given to process which produces alcohol from sugar and yeast?
(b) Explain why the maximum concentration of ethanol which can be made from sugar and yeast is about 12 to 15%.
(c) What name is given to the process which produces pure ethanol from the ethanol/water mix?
(d) Why can ethanol and water be separated?
(e) What two substances are made when ethanol is burned?
(f) Explain why ethanol produced from carbohydrates is a renewable fuel.

2. The bar chart shows the percentage of alcohol in different drinks.



(a) Which drink contains the least alcohol?
(b) Which drink contains 15% alcohol?
(c) What is the percentage of alcohol in wine?

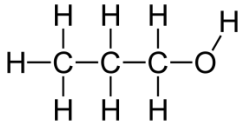
Alcohols 15

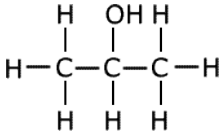
1. Draw the extended structural **and** shortened structural formulae of the following alcohols:

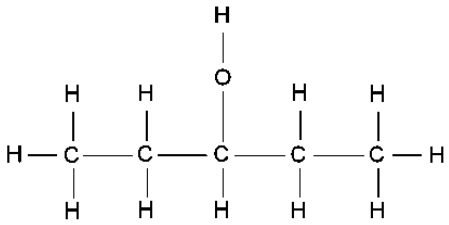
(a) Methanol (b) Ethanol (c) Butan-1-ol

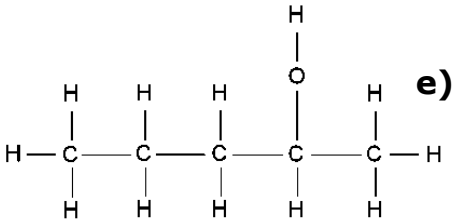
(d) Hexan-1-ol (e) Pentan-2-ol

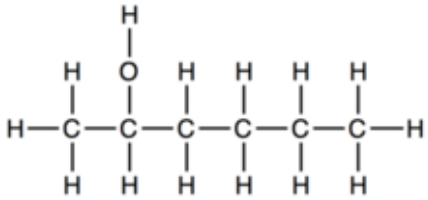
2. Name the following alcohols:

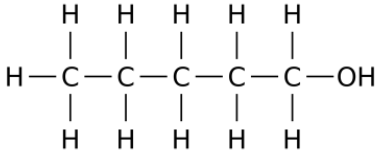
a) 

b) 

c) 

d) 

e) 

f) 

3. Give **two** uses of alcohols

4. Identify the following:

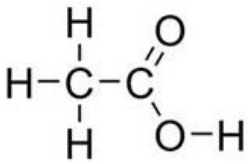
(i) The name of the functional group that identifies alcohols
(ii) The general formula of the alkanols

Carboxylic acids 16

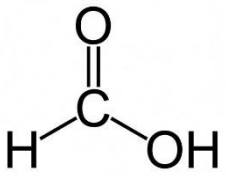
1. For each of the alkanoic (carboxylic) acids shown below give

(i) the name of the acid (ii) its shortened structural formula

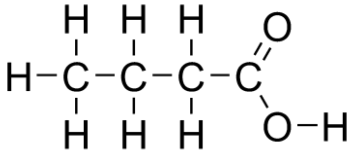
a)



b)



c)



2. For each of the alkanoic (carboxylic) acids below give:

(i) the name of the acid (ii) its extended structural formula

(a) $CH_3CH_2CH_2CH_2CO_2H$ (b) $CH_3CH_2CH_2CH_2CH_2CO_2H$

3. The table below gives information about some carboxylic acids.

Name	Molecular formula	Boiling point (°C)	pH
Methanoic acid	HCO_2H	101	2.1
Ethanoic acid	CH_3CO_2H	118	2.8
Propanoic acid	$C_2H_5CO_2H$	141	3.4
Butanoic acid	$C_3H_7CO_2H$	164	3.6

(a) Identify the conclusion(s) which can be made from this data.

A As the formula mass increases the pH decreases.
B As the formula mass decreases the boiling point increases.
C As the boiling point increases the pH increases
D Hexanoic acid will have the formula $C_6H_{13}CO_2H$
E The smaller the molecule, the lower the boiling point.

(b) Predict the boiling point of pentanoic acid.

(c) Explain why propanoic acid has a higher boiling point than ethanoic acid.

Combustion 17

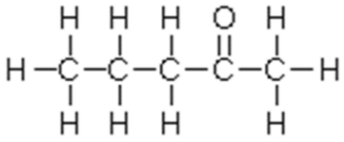
1. Write **balanced formulae equations** for the following combustion reactions:

(a) Methane burning in excess oxygen to produce carbon dioxide and water.

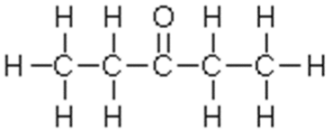
(b) Propane burning in excess oxygen to produce carbon dioxide and water.

(c) Ethanol burning in oxygen to produce carbon dioxide and water.

2. Chemicals in food provide flavour and smell. Ketones are responsible for the flavour in blue cheese. Two examples of ketones are shown below.



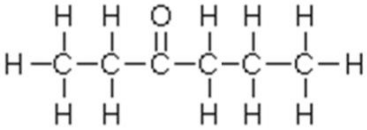
pentan-2-one and



pentan-3-one

(a) Draw a structure for hexan-3-one.

(b) Suggest a name for the ketone shown below.



heptan-3-one

(c) Information about the boiling points of four ketones is shown in the table.

Ketone	Boiling point (°C)
C_3H_6O	56
C_4H_8O	80
$C_5H_{10}O$	102
$C_6H_{12}O$	127

Predict the boiling point of $C_7H_{14}O$.

Energy from Combustion 18

1. Calculate the quantity of heat energy in kilojoules required to

   (a) Raise the temperature of 0.2 kg of water by 5°C.

   (b) Raise the temperature of 0.2 kg of water by 30°C

2. Convert

   (a) 250 grams into kilograms

   (d) 125 grams into kilograms

3. Calculate the quantity of heat energy in kilojoules required to

   (a) Raise the temperature of 200g of water by 20°C.

   (b) Raise the temperature of 25 g of water by 50°C.

4. When 0.45g of methanol is burned the temperature of 100g of water rose by 9.8°C.
Calculate the energy released.

5. A Bunsen burner heated 200g of water from 23°C until it boiled.
Calculate the energy required to do this.

6. Ethanol can be used in portable camping stoves.
Calculate the energy required to raise the temperature of 100g of water by 55°C.

Further energy from combustion 19

1. Gavin and Angus were camping in the Highlands. To prepare dinner, some water was heated in a kettle using a butane gas stove.

6.70g of butane (C_4H_{10}) raised the temperature of the water by 58^{o}C.

Calculate the energy released in the reaction, in kJ.

2. When 0.72g of methanol is burned and 12.6 kJ of energy is released, the temperature of 100g of glucose solution rose by 27.1°C.
Calculate the specific heat capacity, in kJ kg^{-1} ^{o}C^{-1}, of the glucose solution.

3. A Bunsen burner heated 200cm^3 of water. 106.78kJ of energy was absorbed by the water. Calculate the temperature change of the water.

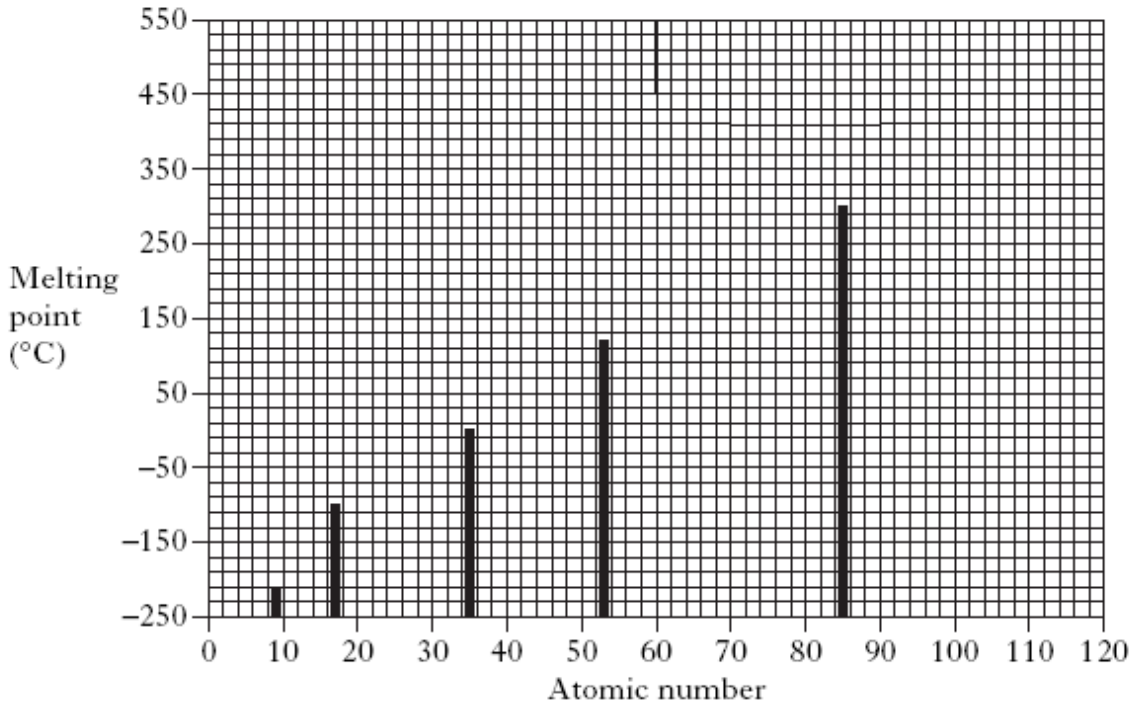
4. 1.13g of butanol was burned. It released 13.86kJ of energy. The temperature change of the water being heated was 69^{o}C. Calculate the mass of water heated.

5. 28.39kJ of energy was released to heat 500g of vegetable oil by 34^{o}C.

Calculate the specific heat capacity, in kJ kg^{-1} ^{o}C^{-1}, of vegetable oil.

Skills questions 20

1. Chlorine is a member of the Group 7 elements. The graph shows the melting points of these elements.



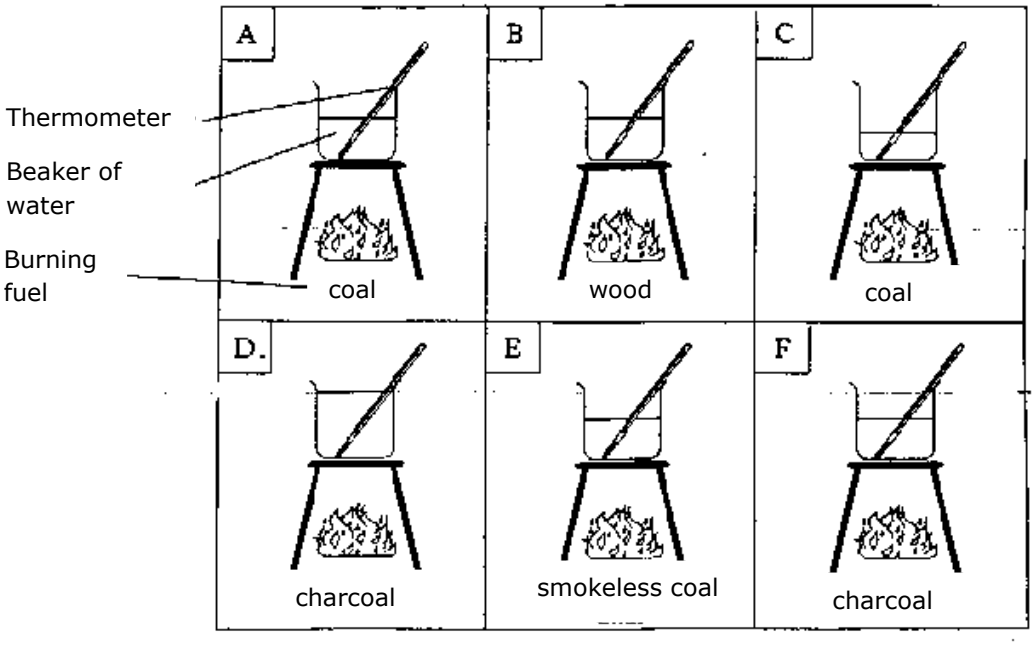
(a) State the relationship between the atomic number and the melting point of the Group 7 elements.

(b) The next member of this group would have an atomic number of 117. Using the graph, predict the melting point of this element.

2. Some famous **diamonds** have been found in different **countries**.
Each diamond has a different **weight** measured in carats.
The Kohinoor diamond, from India, has a weight of 105.60 carats. The Millenium Star diamond has a weight of 203.04 carats and was found in Congo. The Centenary diamond weighs 273.85 carats and the Cullinan diamond, the largest ever found, weighs 530.20 carats. Both the Centenary and Cullinan diamonds were found in South Africa.

Present this information in a table with **three** suitable headings.

3. Sandy set up the following experiments to find out which fuel gives out the most heat.

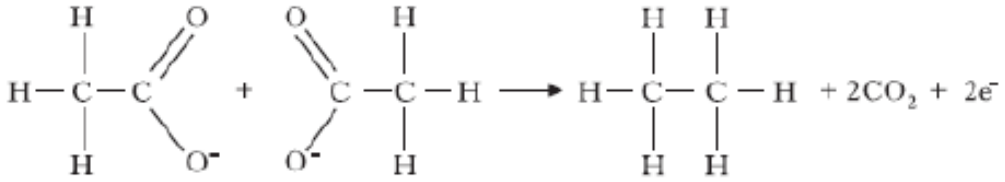


(a) To keep the experiments fair the volume of water should be kept the same. Name one other factor which should be kept the same.

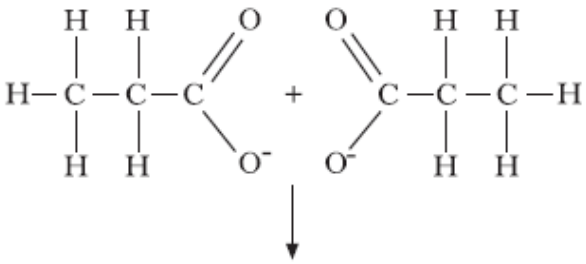
(b) Which **two** experiments should sandy use to find out if charcoal gives out more heat that coal?

(c) What would sandy be investigating if she compared experiment A with experiment E?

4. Alkanes can be prepared by the Kolbé synthesis. For example ethane can be prepared in the Kolbe synthesis reaction between two ethanoate ions.



Draw a structural formula for and give the name of the alkane ions are used instead of ethanoate ions.



Using your knowledge of Chemistry questions 21

1. Fuels have developed greatly in the past 200 years. More traditional fuels such as candle wax, peat and coal were the most commonly used fuels in the 19th century.

   Using your knowledge of chemistry, describe how you could establish which of these fuels was the most efficient and which produced the least pollution.

2. *Using your knowledge of chemistry,* suggest methods of producing alcohols and how you could determine that you had produced this alcohol.

3. Stephen had 3 different alcohols. He wanted to find out how much energy each one released when it burnt.

   Using your knowledge of Chemistry, describe and explain an experiment that Stephen could carry out to determine which alcohol released the most energy when burnt.

4. Alkynes are another homologous series of hydrocarbons. They contain at least one carbon to carbon triple bond.

   Using your knowledge of Chemistry, describe an experimental procedure that can be carried out to distinguish between alkanes and alkynes.

5. Carboxylic acids have many everyday uses. *Using your knowledge of Chemistry, comment on this homologous series and the members' many uses.*