This is your booklet for the year.

Look after it.

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<u>The Departmental Website</u>.

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2. Science Link
3. Chemistry
4. AQA GCSE

11.1 - Oil & Alkanes

I have reviewed the syllabus statements for this topic	
I have completed the questions in this section	
I have read the relevant sections of the College Website	
I have made some revision material (mind-map, key-words & definitions etc)	
Prep Grade	
Test Grade	

Target	Pupil Signature

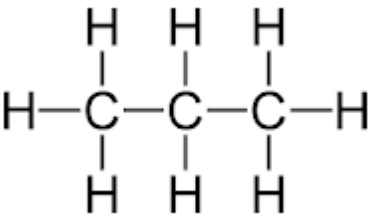
11.1 - Oil & Alkanes

Syllabus

- Crude oil is a ***finite*** resource found ***in*** rocks.

- Crude oil is the remains of an ***ancient biomass*** consisting mainly of ***plankton*** that was buried in mud.
- Crude oil is a ***mixture*** of a very large number of compounds.

- Most of the compounds in crude oil are ***Hydrocarbons***, which are molecules made up of ***Hydrogen*** and ***Carbon*** atoms ***only***.
- Most of the Hydrocarbons in crude oil are Hydrocarbons called Alkanes.
- The ***general formula*** for the homologous series of Alkanes is C_nH_{2n+2}
- The first four members of the Alkanes are ***Methane***, ***Ethane***, ***Propane*** and ***Butane***.
- Alkane molecules can be represented in the following forms: C_3H_6 or



- Students should be able to recognise substances as Alkanes given their formulae in these forms.
- Students ***do not need to know*** the names of specific Alkanes except Methane, Ethane, Propane & Butane.

- The many Hydrocarbons in crude oil may be separated into ***fractions***, each of which contains molecules with a ***similar*** number of Carbon atoms, by ***fractional distillation***.
- The fractions can be processed to produce ***fuels*** and ***feedstock*** for the petrochemical industry.
- Many of the fuels on which we depend for our modern lifestyle, such as ***petrol***, ***diesel oil***, ***kerosene***, ***heavy fuel oil*** and ***liquefied petroleum gases***, are produced from crude oil.
- Many useful materials on which modern life depends are produced by the petrochemical industry, such as ***solvents***, ***lubricants***, ***polymers***, ***detergents***.
- The vast array of natural and synthetic Carbon compounds occur due to the ability of Carbon atoms to form families of similar compounds.
- Students should be able to explain how fractional distillation works in terms of ***evaporation*** and ***condensation***.
- Knowledge of the names of other fractions or fuels is ***not required***.

- Some properties of Hydrocarbons depend on the size of their molecules, including ***boiling point, viscosity*** and ***flammability***.
- These properties influence how Hydrocarbons are used as fuels. Students should be able to recall how boiling point, viscosity and flammability change with ***increasing molecular size***.

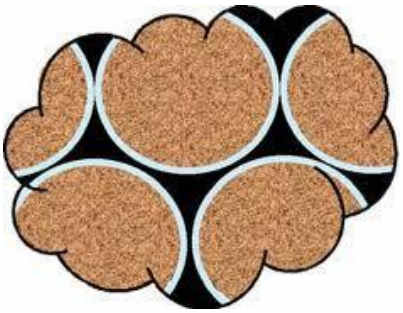
- The ***combustion*** of Hydrocarbon fuels releases ***energy***.
- During combustion, the Carbon and Hydrogen in the fuels are ***oxidised***.
- The ***complete combustion*** of a Hydrocarbon produces ***Carbon Dioxide*** and ***water***.
- Students should be able to ***write balanced equations*** for the complete combustion of Hydrocarbons with a given formula.
- Hydrocarbons can be broken down (***cracked***) to produce ***smaller***, ***more useful*** molecules.
- Cracking can be done by various methods including ***catalytic cracking*** and ***steam cracking***.
- Students should be able to describe in ***general terms*** the ***conditions*** used for catalytic cracking and steam cracking.
- The products of cracking include ***Alkanes*** and another type of Hydrocarbon called ***Alkenes***.
- Alkenes are ***more reactive*** than Alkanes and react with ***Bromine water***, which is used as a test for alkenes.
- Students should recall the ***colour change*** when Bromine water reacts with an Alkene.
- There is a ***high demand*** for fuels with ***small molecule***s and so some of the products of cracking are useful as fuels.
- Alkenes are used to produce ***polymers*** and as starting materials for the production of many other chemicals.
- Students should be able to ***balance chemical equations*** as examples of cracking given the formulae of the reactants and products.
- Students should be able to ***give examples*** to illustrate the usefulness of cracking.
- They should also be able to ***explain*** how modern life depends on the uses of Hydrocarbons.

Where does oil come from?

Most people know that oil comes from ***oil-wells*** drilled into ***oil-fields*** underground.

But many people think of oil-fields as being giant underground caves filled with oil.

Actually, they are layers of rock with oil ***between*** the grains like water in a sponge.



That's why it's so difficult to extract.

A bigger question ***is*** what is Crude Oil?

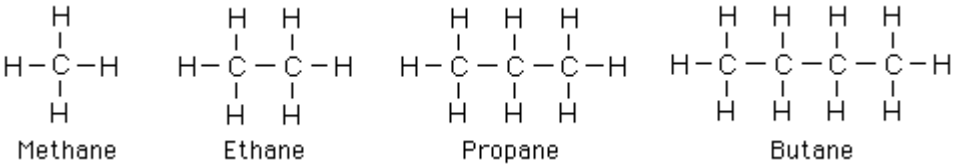
It is a ***mixture*** of Hydrocarbons. But different oil fields have different mixtures because the oil came from organisms living in different types of sea. So it can be thick and black, or quite runny and light brown.

Alkanes

Alkanes are a family (*Homologous Series*) of Hydrocarbons.

Hydrocarbons contain nothing but Carbon and Hydrogen.

They are said to be ***saturated*** because they have <u>*no double bonds*</u> and so contain the maximum number of Hydrogen atoms.



This lesson involves …

*Generalisation
*Connection-finding
*Big Picture Thinking
*Abstraction
*Imagination

Q1. Write the Formulae of the first four alkanes.

Q2. Complete the sentence:

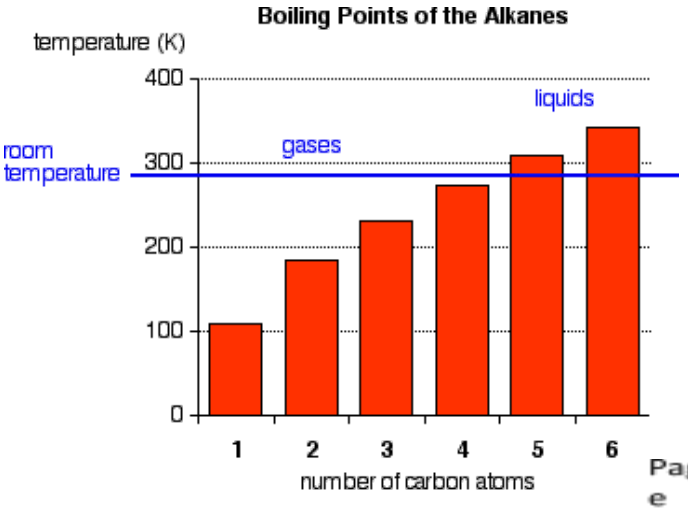
"For every extra Carbon atom another _____ Hydrogen atoms are added".

Q3. The general formula for alkanes (where there are n Carbon atoms) is:

C_nH_____

Q4. Write down the formula of an Alkane with 20 carbon atoms.

Q5. Look at the graph of boiling points of Alkanes below:



a) Which alkanes are gases at Room Temp?

b) What is the trend shown in this graph?

c) As the number of Carbon atoms increases, what happens to the intermolecular forces between Hydrocarbon molecules? How do you know?

d) Using the graph, suggest a boiling point in Kelvin (K) for alkanes with 7 carbons.

Naming Alkanes.

All Alkanes end with the suffix ***–ane***.

The prefix (start of the name) tells you how long the carbon chain is.

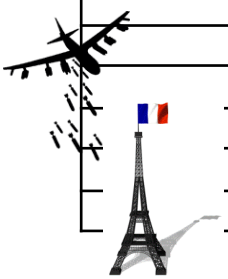
Many of these are the same as in the names of Polygons you learn in Maths.

To remember the own

Or learn:

My **E**vil **P**lane

Number of Carbon atoms	Prefix
1	Meth
2	Eth
3	Prop
4	But
5	Pent
6	Hex
7	Hept
8	Oct
9	Non
10	Dec



Prefixes you can make up your Mnemonic.

Bombed **P**aris, **H**a **H**a

Q1. Name the alkanes shown below.

Q2. Draw a picture of Nonane and Decane.

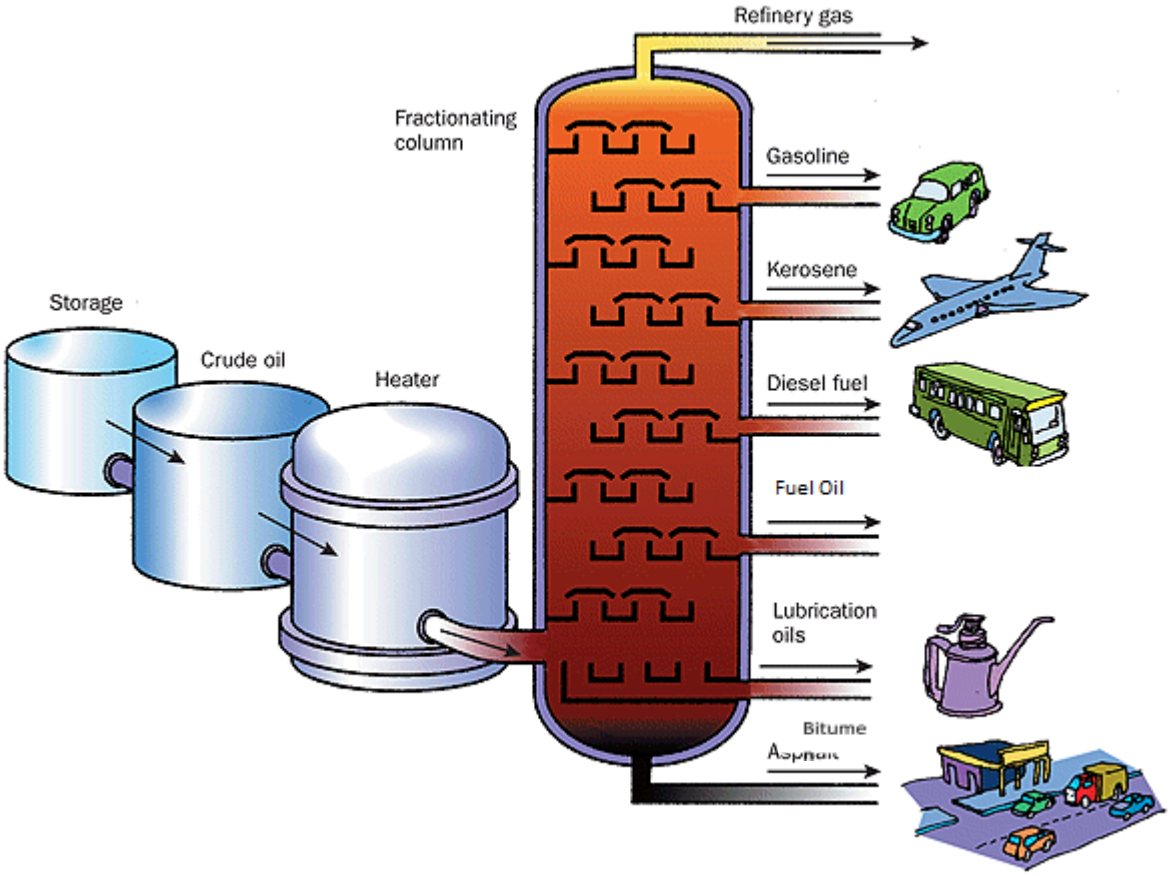
Separating Crude Oil

Mixed together the compounds in Crude Oil are almost useless.

They're even quite difficult to set fire to – although when oil-wells catch fire they're very difficult to put out.

To make oil really useful we separate the compounds into ***Fractions*** – groups of Hydrocarbons of a similar length that have similar ***physical properties***.

The separation technique used is called ***Fractional Distillation*** – ***Fractional*** because it separates into fractions, ***Distillation*** because it involves boiling and condensing (most) fractions.



Q1 Why is it necessary to ***heat*** the oil?

Q2 What would the danger be if ***air/oxygen*** got into the heater?

Q3. What would ***refinery gas*** be used for?

Q4. What is ***Bitumen*** used for?

Q5. Some people have deliveries of ***fuel oil*** to their houses. What for?

Q6. Two of these fractions are ***not*** fuels. Which ones?

Q7. Where would the hottest part of the ***fractionating column*** be?

Q8. One of the fractions never boils and so always remains a liquid. Which one?

Q9. One fraction never condenses and so stays a gas. Which one?

Q 10. The fractions are not pure substances. They are mixtures of similar compounds. Why do you think we don't bother to separate them further?

Q11. What does the word ***viscous*** mean?

Q12. Which fraction is the ***most*** viscous?

Q13. Which fraction is the easiest to ignite (set fire to)?

Q14. Which fraction burns with the cleanest flame?

Q15. Which fraction has molecules with the most energy?

Q16. Which fraction has the strongest intermolecular forces? How can we know?

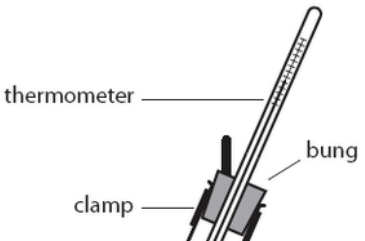
Q17. Complete the trends;

As we go down the fractionating column the boiling point of the fractions _____

As we go up the fractionating column the viscosity of the fractions _____

As we go down the fractionating column the intermolecular forces of the fractions _____

Practical Task



- Set up the apparatus carefully, making sure that the heat is pointing away from the delivery tube and away from the bung.
- Heat strongly, collecting the condensing liquid in an ignition tube.
- When the condensing liquid is beginning to change colour change tube to collect a new fraction.
- Try to collect at least 3 different fractions.
- Your teacher may allow you to burn them later!

This lesson involves …

*Enquiring
*Creative/Enterprising
*Open-minded
*Risk-taking

Q1. What do you notice about the colours of the fractions you collected?

Q2. Was there any change in temperature as the fractions changed?

Q3. If you saw your fractions burning: which ones lit most easily?

Which ones had the smokiest flames?

Catalytic Cracking

Long fractions burn poorly and are in low demand.

The biggest demand is for ***petrol*** because it burns well and has quite a lot of energy. But it is a ***short fraction*** which makes up less than 20% of Crude Oil.

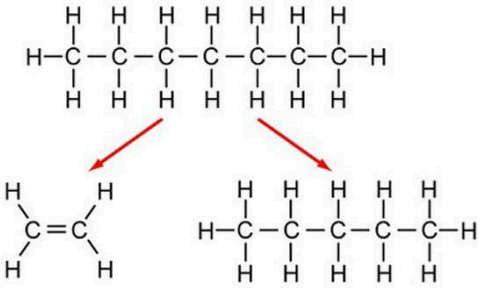
This means that either there would not be enough petrol to go round, or we would have to extract more oil and simply waste the long fractions.

The solution is to shorten long molecules to make more useful shorter ones

This process is called ***Catalytic Cracking***.

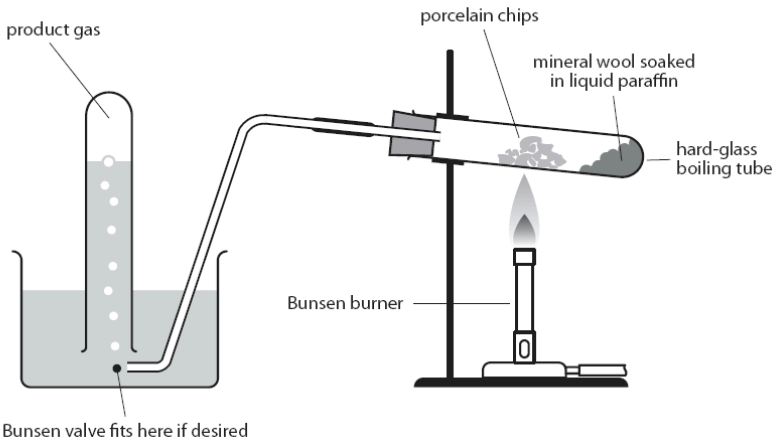
A catalyst allows the reaction to happen but isn't used up.

Long Alkane → Shorter Alkane + Alkene



Practical Task.

- Set up the apparatus.
- Heat the broken pottery strongly.
- Then begin to heat the mineral wool, occasionally reheating the pottery.
- When you have a full tube of product gas you must continue to heat while you put a bung in the tube.
- Do not stop heating until you have taken the delivery tube out of the water.
- Test the gas with Bromine water.



Q1. What happened to the Bromine water?

Q2. Why?

This lesson involves …

*Enquiring
*Creative/Enterprising
*Open-minded
*Risk-taking

Page PAGE * MERGEFORMAT 137

Q3. What would happen if we tested the natural gas from the gas-taps with Bromine water?

Q4. Why?

Q5. Why remove the delivery tube from the water before stopping heating?

Q6. What is the job of the broken pottery?

Q7. Under what conditions does industry crack long oil fractions?

Q8. Why does the oil industry bother to crack some fractions?

Q9. Apart from shorter alkanes what other useful products does cracking make and what are they used for?

Q10. How can we test the products of cracking to prove one of them contains a C=C double bond?

Combustion of Alkanes.

Alkanes have ***very strong bonds***, so few other substances react with Alkanes.

However, they burn well in air making CO_2 and water – ***Combustion***.

eg. $C_3H_8 + O_2 \rightarrow CO_2 + H_2O$

Unbalanced: Too few Carbons on right

Unbalanced: Too few Hydrogens on right

$C_3H_8 + O_2 \rightarrow 3CO_2 + 4H_2O$

Unbalanced: Too few Oxygens on left

$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

H_2O

This lesson involves …

*Logical Thinking
*Precision
*Multi-step problem-solving

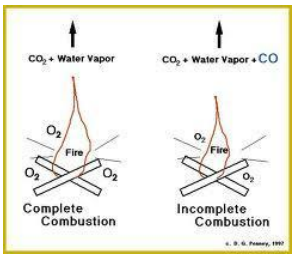
Q1. Write balanced symbol equations for the combustion of:

a) $CH_4 + O_2 \rightarrow$

b) $C_5H_{12} + O_2 \rightarrow$

c) $C_9H_{20} + O_2 \rightarrow$

Q2. If there is too little Oxygen for Complete Combustion then Incomplete Combustion will happen. Why is this a problem?



Q3. What is the purpose of Red blood cells? What will happen if they can no longer carry out this job?

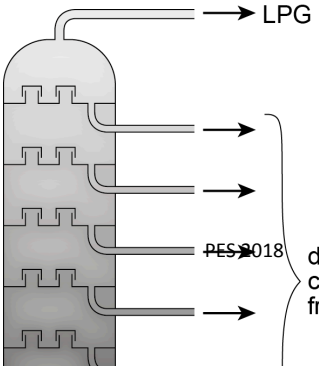
Extended Response Question

Fractional distillation and petrochemicals

Crude oil is a mixture of hydrocarbons.

This mixture can be separated into different parts by fractional distillation using a fractionating column as shown in **Figure 5**.

Figure 5



Give the general formula of the alkane homologous series. **[1 mark]**

Compare the properties of hydrocarbon molecules in the bitumen fraction with those of the LPG fraction. Include reference to how this allows these molecules to be separated into fractions.

[6 marks]

Mark scheme

Answers	Mark
C_nH_{2n+2}	1
Level 2: Scientifically relevant features are identified; the way(s) in which they are similar/different is made clear and (where appropriate) the magnitude of the similarity/difference is noted.	4–6
Level 1: Relevant features are identified and differences noted.	1–3
No relevant content	0
Indicative content **Molecular properties** Similarity ● **Both** are mixtures of hydrocarbons **or** reference to **both** not being one pure substance. Differences ● Reference to the different boiling points of the molecules / LPG has a lower boiling point (than bitumen) / or reverse argument (ORA.) ● Reference to the different viscosity of the molecules/ LPG are gases and flow easily but bitumen is a thick liquid and flows slowly. ● Reference to the different flammability of the molecules/ LPG is very **or** highly flammable/burns easily but bitumen is not very flammable/does not burn easily. **Separation** ● Reference to the temperature gradient of the fractionating column. ● Smaller molecules have lower boiling points / ORA. ● Intermolecular forces between small molecules are weak(er) / ORA / Smaller molecules have less intermolecular forces / ORA. ● The weaker the intermolecular forces then the less energy **or** heat is required to break them / ORA. ● So, LPG (at the top of the column) is made up of small(er) molecules ● And bitumen (at the bottom of the column) is made up of large(r) molecules.	

Extended Response Question

Cracking

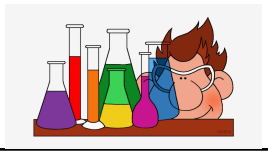
After Crude oil is distilled, some fractions then undergo one of two forms of Thermal Decomposition: either **Catalytic Cracking** Or **Steam Cracking**

Explain what is meant by Thermal Decomposition, how & why it is carried out, and why one method of cracking may be preferred to the other. Include a symbol equation for cracking Decane ($C_{10}H_{22}$) in your answer.

[6 marks]

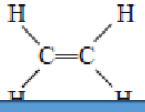
Mark scheme

Answers	Mark



Level 2: A definition of Thermal decomposition **and** reasons for cracking **and** a suitable equation **and** the conditions for one method **and** reasons for the choice of method of cracking	
Level 1: A definition of Thermal decomposition **and/or** reasons for cracking **and/or** a suitable equation **and/or** the conditions for one method **and/or** reasons for the choice of method of cracking	1–3
No relevant content	0
Indicative content **Thermal Decomposition –** Breaking down/ Breaking up (long) molecules using heat **Conditions** ● **Catalytic cracking** uses a high temperature and a catalyst ● The catalyst may be Aluminium Oxide/Alumina/ Pottery or Zeolites ● **Steam cracking** uses a high temperature and a **catalyst and is done in the presence of steam** **Differences** ● Both methods crack long alkanes into short(er) alkanes and alkenes (and Hydrogen) ● Shorter alkanes are more valuable, burn more easily, make better fuels **Reasons for cracking** ● Alkenes can be made into other products/ polymers ● Hydrogen can be used as fuel/ in the Haber process or to make other products ● There is an over supply of long alkanes ● There is an undersupply or shorter alkanes ● The products of cracking can be sold for a higher price than the longer alkanes **Equation** ● $C_{10}H_{22}$ □ $C_8H_{18} + C_2H_4$ or similar state symbols not required	($C_{10}H_{22}$)□

8 A teacher explained the different types of formula used in organic chemistry, using ethene as an example.

Description	Formula
general	C_nH_{2n}
empirical	CH_2
molecular	C_2H_4
structural	$CH_2{=}CH_2$
displayed	

This lesson involves …

*Practice
*Perseverance
*Resilience

(a) Use this example to help you write the formulae described below.

(i) The empirical formula of methane

(1)

(ii) The molecular formula of ethane

(1)

11 2c Alkenes

(c) All the compounds in part (a) are hydrocarbons. They can undergo complete combustion when burned in oxygen to form carbon dioxide and water.

(i) Write a chemical equation for the **complete** combustion of propane (C_3H_8).

(2)

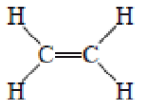
(ii) Identify one solid product and one gaseous product that could form during the **incomplete** combustion of propane.

(2)

Solid product

Gaseous product

4 Here are some statements about the compound ethene.

- ethene has the displayed formula 
- ethene is a gas at room temperature
- ethene burns with a smoky flame
- ethene is unsaturated
- ethene is insoluble in water
- ethene can be prepared from ethanol
- ethene is used to make the polymer poly(ethene)

This lesson involves ...

*Practice
*Perseverance
*Resilience

(a) (i) State why ethene is described as **unsaturated**.

(1)

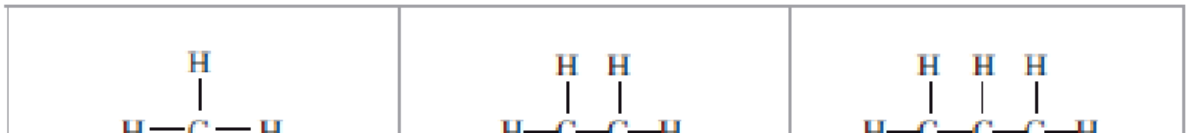
(ii) Describe a chemical test to show that ethene is an alkene.

(2)

Test

Result

5 These are the displayed formulae of six organic compounds.



(d) Three of the compounds belong to the alkane homologous series.
All the alkanes in this homologous series have the same general formula.

(i) What is the general formula of the alkanes?

(1)

.....

(ii) State **two** other features of a homologous series.

(2)

1 .....

.....

2 .....

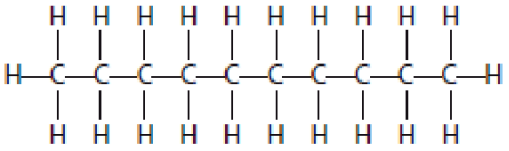
.....

This lesson involves ...

*Practice
*Perseverance
*Resilience

7 Decane is a hydrocarbon found in crude oil.

The diagram shows the structure of a decane molecule.



(a) (i) Explain why decane is described as a hydrocarbon.

(2)

.....

.....

(ii) Give the molecular formula for decane.

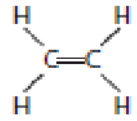
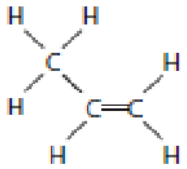
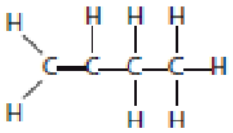
(1)

.....

(c) Explain why cracking is an important process in the oil industry.

(4)

5 The table shows the displayed formulae of three unsaturated hydrocarbons.

		
Compound **A**	Compound **B**	Compound **C**

This lesson involves …

*Practice
*Perseverance
*Resilience

(a) Explain the meaning of the term **hydrocarbon**.

(2)

(b) Explain the meaning of the term **unsaturated**.

(1)

(c) Compounds **A**, **B** and **C** belong to the same homologous series. One characteristic of the compounds in a homologous series is that they have the same general formula.

(i) State the name of this homologous series.

(1)

(ii) State the general formula of this homologous series.

(1)

(iii) State **two** other characteristics of the compounds in a homologous series.

(2)

1 .....

.....

2 .....

.....

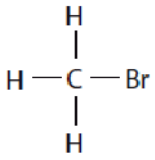
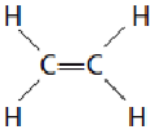
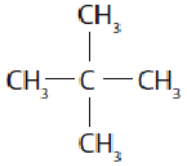
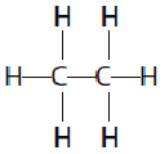
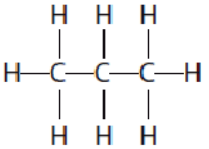
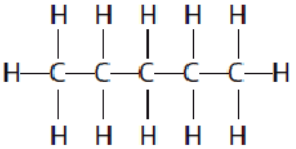
(e) Bromine water can be used to distinguish compound **A** from ethane.

(i) Complete the sentence to show the colour change when compound **A** is bubbled through bromine water.

(1)

Bromine water changes from orange to ..... .

6 The table shows the structures of six organic compounds, A to F.

A 	**B** 	**C** 
D 	**E** 	**F** 

(a) The letter of the compound in the table that is **not** shown as a displayed formula is .....

(1)

(b) **(i)** State what is meant by the **term hydrocarbon**, and give the letter of one compound in the table that is **not** a hydrocarbon.

(3)

Hydrocarbon .....

.....

Letter .....

(ii) State what is meant by the **term unsaturated**, and give the letter of one **compound** in the table that is unsaturated.

(2)

Unsaturated .....

.....

Letter .....

(c) Some of the compounds in the table are members of the same homologous series.

(i) One feature of a homologous series is that adjacent members have formulae that differ by CH_2

State two other features of members of the same homologous series.

(2)

1 .....

.....

2 .....

.....

(ii) Give the letters of two adjacent members of the same homologous series shown in the table.

(1)

Letters ..... and .....

(c) Heptane belongs to a homologous series of compounds called alkanes.

The general formula of the alkanes is C_nH_{2n+2}

(i) Heptene belongs to a homologous series of compounds called alkenes.

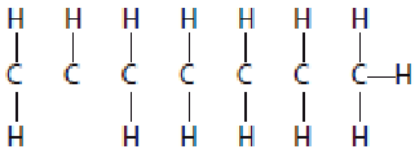
Give the general formula of the alkenes.

(1)

.....

(ii) Complete the following diagram to show the structural formula of heptene (C_7H_{14}) by inserting lines to represent the covalent bonds between the carbon atoms.

(2)



This lesson involves ...

*Practice
*Perseverance
*Resilience

(d) When heptene is added to bromine water, and the mixture is shaken, a reaction occurs.

State the type of reaction and give the colour of the bromine water before and after the reaction with heptene.

(3)

Type of reaction.....

Colour before.....

Colour after.....

(e) Explain, in terms of the bonds present, why heptane is described as saturated and heptene as unsaturated.

(2)

.....

.....

.....

.....

(Total for Question 5 = 11 marks)

(ii) What is the relationship between the boiling point of an alkane and the number of carbon atoms in its molecule?

(1)

.....

.....

.....

.....

(c) Many plastic bags are not biodegradable.

Used plastic bags can be

A buried underground, which is called landfill

or

B burned to release energy, which also produces large amounts of gases.

Suggest which of these methods of disposal is better for the environment, giving two reasons for your choice.

(2)

This lesson involves ...

*Practice
*Perseverance
*Resilience

Choice .....

Reason 1 .....

.....

.....

.....

Reason 2 .....

.....

6 The table gives some data about the first six members of a homologous series of compounds called the alkanes.

Alkane	Molecular formula	Relative formula mass	Boiling point in °C
methane	CH_4	16	–164
ethane	C_2H_6	30	–87
propane	C_3H_8	44	–42
butane	C_4H_{10}		0
pentane	C_5H_{12}	72	
hexane		86	69

This lesson involves …

*Practice
*Perseverance
*Resilience

(a) Complete the table by

- giving the molecular formula of hexane
- giving the relative formula mass of butane
- suggesting the boiling point of pentane

(3)

(b) What does the data show about the relationship between boiling point and relative formula mass?

(1)

.....

.....

.....

(c) The molecular formula of ethene is C_2H_4

Ethene and ethane are in different homologous series.

Explain how the formulae of these compounds show that they are in different series.

(1)

.....

.....

(c) The equation for one reaction that could occur in process 2 is

$$C_xH_y \rightarrow C_5H_{12} + 2C_2H_4$$

(i) Deduce the formula of C_xH_y

(1)

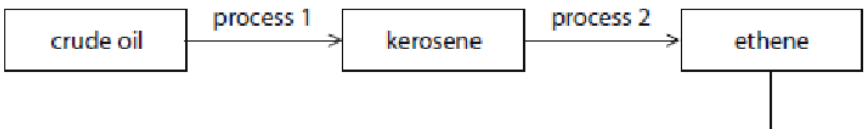
(ii) Give the name of the compound C_5H_{12}

(1)

(iii) Draw the displayed formula of C_2H_4

(1)

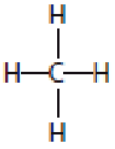
5 The diagram shows some important conversion processes used in the oil industry.



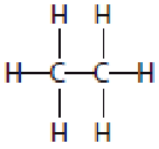
This lesson involves …

*Practice
*Perseverance
*Resilience

9 The diagram shows the displayed formulae of five hydrocarbons A, B, C, D and E.



A



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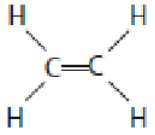

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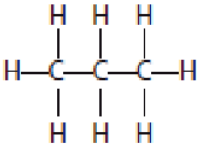
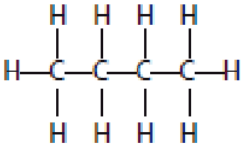


D



E

(a) Give the letter of a hydrocarbon to answer these questions.

You may use each letter once, more than once or not at all.

(i) Which hydrocarbon is the main component of natural gas?

(1)

.....

(ii) Which other hydrocarbon is produced, together with D, when pentane (C_5H_{12}) is cracked?

(1)

.....

(iii) Which hydrocarbon can undergo an addition reaction with hydrogen to form B?

(1)

.....

(c) Hydrocarbons A, B, D and E all belong to the same homologous series.

(i) Give the name and the general formula of this homologous series.

(2)

name .....

general formula .....

(d) Two reactions that can occur when hydrocarbon A is burned in air are represented by these equations.

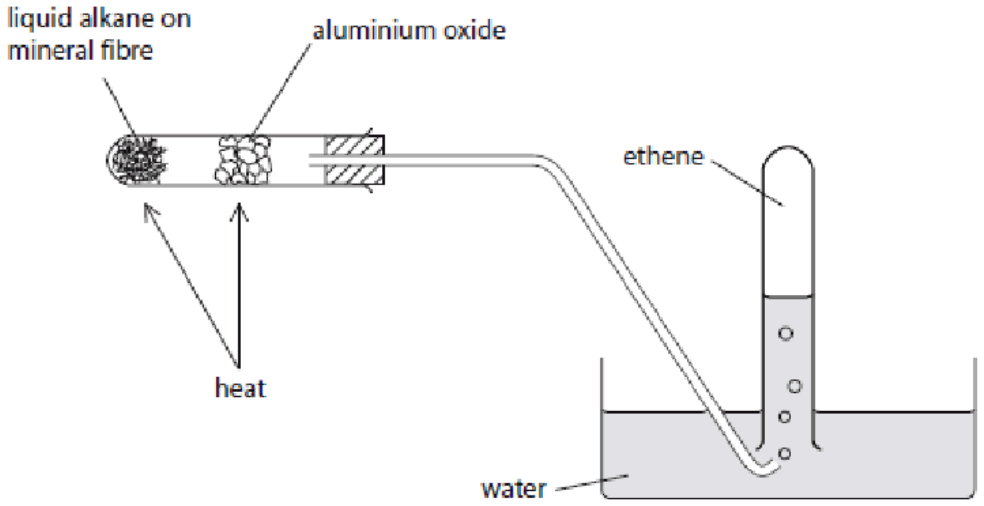
Equation for reaction 1 $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

Equation for reaction 2 $CH_4 + 1½O_2 \rightarrow CO + 2H_2O$

Explain why a different product is formed in reaction 2 and why this product is dangerous.

(3)

11 This apparatus can be used to obtain ethene by cracking a liquid alkane.



(a) What is meant by the term **cracking**?

(1)

(b) Give a chemical test to show that the gas collected is unsaturated.

(2)

(c) Cracking is also carried out in industry.

Give the name of the catalyst and the temperature used in the catalytic cracking of hydrocarbons.

(2)

catalyst .....

temperature .....

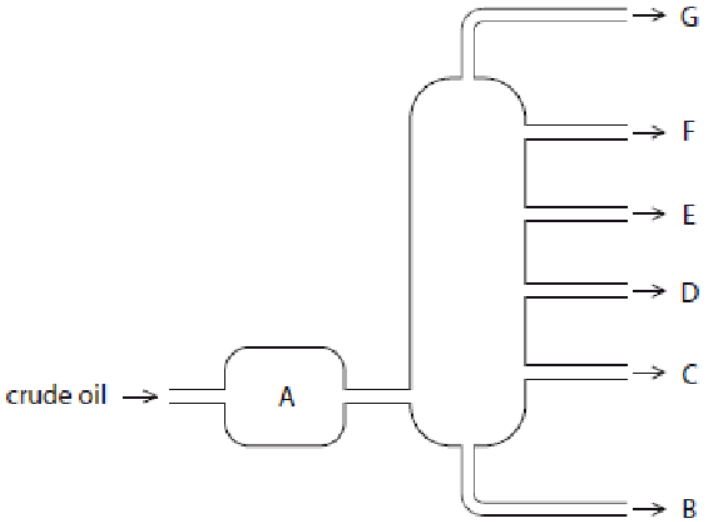
(Total for Question 11 = 5 marks)

6 Crude oil is an important source of organic compounds.

(a) The diagram shows how crude oil is separated into fractions in the oil industry.

This lesson involves …

*Practice
*Perseverance
*Resilience



(i) What happens to the crude oil in A?

(1)

(ii) Most of the compounds in crude oil are hydrocarbons.

What is meant by the term **hydrocarbons**?

(2)

(b) Some of the fractions are catalytically cracked. The general equation for some reactions in this process is

alkane → alkane + alkene

(i) State two conditions used in catalytic cracking.

(2)

(d) Ethene and acetylene can both be used for welding metals.

The equations for the reactions of these gases in welding are

ethene $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$

acetylene $C_2H_2 + 2.5O_2 \rightarrow 2CO_2 + H_2O$

This lesson involves ...

*Practice
*Perseverance
*Resilience

One problem with using hydrocarbons as fuels is incomplete combustion.

(i) Incomplete combustion is a bigger problem with ethene than with acetylene.

Suggest why.

(1)

.....

.....

.....

(ii) One of the gases produced during incomplete combustion is dangerous to humans.

Identify this gas and explain how it is dangerous.

(3)

.....

.....

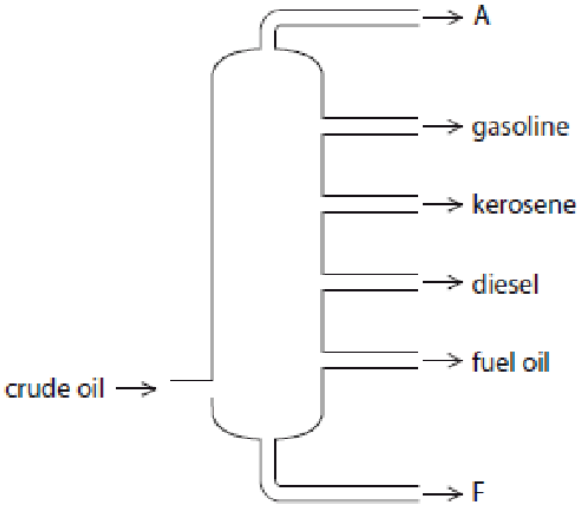
.....

.....

.....

.....

6 The diagram shows a typical fractionating column used to separate crude oil into fractions.



This lesson involves ...

*Practice
*Perseverance
*Resilience

(a) The diagram shows the names of some of the fractions.

State the name of fraction A and the name of fraction F.

(2)

fraction A .....

fraction F .....

(b) Most compounds in crude oil are hydrocarbons.

State the meaning of the term **hydrocarbons**.

(2)

.....

.....

(c) Describe how the boiling point, colour and viscosity of the fuel oil fraction differ from those of the gasoline fraction.

(3)

(d) Some fuel oil undergoes catalytic cracking. This involves the conversion of long-chain alkanes into alkenes and short-chain alkanes.

(i) A temperature of about 650 °C is used in this process.

Identify a catalyst that is used.

(1)

(ii) The alkane tridecane can be cracked to produce octane and two different alkenes.

Complete the equation to show the formulae of the two alkenes.

(2)

$C_{13}H_{28} \rightarrow C_8H_{18}$ + ... + ...

This lesson involves …

*Practice
*Perseverance
*Resilience

(c) State the relationship between the number of carbon atoms per molecule and the boiling point of the fraction.

(1)

.....

.....

2 The diagram shows the separation of crude oil into fractions.

Fraction	Typical number of carbon atoms per molecule

This lesson involves …

*Practice
*Perseverance
*Resilience

7 Alkanes are saturated hydrocarbons that can be obtained from crude oil.

The general formula of the homologous series of alkanes is C_nH_{2n+2}

(a) (i) What is the meaning of the term **saturated**?

(1)

(ii) What is the meaning of the term **hydrocarbons**?

(2)

(iii) Pentane is an alkane with five carbon atoms in its molecule.

What is the molecular formula of pentane?

(1)

- ☐ **A** C_5H_8
- ☐ **B** C_5H_{10}
- ☐ **C** C_5H_{12}
- ☐ **D** C_5H_{14}

(b) (i) Octane (C_8H_{18}) is an alkane that is present in petrol.

When octane burns completely in oxygen it forms carbon dioxide and water.

Write a chemical equation for the complete combustion of octane.

(2)

(ii) Give the name of a toxic gas that may be produced by the incomplete combustion of octane.

(1)

(c) Dodecane ($C_{12}H_{26}$) is another alkane. When heated and passed over a suitable catalyst, it decomposes to form octane and one other hydrocarbon.

(i) State how a catalyst increases the rate of this decomposition.

(1)

(ii) Give the name of a suitable catalyst for this process.

(1)

(iii) Complete the equation that represents the reaction

(1)

$$C_{12}H_{26} \rightarrow C_8H_{18} + 2 \text{.....}$$

(iv) Name the other hydrocarbon produced in this reaction.

(1)

This lesson involves ...

*Automaticity
*Speed & Accuracy

2 Ethene is an unsaturated hydrocarbon.

(a) (i) The molecular formula of ethene is

(1)

- ☐ **A** CH_4
- ☐ **B** C_2H_6
- ☐ **C** C_2H_4
- ☐ **D** C_3H_6

(ii) Ethene is bubbled into bromine water until there is no further change.

What is the appearance of the solution formed?

(1)

- ☐ **A** brown
- ☐ **B** colourless
- ☐ **C** purple
- ☐ **D** red

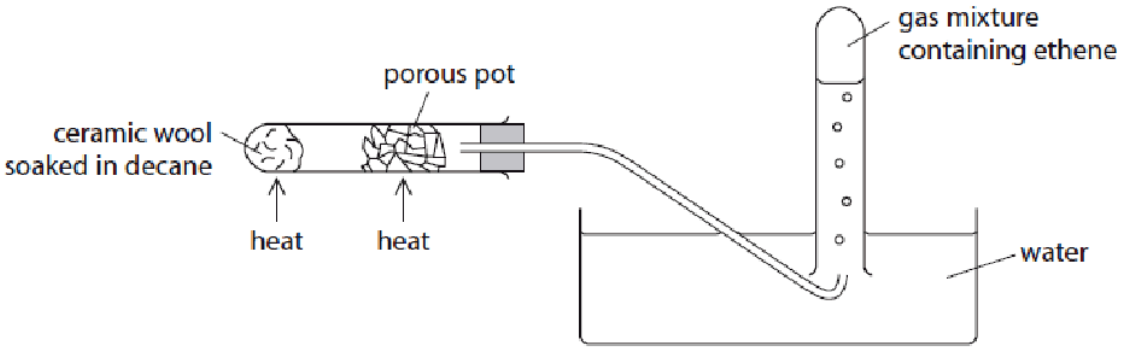
(iii) Ethene can be formed from ethanol.

This type of reaction is called

(1)

- ☐ **A** dehydration
- ☐ **B** oxidation
- ☐ **C** reduction
- ☐ **D** substitution

(b) This apparatus can be used to decompose decane ($C_{10}H_{22}$).



(i) What name is given to this type of thermal decomposition?

(1)

.....

(ii) Porous pot contains oxides such as silica and alumina.

What is the purpose of the porous pot in this experiment?

(1)

.....

.....

(iii) Suggest why the gas collected is a mixture and not pure ethene.

(1)

.....

.....

(Total for Question 2 = 6 marks)

10 Alkenes are unsaturated hydrocarbons.

(a) State what is meant by the term **unsaturated**.

(1)

.....

.....

(b) One method of producing alkenes is by cracking alkanes.

(i) Complete the equation for the cracking of decane into octane (C_8H_{18}) and ethene.

(1)

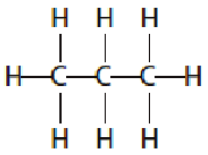
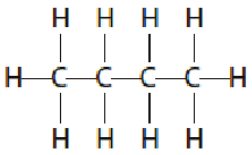
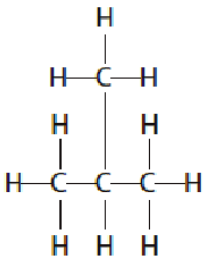
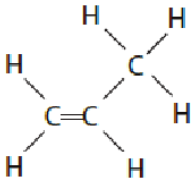
$C_{10}H_{22} \rightarrow$ ..... + ...

decane

This lesson involves ...

*Practice
*Perseverance
*Resilience

11 The table shows the displayed formulae of four hydrocarbons, W, X, Y and Z.

W 	**X** 
Y 	**Z** 

This lesson involves …

*Automaticity
*Speed & Accuracy

(a) Give the name of hydrocarbon W.

(1)

.....

(b) Give the molecular formula for hydrocarbon X.

(1)

.....

(c) Which of the hydrocarbons belong to the same homologous series of compounds?

(1)

.....

(e) Z is an unsaturated hydrocarbon.

Explain what is meant by the term **unsaturated hydrocarbon**.

(3)

unsaturated .....

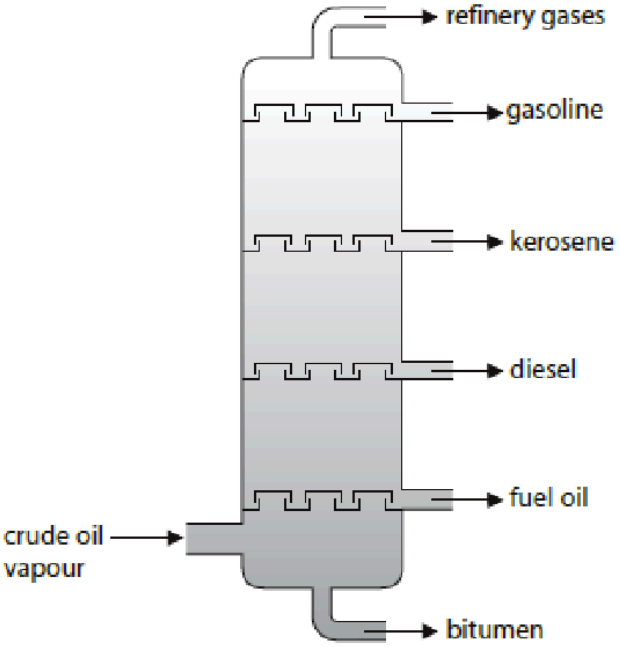
.....

hydrocarbon .....

.....

.....

7 Crude oil is a complex mixture of organic compounds called hydrocarbons. It is separated into fractions using a fractionating tower.



This lesson involves ...

*Automaticity
*Speed & Accuracy

(a) Which fraction has the lowest boiling point?

(1)

(b) Which fraction is the most viscous?

(1)

11 Synthetic polymers are often manufactured from crude oil.

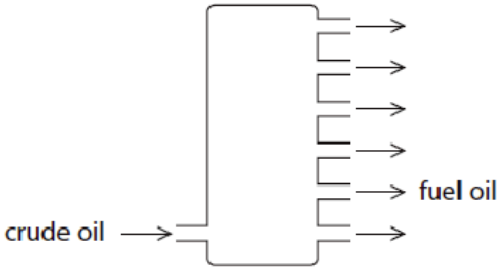
The main stages in the manufacture of one of these polymers are shown in this sequence.

crude oil → fuel oil → propene → poly(propene)

This lesson involves ...

*Practice
*Perseverance
*Resilience

(a) The diagram represents the fractionating column used in an oil refinery.



Describe how fractional distillation produces fuel oil from crude oil.

(4)

(b) Catalytic cracking at about 650 °C converts fuel oil into propene.

(i) Name a catalyst used in this process.

(1)

(ii) One of the compounds in fuel oil has the formula $C_{17}H_{36}$

Complete the equation for the cracking of one molecule of $C_{17}H_{36}$ to form two molecules of propene and one molecule of another compound.

(1)

$C_{17}H_{36} \rightarrow 2C_3H_6 +$ .....

(iii) Explain why all the compounds in this cracking reaction are classified as hydrocarbons.

(2)

This lesson involves ...

*Automaticity
*Speed & Accuracy

(iv) Explain which two compounds in this cracking reaction are described as saturated.

(2)

(b) The table lists some statements about cracking.

Place ticks (✓) in the boxes to show the three correct statements.

(3)

the molecules that are cracked are hydrocarbons	
catalytic cracking uses iron as the catalyst	
cracking is used because of different demands for hydrocarbons	
cracking reactions are examples of addition reactions	
cracking produces molecules with shorter chains	
$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ is an equation for a cracking reaction	

(c) When one molecule of butane is cracked, there are three possible reactions.

The equations for these reactions are

reaction 1 $C_4H_{10} \rightarrow C_3H_6 + CH_4$

reaction 2 $C_4H_{10} \rightarrow C_2H_6 + C_2H_4$

reaction 3 $C_4H_{10} \rightarrow C_4H_8 + H_2$

(i) One product in each of these reactions is an alkene.

What is the general formula for the homologous series of alkenes?

(1)

.....

(ii) What are the names of the products of reaction 1?

(2)

..... and .....

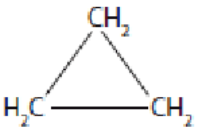
(iii) Draw the displayed formula of the saturated product of reaction 2.

(1)

11 The alkanes are a homologous series of hydrocarbons.

The cycloalkanes are another homologous series of hydrocarbons, where the carbon atoms are arranged in a ring structure.

Cyclopropane is the simplest cycloalkane. It can be represented as



The tables give the names and molecular formulae of the first three members of each series.

Name of alkane	Molecular formula
methane	CH_4
ethane	C_2H_6
propane	C_3H_8

Name of cycloalkane	Molecular formula
cyclopropane	C_3H_6
cyclobutane	C_4H_8
cyclopentane	C_5H_{10}

This lesson involves ...

*Automaticity
*Speed & Accuracy

(a) One feature of a homologous series is that each member has the same general formula.

(i) What is the general formula for the homologous series of alkanes?

(1)

☒ **A** C_nH_n

☒ **B** C_nH_{2n-2}

☒ **C** C_nH_{2n}

☒ **D** C_nH_{2n+2}

(ii) What is the general formula for the homologous series of cycloalkanes?

Use the information from the cycloalkane table to help you answer the question.

(1)

☒ **A** C_nH_n

☒ **B** C_nH_{2n-2}

☒ **C** C_nH_{2n}

☒ **D** C_nH_{2n+2}

(iii) State two other features of a homologous series of compounds.

(2)

1 .....

.....

2 .....

.....

(b) Alkanes and cycloalkanes are saturated hydrocarbons.

(i) State what is meant by the term **saturated**.

(1)

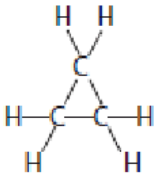
.....

.....

(ii) Draw the displayed formula for ethane, C_2H_6

(1)

(iii) The displayed formula for cyclopropane is



Draw a displayed formula for cyclobutane, C_4H_8

(1)

11.2 –Alkenes and Addition Polymers

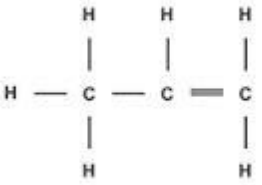
I have reviewed the syllabus statements for this topic	
I have completed the questions in this section	
I have read the relevant sections of the College Website	
I have made some revision material (mind-map, key-words & definitions etc)	
Prep Grade	
Test Grade	

Target	Pupil Signature

11.2 – Alkenes and Addition Polymers

Syllabus

- Alkenes are ***Hydrocarbons*** with a double Carbon-Carbon bond (C=C).
  - The ***general formula*** for the homologous series of Alkenes is C_nH_{2n}
- Alkene molecules are ***unsaturated*** because they contain two fewer Hydrogen atoms than the Alkane with the same number of Carbon atoms.
- The first four members of the homologous series of Alkenes are Ethene, Propene, Butene and Pentene.
- Alkene molecules can be represented in the following forms: C_3H_6 or

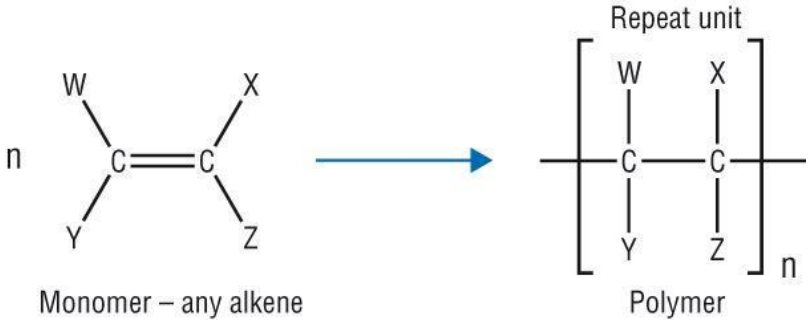


- Students do not need to know the names of alkenes other than ethene, propene, butene & pentene.

- Alkenes are Hydrocarbons with the functional group C=C.
- It is the generality of reactions of functional groups that determine the reactions of organic compounds.
- Alkenes react with Oxygen in combustion reactions in the same way as other Hydrocarbons, but they tend to burn in air with smoky flames because of incomplete combustion.
- Alkenes react with Hydrogen, water and the halogens, by the addition of atoms across the Carbon -Carbon double bond so that the double bond becomes a single Carbon-Carbon bond.
- Students should be able to:

1. describe the reactions and conditions for the addition of Hydrogen, water and Halogens to alkenes
2. draw displayed structural formulae of the first 4 Alkenes & the products of their addition reactions with Hydrogen, water, Chlorine, Bromine & Iodine.

- Alkenes can be used to make ***polymers*** such as ***poly(ethene)*** and ***poly(propene)*** by ***addition polymerisation.***
- In addition polymerisation reactions, many small molecules (***monomers***) join together to form very large molecules (***polymers***).



- Polymers have ***very large molecules***. The atoms in the polymer molecules are linked to other atoms by ***strong covalent bonds***. The ***intermolecular forces*** between polymer molecules are relatively strong and so these substances are ***solids*** at room temperature.
- Students should be able to ***recognise*** polymers from diagrams showing their bonding and structure.
- In addition polymers the ***repeating unit*** has the same atoms as the monomer because no other molecule is formed in the reaction.
- Students should be able to:

1. recognise addition polymers and monomers from diagrams in the forms shown and from the presence of the functional group C=C in the monomers
2. draw diagrams to represent the formation of a polymer from a given alkene monomer
3. relate the repeating unit to the monomer

Alkenes

Another ***homologous series*** of Hydrocarbons are the Alkenes.

Alkenes are said to be ***unsaturated*** because they contain double bonds.

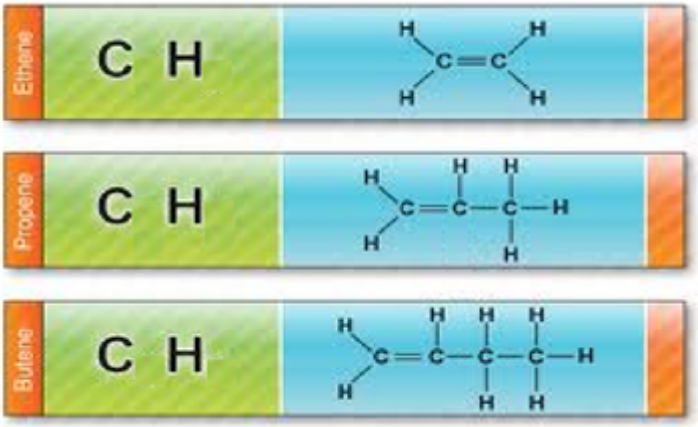
This lesson involves …

3

7

*Generalisation
*Connection-finding
*Big Picture Thinking
*Abstraction
*Imagination

Q1. Complete the formulae of the first 3 alkenes in the homologous series:



Q2. Why is there no Methene – an alkene with one Carbon atom?

Q3. The general formula of an alkene with n Carbon atoms is…. C_nH____

Q4. Alkenes also burn, although they're too useful to use as fuel.

Complete the equations for the combustion of Alkenes:

This lesson involves …

*Logical Thinking
*Precision
*Multi-step problem-solving

a) $C_2H_4 + O_2 \rightarrow CO_2 + H_2O$

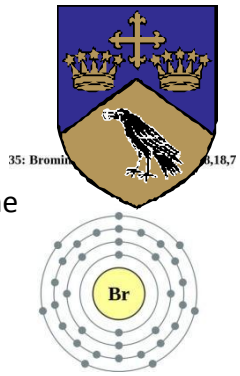
b) $C_6H_{12} + O_2 \rightarrow CO_2 + H_2O$

c) $C_8H_{16} + O_2 \rightarrow CO_2 + H_2O$

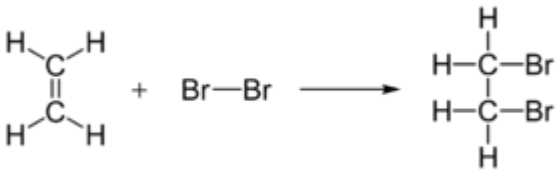
Q5. Another reason Alkenes aren't used as fuel is that their flames are generally very smoky. Why would a smoky flame in a domestic gas fire be undesirable?

Bromine and Alkenes.

- The reaction of Alkenes with Bromine or Bromine water is the test to show the hydrocarbon is unsaturated.



- No special conditions are necessary to start this reaction. It happens as soon as the reactants mix.
- Both Bromine atoms in the Bromine molecule (Br_2) bond to the same alkene molecule.
- They simply bond either side of the double bond making a single product.



Q1. What colour is Bromine/Bromine water? What colour is the product?

Q2. Why do you think this reaction is called an addition reaction?

Q3. Why do you think the product is known as a di-bromo compound?

Q4. Write a balanced symbol equation for the reaction above.

This lesson involves …

*Logical Thinking
*Precision
*Multi-step problem-solving

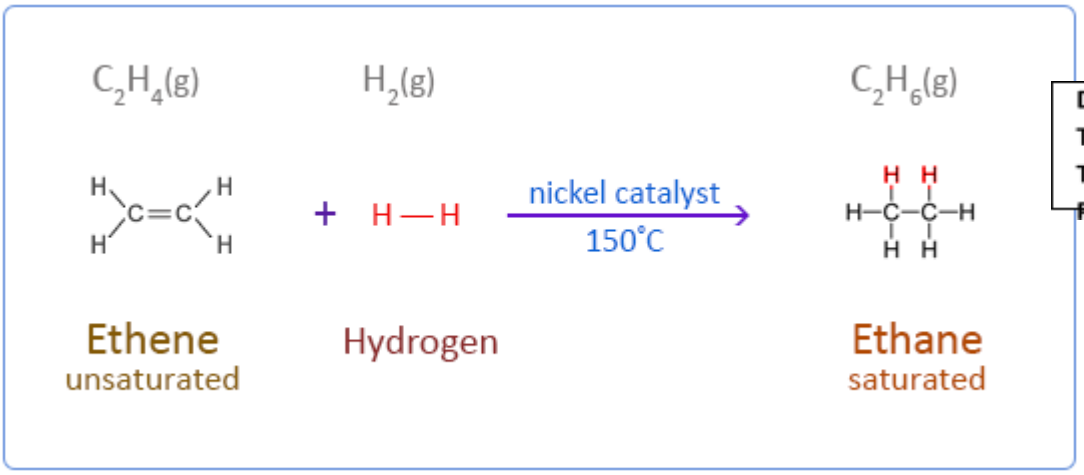
Q5. Draw the displayed formula of the products of

a) The reaction of Ethene with Chlorine (Cl_2)

b) The reaction of Propene with Iodine (I_2)

c) The reaction of Butene with Bromine (Br_2)

Other Addition Reactions



DON'T LEARN THE TEMPERATURE & PRESSURE!

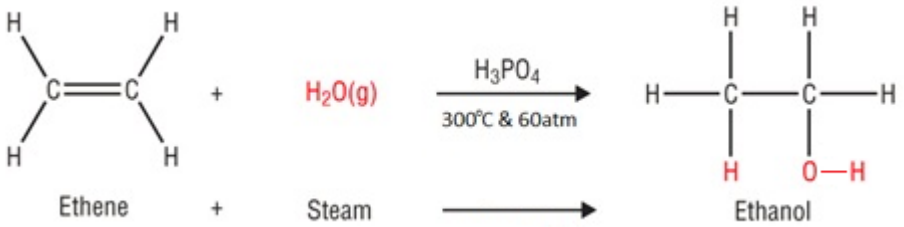
1. Alkenes don't react as easily with Hydrogen as they do with Halogens. What evidence is there for this in the conditions used above?

2. Explain why this is referred to as an addition reaction.

3. Why is Ethane Saturated while Ethene is Unsaturated?

4. Why are they both Hydrocarbons?

DON'T LEARN THE TEMPERATURE & PRESSURE!



5. Ethene can also react with steam. What evidence is there that this reaction is even more difficult to achieve?

6. Using displayed formulae, write reactions for :

a. Propene and Hydrogen

This lesson involves …

*Logical Thinking
*Precision
*Multi-step problem-solving

b. Butene and Steam

This lesson involves …

*Generalisation
*Connection-finding
*Big Picture Thinking
*Abstraction
*Imagination

c. Pentene and Hydrogen

d. Propene and Chlorine

Polymers and Monomers

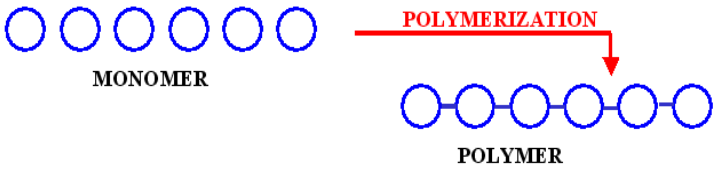
MONO- as in ***mono*rail**, ***mono*plane**, ***mono*cle** or even ***mono*-brow** means **ONE**: one rail, one wing, one lens, etc.

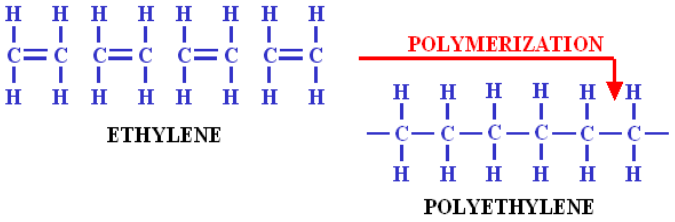
POLY- means **MANY** : a ***poly****glot* speaks many languages, a ***poly****gamist* has many wives etc.

In Chemistry a ***polymer*** is a long chain-molecule made up of many repeating units.

The short molecules the ***polymer*** is made from are called ***Monomers***.

The process of turning monomers into polymers is – ***Addition Polymerisation***.





Notice that the ***monomer*** (now called Ethene) contains a ***C=C double bond***.

The ***Polymer*** (now called (Polyethene) does not.

So the monomer is ***unsaturated*** and the polymer is ***saturated***.

Notice also that the polymer molecule doesn't end because we don't really know how many monomers will join together to form the polymer.

Q1. What would we call the polymers formed from:

a) Propene

b) Styrene

Q2. What would we call the monomer needed to produce:

a) Polychloroethene
b) Polymethacrylate

This lesson involves …

*Generalisation
*Connection-finding
*Big Picture Thinking
*Abstraction
*Imagination

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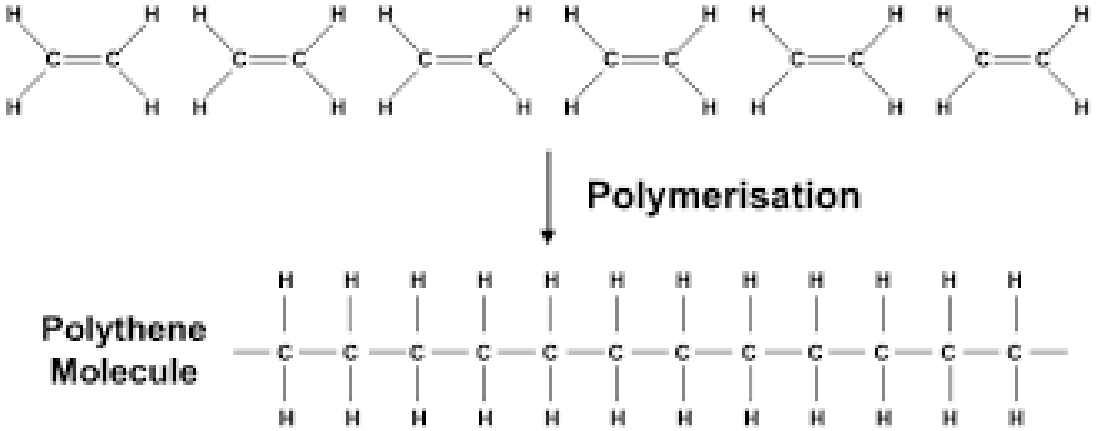
Repeat units and Polymerisation reactions.

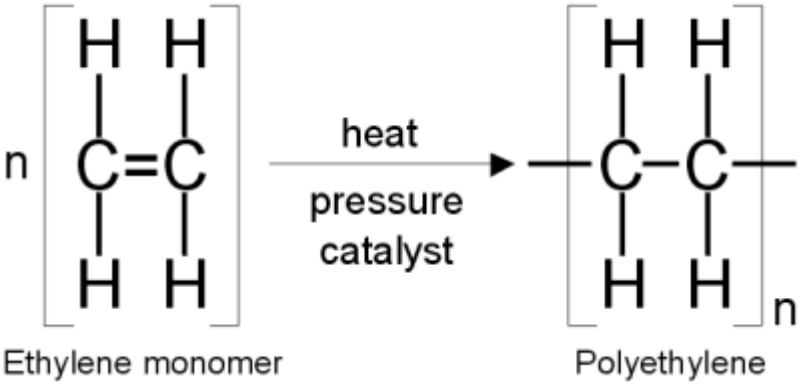
The diagram to the right shows the polymerisation reaction for



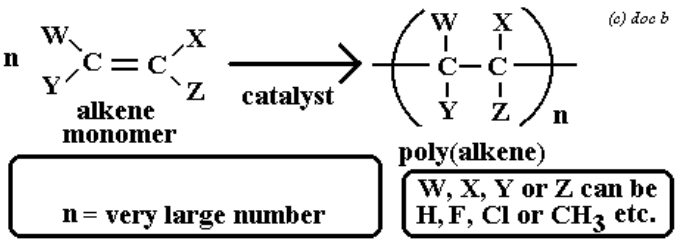
ethene.

But the problem with this is that it is impossible to draw the whole polyethene molecule or to say how many ethane molecules react to form it.

So we say that ***n*** ethane molecules react to make a chain containing ***n*** repeating units.

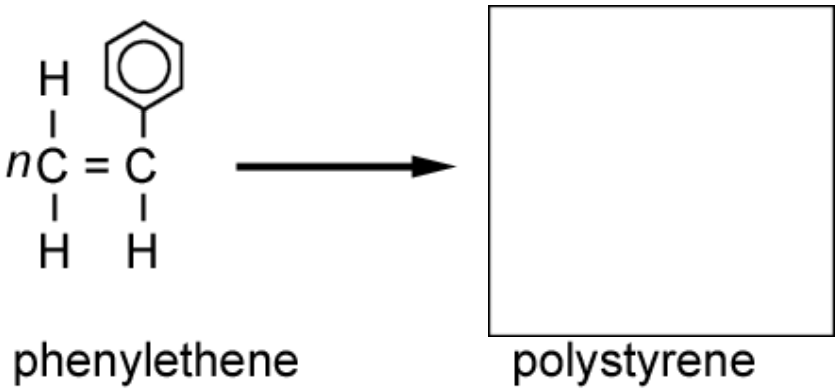


In general then;



(c) doc b

Q3. Complete the polymerisation equation for:

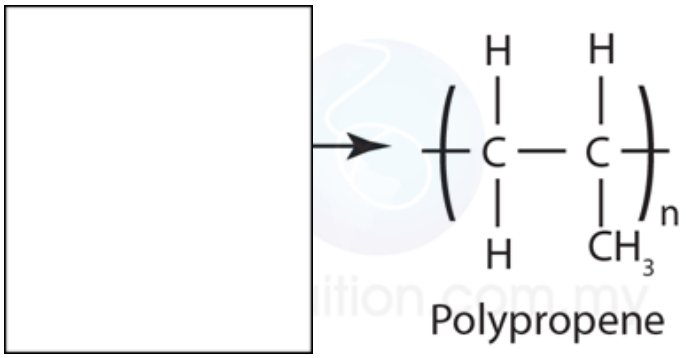


phenylethene

polystyrene

This lesson involves …

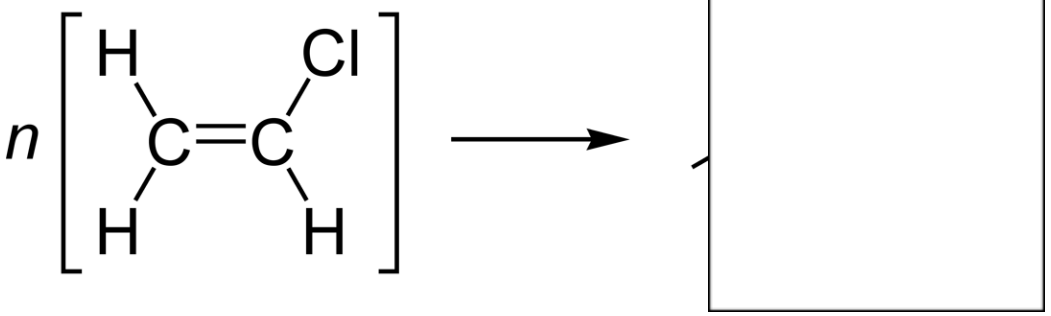
*Generalisation
*Connection-finding
*Big Picture Thinking
*Abstraction
*Imagination



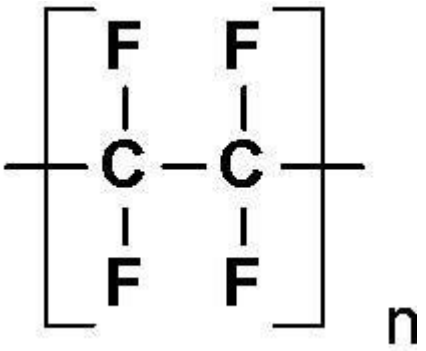
Polypropene

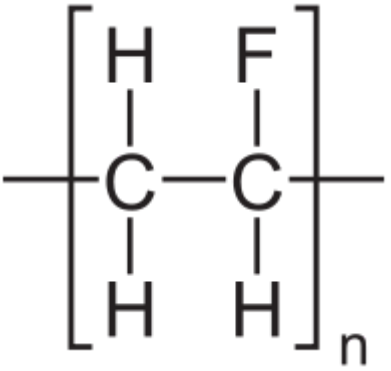
This lesson involves …

*Automaticity
*Speed & Accuracy



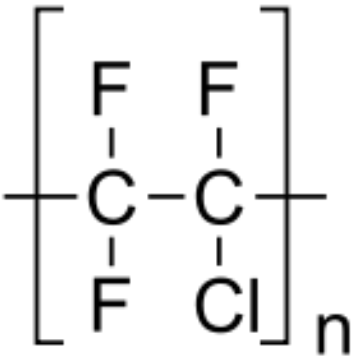
Q4. Draw the monomer that would form the following polymers:





This lesson involves …

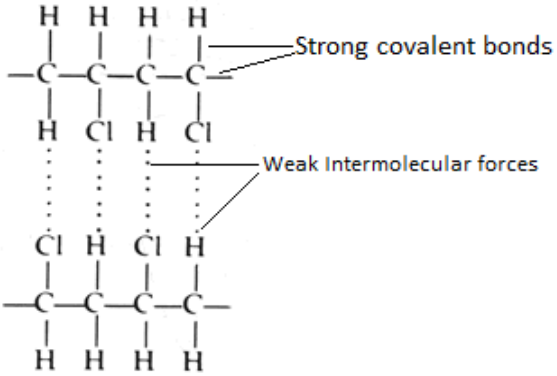
*Automaticity
*Speed & Accuracy



Bonds and Intermolecular forces

We saw in Year 9 that covalent bonds are very strong but that forces between molecules (Intermolecular forces) are weak.

We also learned that the bigger the molecule the stronger the Intermolecular forces.



This lesson involves ...

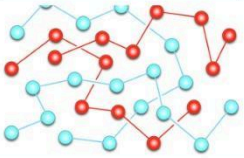
*Generalisation
*Connection-finding
*Big Picture Thinking
*Abstraction
*Imagination

1.Polymers have very long molecules, what does this suggest about their intermolecular forces?

2.If we heat polymer will the intermolecular forces or the bonds break first?

3.Explain the melting point of addition polymers

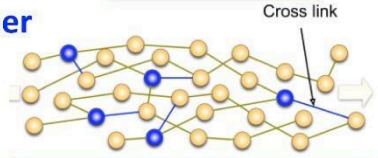
Thermosoftening (thermoplastic)



- Tangled polymer chains
- No cross-links between chains
- Weak forces of attraction between chains
- Softens when heated

Two types of polymer

Thermosetting (thermoset)



- Polymer chains held together by **strong covalent cross-link bonding** that does not break on heating.
- Remains hard when heated

4. Why don't Thermosetting polymers melt the way normal Thermosoftening polymers do?

HDPE & LDPE

HDPE and LDPE stand for High and Low Density PolyEthene.

Q1. Both are made from the same monomer but under different conditions. What is the monomer for these two types of polymer?

Q2. Draw the displayed formula of the monomer

Q3. When the monomers combine in an almost straight chain we get the Higher Density form. What is it about LDPE that stops the polymer chains from packing closely together?

HDPE LDPE

Q4. Which type of PE will have the strongest intermolecular forces? Why?

{HINT: Think about the amount of contact between chains}

Q5. Which of the two types of PE will have the highest melting point? How do you know?

Q6. Which is likely to be flexible enough to make a carrier bag?

Disposing of Polymers.

The problem with most polymers is that they are non-biodegradable – they don't rot.

It is possible to melt most polymers and form them into new shapes. But most polymers look the same so sorting them into different types before recycling them is time-consuming and has to be done by hand.

Most polymers will also burn. But some of them contain Chlorine and others may form toxic compounds which should not be released into the atmosphere.

This lesson involves …

*Collaborative
*Concerned for Society
*Confident

Q1. Much waste is ***Land-filled***. What does this mean?

Q2. In what way is land-filling addition polymers a waste of resources?

Q3. How might the economy benefit from incinerating some polymers?

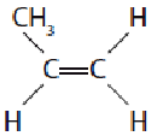
Q4. Why is this rarely done in the UK?

Q5. Recycled polymers are lower quality that freshly made polymers. Suggest why.

Q6. Biodegradable polymers are becoming more common. Why is this a good thing?

Q7. Thermoset polymers can't be easily melted. Why is this a problem?

(d) The structure of propene is



This lesson involves ...

*Automaticity
*Speed & Accuracy

Propene can be polymerised.

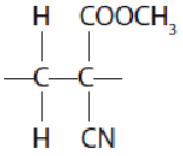
(i) Give the name of the polymer formed from propene.

.....

(ii) Draw the repeat unit for this polymer.

(2)

(e) The repeat unit of an addition polymer used in a type of glue is shown in the diagram.



Draw the structure of the monomer used to make this polymer.

(1)

6 Poly(ethene) is a common polymer. It is obtained from crude oil by fractional distillation, cracking and polymerisation.

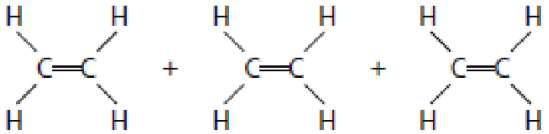
(a) The passage is about the fractional distillation of crude oil.

Use words from the box to complete the passage.

You may use each word once, more than once or not at all.

(b) Decane and ethene, C_2H_4, are produced during the cracking of eicosane, $C_{20}H_{42}$

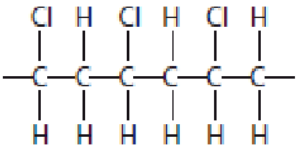
Ethene is used to make poly(ethene).



ethene

(d) Chloroethene can be used to make the polymer poly(chloroethene), also known as PVC.

The displayed formula for part of the PVC molecule is



This lesson involves …

*Automaticity
*Speed & Accuracy

(i) Draw a displayed formula for a chloroethene molecule.

(1)

(ii) Describe, in terms of structure and bonding, what happens when chloroethene molecules are converted into poly(chloroethene).

(3)

(Total for Question 6 = 11 marks)

(d) The structural formula of chloroethene formed in process 3 is $CH_2{=}CHCl$

The polymer formed in process 4 is poly(chloroethene).

Draw the **displayed** formula for the repeat unit of poly(chloroethene).

(2)

This lesson involves …

*Automaticity
*Speed & Accuracy

(e) Poly(chloroethene) is formed by addition polymerisation.

Nylon is formed by condensation polymerisation.

(i) How does condensation polymerisation differ from addition polymerisation?

(1)

.....

.....

(ii) Poly(chloroethene) and nylon do not biodegrade easily.

What is meant by the term **biodegrade**?

(2)

.....

.....

.....

.....

(c) Addition polymers such as poly(ethene) are very difficult to dispose of because they do not biodegrade easily.

(i) State a reason why addition polymers do not biodegrade easily.

(1)

.....

.....

(ii) Burning and landfill (burying in the ground) are two methods used to dispose of addition polymers.

Suggest a problem with each method of disposal.

(2)

burning.....

.....

landfill.....

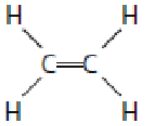
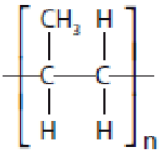
.....

(Total for Question 14 = 9 marks)

14 (a) The table shows information about two common addition polymers.

Complete the table for these two polymers.

(4)

Name of polymer	Structure of monomer	Structure of polymer	One use for the polymer
poly(ethene)			
			water pipes

(b) State two changes that occur in the formation of an addition polymer from its monomer.

(2)

1 .....

.....

2 .....

.....

(c) The compound with molecular formula C_3H_6 can be used to make a polymer.

(i) Give the name of the compound C_3H_6

(1)

.....

(iii) Complete this structure to show the part of the polymer formed from two molecules of C_3H_6

(2)

——C——C——C——C——

(e) The conversion of propene into poly(propene) can be represented by this equation.

$$nC_3H_6 \rightarrow (C_3H_6)_n$$

(i) Draw the displayed formula of propene.

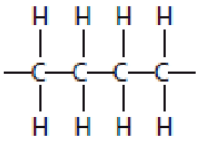
(1)

(ii) Draw the repeat unit of poly(propene).

(2)

(d) Alkenes can be polymerised.

Part of the structure of poly(ethene) can be represented as



This structure shows the atoms coming from two molecules of ethene.

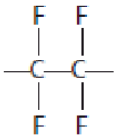
Draw part of the structure of poly(propene) that shows the atoms coming from two molecules of propene (CH_2=CH—CH_3).

(2)

This lesson involves ...

*Automaticity
*Speed & Accuracy

(e) The repeat unit of another addition polymer can be represented as



Draw the structure of the monomer used to make this polymer.

(1)

(f) The disposal of most addition polymers is a problem because they do not biodegrade.

(i) What is meant by the term **biodegrade**?

(2)

.....

.....

.....

.....

(ii) Identify the property that prevents addition polymers from easily biodegrading.

(1)

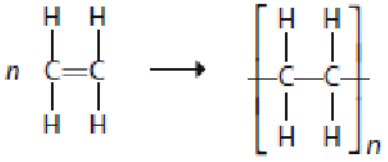
.....

This lesson involves …

*Automaticity
*Speed & Accuracy

7 This question is about polymers.

The formation of poly(ethene) can be represented as



(a) What is the name of this type of reaction?

(1)

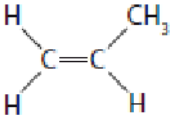
- ☐ **A** addition
- ☐ **B** decomposition
- ☐ **C** reduction
- ☐ **D** substitution

(b) Which of these is a correct description of a monomer?

(1)

- ☐ **A** a molecule used to make a polymer
- ☐ **B** a molecule with only single bonds
- ☐ **C** an atom in a polymer
- ☐ **D** a repeat unit in a polymer

(c) This compound is used to make a polymer.



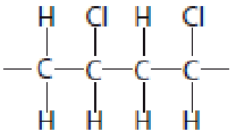
(i) State the name of this compound.

(1)

(ii) Draw the structure of the repeat unit of the polymer formed from this compound.

(2)

(d) This is part of the structure of another polymer.



Draw the displayed formula of the monomer used to make this polymer.

(1)

(e) Many polymers do not biodegrade when they are thrown away.

(i) State the meaning of the term **biodegrade**.

(2)

.....

.....

.....

.....

(ii) What property of these polymers prevents them from biodegrading?

(1)

.....

11 Tetrafluoroethene (C_2F_4) is a gas that is stored in cylinders.

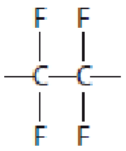
A chemist opened the valve on a new cylinder of tetrafluoroethene. He was surprised when no gas came out.

He decided to check the contents of the cylinder. He found it contained a white powder. The tetrafluoroethene had formed a polymer.

This lesson involves …

*Automaticity
*Speed & Accuracy

(a) The displayed formula for the repeat unit of the addition polymer formed is



(i) Draw the displayed formula of the monomer.

(1)

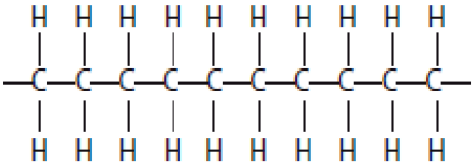
(ii) What is the meaning of the term **polymer**?

(2)

(iii) Suggest the name of this polymer.

(1)

(b) The displayed formula for a section of another addition polymer is



Give the name and molecular formula of the monomer used to form this polymer.

(2)

name .....

molecular formula .....

(c) Explain why addition polymers that are buried in landfill sites remain chemically unchanged for many years.

(2)

.....

.....

.....

.....

11.03 Alcohols, Carboxylic Acids & Condensation Polymers

I have reviewed the syllabus statements for this topic	
I have completed the questions in this section	
I have read the relevant sections of the College Website	

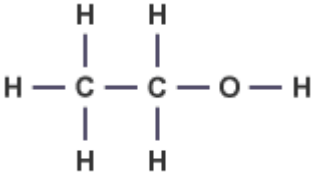
I have made some revision material (mind-map, key-words & definitions etc)	
Prep Grade	
Test Grade	

Target	Pupil Signature

11.03 Alcohols, Carboxylic Acids and Condensation Polymers

Syllabus

- Alcohols contain the ***functional group –OH***.
- Methanol, Ethanol, Propanol and Butanol are the first four members of a homologous series of alcohols.



- Alcohols can be represented in the following forms: CH_3CH_2OH or

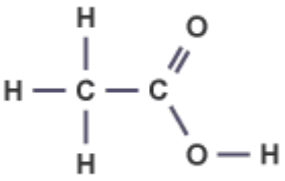
- Students should :

1. be able to describe what happens when any of the first four alcohols react with Sodium, burn in air, are added to water, react with an oxidising agent
2. be able to recall the main uses of these Alcohols. Aqueous solutions of Ethanol are produced when sugar solutions are fermented using yeast.
3. know the conditions used for fermentation of sugar using yeast.
4. be able to recognise Alcohols from their names or from given formulae.

- Students do not need to know the names of individual alcohols other than Methanol, Ethanol, Propanol and Butanol.

- Students are not expected to write balanced chemical equations for the reactions of alcohols other than for combustion reactions.

- ***Carboxylic acids*** have the ***functional group –COOH***.
- The first four members of a homologous series of Carboxylic Acids are ***Methanoic acid***, ***Ethanoic acid***, ***Propanoic acid*** and ***Butanoic acid***.
- The structures of Carboxylic acids can be represented in the following forms: CH_3COOH or



- Students should be able to:

1. describe what happens when any of the first four Carboxylic acids react with Carbonates, dissolve in water, react with Alcohols
2. (HT only) explain why Carboxylic acids are weak acids in terms of ionisation and pH
3. recognise Carboxylic acids from their names or from given formulae.

- Students do not need to

1. know the names of individual carboxylic acids other than Methanoic acid, Ethanoic acid, Propanoic acid and Butanoic acid.
2. write balanced chemical equations for the reactions of carboxylic acids.
3. know the names of esters other than ethyl ethanoate.

- Condensation polymerisation involves ***monomers with two functional groups***.
- When these types of monomers react they join together, usually ***losing small molecules such as wate***r, and so the reactions are called condensation reactions.
- The simplest polymers are produced from two different monomers with two of the same functional groups on each monomer.
- Students should be able to explain the basic principles of condensation polymerisation by reference to the functional groups in the monomers and the repeating units in the polymers.

- Amino acids have ***two different functional groups*** in a molecule.

- Amino acids react by condensation polymerisation to produce ***polypeptides***.
- For example: ***Glycine*** is H_2NCH_2COOH and polymerises to produce the polypeptide $(-HNCH_2COO-)_n$ and n H_2O
- Different amino acids can be combined in the same chain to produce proteins.

- ***DNA*** (deoxyribonucleic acid) is a large molecule essential for life. DNA encodes genetic instructions for the development and functioning of living organisms and viruses.
- Most DNA molecules are ***two polymer chains***, made from four different monomers called nucleotides, in the form of a ***double helix***. Other naturally occurring polymers important for life include ***proteins***, ***starch*** and ***cellulose***.
- Students should be able to ***name the types of monomers*** from which these naturally occurring polymers are made.

Alcohols

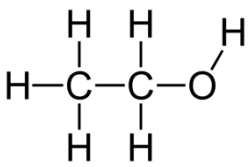
When we talk about alcohol we usually mean ***Ethanol***.

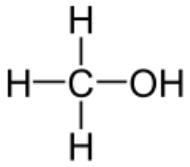
Ethanol is present in ***alcoholic drinks*** but there are many different alcohols.

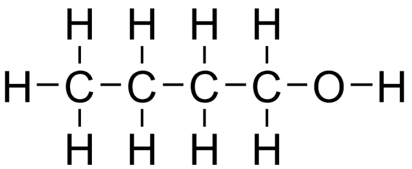
And all alcohols are ***poisonous***- even Ethanol.

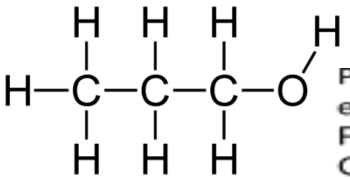
Alcohols are similar to hydrocarbons but contain an **–OH** group.

Q1. Name these four









alcohols;

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This lesson involves ...

1 3 7

*Generalisation
*Connection-finding
*Big Picture Thinking
*Abstraction
*Imagination

Q2. Traditionally, Ethanol has been produced by ***fermentation***.

a) Fermentation happens in ***anaerobic conditions***. What does this mean?

b) During fermentation enzymes convert sugar to ethanol. What ***living organism*** supplies the enzymes?

c) What are ***enzymes***?

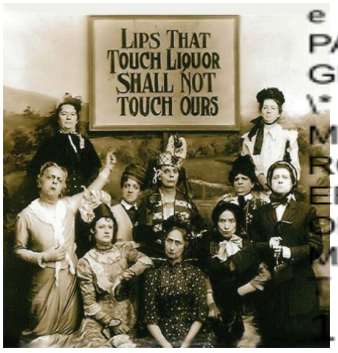
d) Enzymes require a suitable ***temperature*** range. What temperatures can fermentation happen within?

e) Apart from Ethanol, what ***other product*** is formed during fermentation

f) Fermentation can produce alcohol solutions no more concentrated than around 15%. What happens when the concentration gets to 15%?

Making Alcohols

Q1. Fermentation converts Glucose (simple sugar) to ethanol and Carbon Dioxide. Write a word equation for this reaction.

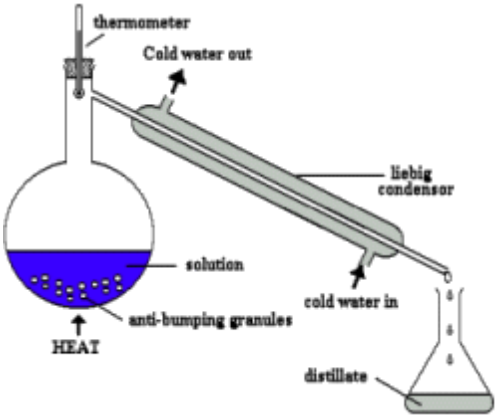


Q2. The formula of Glucose is $C_6H_{12}O_6$; the formula of Ethanol is C_2H_5OH.

Write a balanced symbol equation for the fermentation of Glucose into Ethanol.

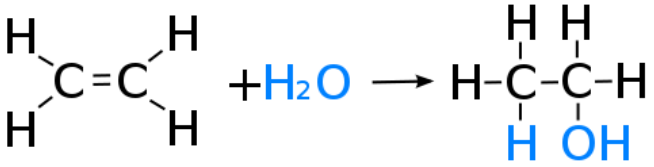
Q3. Spirits like Vodka are often 40% Ethanol. How is the water removed?

Q4. The apparatus right is used to separate water and Ethanol. Ethanol boils at 76°C, Water at 100 °C. If a Bunsen is used to heat the round-bottom flask to 80 °C most of the distillate in the conical flask is likely to_____.



Making alcohols 2.

It's possible to make ethanol faster by starting with Ethene from the Cracking of oil fractions.



This process is called the ***HYDRATION of Ethene***. It makes almost 100% ethanol and can run 24 hours a day, every day of the year. But it requires a temperature of around 300°C and a pressure of about 60 atmospheres (sixty times atmospheric pressure) as well as a Phosphoric Acid Catalyst.

In contrast, ***Fermentation*** works best around 30°C. It takes 4 or 5 days for fermentation to finish and must then be followed by distillation. Even then the alcohol made contains some water that cannot be removed. Its raw material is sugar – usually from sugar cane. We don't need to remember the conditions but we may be asked to compare to fermentation.

This lesson involves …

*Collaborative
*Concerned for Society
*Confident

Q1. Which process is most energy intensive?

Q2. Which process has a non-renewable raw material?

Q3. Which process could be said to be ***"carbon-neutral"?*** What does this phrase mean?

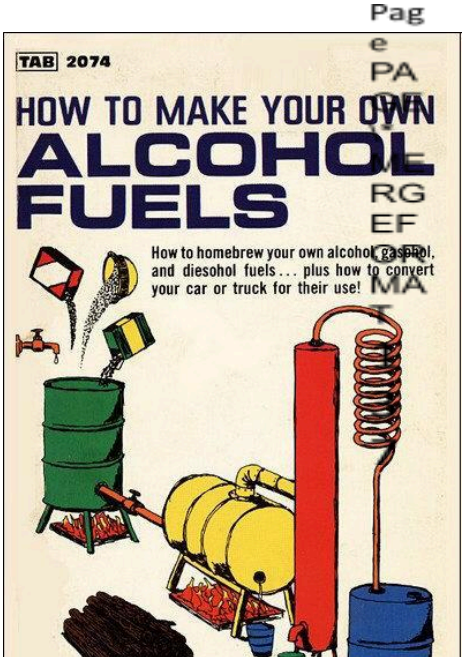
Q4. The hydration process needs a cheap Phosphoric Acid catalyst. Why wouldn't it add much to the cost if the catalyst was Gold or Platinum?

Q5. One process could be described as a Batch Process, the other as a Continuous Process. What do you think these phrases mean? And which is which?

Alcohols as fuels.

When alcohols burn completely in Oxygen they form CO_2 and water, just as Alkanes and Alkenes do when burned.

But alcohols are liquids, which makes them more convenient for use as a fuel in cars than gases.



1. Why is a liquid fuel more convenient than a gas?

2. Write a balanced symbol equation for the combustion of ethanol (C_2H_5OH) in Oxygen (O_2).

$C_2H_5OH + O_2$?

3. Write a balanced symbol equation for the combustion of propanol (C_3H_7OH) in Oxygen (O_2).

This lesson involves …

*Logical Thinking
*Precision
*Multi-step problem-solving

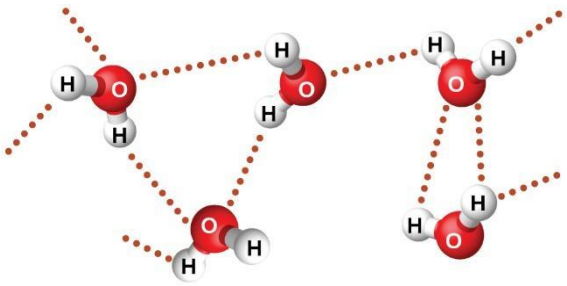
$C_3H_7OH + O_2$?

4. Write a balanced symbol equation for the combustion of butanol (C_4H_9OH) in Oxygen (O_2)

$C_4H_9OH + O_2$?

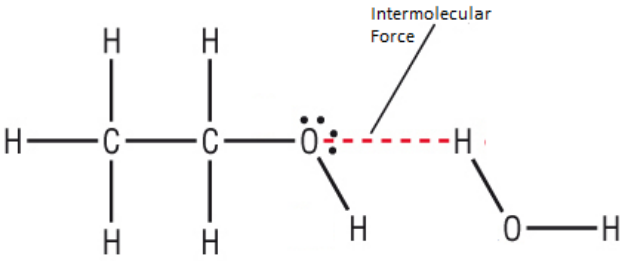
Alcohol Solutions

To dissolve in water substances usually have to be ionic (alcohols are not) or be able to form the same very strong intermolecular forces that water can make.



These forces are caused by the –O-H groups on water molecules.

Alcohols also have –O-H groups so they can form the same forces.



This lesson involves …

*Logical Thinking
*Precision
*Multi-step problem-solving

Short alcohols are totally miscible – mix perfectly – with water.

1. Alcohols: structure and properties

Name	Formula	Water solubility*
methanol	CH_3OH	miscible
ethanol	C_2H_5OH	miscible
propanol	C_3H_7OH	miscible
butanol	C_4H_9OH	0.11
pentanol	$C_5H_{11}OH$	0.030
hexanol	$C_6H_{13}OH$	0.0058
heptanol	$C_7H_{15}OH$	0.0008

*mol/100g at 25°C

7

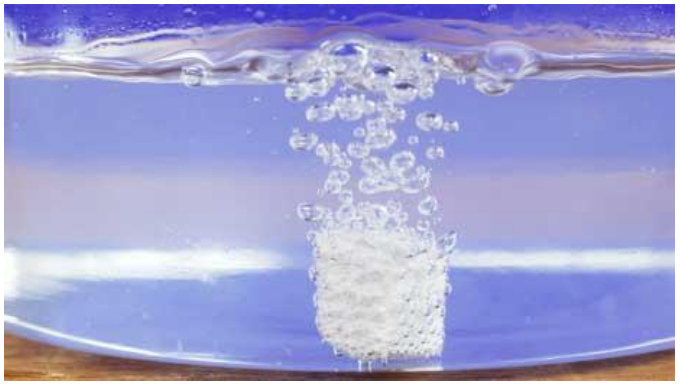
This lesson involves …

*Generalisation
*Connection-finding
*Big Picture Thinking
*Abstraction
*Imagination

1. What is the trend in solubility as alcohol molecules get longer?

2. Suggest a reason for this trend.

Alcohols and Sodium



This lesson involves …*

*Generalisation
*Connection-finding
*Big Picture Thinking
*Abstraction
*Imagination

When Sodium is dropped in alcohols it releases Hydrogen gas. We're not required to write symbol equations. But we may need to be able to complete a word equation based on the example of Methanol. You are not required to learn these!

sodium + methanol ⟶ sodium methoxide + hydrogen

sodium + _____ ⟶ sodium ethoxide + hydrogen

sodium + propanol ⟶ _____ + hydrogen

sodium + butanol ⟶ _____ + _____

1. Fill in the gaps above.
2. How would we prove the gas was Hydrogen?

3. Why might it be dangerous to try this experiment with Potassium?

Carboxylic Acids

In Year 9 we learn ***Strong acids ionise completely when dissolved in water.***

This lesson involves …

*Generalisation
*Connection-finding
*Big Picture Thinking
*Abstraction
*Imagination

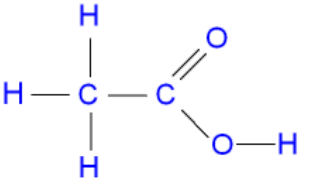
$$HCl\ (aq) \rightleftharpoons H^+_{(aq)} + Cl^-_{(aq)}$$

And ***Weak acids only partly dissociate***.

$$CH_3CO_2H \rightleftharpoons CH_3CO_2^-{}_{(aq)} + H^+_{(aq)}$$

Ethanoic Acid contains the functional group COOH.

1. Write the displayed formulas for



a. Methanoic Acid (one Carbon atom)

b. Propanoic Acid (three Carbon atoms)

Q1. If we had 1mol/dm^3 solutions of a strong acid (HCl) and a weak acid (Ethanoic). Which would

i. Have the highest concentration of H^+ ions?

ii. Have the highest pH?

iii. What colour would each go if Universal Indicator were added?

iv. Which would react with Magnesium fastest?

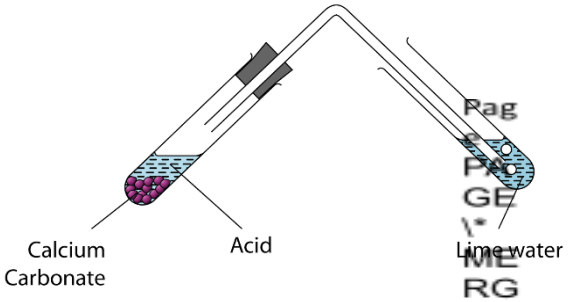
v. Which gas would be made when these acids react with Magnesium?

vi. Assuming that both Acids were in Excess, which would make the most Hydrogen when reacting with 1g of Magnesium?

Practical

a. Add some marble chips to 2 mol/dm^3 Hydrochloric acid and bubble the gas through Limewater

b. Repeat the experiment with 2 mol/dm^3 Ethanoic acid



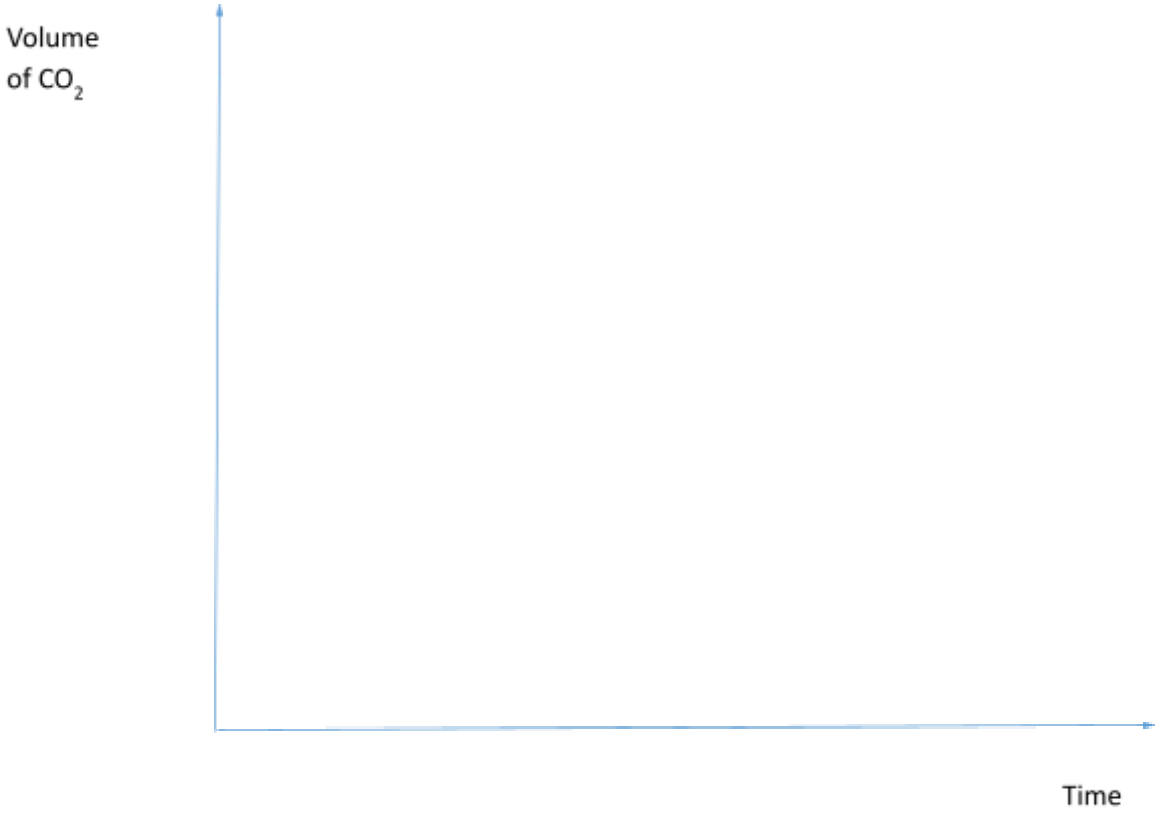
Q1. What do the reactions have in common?

Q2. What is different about the reactions? Why?

This lesson involves …

*Collaborative
*Concerned for Society
*Confident

Q3. Sketch two graphs (on the same axes) of the production of Carbon Dioxide for both Hydrochloric and Ethanoic Acid when reacting with 2g of Limestone. Assume that all the Limestone is used up.



Extended Response Question Ca

25 Ethanoic acid is a carboxylic acid and reacts with carbonates to produce carbon dioxide.

25.1 Complete the equation for the reaction between ethanoic acid and sodium carbonate.

[1 mark]

……$CH_3COOH + Na_2CO_3$ → …. CH_3COONa + …….. + ……..

25.2 Design an experiment to show that ethanoic acid is a weak acid and reacts slower than the strong acid hydrochloric acid when added to sodium carbonate solution.

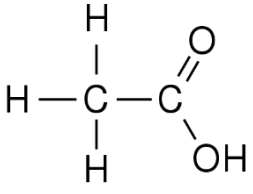
[6 marks]

Mark scheme

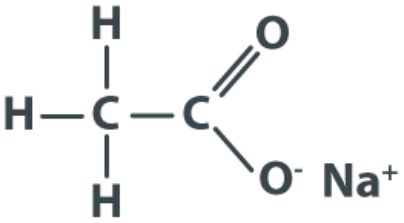
Answers	Mark
Level 3: The method would lead to the production of a valid outcome. The key steps are identified and logically sequenced.	5–6
Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the method is not fully logically sequenced.	3–4
Level 1: The method plan would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.	1–2
No relevant content	0
Indicative content **Method** ● Use the same volume/concentration of acids. ● Use the same volume of sodium carbonate (solution). ● Apparatus to collect gas such as ● Inverted measuring cylinder **or** burette/ gas syringe OR ● Test tube **or** beaker of limewater. ● Collect the gas over a specified time **or** time for the limewater to go cloudy. ● Measuring cylinder(s) to measure the acids and the sodium carbonate. ● Conical flask **and** bung **and** delivery tube. **Results** ● Hydrochloric acid would produce gas/carbon dioxide quicker. ● Proves ethanoic acid is a weak acid **and** hydrochloric acid is a strong acid. [The above indicative content may be evidenced in an annotated sketch.]	

Salts and Esters

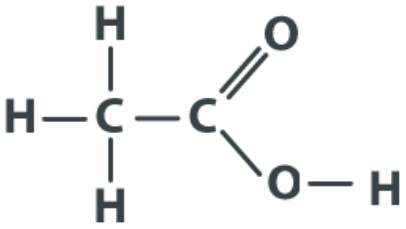
You should already know that this is ***Ethanoic Acid***.

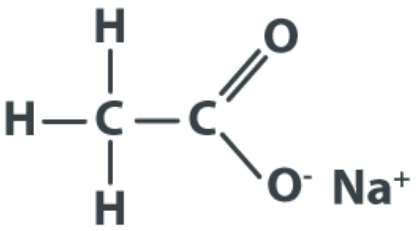


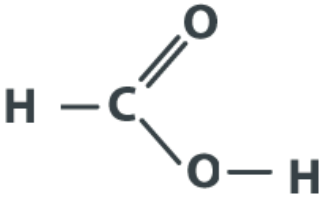
And that when it's been ***neutralised*** with Sodium Hydroxide (or Sodium Oxide or Sodium Carbonate) the H atom on the right is replaced with a Sodium ion and it forms a salt called ***Sodium Ethanoate.***

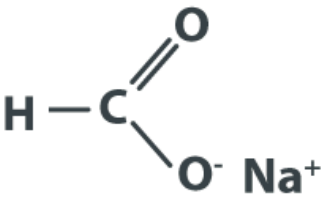


Q1. What are the names of these molecules?









Q2. Complete the general equations of acids;

Acid + Base/Alkali → Salt + _____

This lesson involves ...

*Generalisation
*Connection-finding
*Big Picture Thinking
*Abstraction

Acid + Carbonate → Salt + _____ + _____

Acid + Metal → Salt + _____

Q3. Complete the following word equations:

Sulphuric Acid + Copper Oxide → _____ + _____

Hydrochloric Acid + Lithium Carbonate → _____ + _____ + _____

Nitric Acid + Sodium → _____ + _____

Ethanoic Acid + Sodium Hydroxide → _____ + _____

Propanoic Acid + Sodium Carbonate → _____ + _____ + _____

Methanoic Acid + Potassium → _____ + _____

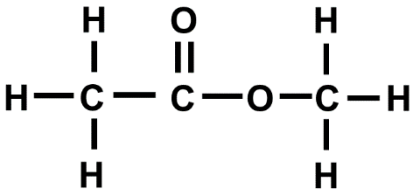
Methanoic Acid + Lithium Hydroxide → _____ + _____

Butanoic Acid + Copper Carbonate → _____ + _____ + _____

Propanoic Acid + Potassium Oxide → _____ + _____

Salts and Esters

So, it shouldn't be a big surprise to learn that, if we replace the H atom with a methyl group, we would form a substance called ***Methyl Ethanoate***.



Methyl ethanoate (CH_3COOCH_3)

Substances like this contain the ***functional group*** **-COO-** and are called ***Esters***.

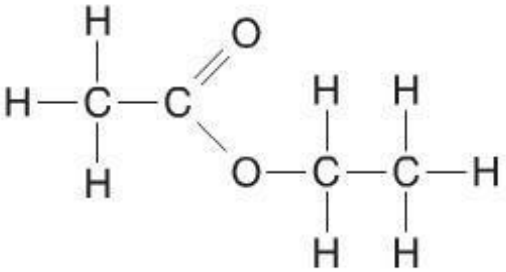
Functional groups are the part of a molecule where reactions generally happen.

Esters have low boiling points - they are ***volatile***.

And generally they ***smell*** fruity, so esters are commonly used in ***perfumes*** and as ***food flavourings***.

You only need to be able to name one Ester!

Q1. What would the name of this ester be?



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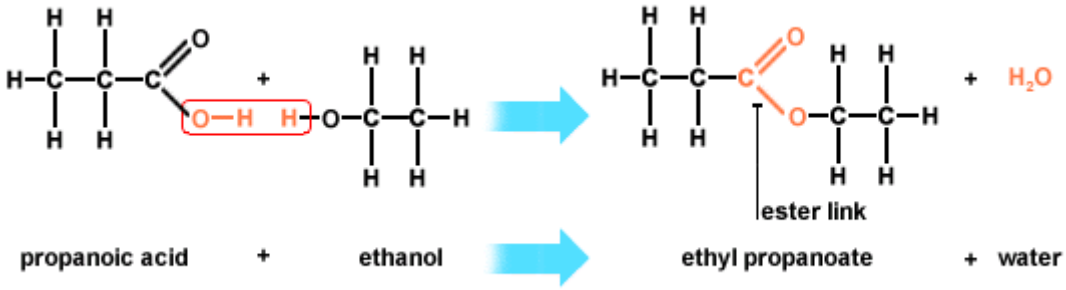
Making Esters

To make an ester we need to start with a ***Carboxylic Acid*** and add an ***Alcohol***



This also creates some water.

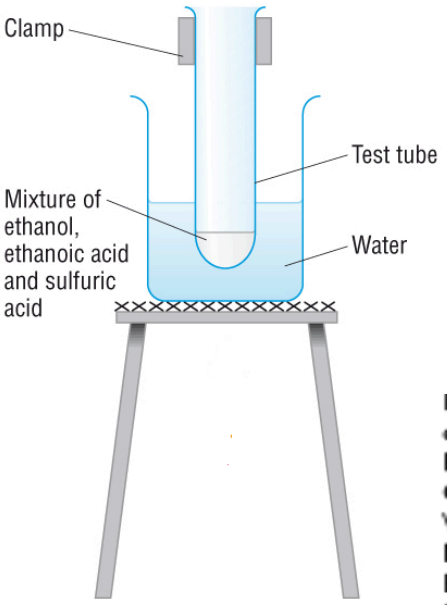
But the reaction is very slow unless a ***catalyst*** is added.

The catalyst for this reaction is any ***strong acid*** - usually Sulphuric Acid.

Some heat helps but because Esters are volatile a high heat would evaporate all the product, and a naked flame might set fire to the alcohol vapour.

PRACTICAL

- Mix 5 cm^3 of Ethanoic Acid with 5 cm^3 of Ethanol in a boiling tube.
- Carefully add 2cm^3 of Concentrated Acid
- Heat half a beaker of water until it almost boils
- Switch off the heat.
- Place a bung in the boiling tube and add to the water – it may pop off a few times!
- Wait for 5 minutes.
- Carefully smell the product

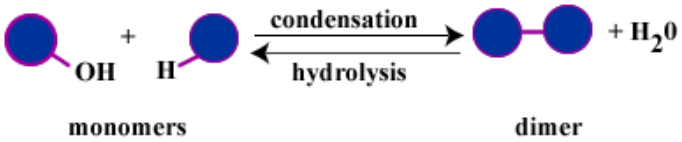


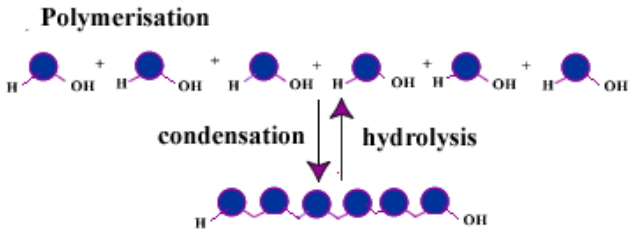
This lesson involves ...

*Collaborative
*Concerned for Society
*Confident

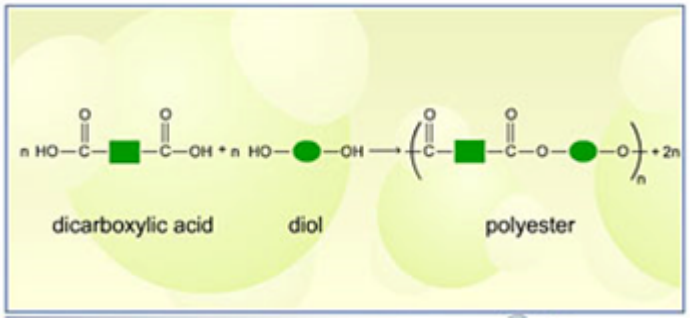
Condensation Polymers

We've seen that carboxylic acids and alcohols can link together, producing an ester and some water. This is a condensation reaction.



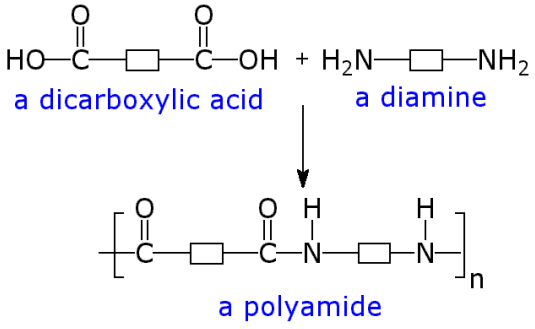


If a molecule has an acid group at one end and an alcohol at the other then these molecules join into long chains and also form water molecules – hence ***condensation polymerisation***.



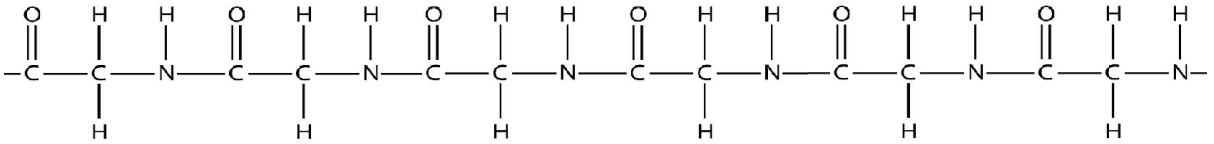
Or there could be two monomers – one with two acid groups, one with two alcohol groups. You don't need to know the details of how this works but you should note that the two monomers join up alternately, that one loses an **–OH** group and the other loses an **-H** to form H_2O

Nylon and Polyester are examples of a slightly different Condensation Polymers.

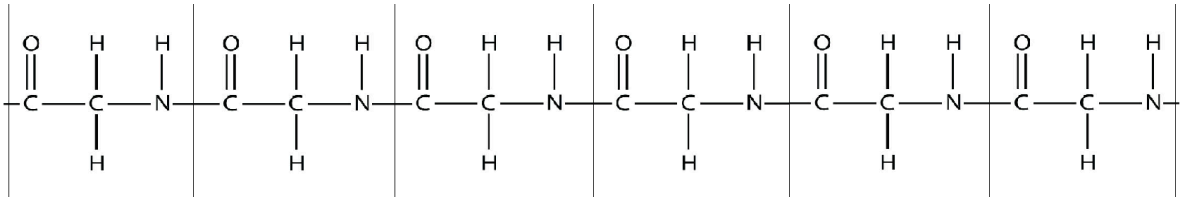


Working out the monomers from the Polymer

Given part of a polymer chain such as:

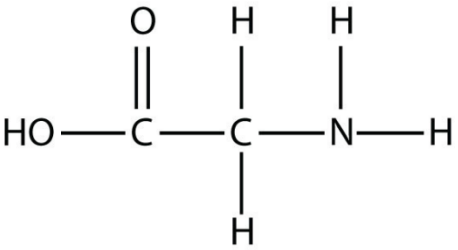


We break the chain at the C=O

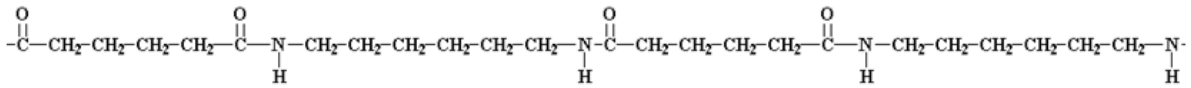


In this case every part is the same – so only one monomer was used.

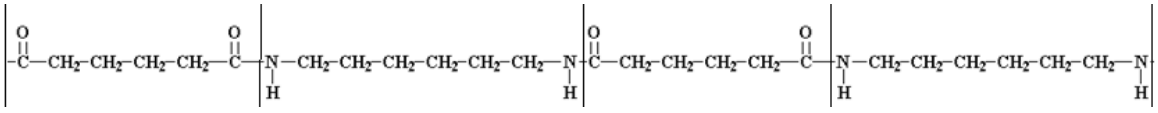
We can replace an H atom and an OH group (to make an acid) to show what the monomer looked like



Example 2

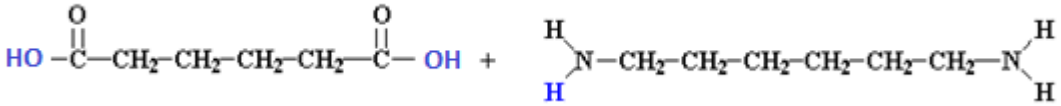


Becomes…



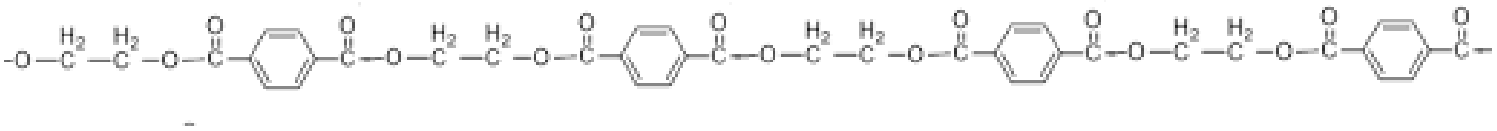
In this case not every part is the same – so two monomer were used.

We can replace an H atom and an OH group (to make acids) to show what the monomers looked like



QUESTIONS

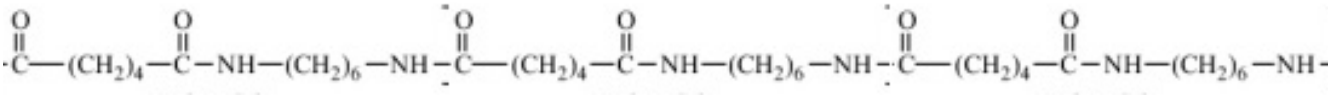
Draw the two monomers that react to form:



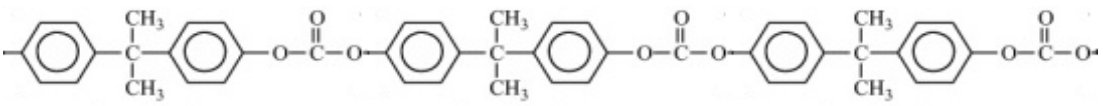
This lesson involves …

*Generalisation
*Connection-finding
*Big Picture Thinking
*Abstraction
*Imagination

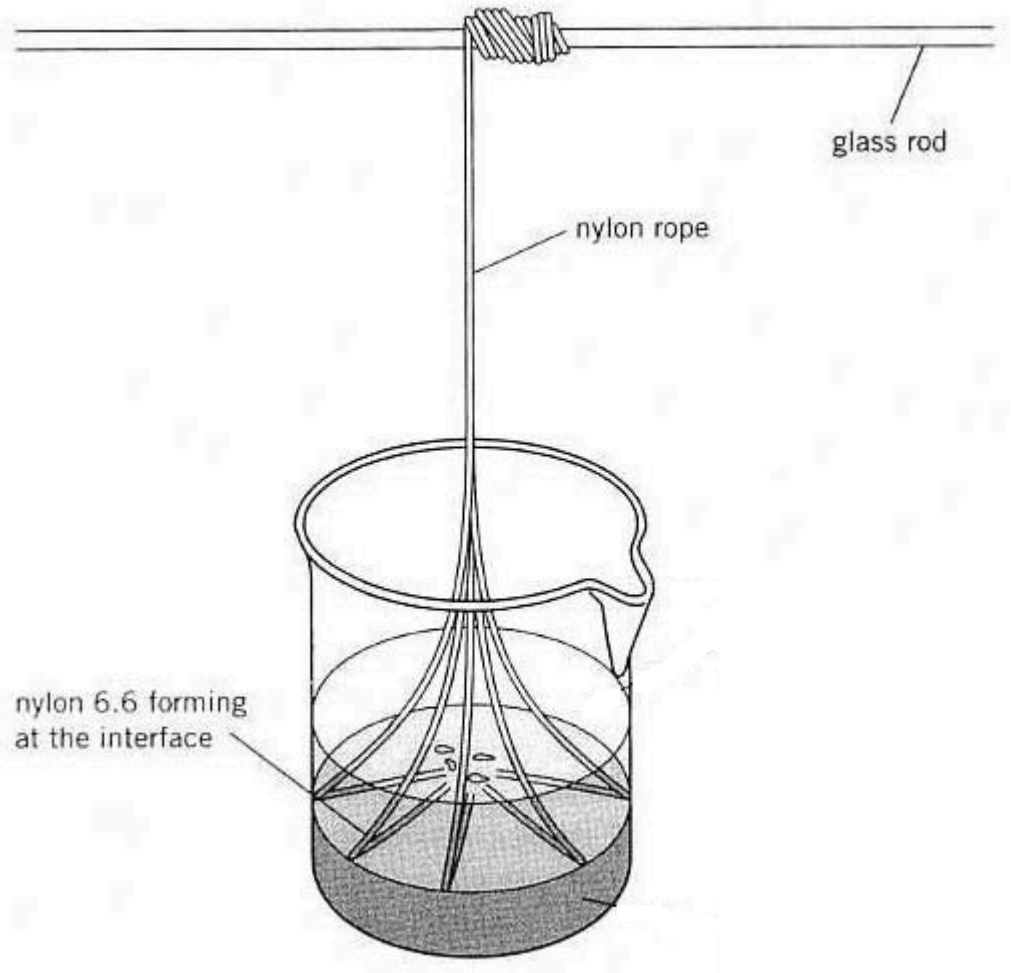
Draw the two monomers that react to form:



Draw the two monomers that react to form



The Nylon Rope Experiment



- Your teacher will give you two monomers which can react to make Nylon.
- Slowly pull away the skin that form between the two layers.
- Wrap it around a glass rod and slowly rotate
- Enjoy!

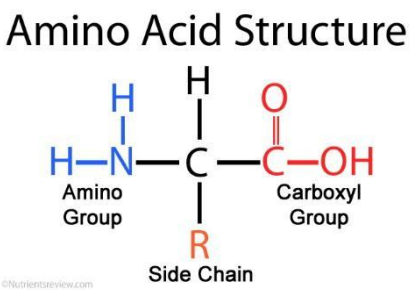
This lesson involves …

*Collaborative
*Concerned for Society
*Confident

Amino Acids

Amino acids are vital for life.

They share a common structure.



This lesson involves …

*Generalisation
*Connection-finding
*Big Picture Thinking
*Abstraction
*Imagination

The only thing that changes is the **"R group"** – which can be a single atom or a long chain of atoms.

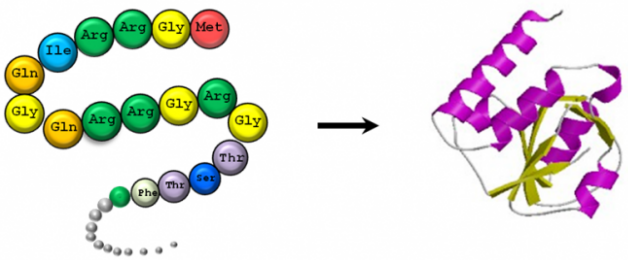
They all have two functional groups.

1. Draw Glycine – the amino acid where the R group is a single H atom.

2. Draw Alanine – the amino acid where the R group is a CH_3 group.

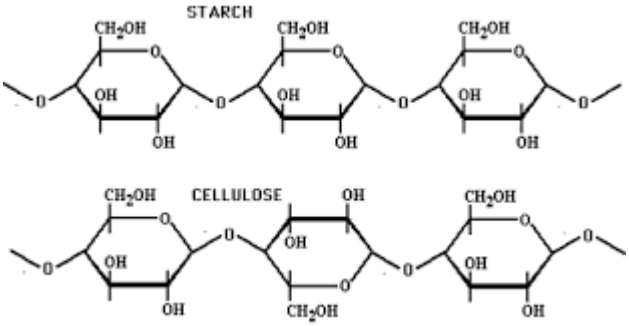
3. Glycine can be represented as **H_2NCH_2COOH**, draw the condensation polymer that could be made from glycine molecules.

When we produce protein made up of many different amino acids we have made a **P**_____



Polymers from sugars?

When a few sugars join we eventually make longer structures.

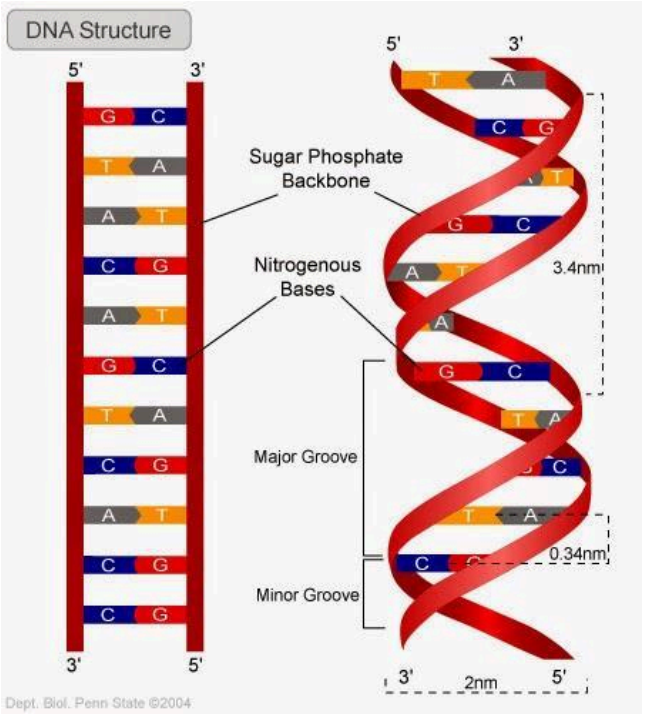


As you can see, there's not much difference in the structure of starch and cellulose.

But, importantly, humans can only digest _____

WE don't need to know any details about the sugar-phosphates in the two helixes that bond together to form DNA

Just that there are 4 "nucleotides" – though we don't even seem to need to know about those



This lesson involves …

*Generalisation
*Connection-finding
*Big Picture Thinking
*Abstraction
*Imagination

Extended Response Question

Reactions of alkenes and alcohols

Ethanol can be produced either from the hydration of ethene or from the fermentation of sugar.

Table 8 shows some information on these two methods of producing ethanol, C_2H_5OH.

Table 8

	Hydration of ethene	**Fermentation of sugar**
Raw material obtained from	Crude oil	Sugar cane/beet
Reactant(s)	$C_2H_4 + H_2O$	$C_6H_{12}O_6$
Temperature of process	Approximately 300°C	Approximately 30°C
Pressure of process	60 times normal/room pressure	Normal/room pressure
Catalyst	Phosphoric acid	Yeast
Equation	$C_2H_4 + H_2O \rightleftharpoons C_2H_5OH$	$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$

Evaluate the method of producing ethanol by the hydration of ethene compared to the fermentation of sugar method.

[6 marks]

Mark scheme

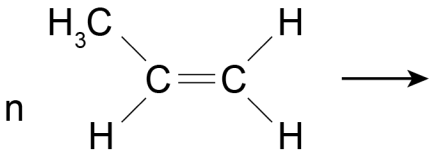
Answers	Mark
Level 3: A judgement, strongly linked and logically supported by a sufficient range of correct reasons, is given.	5–6
Level 2: Some logically linked reasons are given. There may also be a simple judgement.	3–4
Level 1: Relevant points are made. They are not logically linked.	1–2
No relevant content	0
Indicative content **Raw materials** ● Crude oil is finite **or** will run out **or** is non-renewable. ● Crude oil needs to undergo fractional distillation to give ethene. ● Ethene is only one of the fractions of crude oil. ● Crude oil fractions may need to be cracked to produce sufficient quantities of ethene. ● Sugar cane/beet is a renewable resource. ● Sugar cane/beet requires land for growth. ● Sugar cane/beet needs to be processed to release the glucose. ● The processing of sugar cane/beet requires energy. ● The remainder of the sugar cane/beet needs to be disposed of. **Conditions** ● Hydration requires more energy for higher temperature. ● Hydration requires more energy to give higher pressure. ● Hydration requires acid catalyst, which is more dangerous **or** corrosive **or** toxic than yeast. ● Fermentation uses yeast, which some workers may be allergic to. **Equation** ● Hydration only produces a single product (so higher atom economy). ● Hydration is a reversible reaction so (potentially) a lower yield. ● Use of excess, cheap water or steam will shift equilibrium to the right to increase yield. ● Fermentation produces gaseous by-product. ● Fermentation releases carbon dioxide into the atmosphere (which increases global warming). ● Yeast catalyses an irreversible reaction so (potentially) a higher yield.	

Extended Response Question — Polymerisation

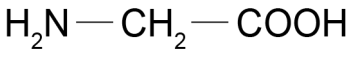
Poly(propene) is a polymer made from propene.

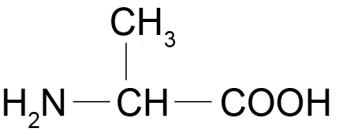
23.1 Draw the repeat unit of the polymer, poly(propene).

[1 mark]

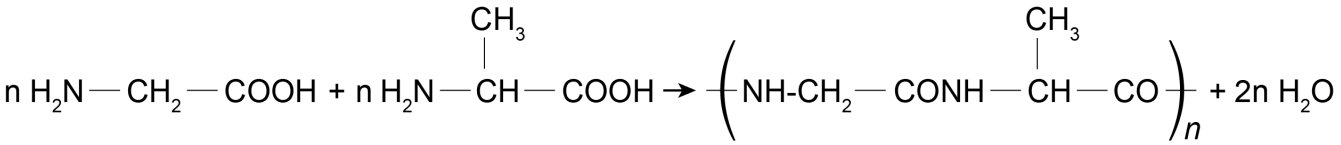


23.2 Polypeptides are polymers made from amino acids. Polypeptides are made from a different type of polymerisation. Glycine and alanine are two amino acids.

Glycine 

Alanine 

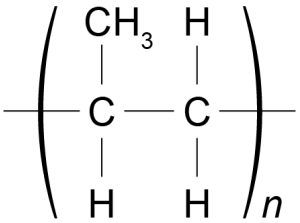
The equation for the formation of a polypeptide made from glycine and alanine can be represented as



Compare the polymerisation reaction which produces poly(propene) with the polymerisation reaction to produce the polypeptide of glycine and alanine.

[4 marks]

Mark scheme

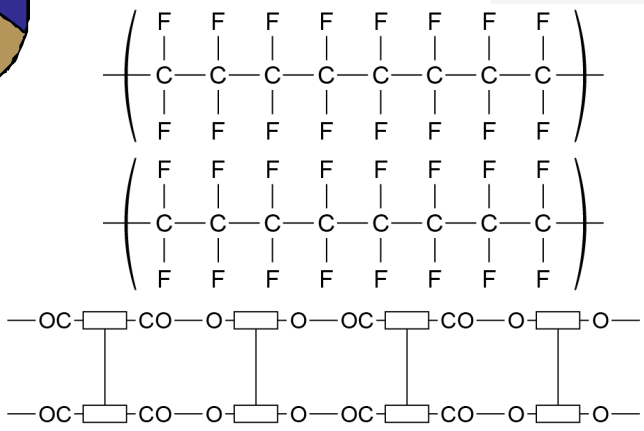
Answers	Mark
	1
Level 2: Scientifically relevant features are identified; the way(s) in which they are similar/different is made clear and (where appropriate) the magnitude of the similarity/difference is noted.	3–4
Level 1: Relevant features are identified and differences noted.	1–2
No relevant content	0
Indicative content Any four from: ● Addition polymerisation reaction forms poly(propene) whereas condensation polymerisation forms polypeptide. ● Poly(propene) is formed from one type of monomer whereas polypeptide is made from two different monomers. ● Poly(propene) is formed from an alkene whereas polypeptide is made from amino acids. ● Poly(propene) is formed from a monomer with one functional group whereas polypeptide monomers have two functional groups. ● Poly(propene) is the only product of its polymerisation whereas water is also formed with polypeptide. ● Poly(propene) has a hydrocarbon repeat unit whereas the polypeptide has a peptide linkage.	

Extended Response Question — Polymers

26 The structures of polymer **A** and polymer **B** are partly shown in **Figure 9** using sections of two chains.

Figure 9

Polymer **A** Polymer **B**



Polymer **A** and polymer **B** have different properties.

Compare the polymers **A** and **B** by referring to their properties, their types of polymerisation and their types of monomer.

[6 marks]

Mark scheme

Question	Answers	Mark
26	**Level 2**: Scientifically relevant features are identified; the way(s) in which they are similar/different is made clear and (where appropriate) the magnitude of the similarity/difference is noted.	4–6
	Level 1: Relevant features are identified and differences noted.	1–3
	No relevant content	0
	Indicative content **Differences** (Properties) ● Polymer **A** is a thermoplastic polymer **and** Polymer **B** is a thermosetting plastic. ● Thermoplastic polymers can be heated **and** reshaped. ● Thermosetting polymers do not soften on heating. ● Polymer **B** has cross-links between the chains and polymer **A** does not. (Types of polymerisation) ● Polymer **A** is an addition polymer **and** polymer **B** is a condensation polymer. (Types of monomer) ● Polymer **A** has a single alkene monomer. ● Polymer **A** monomer has one functional group. ● Polymer **B** monomers are a carboxylic acid and an alcohol. ● Polymer **B** monomers have two of the same functional group.	

(b) (i) Complete the following equation that represents the preparation of ethene from ethanol.

(1)

$C_2H_5OH \rightarrow C_2H_4 +$ .....

(ii) What is the name given to this type of reaction?

(1)

.....

This lesson involves ...

*Practice

4 There are two important ways to manufacture ethanol.

Reaction 1 $C_2H_4 + H_2O \rightarrow C_2H_5OH$

Reaction 2 $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$

(a) (i) Identify one raw material that could be used as the source of $C_6H_{12}O_6$

(1)

.....

(ii) Reaction 2 uses a catalyst called zymase, which is present in yeast.

Identify the catalyst used in reaction 1.

(1)

.....

(iii) In both reactions it is important to control the temperature.

State why the temperature in reaction 2 is kept below 35 °C.

(1)

.....

.....

(b) A manufacturing company plans to build a factory to produce ethanol on a large scale. The factory will be near an oilfield. The ethanol will be used as a solvent for perfume.

Suggest why the company should use reaction 1 rather than reaction 2.

(3)

(c) In the future, it may be necessary to convert the ethanol (produced by reaction 2) into ethene.

Write the equation for this reaction and state the type of reaction that occurs.

(2)

Equation .....

Type of reaction .....

(Total for Question 4 = 8 marks)

This lesson involves

*Practice
*Perseverance
*Resilience

6 This is a recipe for making plum wine.

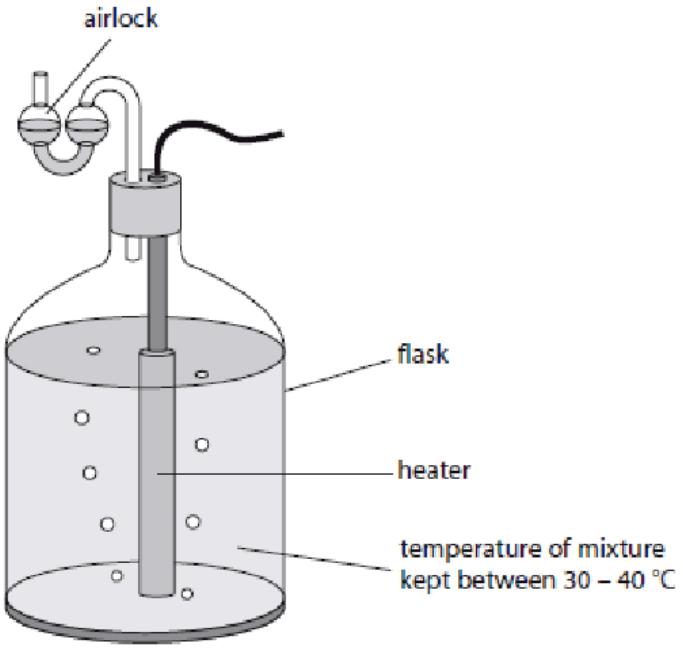
Dissolve 1.5 kg of sugar in 5 dm^3 of warm water.

Add yeast and 8 kg of plums.

Pour the mixture into a flask.

Leave the flask for several weeks until the reaction has stopped.

Remove the solid yeast and pour the clear liquid into bottles.



(a) Sugar contains sucrose, $C_{12}H_{22}O_{11}$

When yeast is added, water reacts with sucrose to form glucose, $C_6H_{12}O_6$

Write a chemical equation for this reaction.

(1)

(b) The glucose is then converted into ethanol by the yeast

$$C_6H_{12}O_6(aq) \rightarrow 2C_2H_5OH(aq) + 2CO_2(g)$$

(i) How would you know when the reaction has stopped?

(1)

.....

(ii) How could the solid yeast be removed from the mixture?

(1)

.....

(d) Ethanol can be manufactured by the hydration of ethene. The equation for this reaction is

$$C_2H_4(g) + H_2O(g) \rightarrow C_2H_5OH(g)$$

(i) Identify the catalyst and state the temperature used in this process.

(2)

Catalyst.....

Temperature.....

7 (a) The first two members of the homologous series of alcohols are methanol and ethanol.

(i) Give two characteristics of the compounds in a homologous series.

(2)

1 .....

.....

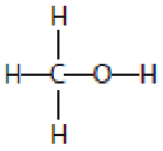
2 .....

.....

This lesson involves …

*Practice
*Perseverance
*Resilience

(ii) The displayed formula for methanol is



Suggest a displayed formula for ethanol, CH_3CH_2OH

(1)

(b) The table shows the two different processes for making ethanol on a large scale.

Process	Explanation
batch process	the fermentation of sugars with yeast
continuous process	the hydration of ethene (produced from crude oil) with steam

Compare the two processes in terms of

- the rate at which the ethanol can be produced
- the purity of the product
- the use of finite resources

(3)

4 (a) Ethanol can be manufactured by two different processes.

This lesson involves ...

*Practice
*Perseverance
*Resilience

Process 1 sucrose $\xrightarrow{\text{stage 1}}$ glucose $\xrightarrow{\text{stage 2}}$ ethanol

Process 2 ethene $\longrightarrow$ ethanol

(i) What is the general name for compounds such as sucrose and glucose?

.....

(ii) What type of reaction occurs in stage 2?

(1)

.....

(iii) What is the catalyst used in stage 2?

(1)

.....

(iv) What type of reaction occurs in process 2?

(1)

.....

4 (a) Wine can be made from grapes.

The grapes are crushed to produce an aqueous solution containing glucose.
Yeast is then added to this solution.

The solution is kept at a constant temperature for a period of time. The glucose is converted into ethanol.

(i) Name the process in which glucose is converted into ethanol.

(1)

.....

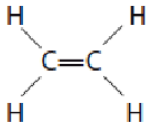
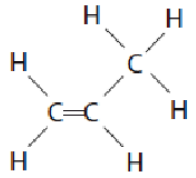
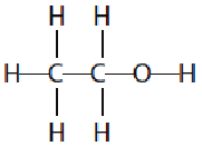
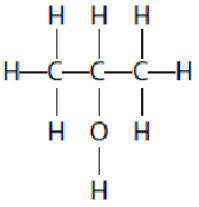
(ii) What is the purpose of the yeast?

(1)

.....

.....

(b) The table shows the displayed formulae of four organic compounds.

ethene	propene
	
ethanol	**compound D**
	

Ethanol and compound D are members of the homologous series of alcohols.

(i) The first member of this homologous series is methanol.

Draw the displayed formula of methanol.

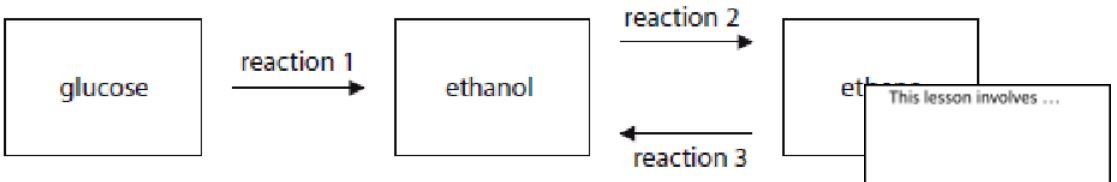
(1)

(ii) Suggest the name of compound D.

(1)

.....

4 The scheme shows some reactions involving ethanol.



This lesson involves …

*Practice
*Perseverance
*Resilience

(a) (i) Two conditions used in reaction 1 are

- a temperature of about 30 °C
- the use of water as a solvent for the glucose

State the name of the catalyst used in this reaction.

(1)

.....

(ii) Complete the equation for reaction 1.

(1)

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + \text{.....}$$

(b) Ethanol can also be manufactured by reaction 3, which uses steam, a catalyst of phosphoric acid and a pressure of about 65 atm.

State the temperature used in reaction 3.

(1)

.....

(c) State the type of reaction that occurs in

(2)

reaction 1 .....

reaction 3 .....

(d) State two advantages of using reaction 3 to manufacture ethanol rather than reaction 1.

(2)

1 .....

.....

2 .....

.....

(e) Give a reason why some countries use reaction 1 to manufacture ethanol.

(1)

.....

.....

4 An industrial chemical company has supplies of ethene and ethanol.

The company considers using these two processes.

process 1 converting ethene to ethanol

process 2 converting ethanol to ethene

A chemical equation for process 1 is

$$C_2H_4 + H_2O \rightarrow C_2H_6O$$

(a) Which condition does the chemical company use in process 1?

(1)

- ☐ **A** aluminium oxide as a catalyst
- ☐ **B** a pressure of 65 atm
- ☐ **C** a temperature of 1000 °C
- ☐ **D** sodium hydroxide as a solvent

(b) The equation for process 1 shows the molecular formulae of ethene and ethanol.

Draw the displayed formulae of ethene and ethanol.

(2)

Compound	Displayed formula
ethene	
ethanol	

(c) Why is it correct to describe ethanol as saturated, but incorrect to describe it as a hydrocarbon?

(2)

.....

(d) A scientist working for the chemical company makes the following predictions that could affect processes 1 and 2 in the future:

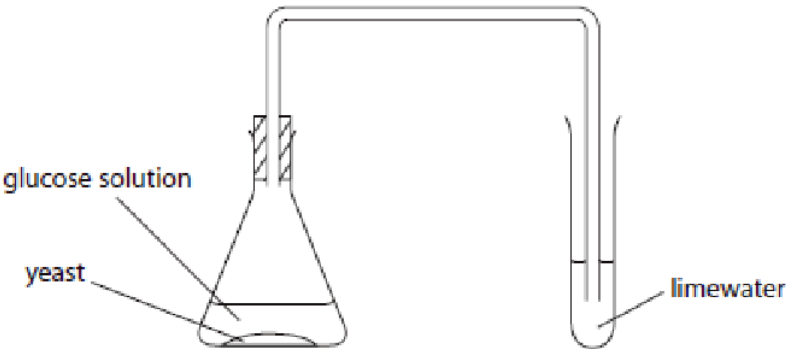
- crude oil will be less available and more expensive
- the climate will be warmer and allow more sugar cane to be grown

Suggest how each of these predictions would affect the two processes.

(3)

6 Ethanol can be produced when yeast is added to a glucose solution.

This apparatus is used to investigate the reaction.



(a) The equation for the reaction is

$$C_6H_{12}O_6(aq) \rightarrow 2C_2H_5OH(aq) + 2CO_2(g)$$

(i) State the purpose of the yeast.

(1)

.....

.....

(ii) State how the appearance of the limewater changes during the reaction.

(1)

.....

.....

(iii) State the temperature at which this reaction is carried out in industry.

(1)

.....

(b) Ethanol can be manufactured from compound A using reaction 1.
Ethanol can also be manufactured from glucose using reaction 2.

The equations for these reactions are

reaction 1 $C_2H_4 + H_2O \rightarrow C_2H_5OH$

reaction 2 $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$

Give two advantages of using each reaction to manufacture ethanol.

(4)

This lesson involves …

*Practice
*Perseverance
*Resilience

reaction 1 .....

.....

.....

.....

.....

reaction 2 .....

.....

.....

.....

(ii) The equation for the conversion of compound X to an alcohol is

$$CH_2{=}CH{-}CH_2{-}CH_3 + H_2O \rightarrow CH_3{-}\underset{\displaystyle OH}{\underset{|}{CH}}{-}CH_2{-}CH_3$$

Place ticks (✓) in the boxes to show the two correct descriptions of this reaction.

(2)

addition	
dehydration	
hydration	
oxidation	
reduction	

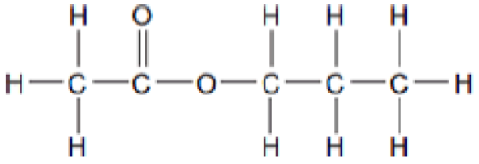
This lesson involves …

*Practice
*Perseverance
*Resilience

(b) Propyl ethanoate, a fragrance, can be produced by reacting ethanoic acid with an alcohol.

Propyl ethanoate is a member of a series of organic compounds. The members of the series all have the same functional group.

The displayed structure of propyl ethanoate is:



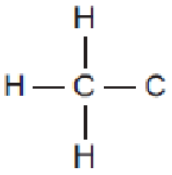
(i) Draw a ring around the functional group for this series on the displayed structure of propyl ethanoate.

(1)

Q1. This question is about organic compounds.

(a) Ethanol is an alcohol.
One use of ethanol is in alcoholic drinks.

Give two other uses of ethanol.



(1)

(iii) Solutions of ethanoic acid and hydrochloric acid with the same concentration have different pH values.

Explain why the solution of ethanoic acid has a higher pH than the solution of hydrochloric acid.

.....

.....

.....

.....

(2)

(d) Ethanol and ethanoic acid react in the presence of a catalyst to form an ester.

(i) Name the ester made from ethanol and ethanoic acid.

.....

(1)

(ii) What type of chemical is used as a catalyst in this reaction?

.....

(1)

(iii) Esters are used in perfumes because they smell pleasant and are volatile.

What does volatile mean?

.....

(1)

(Total 10 marks)

(ii) Name the series of organic compounds with this functional group.

.....

(1)

(iii) The alcohol used to make propyl ethanoate has the formula $CH_3CH_2CH_2OH$

Name this alcohol.

.....

11.04 Earth's Resources

I have reviewed the syllabus statements for this topic	
I have completed the questions in this section	
I have read the relevant sections of the College Website	

I have made some revision material (mind-map, key-words & definitions etc)	
Prep Grade	
Test Grade	

Target	Pupil Signature

11.04 Earth's Resources

Syllabus

- Humans use the Earth's resources to provide warmth, shelter, food and transport.
- ***Natural resources***, supplemented by agriculture, provide food, timber, clothing and fuels.
- ***Finite resources*** from the Earth, oceans & atmosphere are processed to for energy & materials.
- Chemistry plays an important role in improving agricultural and industrial processes to provide new products and in sustainable development, which is development that meets the needs of current generations without compromising the ability of future generations to meet their own needs.
- Students should be able to:

1. state examples of natural products that are supplemented/ replaced by agricultural & synthetic products
2. distinguish between finite and renewable resources given appropriate information.
3. extract and interpret information about resources from charts, graphs and tables
4. use orders of magnitude to evaluate the significance of data.

- Water of appropriate quality is essential for life.

- For humans, drinking water should have ***sufficiently low levels of dissolved salts*** and ***microbes***. Water that is safe to drink is called ***potable water***.
- Potable water is ***not pure wate***r in the chemical sense because it contains dissolved substances.
- The methods used to produce potable water depend on available supplies of water and local conditions. In the United Kingdom (UK), rain provides water with low levels of dissolved substances (fresh water) that collects in the ground and in lakes and rivers, and most potable water is produced by:

1. choosing an appropriate source of ***fresh water***
2. passing the water through ***filter beds***
3. ***sterilising***.

- ***Sterilising agents*** used for potable water include ***Chlorine***, ***Ozone*** or ***Ultraviolet light***.
- Sewage and agricultural waste water require removal of organic matter and harmful microbes. Industrial waste water may require removal of organic matter and harmful chemicals.
- Urban lifestyles and industrial processes produce large amounts of waste water that require treatment before being released into the environment.
- Sewage treatment includes:• screening and grit removal • sedimentation to produce sewage sludge & effluent • anaerobic digestion of sewage sludge • aerobic biological treatment of effluent.
- If supplies of fresh water are limited, ***desalination*** of salty water or sea water may be required.
- Desalination can be done by ***distillation*** or by processes that use membranes such as ***reverse osmosis***.
- These processes require large amounts of energy.
- Students should be able to:

1. distinguish between potable water and pure water
2. describe the differences in treatment of ground water and salty water
3. give reasons for the steps used to produce potable water.
4. comment on the relative ease of obtaining potable water from waste, ground and salt water.

Required practical 8: analysis and purification of water samples from different sources, including pH, dissolved solids and distillation.

- Most of the glass we use is ***soda-lime glass***, made by heating a mixture of sand, Sodium Carbonate and limestone.

- ***Borosilicate glass***, made from ***sand*** and ***Boron Trioxide***, melts at ***higher temperatures*** than soda-lime glass.
- ***Clay ceramics***, including pottery & bricks, are made by shaping wet clay and then heating in a furnace.

- The properties of polymers depend on what monomers they are made from and the ***conditions*** under which they are made. For example, ***low density (LD)*** and ***high density (HD) poly(ethene)*** are produced from Ethene.
- ***Thermosoftening*** polymers melt when heated. ***Thermosetting*** polymers do not melt when heated.
- Students should be able to:

1. explain how low density and high density poly(ethene) are both produced from Ethene
2. explain the difference between Thermosoftening and Thermosetting polymers in terms of their structures.
3. recall that most composites are made of two materials, a matrix or binder surrounding and binding together fibres or fragments of the other material, which is called the reinforcement.
4. recall some examples of composites.
5. compare quantitatively the physical properties of glass and clay ceramics, polymers, composites and metals given appropriate information:
6. explain how the properties of materials are related to their uses and select appropriate materials given appropriate information.

- ***Life cycle assessments*** (LCAs) are carried out to assess the ***environmental impact*** of products in each of these stages:

1. extracting and processing ***raw materials***
2. ***manufacturing*** and ***packaging***
3. ***use*** and operation during its lifetime
4. ***disposal*** at the end of its useful life, including transport and distribution at each stage.

- Use of water, resources, energy sources and production of some wastes can be fairly easily quantified.
- Allocating numerical values to pollutant effects is less straightforward and requires value judgements, so LCA is not a purely objective process.
- Selective or abbreviated LCAs can be devised to evaluate a product but these can be misused to reach pre-determined conclusions, eg in support of claims for advertising purposes.
- Students should carry out simple comparative LCAs for shopping bags made from plastic & paper.

- The reduction in use, reuse and recycling of materials by end users reduces the use of ***limited resources***, use of ***energy*** sources, ***waste*** and ***environmental impacts***.
- Metals, glass, building materials, clay ceramics and most plastics are produced from limited raw materials. Much of the energy for the processes comes from limited resources.
- Obtaining raw materials from the Earth by ***quarrying*** and ***mining*** causes environmental impacts. Some products, such as glass bottles, can be reused.
- Glass bottles can be crushed and melted to make different glass products. Other products cannot be reused and so are recycled for a different use.
- Metals can be ***recycled*** by melting and recasting or reforming into different products.

- The amount of ***separation*** required for recycling depends on the material and the properties required of the final product. For example, some scrap steel can be added to Iron from a blast furnace to reduce the amount of Iron that needs to be extracted from Iron ore.
- Students should be able to evaluate ways of reducing the use of limited resources, given appropriate information.

Finite and Renewable Resources

Finite means “will finish” or “will run out”. Renewable resources are quickly replaced.

This lesson involves …

*Collaborative
*Concerned for Society
*Confident

Classify each resource as either finite or renewable:

- coal …….
- natural gas …….
- metal …….
  …….
- nuclear fuels …….
- ethanol (produced by fermentation) …….
- cotton …….
- leather …….
- crude oil
- wood …….
- solar power

……

Humans use the Earth's resources to provide:

- warmth
- ……
- food
- ……..

Define the terms:

finite resources

……

……..……

……

……..

renewable resources

……

……..……

……

……..

• Natural resources provide: food, timber (wood), clothing and fuels

• This is …… by <u>agriculture</u> (farming crops and animals)

• Give an example of a natural resource used to provide each of:

- food ……..
- timber ……..
- clothing ……
- fuel ……

• Give two examples of how agriculture <u>supplements</u> natural resources to provide two of these things:

1. natural resource: …… for …… (food/timber/clothing/fuel)

   agriculture supplements this with: ……

2. natural resource: …… for …… (food/timber/clothing/fuel)

   agriculture supplements this with: ……

Finite resources from the Earth, oceans and atmosphere are processed to provide energy and materials.

Give two examples of <u>finite resources</u> that are processed to provide *either* energy or materials:

1. ……

2. ……

This lesson involves …

*Collaborative
*Concerned for Society
*Confident

- Chemists provide new …… products which <u>supplement/replace</u> natura products.
- This helps <u>reduce our reliance</u> on natural pro ducts

natural resource:
……

used for:
……

Chemist produces new product.

……
product:
polyester—replaces/supplements cotton

Natural product	Use	Synthetic product that <u>supplements</u> or <u>replaces</u> it
cotton	clothing	……...
wood	……	PVC

<u>Sustainable Development</u>

Definition: meeting the …… of current …… **without** …… the ability of …… generations to meet their own needs.

Chemists have a role in finding ways to:

- reduce our use of ……

- provide new …….. products that we can use instead of

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natural/……resources

Potable Water, Waste Water Treatment

Potable water = safe to drink

This lesson involves …

*Collaborative
*Concerned for Society
*Confident

• Drinking water should have low levels of:

•

……

……..

•

……

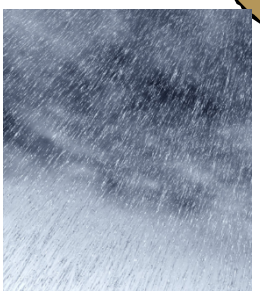
…….

Potable water ≠ pure water

• Most drinking water contains *some* …….

• Pure water has no dissolved salts.

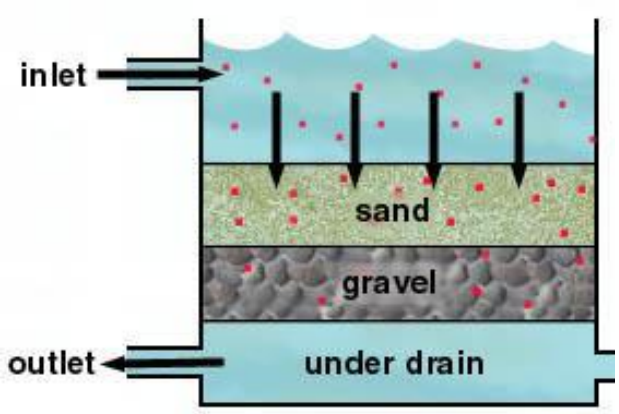
• Pure water would taste weird!



Potable Water, Waste Water Treatment

Obtaining Potable Water

1
Choosing an appropriate source of
……..
……..



2
Passing the water through ……
……..

3
……..
(killing microorganisms)

- Chlorine
- ……..
- Ultraviolet light (UV)

are all used to sterilise fresh water.

These are called ……

Potable Water, Waste Water Treatment

Desalination

If …… supplies are limited, then we may have to …… salty water and/or sea water.

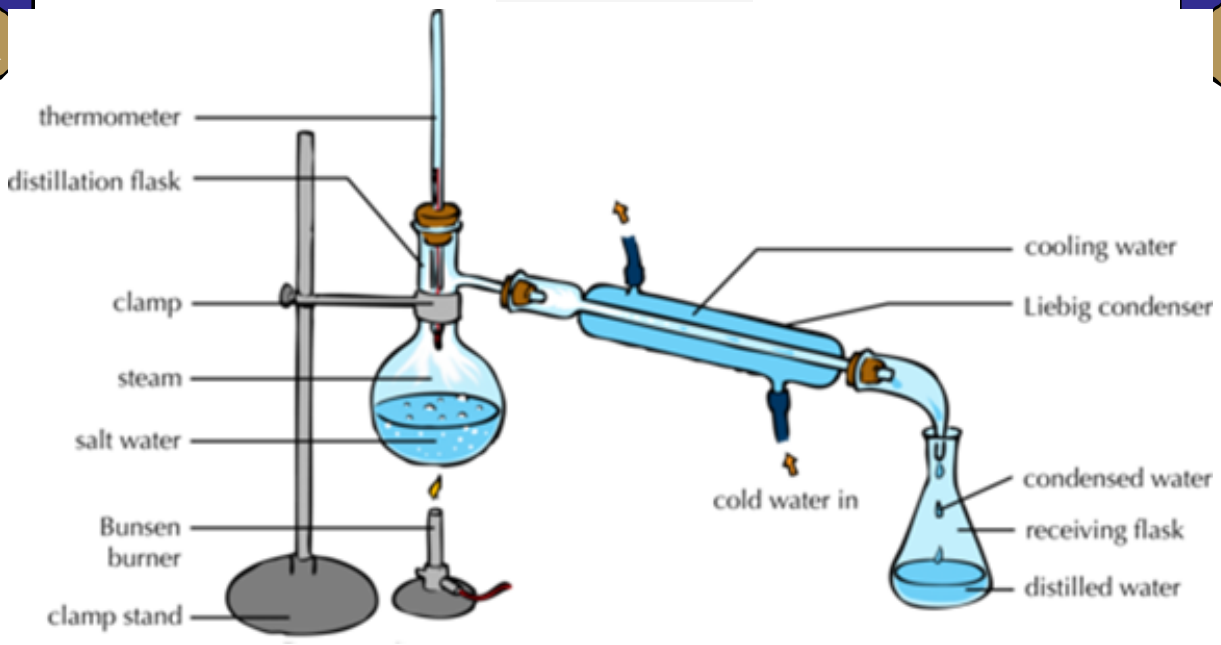
This lesson involves …

*Collaborative
*Concerned for Society
*Confident

Desalination is done by:

1. Distillation

2. Using membranes e.g. ……..



• Distillation separates mixtures with different ……

• Separates the salt from the …….. water

Required practical 8: analysis and purification of water samples from different sources, including pH, dissolved solids and distillation.

- You will be given: Drinking Water, Non-potable tap-water, Pond Water and Rain-water.
- Tear a strip of pH paper into 4 pieces and test the pH of each source.
- Weigh four small beakers and label them.
- Add 50 cm3 of the samples to individual beakers and boil dry.
- When it is safe to do so, Re-weigh your samples.

	Drinking Water	Non-potable Tap water	Pond water	Rainwater
pH				
Initial mass of beaker				
Final Mass of beaker				
Mass of dissolved solids				

1. Which sample was closest to neutral? Which was furthest from neutral? Why do you think this was?

This lesson involves …

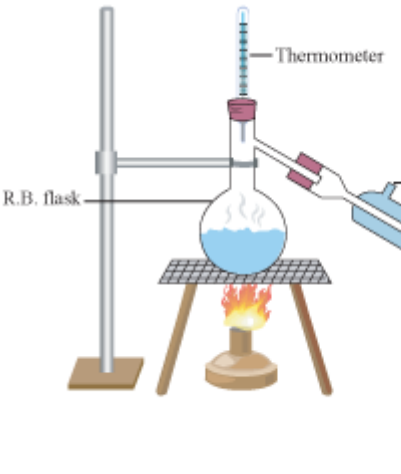
*Enquiring
*Creative/Enterprising
*Open-minded
*Risk-taking

2. Which samples had the least dissolved solid? Why would this be?

3. Which samples had the most dissolved solid? Why would this be?

Distillation

- Carefully set up your distillation apparatus.
- Careless breakages will go on the bill!
- Put 100cm3 of tap water in the flask
- Add 20 cm3 of Hydrochloric acid
- Distil your sample until around half the water has been collected.
- Do not heat to dryness.
- Test the pH of the water you collect.



1. How close to neutral is the sample you collected?

This lesson involves …

*Collaborative
*Concerned for Society
*Confident

2. Why isn't the water acidic?

3. The oceans are an inexhaustible supply of water. Why isn't distillation a good way to produce drinking water?

Treating Sewage.

We don't just release sewage into rivers.

Why not?

_____

_____

_____

First it is screened an filtered to produce ***Sewage Sludge.***

This is still be dangerous and requires further treatment.

This lesson involves …

*Collaborative
*Concerned for Society
*Confident

Anaerobic and Aerobic Digestion.

Both of these processes breakdown the waste using _____.

The difference between the two is the presence or absence of _____.

Anaerobic digestion is usually reserved for the sludge – it produces _____ gas that can be used for _____ & harmless solid waste that can be used for_____.

Aerobic digestion is usually used for watery effluent – it produces _____ gas as well as some of the same solid waste.

Extended Response Question Potable water

34 Water of a suitable quality is vital for life. Treatment of water supplies is therefore needed before it can safely be used.

34.1 Suggest **one** difference between household wastewater and the water from a lake.

[1 mark]

34.2 Describe how fresh water from a lake and how salt water from the sea are treated to make them fit to drink.

[4 marks]

Mark scheme

Answers	Extra information	Mark
Any one from: (Household wastewater contains) • Detergent **or** soap **or** bleach • Food debris **or** particles **or** organic matter • More microbes.		1
Level 2: Scientifically relevant facts, events or processes are identified and given in detail to form an accurate account.		3–4
Level 1: Facts, events or processes are identified and simply stated but their relevance is not clear.		1–2
No relevant content		0
Indictive content (Treatment of fresh water) Any two from: • Filter **or** pass through beds to remove solids • Sterilise to kill microbes • Use of chlorine or ozone or ultraviolet light. (Treatment of salt water) Any two from: • Reference to desalination • Distillation **or** description of boiling and condensing • Reverse osmosis **or** description of use of a membrane to only allow water through.		

Glass

All glass is made using sand. Sand is primarily a compound with the formula SiO_2

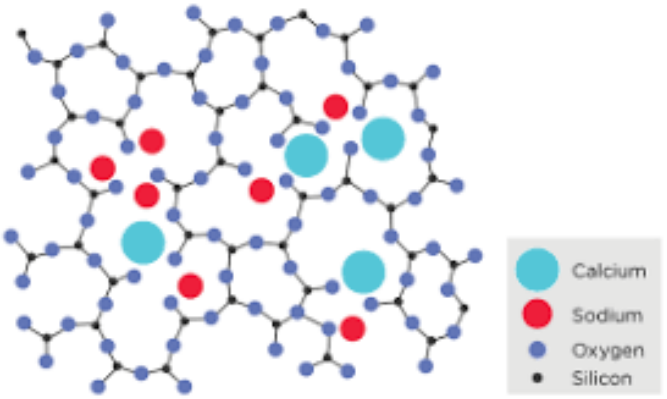
1. SiO_2 would be called _____
2. Silicon is a **metal/non-metal**

3. So SiO_2 should be **acidic/basic**

Most glass is Soda-lime glass – glass made from sand, limestone (Calcium Carbonate) and Sodium Carbonate

1. Calcium & Sodium Carbonates are both Metal Carbonates and should be **acidic/basic**

2. The reaction between SiO_2 and the metal Carbonates could be called **n**_____



The glass produced is mostly a network of _____ and _____ atoms with _____ and _____ ions held in the spaces. It's transparent but brittle and not particularly difficult to melt.

Making the glass from sand and Boron Trioxide is much more expensive but gives a glass with a much higher melting point.

1 Give two uses that would justify using this expensive form of glass.

Other Materials

Clay can be found in river banks.

In order to make a useful pot the clay would first have to be dug out, mixed with water and _____

And then chemically changed by

_____

The result is a ***ceramic*** – other ceramics include building materials such as

_____ & _____.

Ceramics are brittle but very strong in compression.

What does strong in compression mean and is it important an important property of bricks or tiles?

_____

Ceramics also have extremely high melting points so are useful for constructing _____

High and Low Density Polyethene

Polyethene is a polymer made from _____.

If we change the conditions in which it is made we can change the structure of the polymer.

1. Higher density polymers have fewer

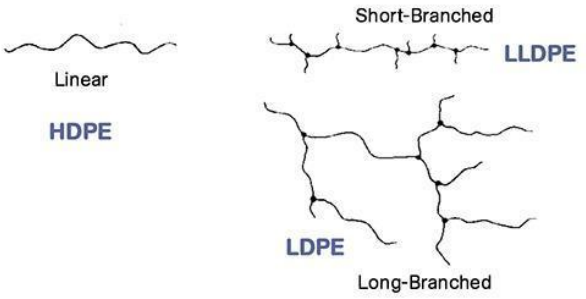
_____

2. This means that the polymer chains can

_____

3. HDPE has _____ intermolecular forces making it _____er and giving it a _____er melting point

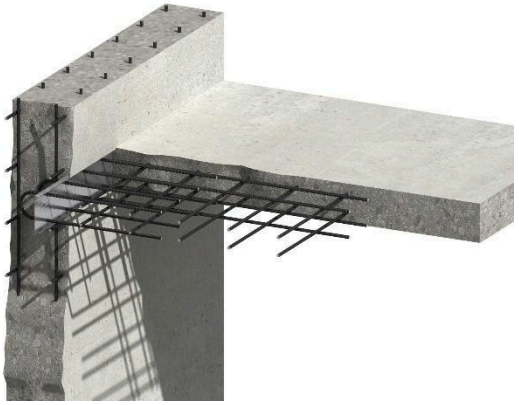
FIG. 1 Effect of Branching on Density



Composites

Composites are materials that contain two or more materials mixed.

Like reinforced concrete.



Concrete is ***strong in compression*** – difficult to break when _____

The steel reinforcers are ***strong in tension*** – difficult to break when _____

The ***Matrix*** (material running through the composite) is the steel and the ***Binder*** (holding the matrix together is the composite

MDF – stands for ***Medium Density Fibreboard.*** It's made from compressed wood, wood fibre and glue.

What is the Matrix? _____ What is the binder? _____

Where is MDF used? _____

GRP – ***Glass Reinforced Plastic*** is made from fibre-glass coated with plastic resin. It's lightweight and waterproof. It's found in all sorts of places such as waterslides, pipes even the Eurofighter.

What is the Matrix? _____ What is the binder? _____

This lesson involves …

*Collaborative
*Concerned
Society
*Confident

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Life Cycle Assessments

An LCA tries to assess the damage done to the environment for the whole life of a product

LCA STAGE	Paper Bag (Description & Score 1/10)	Plastic Bag (Description & Score 1/10)
Extraction and processing of raw materials	1. Raw material = 2. Energy use in cutting and pulping wood = 3. Level of waste produced = /10	1. Raw material = 2. Energy use in Extracting, Fractionally distilling, cracking and polymerising = 3. Level of waste produced = /10
Manufacturing and Packaging	/10	/10
Use and Re-use	Is it possible to re-use? /10	Is it possible to re-use? /10
Disposal	Recyclable? Biodegradable? Can it be incinerated? /10	Recyclable? Biodegradable? Can it be incinerated? /10
Transport and distribution at all stages	/10	/10
Total	/50	/50

We may be surprised that a paper bag has a worse LCA rating than a quality plastic bag.

What does it even mean?

Well, if we only used quality plastic bags and used them many times before disposing of them by recycling then we should use them rather than paper bags.

But real-life means that this may not happen.

So, we may be better off with paper bags anyway - especially if we move towards making them with renewable energy rather than fossil fuels.

Problems with LCAs

In the real world it <u>is</u> easy to quantify:

1. Use of water
2. Use of resources
3. Amount of energy used
4. How much waste is produced

But it is <u>not</u> easy to quantify the effects of pollutants because we can't be sure what the overall total effect will be.

And this means we have to use <u>value judgements</u> - which differ from person to person and are, therefore, unreliable.

LCAs use facts mixed with judgements - making them unreliable too.

Selective or abbreviated LCAs

If a paper bag manufacturer wanted to advertise their product, they might use a ***selective/abbreviated LCA*** – which only shows <u>some</u> of the impacts of the product on the environment.

Should we take any notice of these?

They might "***approximate***" the raw material processing impact and use a ***value judgement*** to make it seem less than it is.

So can they be trusted?

Unless an LCA has been peer-reviewed by an independent group we should beware that it may have been ***<u>misused</u>*** to reach a pre-determined conclusion - one that suits the manufacturer.

Extended Response Question — Life cycle assessment

35 The life cycle assessment process involves four key stages:

- extraction of raw materials
- manufacture of product
- use of product
- disposal of product.

Data on these four stages for two types of disposable drink containers is shown below

	Glass bottles	Plastic bottles (PET)
Raw materials	Sand, sodium carbonate and limestone	Crude oil
Energy required per container in kJ	76	9
Product life span	Recycling potential 100%	Recycling potential 30%
Time to break down in years	~ 1 million	450

Evaluate, using the information in **Table 12**, the use of glass bottles and of plastic bottles in terms of their environmental impact.

[6 marks]

Mark scheme

Answers	Mark
Level 3: A judgement, strongly linked and logically supported by a sufficient range of correct reasons, is given.	5–6
Level 2: Some logically linked reasons are given. There may also be a simple judgement.	3–4
Level 1: Relevant points are made. They are not logically linked.	1–2
No relevant content	0
Indicative content Glass bottles ● Readily available raw materials. ● High energy use for manufacture. ● Can be (re-)used indefinitely. ● Will not **or** takes a very long time to break down/decompose. Plastic bottles ● Crude oil is a finite resource **or** is non-renewable. ● Low energy use for manufacture. ● Low recyclable potential. ● Takes a long time to break down **or** decompose. General properties ● Glass is heavier so more energy required to transport / or reverse argument (ORA). ● Glass is more likely to break so no longer used / ORA. ● Glass releases more carbon dioxide during production / ORA.	