Answer Booklet

C5.1 Carbon Chemistry

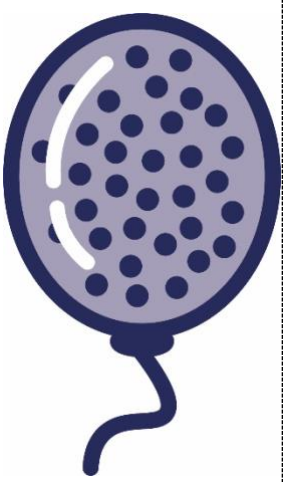
Separate Science (Chemistry)

Science
Mastery

ArkCurriculum+

The Big Idea

Carbon Chemistry



What is crude oil actually made from? Why is so useful? How can we separate it and use it for different things? How is crude oil related to petrol and other fuels?

Organic chemistry is the study of the structure and properties of compounds that contain carbon. One of the biggest sources of carbon compounds is crude oil, which can be separated into many different compounds called hydrocarbons. Humans use these hydrocarbons for many different purposes.

This is the **sixth** unit we are studying as part of the big idea: **Structure Determines Properties.**

In this unit we will learn about what crude oil is and how it can be separated into different useful products. We will learn about different groups of hydrocarbons that can be obtained by fractional distillation of crude oil and the properties of these compounds and the different reactions they are involved in. We will also look at how some of these products can be made into useful polymers.

Chemistry students will also look at other groups of compounds, including alkenes, alcohols and carboxylic acids and reactions involving these compounds.

We will develop our skills in this unit by practising drawing models of covalent bonding in molecules. We will also revisit distillation as a method of separating a mixture based on the boiling points of the substances in it.

TASKS:

What subject will this unit focus on? BIOLOGY CHEMISTRY PHYSICS

(circle the correct subject)

There are lots of keywords underlined above. List these into the two columns:

Words I know	Words I haven't seen before

To answer before the unit:

1. What are you most excited to learn about in this topic?

   _____

   _____

   _____

2. What do you already know about this topic?

   _____

   _____

   _____

3. Why do you think it's important to learn that structure determines properties?

   _____

   _____

4. What knowledge from previous science lessons might help us?

   _____

   _____

   _____

5. What questions do you have about this topic?

   _____

   _____

To answer at the end of the unit:

1. Tick off any words in the 'words I haven't seen before' column that you are now confident with. Circle any you still need more practice to use.

2. What have you most enjoyed about this unit?

   _____

   _____

   _____

3. What more would you like to learn about bonding as part of the big idea: 'Structure Determines Properties'?

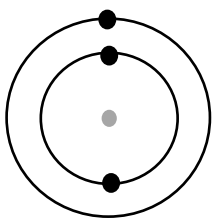
   _____

   _____

Pre-Test

1. The atomic structure of elements relates to their position on the Periodic Table.

   In which group of the Periodic Table would you find the element represented by this electronic configuration? [1]

   Tick (✓) **one** box.

   A. Group 2 ☐

   B. Group 3 ☐

   C. Group 1 ☐

2. Which is the correct definition of a compound?

   Tick (✓) **one** box. [1]

   A. Two or more elements mixed together ☐

   B. Two or more elements chemically bonded together ☐

   C. A group of non-metal atoms bonded together ☐

3. Which is the correct definition of a molecule?

   Tick (✓) **one** box. [1]

   A. A group of metals atoms bonded together ☐

   B. A group of metal and non-metal atoms bonded together ☐

   C. A group of non-metal atoms bonded together ☐

4. Which type of bonding would be found in a molecule of oxygen?

Tick (✓) **one** box. [1]

A. Covalent ☐

B. Ionic ☐

C. There would be no bonding ☐

5. Which type of bonding would be found in sodium chloride?

Tick (✓) **one** box. [1]

A. Covalent ☐

B. Ionic ☐

C. Metallic ☐

6. Which statement is true of covalent substances?

Tick (✓) **one** box. [1]

A. They contain non-metal atoms ☐

B. They contain metal atoms ☐

C. They contain metal and non-metal atoms ☐

7. What type of atoms make up both diamond and graphite?

Tick (✓) **one** boxes. [1]

A. oxygen ☐

B. hydrogen ☐

C. carbon ☐

D. copper ☐

8. Choose the correct electronic configuration of a carbon atom.

The atomic number of carbon is 6. [1]

Tick (✓) **one** box.

A. 2,4 ☐

B. 2,2,2 ☐

C. 2,8 ☐

9. Choose the best explanation for why noble gases are unreactive. [1]

Tick (✓) **one** box.

A. They all have 8 electrons in their outer shell ☐

B. They have a stable electron arrangement ☐

C. They are neutral because they have equal numbers of protons and electrons ☐

10. Define 'polymer'.

Tick (✓) **one** box. [1]

A. A polymer is a type of plastic ☐

B. A polymer is a long chain molecule made up of many units ☐

C. A polymer is a type of plastic that melts when heated ☐

End of Unit Pre-Test. Turn over to see the answers. Give yourself a mark out of 10.

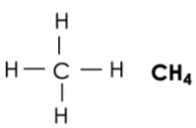
Qu	Answer	Marks
1	C	1
2	B	1
3	C	1
4	A	1
5	B	1
6	A	1
7	C	1
8	A	1
9	B	1
10	B	1

Knowledge Organiser

Crude Oil and Hydrocarbons

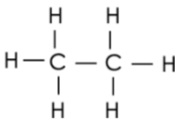
1. Crude oil is a **finite** resource found in **rocks**.
2. Crude oil is the remains of an ancient **biomass** consisting mainly of **plankton** that was buried in mud.
3. Crude oil is a mixture of a very large number of compounds. Most of the compounds in crude oil are hydrocarbons.
4. **Hydrocarbons** are molecules made up of **hydrogen** and **carbon** atoms only.
5. Most of the hydrocarbons in crude oil are hydrocarbons called **alkanes**.
6. The general formula for the homologous series of alkanes is C_nH2_{n+2}
7. The first four members of the alkanes are methane, ethane, propane and butane.
8. Many useful materials on which modern life depends are produced by the **petrochemical industry**, such as solvents, lubricants, polymers, detergents.
9. The vast array of natural and synthetic carbon compounds occur due to the ability of carbon atoms to form families of similar compounds.

Methane Monkeys



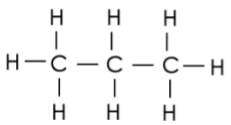
CH_4

Ethane Eat



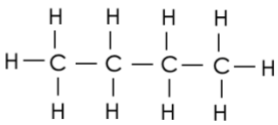
C_2H_6

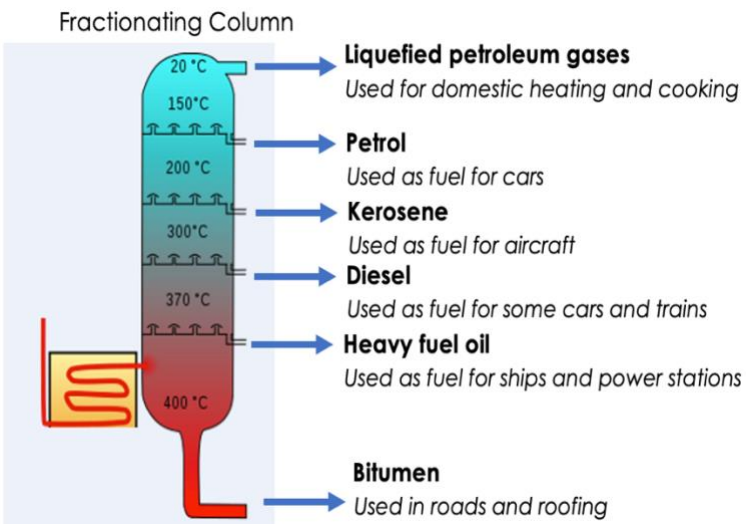
Propane Peanut



C_3H_8

Butane Butter





Fractional Distillation

10. 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.
11. The fractions can be processed to produce fuels and feedstock for the petrochemical industry.
12. 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.
13. During fractional distillation, a **fractionating column** is used. This column has **condensers** at varying heights.
14. A fractionating column is **hot** at the **bottom** and **cooler** at the **top**
15. Substances with **high boiling points condense** at the **bottom** and those with **low boiling points condense** at the **top**
16. During fractional distillation, crude oil is **evaporated**. It's **vapours condense at different temperatures** in the fractionating column.
17. Each fraction produced during fractional distillation has a similar number of carbons (or size of hydrocarbons)

18. 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.
19. **Boiling point, viscosity and flammability** change with **increasing molecular size.**

Combustion of Hydrocarbons

20. The combustion of hydrocarbon fuels **releases energy**.
21. During combustion, the carbon and hydrogen in the fuels are oxidised.
22. The complete combustion of a hydrocarbon produces carbon dioxide and water.
23. The general word equation that describes the complete combustion of an alkane is:

alkane + oxygen → carbon dioxide + water

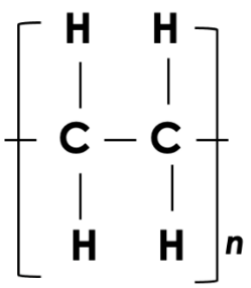
24. Complete combustion reactions of alkanes can be represented by balanced symbol equations, for example:
    $CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$
25. Incomplete combustion can occur if there is not enough oxygen. In this case, carbon, carbon monoxide are produced.

Cracking

26. Hydrocarbons can be bro**ken down (cracked)** to produce **smaller**, **more useful** molecules.
27. Cracking can be done by various methods including **catalytic cracking** and **steam cracking**.
28. The products of cracking include **alkanes** and another type of hydrocarbon called **alkenes**.
29. **Alkenes** are more reactive than alkanes and **react with bromine water**, which is used as a test for alkenes.
30. If **alkenes** are present, the bromine water will turn from **orange** to **colourless**.
31. Alkenes are used to produce polymers and as starting materials for the production of many other chemicals.
32. There is a **high demand for fuels** with **small molecules** and so some of the products of cracking are useful as fuels.

Polymers

33. **Polymers** have very large molecules. The atoms in the polymer molecules are linked to other atoms by **strong covalent bonds**.
34. Polymers can be represented in the form:

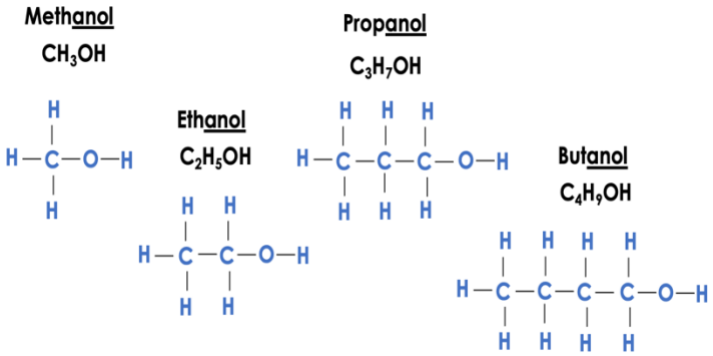


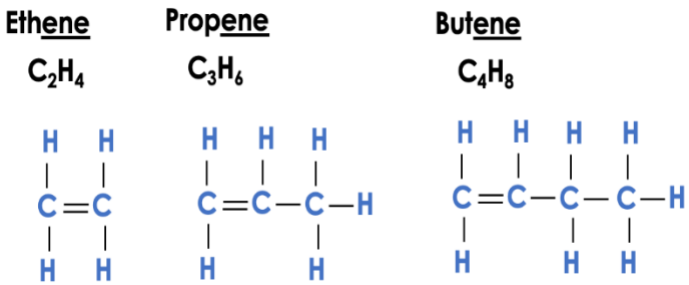
where n is a large number

35. The intermolecular forces between polymer molecules are relatively strong and so these substances are solids at room temperature.
36. 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.
37. **Thermosoftening polymers** melt when they are heated.
38. **Thermosetting polymers** do not melt when they are heated.

Alkenes (Chemistry only)

39. **Alkenes** are hydrocarbons with a **double carbon-carbon** bond.
40. The general formula for the homologous series of alkenes is C_nH_{2n}
41. Alkene molecules are **unsaturated** because they contain two fewer hydrogen atoms than the alkane with the same number of carbon atoms.
42. The first four members of the homologous series of alkenes are ethene, propene, butene and pentene.





43. Alkenes can be represented with a chemical formula or a displayed formula
44. 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.
45. 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.
46. Alkenes are hydrocarbons with the functional group C=C.

Alcohols (Chemistry only)

47. It is the generality of reactions of **functional groups** that determine the reactions of organic compounds.
48. Alcohols contain the functional group –**OH** (a **hydroxyl** group)
49. Methanol, ethanol, propanol and butanol are the first four members of a homologous series of alcohols.
50. Methanol is used as a chemical feedstock.
51. Ethanol is the alcohol present in alcoholic drinks
52. Ethanol is used as a solvent.
53. Propanol is used as a fuel and a solvent.
54. If a small piece of sodium is dropped into ethanol, bubbles of hydrogen gas are produced and the liquid contains sodium ethoxide
55. The reaction between sodium and ethanol can be represented by the equation:

sodium + ethanol → sodium ethoxide + hydrogen gas

56. This reaction can be represented by the balanced symbol equation:

$2\ Na + 2\ C_2H_5OH \rightarrow 2\ C_2H_5ONa + H_2$

57. Ethanol can be produced by fermentation or from ethene
58. Ethanol is concentrated by distillation.
59. **Fermentation** is an **anaerobic** process.
60. The equation for the production of ethanol by fermentation is:

glucose → ethanol + carbon dioxide

61. Yeast provides the enzymes that are needed for fermentation
62. The typical **conditions** required for fermentation are

- anaerobic conditions (no oxygen present)

- sugar dissolved in water, with yeast mixed in

- a warm temperature (25-35 degrees Celsius)

63. Fermentation is a **slow** reaction which may take days or weeks to finish.
64. Alcohols with short hydrocarbon chains mix with water easily to form a solution
65. The solubility of alcohols decreases as the size of the hydrocarbon chain increases
66. Alkenes can be hydrated to produce alcohols according to the equation:

Alkene + water (steam) → alcohol

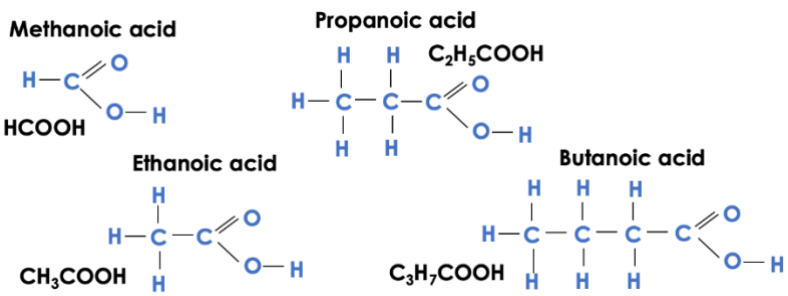
67. This is called hydration, and it needs a temperature of approximately 300°C and a catalyst.
68. For example: Butene + water → butanol
69. **Ethanol** can be manufactured by the hydration of **ethene**
70. The ethene for this reaction comes from **cracking crude oil** fractions
71. In this process, ethene is heated with steam in the presence of a catalyst of phosphoric acid
72. The catalyst speeds up the reaction
73. The word equation for this reaction is: **ethene + steam → ethanol**
74. The chemical equation for this reaction is: $C_2H_4 + H_2O \rightarrow C_2H_5OH$
75. The conditions for this reaction are

- a high temperature (around 300 °C)

- a pressure of 60-70 atmospheres

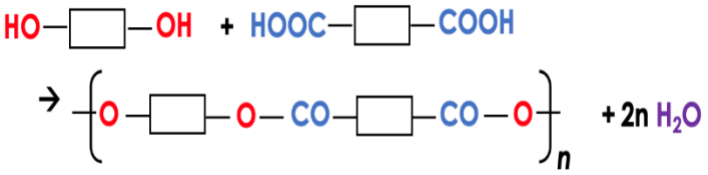
76. Ethanol is the only product of this reaction
77. This is a **continuous** reaction, which means that as long as ethene and steam are fed into the reaction, ethanol will be produced continually. This makes it an **efficient** process.
78. Ethene is made from crude oil which is a non-renewable resource.
79. The reaction of ethene with steam can be reversed, allowing ethanol to be converted back to ethene.
80. A catalyst called aluminium oxide can speed up this reaction
81. The word equation for this reaction is: ethanol → ethene + steam
82. The chemical equation for this reaction is:
$C_2H_5OH \rightarrow C_2H_4 + H_2O$

Carboxylic Acids and Esters (Chemistry only)



83. Carboxylic acids have the functional group **–COOH**.
84. The functional group -COOH is also called the **carboxyl group**
85. Carboxylic acids can be represented using a chemical formula or a displayed formula
86. Carboxylic acids have the same general formula: $C_nH_{2n+1}COOH$, where n is the number of carbon atoms in the molecule minus 1 (or $C_nH_{2n}O_2$)
87. The first four members of a homologous series of carboxylic acids are methanoic acid, ethanoic acid, propanoic acid and butanoic acid.
88. Carboxylic acids are **weak acids**, which have the typical properties of acids.
89. Carboxylic acids dissolve in water to form **acidic** solutions with **pH** values of **less than 7**
90. **Vinegar** is a dilute solution of **ethanoic acid**

91. Carboxylic acids react with carbonates to form a salt, water and carbon dioxide
92. Because carboxylic acids are weak acids, their solutions do not contain many hydrogen ions compared to a strong acid of the same concentration
93. **Carboxylic acids** can react with **alcohols** to make **esters**

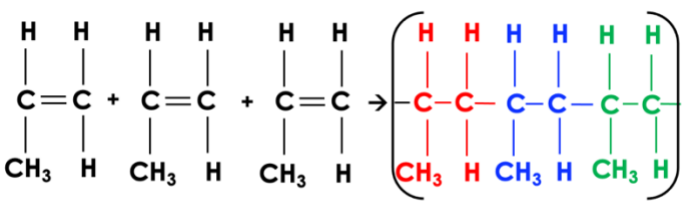


94. Esters contain the functional group -COO-
95. Esters have fruity smells and can be used as solvents
96. The general equation for the formation of an ester is:**alcohol + carboxylic acid → ester + water**
97. For example:

ethanol + ethanoic acid → ethyl ethanoate + water

Polymerisation (Chemistry only)

98. **Alkenes** can be used to make **polymers** such as poly(ethene) and poly(propene) by addition polymerisation.
99. In **addition polymerisation** reactions, many small molecules (monomers) join together to form very large molecules (polymers).
100. In addition polymers the repeating unit has the same atoms as the monomer because **no other molecule is formed** in the reaction.
101. Condensation polymerisation involves **monomers with two functional groups**.
102. When these types of monomers react they join together, usually losing small molecules such as water, and so the reactions are called condensation reactions.
103. The simplest polymers are produced from two different monomers with two of the same functional groups on each monomer.



104. **Amino acids** have t**wo different functional groups** in a molecule.
105. Amino acids react by **condensation polymerisation** to produce polypeptides.
106. Different amino acids can be combined in the same chain to produce proteins.
107. **DNA** (deoxyribonucleic acid) is a large molecule essential for life.
108. DNA encodes **genetic instructions** for the development and functioning of living organisms and viruses.
109. Most DNA molecules are tw**o polymer chains**, made from four different **monomers** called **nucleotides**, in the form of a double helix.
110. Other naturally occurring polymers important for life include **proteins**, **starch** and **cellulose**.

Glossary

Alcohol	An organic compound that contains a hydroxyl (OH) group. *Ethanol is the **alcohol** found in alcoholic drinks.*
Alkane	A hydrocarbon molecule with the general formula C_nH_{2n+2}. *Methane, ethane and propane are all **alkanes**.*
Alkene	A hydrocarbon molecule with the general formula C_nH_{2n}. ***Alkenes** contain a carbon-carbon double bond.*
Amino acid	A naturally occurring monomer that contains two different functional groups. ***Amino acids** can be joined together to make polypeptides and proteins.*
Carboxyl group	The functional group found in carboxylic acids (-COOH). *Ethanoic acid contains a **carboxyl group**.*
Carboxylic acid	An organic compound that contains a carboxyl (COOH) group. *Ethanoic acid is a **carboxylic acid** found in vinegar.*
Catalyst	A substance that speeds up a chemical reaction without being used up. *Ethanol can be made from ethene, but this requires a **catalyst**.*
Combustion	A reaction where a substance burns in oxygen. ***Combustion** of alkanes produces carbon dioxide and water.*
Covalent bonding	The type of bonding found between non-metals, where electrons are shared to provide full outer shells. ***Covalent bonding** is found in both covalent molecules and giant covalent structures.*
Cracking	The process by which longer hydrocarbon chains are broken down into shorter hydrocarbons. ***Cracking** produces an alkane and an alkene.*

Crude oil	A finite resource found in rocks made from the ancient biomass of plankton. ***Crude oil*** *is a non-renewable resource that is used to provide fuels and make plastics.*
DNA	A molecule containing the genetic information for functioning and development of living organisms and viruses. ***DNA*** *is made up of two strands of repeating nucleotide units.*
Ester	An organic compound made through the reaction between an alcohol and a carboxylic acid. ***Esters*** *are often used in scented products as they have pleasant, fruity smells.*
Fermentation	An anaerobic process where glucose is broken down to produce ethanol and carbon dioxide. ***Fermentation*** *is a method of producing ethanol.*
Fractional distillation	The process by which crude oil is separated into groups of similar compounds based on their boiling points. *During* ***fractional distillation****, crude oil is evaporated and fractions condense at different temperatures.*
Functional group	An atom or group of atoms that is responsible for the chemical properties of a compound. *Alcohols, alkenes and carboxylic acids all contain a* ***functional group****.*
Homologous series	A group of compounds that have similar chemical properties and the same general formula. *The alkanes are a* ***homologous series*** *that all have the general formula* C_nH_{2n+2}*.*
Hydration	A process which adds water. *Alcohols can be made from alkenes by* ***hydration****.*

Hydrocarbon	A molecule that contains carbon and hydrogen atoms only. *Alkenes and alkanes are **hydrocarbons**.*
Hydroxyl group	The functional group found in alcohols (-OH). *Ethanol contains a **hydroxyl group**.*
Intermolecular forces	Attractive forces that hold molecules of a substance together. *Covalent molecules have low melting and boiling points because little energy is required to overcome the **intermolecular forces**.*
Molecule	A small group of non-metal atoms chemically joined together *There are millions of **molecules** of water in a swimming pool.*
Monomer	A repeating subunit used to make a polymer. *Glucose is the **monomer** that makes up starch (a polymer).*
Physical property	A property of a substance that can be observed at any time *A **physical property** of iron is that it is hard.*
Polymer	A substance made up of repeating subunits (monomers). *Plastic is a **polymer**.*
Saturated	A compound that contains only carbon-carbon single bonds. *Alkanes are **saturated** as they contain only single bonds between carbon atoms.*
Thermosetting	Polymers that do not melt when they are heated. *A **thermosetting** plastic's shape cannot be changed.*
Thermosoftening	Polymers that melt when they are heated. *The shape of a **thermosetting** plastic can be changed when it is heated.*

Unsaturated	A compound that contains one or more carbon-carbon double (or triple) bonds. *Alkenes are **unsaturated** as they contain a double bond between carbon atoms.*
Viscosity	A measure of a substance's resistance to flow or how easy it is to pour. *Water has a low **viscosity**, so is not very viscous, but honey has a high viscosity and is very viscous.*

Prior Knowledge Review

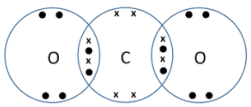
Do Now

1. State the chemical symbol for carbon. **C**

2. Carbon has an atomic number of 6. State its electron configuration. **2,4**
3. State the type of bonding found in water. **Covalent**
4. Give an example of a giant covalent network. **Diamond, graphite, silicon dioxide**
5. Define a compound. **Two or more elements chemically bonded together**

Drill:

1. State the chemical formula for carbon dioxide. **CO_2**
2. Name the type of bonding found in carbon dioxide.**covalent**
3. Draw a dot and cross diagram to show the bonding in a molecule of carbon dioxide.



Read Now:

Covalent bonding takes place between non-metal atoms, where they share electrons to achieve a full outer shell and stable electron arrangement. Some covalent structures are molecules, which are small groups of non-metal atoms held together by strong covalent bonds. Some molecules can actually be very large, including one of the largest naturally-occurring molecules: DNA. Covalent bonding can also be found in giant covalent structures, such as diamond and graphite, which involve huge numbers of atoms covalently bonded to other atoms.

1. Identify the type of elements between which covalent bonds are formed. **Non-metals**
2. Explain why atoms make bonds. **To achieve a stable electron arrangement/full outer shell**
3. Explain what is meant by a stable electron arrangement. **A full outer shell**
4. Define a molecule. **A group of non-metal atoms covalently bonded together.**
5. Give an example of a giant covalent structure. **Diamond, graphite**

Covalent bonding

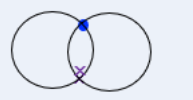
What type of elements form covalent bonds? **Non-metals**

What happens to the electrons in a covalent bond? **Shared between atoms**

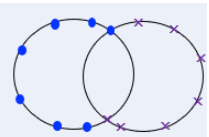
How many electrons are in one covalent bond? **Two**

Draw a dot and cross diagrssm for a molecule of

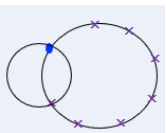
a) hydrogen



b) Chlorine



c) Hydrogen bromide (HBr)



The structure of simple covalent substances

What simple covalent substances consist of? **molecules**

What holds the atoms together?**covalent bonds**

What holds the molecules together? **Intermolecular forces**

Give three names of simple covalent substances **Hydrogen, Nitrogen, Fluorine, water, oxygen, bromine, chlorine, iodine.**

Properties of covalent substances

Name the two types of covalent substances. Label the diagrams with the name of each.

Simple molecules and giant

A: **simple molecules** B **giant**

For each statement write A or B or both or neither

1. Low melting and boiling point **A**
2. May conduct electricity **B**
3. Liquid or gas at room temperature **A**
4. Do not conduct electricity **A**
5. Solid at room temperature **B**
7. High melting and boiling point **B**

Drill

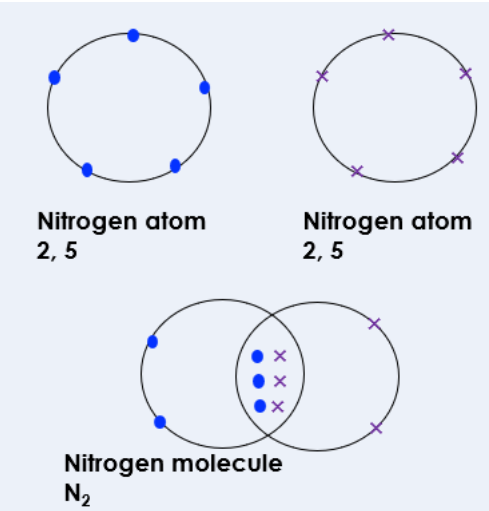
1. What type of elements are bonded during covalent bonding? **Non-metals**
1. What happens during covalent bonding? **non-metals share pairs of electrons.**
2. How is a single covalent bond represented? **by a single line, e.g. H-H**
3. How is a double covalent bond represented? **by a double line, e.g. O=O**
4. What is a double covalent bond? **2 shared pairs of electrons**
5. What is the formula for methane? **CH_4**
6. State one example of a simple covalent substance. **Water, oxygen, and carbon dioxide**
2. What state of matter are simple covalent substances at room temperature? **Liquid and gas**
3. Are covalent bonds weak or strong? **Covalent bonds are strong**
4. Name the forces that act between molecules in a simple covalent substance. **Intermolecular forces**
7. Explain the electrical conductivity of water. **Water is a simple covalent substance. Its molecules are neutral and do not have any free electrons or ions to carry a charge. Therefore, water does not conduct electricity**

I: Drawing covalent bonding diagrams

Use dot-and-cross diagrams to show the covalent bonding in a nitrogen molecule, N_2

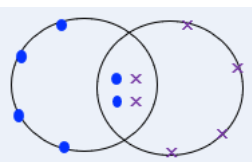
Steps to Success

1. Draw the electronic configuration of the reacting atoms using dots for one type of atom and crosses for the other. Only draw the valance shell.
2. Count how many electrons each atom will need to share in order to get a full valance shell.
3. Draw the atoms overlapping with any shared electrons in the middle



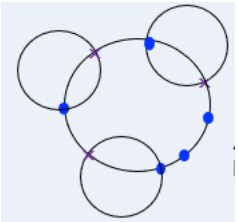
We: Drawing covalent bonding diagrams

Use dot-and-cross diagrams to show the covalent bonding in an oxygen molecule, O_2



You: Drawing covalent bonding diagrams

Use dot-and-cross diagrams to show the covalent bonding in an ammonia molecule, NH_3



Exit Ticket

1. Which answer correctly defines covalent bonding?

- ❑ **A. Covalent bonding occurs where two or more non-metal atoms share pairs of electrons in order to achieve a stable electronic configuration**
- ❑ B. Covalent bonding occurs where two or more metal atoms share pairs of electrons in order to achieve a stable electronic configuration
- ❑ C. Covalent bonding occurs where electrons are transferred from one atom to another in order to achieve a stable electronic configuration

How many pairs of electrons are shared, and how many covalent bonds are shown in this diagram?

- ❑ A. 4 pairs of electrons are shared, and there are two single covalent bonds
- ❑ B. 2 pairs of electrons are shared, and there are two double covalent bonds
- ❑ **C. 4 pairs of electrons are shared, and there are two double covalent bonds**

3. Why doesn't pure water conduct electricity?

- ❑ A. It isn't a solid
- ❑ B. Pure water does conduct electricity
- ❑ **C. It does not contain any free electrons**

Crude Oil and Hydrocarbons

Do Now

1. State the type of elements that form covalent bonds. **Non-metals**
2. Describe what happens to electrons when a covalent bond is formed. **Electrons are shared between atoms to give each atom a full outer shell.**
3. Define a compound. **Two or more elements chemically bonded together.**
4. Define a molecule. **A group of non-metal atoms covalently bonded together.**
5. Calculate the relative formula mass of methane (CH4). C=12, H=1 **16**

Drill: Here are some common chemical formulae: CO2, H2O, O2, NaCl, Ca(OH)2.

1. Identify which of these formulae represent elements. **O_2**
2. Identify which of these formulae represent compounds. **All except O_2**
3. Identify which of these formulae would form molecules. **CO_2, H_2O, O_2**

Read Now:

Crude oil is one of the most important energy sources in the world and is used in many aspects of everyday life, from fuel and heating, to petrochemicals, tarmac for roads and plastics. Crude oil is a fossil fuel found deep underground rocks, so it is a finite or non-renewable resource. It is made of the remains of ancient biomass that lived and died millions of years ago. It is mainly from plankton, which was buried under many layers of mud. Crude oil itself is a mixture of different compounds called hydrocarbons. Crude oil is a very valuable resource, sometimes described as 'liquid gold' because it is so valuable. 5 countries are responsible for nearly half the global production of crude oil: the USA, Saudi Arabia, Russia, Iran and Canada.

1. State how crude oil is used in everyday life. **Fuel, heating, petrochemicals, tarmac, plastics**
2. Describe where crude oil is found. **Deep underground rocks**
3. Describe what crude oil is made from. **Remains of ancient biomass of plankton.**
4. Explain whether crude oil is a renewable or non-renewable resource. **Non-renewable**
5. Name the countries that are the largest producers of crude oil. **USA, Saudi Arabia, Russia, Iran and Canada**

Crude Oil and Hydrocarbons

Give two uses of crude oil

Fuel, heating, making plastics, solvents, lubricant detergents

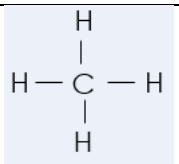
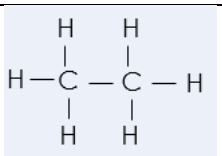
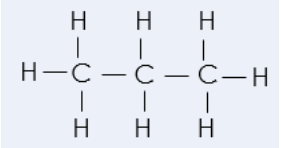
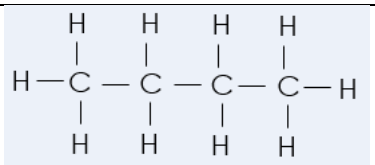
What type of resource is it? **finite**

IS crude oil an element, compound or mixture? **mixture**

Define hydrocarbon

Molecules made up of hydrogen and carbon atoms only.

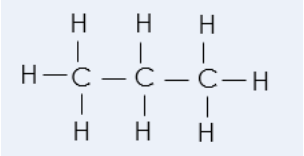
Complete the table below

Name of alkane	Formula	Didplayed formula
Methane	CH_4	
Ethane	C_2H_6	
propane	C_3H_8	
butane	C_4H_{10}	

Drill

1. Describe where crude oil is found. Answer: **Deep underground under rocks.**
2. Describe what crude oil is made from. Answer: **Ancient biomass (mainly plankton) that was buried in mud.**
3. Explain why crude oil is a mixture. Answer: **It contains different compounds**.
4. Define a hydrocarbon. Answer: **Molecules made of carbon and hydrogen atoms only**.
5. State the general formula of the alkanes. Answer: **CnH2n+2**
6. Name the alkane with 1 carbon. Answer: **Methane**

7. Name the alkane with 4 carbons. Answer: **Butane**
8. Draw the displayed formula for the alkane with 3 carbons.



I: Alkane Formulae

We can use the general formula of alkanes to determine how many atoms are in a given molecule.

What is the general formula of the alkanes? **C_nH_{2n+2}**

How many hydrogen atoms would there be in an alkane with 5 carbons? **C_nH_{2n+2}, n=5 2n + 2 (2x5) + 2 = 12 C_5H_{12}**

How many carbon atoms would there be in an alkane with 14 hydrogens? **C_nH_{2n+2} 2n + 2 = 14 2n = 12 n = 6 C_6H_{14}**

We do: Alkane Formulae

How many hydrogen atoms would there be in an alkane with 8 carbons? **18**

How many carbon atoms would there be in an alkane with 22 hydrogens? **10**

You do: Alkane Formulae

How many hydrogen atoms would there be in an alkane with 12 carbons? **26**

How many carbon atoms would there be in an alkane with 38 hydrogens? ***18***

Exit Ticket

1. Which alkane is this?
   - ❑ A. Ethane
   - ❑ **B. Propane**
   - ❑ C. Butane
2. An alkane has 15 carbons. How many hydrogen atoms would it have?
   - ❑ A. 30

- ❑ **B. 32**
- ❑ C. 34

3. What is crude oil?
   - ❑ **A. A finite resource formed from ancient plankton biomass**
   - ❑ B. A finite resource formed from rocks
   - ❑ C. A finite resource containing compounds of carbon and water

Fractional Distillation

Do Now

1. Define a hydrocarbon. **A molecule made up of hydrogen and carbon atoms only.**
2. Name the alkane that contains four carbon atoms. **Butane**
3. State the general formula of the alkanes. **CnH2n+2**
4. Describe what happens when a covalent bond is formed. **Electrons are shared so that each atom gets a full outer shell.**
5. Explain why covalent molecules have relatively low boiling points. **There are weak intermolecular forces between molecules which require little energy to overcome**.

Drill:

The melting and boiling points of some of the alkanes are given in the table.

Alkane	Melting point (°C)	Boiling point (°C)
Methane	-182	-164
Ethane	-183	-89
Propane	-190	-42
Butane	-138	-1

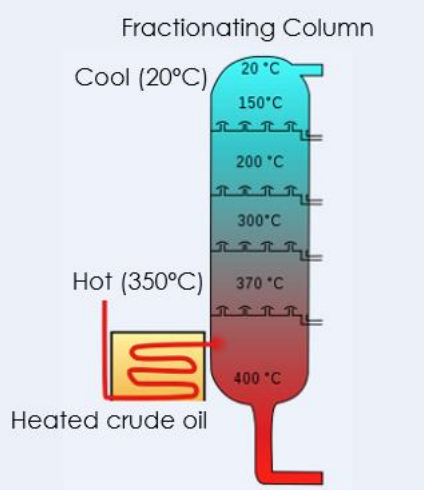
1. Identify which state of matter these alkanes would be at room temperature (20 °C). **All gases**
2. Identify which state of matter these alkanes would be at -50°C. **Methane and ethane would be gases, propane and butane would be liquids.**

Read Now:

Distillation is a method used to separate a mixture into the different compounds or elements within it based on their boiling points. For example, salt can be separated from sea water by distillation, as when it is heated the water will boil before the salt. The water vapour is then collected into a condenser where it cools down to form a pure liquid. Fractional distillation uses heating to separate the mixture of crude oil into its 'fractions', which are groups of different chemical compounds. Each of these fractions contains hydrocarbons of different lengths which are used for different functions. The shortest hydrocarbon molecules are used as gas fuels, while the longer hydrocarbon molecules are used for heavy fuel oil or bitumen for making tar for roads.

1. State the physical property that distillation uses to separate mixtures. **Boiling points**
2. Describe what happens during distillation. **A mixture of liquids is heated. The liquid with the lower boiling point will evaporate first and then be separated using a condenser.**
3. Explain why crude oil is a mixture. **It contains groups of chemical compounds.**
4. Explain what is meant by a 'fraction' of crude oil. **A group of hydrocarbons with similar lengths.**
5. Give a use of the shorter hydrocarbon chains. **Gas fuels**

Fractional Distillation



Fill in the key words in the method

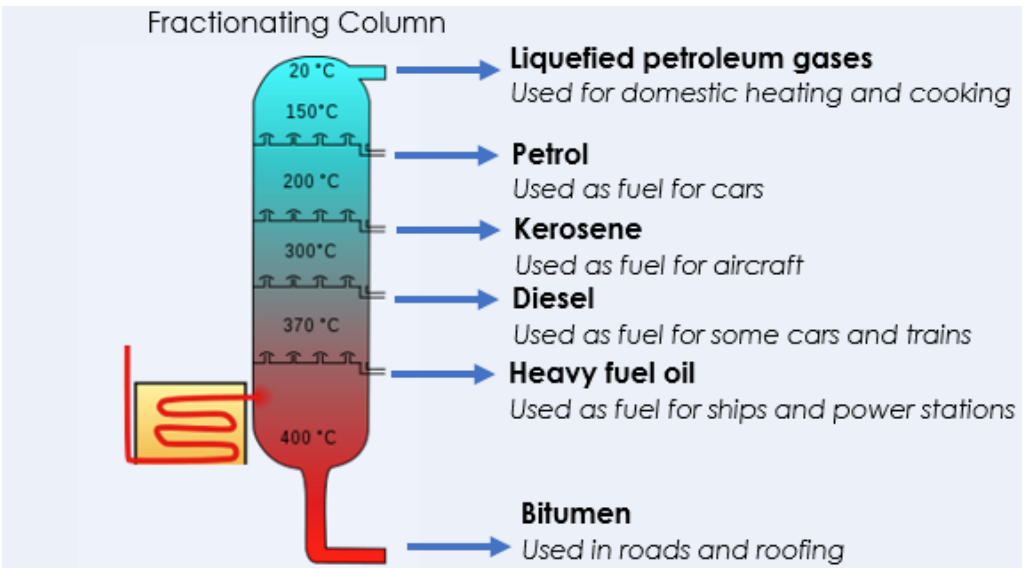
Crude oil is **heated and** vaporises

The column is **hottest/hotter**_ at the bottoma and **coolest/cooler** at the **top**

The smaller molecules have **lower** boiling points, so they rise to the **top** of the column wheras larger molecules have a **higher** boiling point so styay at the bottom.

As the mixture rises it **cools** and **condenses.**

The vapours will consense at different **temperatures** because the hydrocarbons have different **boiling points**



Small molecules (few carbons in alkane chain)

- Low boiling point
- Highly volatile
- Flows easily (low viscosity)
- Highly flammable

- High boiling point
- Low volatility
- Does not flow easily (high viscosity)
- Not very flammable

Large molecules (many carbons in alkane chain)

Drill

1. Explain why crude oil is a mixture**. It contains different compounds.**
2. Name the piece of equipment used to separate crude oil into fractions. **Fractionating column.**
3. State the physical property that fractions are separated based on**. Boiling point.**
4. Name the fraction with the smallest molecules. **Liquefied petroleum gases.**
5. Name the fraction with the largest molecules. **Bitumen.**
6. Give two fractions that are used as fuels for transport. **Petrol, kerosene, diesel, heavy fuel oil.**
7. Describe the relationship between the size of molecules and boiling point. **Boiling point increases with increasing molecule size.**
8. Explain the relationship between the size of molecules and boiling point. **As molecules get larger, intermolecular forces between them increase, requiring more energy to overcome**

I: Describe: ***to recall facts, events or processes in an accurate way***

Describe how viscosity changes with increasing molecule size in fractions of crude oil.

- **Fractions with larger molecules are more viscous than fractions with smaller molecules**
- **Viscosity increases with increasing molecule size**

We: Describe how volatility changes with increasing molecule size in fractions of crude oil.

- **Fractions with larger molecules are less volatile than fractions with smaller molecules**
- **Volatility decreases with increasing molecule size**

You: Describe how boiling point changes with increasing molecule size in fractions of crude oil.

- **Fractions with larger molecules have higher boiling points than fractions with smaller molecules**
- **Boiling point increases with increasing molecule size**

Exit Ticket

1. How does fractional distillation separate crude oil into fractions?
    - ❑ A. Each fraction has a different viscosity
    - ❑ B. Each fraction has a different melting point
    - ❑ **C. Each fraction has a different boiling point**
2. Which fraction is used for producing material for roads?
    - ❑ A. Liquefied gases
    - ❑ B. Petrol
    - ❑ **C. Bitumen**
3. Which best explains the pattern in boiling points of the alkanes?
    - ❑ A. As the alkanes get longer, boiling points increase because there are more atoms
    - ❑ B. As the alkanes get longer, boiling points decrease because they are more likely to be liquid
    - ❑ **C. As the alkanes get longer, boiling points increase because the intermolecular forces increase**

Combustion of Hydrocarbons

Do Now:

1. Name the process used to separate crude oil. **Fractional distillation**
2. Explain how this process separates crude oil. **Hydrocarbons evaporate and condense at different temperatures depending on their boiling point**.
3. Describe the pattern of viscosity as hydrocarbon chains get longer. **As hydrocarbon chains get longer, viscosity increases.**
4. Name the alkane that contains two carbon atoms. **Ethane**
5. Explain the difference between an exothermic and an endothermic reaction. **An exothermic reaction transfers energy to the surroundings whereas an endothermic reaction takes in energy from the surroundings.**

Drill:

1. Name the compound with the formula CH4. **Methane**
2. Calculate the relative formula mass of propane**. C=12, H=1 Mr = (12x2)+(6x1) = 30**
3. Calculate the percentage by mass of carbon in ethane. **% by mass = 24/30 x 100 = 80%**

Read Now:

Many of the hydrocarbons in crude oil are used as fuels. A fuel is any substance that is burned to release energy. Combustion is the chemical reaction that takes place when a substance burns in air, so when hydrocarbons are burned, these are combustion reactions. These reactions are useful as they are highly exothermic, which means they transfer a large amount of energy to the surroundings. The main advantage of burning hydrocarbons is this release of energy, although there are also disadvantages. Combustion of hydrocarbons produces carbon dioxide as a product, which contributes to global warming. Scientists and companies are developing new fuels that are less harmful to the environment, but humans are still dependent on crude oil as a fuel source for heating homes, gas for cooking and fuel for cars and other modes of transport.

1. Explain what is meant by a fuel. **A substance that is burned to release energy.**
2. Explain what is meant by a combustion reaction. **A reaction when a substance burns in air.**
3. Explain why combustion of hydrocarbons is a useful chemical reaction. **It releases large amounts of energy.**
4. Give a disadvantage of burning hydrocarbons. **It produces carbon dioxide.**
5. Describe two uses of hydrocarbons for humans. **Fuel fot heating, gas for cooking and fuel for cars and transport.**

Complete Combustion

Alkane + oxygen → **carbon dioxide** + water

This reaction is **exothermic**

Incomplete Combustion

Incomplete combustion occus where there is a limited supply of **oxygen**

Incomplete combustion produces water, **carbon monoxide** and **carbon**

The toxic product of incomplete combustion is **carbon monoxide**

Incomplete combustion is **less** exothermic than complete combustion

IIf sulfur is present you may also get **sulfur dioxide** produced.

Balancing combustion equations

Always balance C, then H then O!

$$C_2H_6 + 3.5\ O_2 \rightarrow 2\ CO_2 + 3\ H_2O$$

Number of atoms	Element	Number of atoms
	C	
	H	
	O	

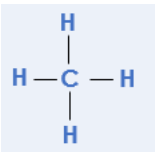
Drill

1. Name the substance that hydrocarbons react with during combustion. - **Oxygen**
2. State the two products of combustion of hydrocarbons. - **Water and carbon dioxide**
3. Identify which product is linked to global warming. - **Carbon dioxide**
4. Explain the difference between complete and incomplete combustion. - **Complete combustion happens when there is plenty of oxygen available whereas incomplete combustion occurs when there is not enough oxygen. Incomplete combustion produces carbon and carbon monoxide (and water) rather than carbon dioxide (and water).**
5. Describe how sulfur dioxide is formed. - **Hydrocarbon fractions may contain sulfur impurities, which react with oxygen during combustion to form sulfur dioxide.**
6. State the environmental problem associated with sulfur dioxide. - **Acid rain**
7. Explain which fractions of crude oil can be burned most easily. - **The fractions with the shortest hydrocarbon chains as they are most flammable.**

I: Combustion Reactions

What is the chemical formula for methane? ***CH_4***

Methane burns in air.



Draw the displayed formula for methane.

Write a word equation for the combustion of methane.

Methane + oxygen → carbon dioxide + water

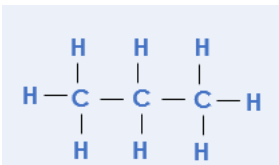
Write a symbol equation for the combustion of methane.

$CH_4 + O_2 \rightarrow CO_2 + H_2O$

Balance the symbol equation.

$CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$

We: Combustion Reactions



What is the chemical formula for propane? ***C_3H_8***

Propane burns in air.

Drw the displayed formula for propane.

Write a word equation for the combustion of propane.

Propane + oxygen → carbon dioxide + water

Write a symbol equation for the combustion of propane.

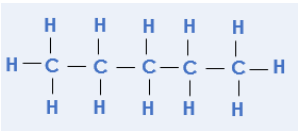
$C_3H_8 + O_2 \rightarrow CO_2 + H_2O$

Balance the symbol equation.

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

You: Combustion Reactions

Pentane (C_5H_{12}) burns in air.



Draw the displayed formula for pentane.

Write a word equation for the combustion of pentane.

Pentane + oxygen → carbon dioxide + water

Write a symbol equation for the combustion of pentane.

$C_5H_{12} + O_2 \rightarrow CO_2 + H_2O$

Balance the symbol equation. **$C_5H_{12} + 8\ O_2 \rightarrow 5\ CO_2 + 6\ H_2O$**

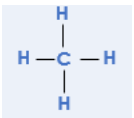
Exit Ticket

1. Which is the correct general equation for the combustion of alkanes?
   - ❑ A. Alkane + water → oxygen + carbon dioxide
   - ❑ **B. Alkane + oxygen → water + carbon dioxide**
   - ❑ C. Alkane + air → water + carbon dioxide
2. Which is an advantage of burning hydrocarbons?
   - ❑ **A. It releases lots of energy**
   - ❑ B. It releases carbon dioxide
   - ❑ C. It releases water
3. When does incomplete combustion take place?
   - ❑ **A. If there is not enough oxygen**
   - ❑ B. If there is not enough alkane
   - ❑ C. If there is not the same amount of alkane and oxygen

Cracking

Do Now

1. State the general equation for the combustion of alkanes. **Alkane + oxygen → carbon dioxide + water**
2. Describe when incomplete combustion takes place. **When there is a limited supply of oxygen.**
3. Name the alkane with the chemical formula C2H6. **Ethane**
4. Describe what short chain hydrocarbons are used for. **As fuels for heating or cooking**
5. Draw the displayed formula for methane.



Drill

1. Determine how many hydrogen atoms would be in an alkane with 14 carbon atoms. **30**
2. Determine how many hydrogen atoms would be in an alkane with 60 carbon atoms. **122**
3. Determine how many carbon atoms would be in an alkane with 104 hydrogen atoms. **51**

Read Now:

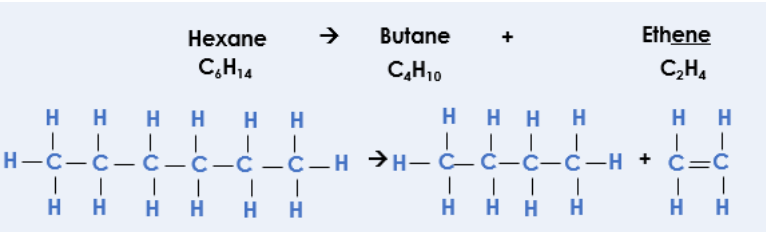
According to a survey from 2022, there are about 1.45 billion cars in the world. That means that over 17 % of the human population has a car, but the cars are not spread evenly as some cars have many more cars than others. Many of these cars have petrol engines, which burn petrol as the fuel. Petrol contains relatively short chain hydrocarbons, such as octane (C_8H_{18}). As there is such high demand for these shorter hydrocarbons, some larger hydrocarbons can be broken down in chemical reactions to form these shorter chains. This type of chemical reaction is called cracking, and produces a shorter chain hydrocarbon as well as another type of hydrocarbon called an alkene. Alkenes are also useful for many different things, including making plastics.

1. State how many cars there are in the world. **1.45 billion**
2. Name an alkane found in petrol. **Octane**
3. Explain why there is high demand for petrol. **Because it is used in cars and lots of people have cars.**
4. Describe what happens in a cracking reaction. **Longer chain hydrocarbons are broken down in a chemical reaction to produce smaller chain hydrocarbons.**
5. Name the other type of product from a cracking reaction. **Alkenes**

Cracking

Small (er) molecules are in high demand as they are used as **fuels**

Cracking **is breaking down larger hydrocarbon chains to form smaller chains**



Cracking produces both alkanes and **alkenes**. These are different to alkanes because they have at lease one **C=C double bond**_. We say alkenes are **unsaturated**

To test for alkenes we can use **bromine** water.

If an alkene is present, it will turn from **orange** to **colourless**

The two types of cracking are **steam and catalytic**

Drill

1. Explain the difference between supply and demand. **Supply is how much of something is produced whereas demand is how much of something is needed.**
2. Describe what happens during cracking. A **longer chain hydrocarbon is broken down to make a shorter chain hydrocarbon.**
3. Name the two types of product produced through cracking. **A (shorter chain) alkane and an alkene.**
4. Give two reasons why cracking is useful. **It increases supply of the smaller molecules used for fuels, and it produces alkenes which are used as feedstocks in the petrochemical industry.**
5. Describe what happens when bromine water is added to alkanes. **Bromine water stays orange.**
6. Describe what happens when bromine water is added to alkenes. **Bromine water turns colorless.**
7. Explain why alkenes are described as unsaturated. **They contain a C=C double bond.**
8. Name two different methods of cracking. **Catalytic cracking and steam cracking.**
9. Describe the conditions needed for catalytic cracking. **A temperature of 550 °C and a catalyst.**
10. Describe the conditions needed for steam cracking. **A temperature of 850 °C.**

I: Determining the products of cracking

Dodecane ($C_{12}H_{26}$) is cracked to produce octane (C_8H_{18}).

$C_{12}H_{26}$ → C_8H_{18} + C_4H_8

What is the chemical formula for the other product formed? Write it on the lane
What homologous group does the other product belong to?_ ***Alkenes***
Explain how you could tell the difference between the two products once they were separated. ***Add bromine water to each. Octane will cause the bromine water to stay orange and the alkene will turn the bromine water colourless.***

Explain why it is useful to crack dodecane. ***There is greater demand for shorter molecules like octane, as they can be used as fuels.***

We: Determining the products of cracking

Dodecane ($C_{12}H_{26}$) is cracked to produce heptane (C_7H_{16}).

$C_{12}H_{26}$ → C_7H_{16} + C_3H_6

What is the chemical formula for the other product formed? Write it on the lane
What homologous group does the other product belong to?_ ***Alkenes***

Explain how you could tell the difference between the two products once they were separated. ***Add bromine water to each. Heptane will cause the bromine water to stay orange and the alkene will turn the bromine water colourless.***

Explain why it is useful to crack dodecane. ***There is greater demand for shorter molecules like heptane, as they can be used as fuels.***

You: Determining the products of cracking

Octane (C_8H_{18}) is cracked to produce hexane (C_6H_{14}).

C_8H_{18} → C_6H_{14} + C_2H_4

What homologous group does the other product belong to?_ ***Alkenes***
Explan how you could tell the difference between the two products once they were separated. ***Add bromine water to each. Hexane will cause the bromine water to stay orange and the alkene will turn the bromine water colourless.***

Explain why it is useful to crack octane. ***There is greater demand for shorter molecules like hexane, as they can be used as fuels.***

Mark it: Looking at a student exam answer

1. Read the question and the student's answer carefully.

2. Use the mark scheme to award the student a number of marks and annotate their answer with suggestions to improve.

Stretch: Rewrite the answer to show how it should be done!

Question: The table below gives some information about some of the fractions in crude oil.

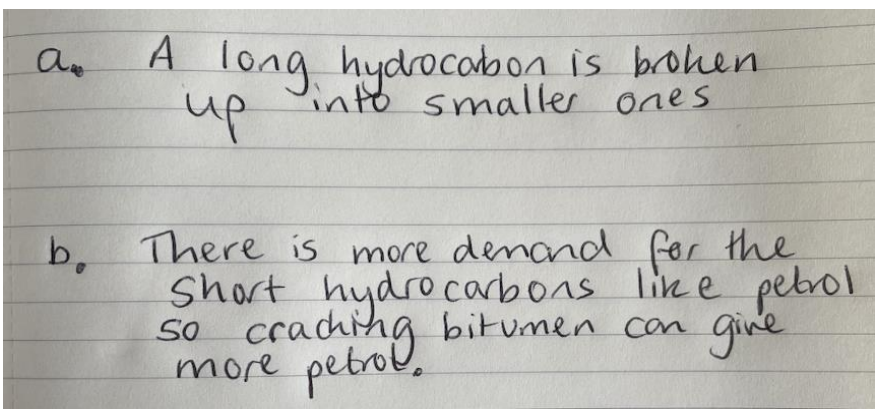
Fraction	Length of hydrocarbons (number of carbon atoms)	% in crude oil	% demand
Gas	1-4	3	14
Petrol	5-8	7	26
Kerosene	9-15	12	18
Diesel	16-24	24	20
Bitumen	>25	54	22

a. The quantity of each fraction can be changed by cracking.
Describe what happens when a hydrocarbon is cracked and the conditions required.

(4)

b. Use information from the table to explain why cracking is useful.
(3)

Student answer:



Marks awarded= _____

Mark scheme:

Point	Mark
Long/large hydrocarbon chains are broken down	1
Into shorter chain hydrocarbons (alkanes)	1
And alkenes	1
A high temperature or catalyst is required	1

Point	Mark
There is higher demand than supply of short chains (from crude oil)	1
So cracking can increase the supply of short chain hydrocarbons	1
Named example, e.g. only 7% of crude oil is petrol but it is over a quarter of the demand, so producing more petrol through cracking can meet this demand	1

Exit Ticket

1. Which explains why cracking is useful?
   - ❑ A. It increases demand for shorter hydrocarbon chains
   - ❑ **B. It increases supply of shorter hydrocarbon chains**
   - ❑ C. It separates crude oil into different useful fractions
2. What is the formula of the other product of this cracking reaction?

$C_{10}H_{22} \rightarrow C_8H_{18}$ + _____

   - ❑ **A. C_2H_4**
   - ❑ B. C_2H_6
   - ❑ C. $C_{18}H_{40}$
3. What is the difference between alkanes and alkenes?
   - ❑ A. Alkanes have a C=C double bond
   - ❑ **B. Alkenes have a C=C double bond**
   - ❑ C. Alkenes contain more hydrogen atoms

Taking it Further: Alkenes

Do Now:

1. State the two products of cracking. **An alkane and an alkene.**
2. Describe the difference between ethane and ethene. **Ethane is an alkane so contains all single bonds while ethene is an alkene so contains a C=C double bond.**
3. Describe how to test for an alkene. **Add bromine water, alkenes turn bromine water colourless.**
4. State the general formula for the alkanes. **CnH2n+2**
5. State how many pairs of electrons are shared in a double covalent bond**. 2**

Drill:

1. Draw the structural formula for ethane. **Drawn out C2H6**
2. Draw the structural formula for ethene. **Drawn out C2H4**
3. Name the type of compound that alkanes and alkenes are. **Hydrocarbons**

Read Now:

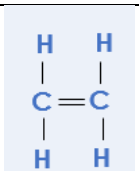
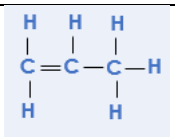
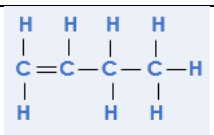
The alkenes are a homologous series of hydrocarbon compounds. Their functional group is a double bond between carbon atoms, which gives them their reactivity. Because of this double bond, alkenes are described as unsaturated. This also means that they are very useful in many chemical reactions in the petrochemical industry, used to make many different polymers and plastics. The smallest of the alkenes is ethene, as there is no such thing as methene, because there could not be a carbon=carbon double bond when there is only one carbon atom present. Alkenes can be very large and branched molecules, and the properties of each molecule determine what the molecule may be useful for.

1. Identify the functional group of the alkenes. **C=C**
2. Explain why the alkenes are described as unsaturated. **They contain a double bond.**
3. Identify the smallest alkene. **Ethene**
4. Explain why there is no such thing as methene. **Becayse there need to be two carbons to have a C=C double bond.**
5. Describe what alkenes are used for. **Making different polymers and plastics**

Alkenes

The general formula for an alkene is _____

Complete the table for the first three alkenes

Name of alkene	Formula	Displayed formula
Ethene	C_2H_4	
propene	C_3H_6	
Butene	C_4H_8	

Reactions of Alkenes

Alkenes are reactive because of the **C=C double bond**

Alkenes react with oxygen but produce a lot of smoke because of **incomplete** combustion

Addition reactions of alkenes

Alk<u>ene</u> + **halogen** → halogenalk<u>ane</u>

Ethene +**iodine** → (1,2-)diiodethane

Alkenes will turn bromine water from **orange to colourless** because of the formation of a **halogenalkane**

Ethene + hydrogen → **ethane**

This reaction requires a **catalyst** to speed it up

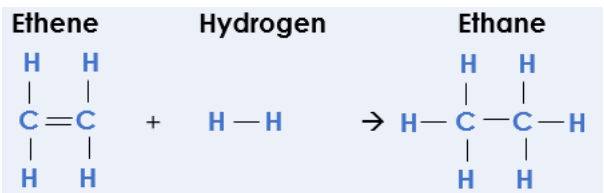
Drill

1. State the general formula for alkenes. **CnH2n**
2. State the chemical formula for ethene. **C2H4**
3. State the chemical formula for butene. **C4H8**
4. Identify the functional group of the alkenes. **C=C**
5. Explain whether the alkenes are saturated or unsaturated. **Unsaturated because they contain the C=C double bond**
6. Describe how to test for the presence of an alkene. **Add bromine water. If an alkene is present, bromine water will turn from orange to colourless.**
7. Predict the product formed when propene reacts with hydrogen. **Propane**
8. Predict the product formed when ethene reacts with bromine. **(1,2) dibromoethane**

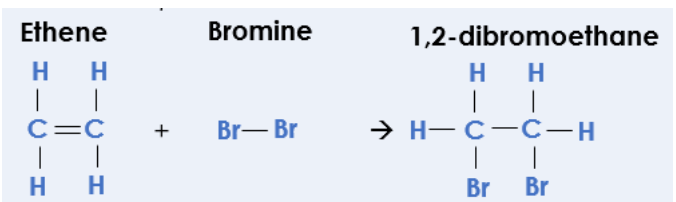
I: Alkene reactions

Ethene can react with bromine or with hydrogen in the presence of a catalyst.

Predict the product of the reaction between ethene and hydrogen.



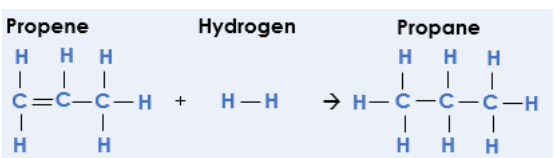
Predict the product of the reaction between ethene and bromine.



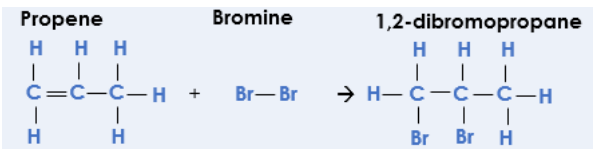
We: Alkene reactions

Propene can react with bromine or with hydrogen in the presence of a catalyst.

Predict the product of the reaction between propene and hydrogen.



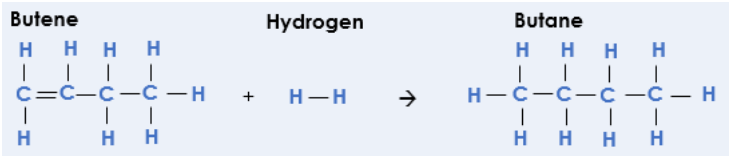
Predict the product of the reaction between propene and bromine.



You: Alkene reactions

Butene can react with bromine or with hydrogen in the presence of a catalyst.

Predict the product of the reaction between butene and hydrogen.



Predict the product of the reaction between butene and bromine.

Exit Ticket

1. What is the general formula for the alkenes?
   - ❑ **A. C_nH_{2n}**
   - ❑ B. C_nH_{2n+2}
   - ❑ C. C_nH_n
2. Which explains why alkenes are reactive?
   - ❑ A. They are saturated
   - ❑ **B. They are unsaturated**
   - ❑ C. They are small molecules
3. What product would be formed when propene reacts with hydrogen?
   - ❑ A. Butene
   - ❑ **B. Propane**
   - ❑ C. Hydropropene

Taking it Further: Alcohols

Do Now:

1. State the general formula of the alkanes. **CnH2n+2**
2. State the general formula of the alkenes. **CnH2n**
3. Explain how bromine water could be used to identify an alkane and an alkene. **Add bromine water to each, the alkene would turn bromine water colourless and the alkane would have no effect so bromine water would stay orange.**
4. Define a hydrocarbon. **A molecule that contains carbon and hydrogen atoms only.**
5. Name the type of bonding present in alkanes and alkenes. **Covalent**

Drill:

1. Ethanol has the chemical formula C2H5OH. Identify how many of each type of atom are present in a molecule of ethanol. **2 carbon atoms, 6 hydrogen atoms, and 1 oxygen atom.**
2. Calculate the relative formula mass of ethanol. **C=12, H=1, O=16 (2x12)+(6x1)+16 = 46**
3. Calculate the percentage by mass of hydrogen in ethanol. **6/46 x 100 = 13.04%**

Read Now:

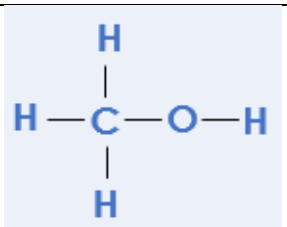
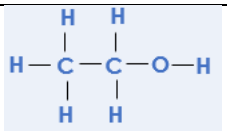
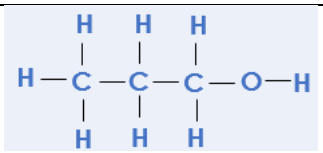
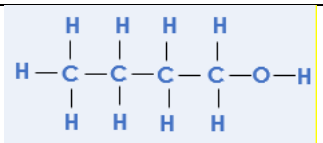
When the word alcohol is used, it generally means an alcoholic drink, such as wine or beer. However, alcohol is actually a homologous series of compounds so there is more than one type of alcohol. The type of alcohol in alcoholic drinks is ethanol, which as the prefix suggests, contains two carbon atoms. Drinking pure ethanol would be dangerous for the body, so most alcoholic drinks contain between 2% and 40% ethanol. In the short term, ethanol interferes with communication pathways in the brain, slowing down nerve impulses. This can cause slurred speech, slow reactions and impaired judgement, which is why it is illegal to drink and drive. In the long term, excessive alcohol consumption can cause liver damage and seriously impact mental health.

1. Name the type of alcohol found in alcoholic drinks. **Ethanol**
2. Identify how many carbon atoms are found in ethanol. **2**
3. Explain why most alcoholic drinks only contain 2%-40% ethanol. **It would be dangerous.**
4. Describe some short term effects of drinking alcohol. **Slurred speech, slow reactions and impaired judgement**
5. Describe some long term effects of excessive alcohol consumption. **Liver damage and impact on mental health**

Alcohols

The functional group for alcohols is **OH**

Complete the table about the first four alcohols

Name of alcohol	Formula	Displayed formula	Use
Methanol	**CH_3OH**		**Chemical feedstock**
Ethanol	C_2H_5OH		**Alcohol drinks** **Fuel** **Solvent**
Propanol	**C_3H_7OH**		**Fuels** **Solvents**
Butanol	C_4H_9OH		

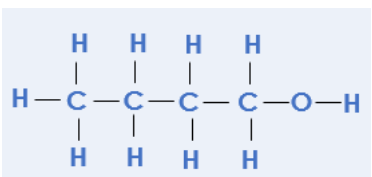
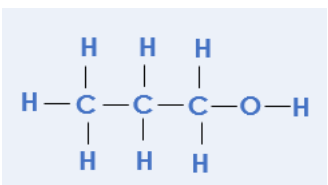
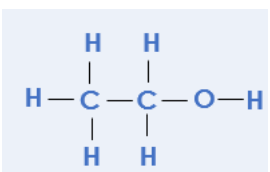
As you go down the series, the solubility **decreases**

Alcohol + oxygen → **carbon dioxide + water**

Alcohol + sodium → **sodium ethoxide + hydrogen**

Drill

1. State the names of the first four alcohols. **Methanol, ethanol, propanol, butanol**
2. State the chemical formula for ethanol. **C2H5OH**
3. Give a use of methanol. **As a chemical feedstock**
4. Give a use of ethanol. **As a solvent or in alcoholic drinks**
5. Give a use of propanol. **As a solvent or a fuel**
6. State the products of the reaction between ethanol and sodium. **Sodium ethoxide and hydrogen gas**
7. Describe the pattern of solubility of alcohols with the size of molecules. **The larger the molecule (the longer the chain), the less soluble it is**

Steps to success	1. Determine the chemical formula of this compound. 2. Name this chemical compound. 3. Give a use of this chemical compound.
I do 	**C_4H_9OH** **Butanol** **A solvent or fuel**
We do 	**A solvent or fuel** **Propanol** **C_3H_7OH**
You do 	**C_2H_5OH** **Ethanol** **A fuel, a solvent or in alcoholic drinks**

Exit Ticket

1. What is the chemical formula of ethanol?
    - ❑ A. C_2H_5O
    - ❑ **B. C_2H_5OH**
    - ❑ C. CH_3OH
2. Which is a use of methanol?
    - ❑ A. In alcoholic drinks
    - ❑ **B. As a chemical feedstock**
    - ❑ C. As a fuel
3. What is the pattern in solubility of the alcohols?
    - ❑ A. The longer the chain, the more soluble it is
    - ❑ **B. The longer the chain, the less soluble it is**
    - ❑ C. The longer the chain, the less reactive it is

Taking It Further: Producing Ethanol by Fermentation

Do Now:

1. Name the alcohol that contains two carbon atoms. **Ethanol**
2. State the functional group of the alcohols. **Hydroxyl group (OH)**
3. Explain why alkenes are described as unsaturated. **They contain a C=C double bond.**
4. Explain what is meant by the term anaerobic. **In the absence of oxygen**
5. Name the process that takes place in cells to release energy. **Respiration**

Drill

1. State the chemical formula of ethanol. **C2H5OH**
2. Compare the structures of ethene and ethanol. **Both contain two carbon atoms. Ethene contains four hydrogen atoms, whereas ethanol contains 5 hydrogens atoms on the main chain, then a hydroxyl group, which ethene does not have. Ethene contains a C=C double bond, which ethanol does not have.**
3. Give a use of ethanol. **As a fuel, a solvent, or in alcoholic drinks.**

Read Now:

Fermentation is an anaerobic chemical process because takes place in the absence of oxygen. It is used to make many products for humans, including bread and alcoholic drinks. It has also now been suggested that eating fermented foods, such as kimchi or kombucha, can have a beneficial effect on gut health. Foods that have been fermented have started to undergo breakdown by microorganisms such as yeast or bacteria, which produces products that give the food a different flavour. Gut microbiologists suggest that eating fermented food, which contain cultures of different microorganisms, can increase the gut biodiversity and provide health benefits.

1. Explain why fermentation is an anaerobic process. **It takes place in the absence of oxygen.**
2. Give an example of a product that humans make from fermentation. **Bread, alcoholic drinks**
3. Give an example of a fermented food. **Kimchi, kombucha**
4. Describe the advantages of eating fermented food that microbiologists suggest. **They contain cultures of different microorganisms which can increase the gut biodiversity.**

Fermentation

Define fermentation

when microorganisms start to break down glucose in the absence of oxygen

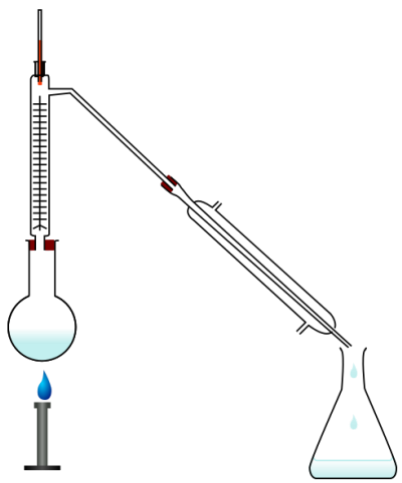
Write the equation for fermentation

Glucose → ethanol + carbon dioxide

For fermentation to take place, there must be:

- A sugar **solution** mixed with **yeast**
- No **air or oxygen** getting in (anaerobic)
- A warm temperature **(25-35** °C)

A solution of ethanol can be purified using **distillation**



Drill

1. Explain why fermentation is an anaerobic process. **It takes place in the absence of oxygen.**
2. State the reactant for fermentation. **Glucose**
3. State the products of fermentation. **Ethanol and carbon dioxide**
4. Describe the conditions required for fermentation. **A temperature of 25-35 °C, no oxygen, and a sugar solution mixed with yeast.**
5. Give a use of ethanol produced through fermentation. **As a solvent, a fuel, or in alcoholic drinks.**
6. Give a use of carbon dioxide produced through fermentation**. In baking (to make dough rise).**
7. Describe how ethanol produced through fermentation can be purified. **Using distillation, as ethanol has a lower boiling point than water so can be separated using evaporation and condensation.**

You: Describe: ***to recall facts, events or processes in an accurate way***

Describe the advantages and disadvantages of producing ethanol by fermentation.

Rate of reaction	Low
Purity of ethanol produced	10-15%
Energy usage	Low
Raw material used	Sugar

- **Fermentation takes a long time as there is a low rate of reaction**
- **Fermentation produces ethanol with relatively low purity, so may need to be distilled**
- **Fermentation takes a long time as there is a low rate of reaction**
- **Fermentation produces ethanol with relatively low purity, so may need to be distilled**

Exit Ticket

1. Choose the word equation for fermentation.
   - ❑ A. Glucose → lactic acid
   - ❑ **B. Glucose → ethanol + carbon dioxide**
   - ❑ C. Glucose + ethanol → carbon dioxide
2. Why should fermentation take place at a warm temperature?
   - ❑ A. So the reaction does not happen too quickly
   - ❑ **B. So the enzymes in yeast are not denatured**
   - ❑ C. So the ethanol can be evaporated
3. What is a disadvantage of producing ethanol by fermentation?
   - ❑ A. It is a very quick process
   - ❑ **B. It can take days or weeks**
   - ❑ C. It does not require much energy

Taking it Further: Producing Ethanol from Ethene

Do Now:

1. State the chemical formula of ethanol. **C2H5OH**
2. Explain why fermentation is an anaerobic process. **It takes place in the absence of oxygen.**
3. Describe the conditions needed for fermentation. **No oxygen, a sugar solution mixed with yeast, temperature of 25-35 °C**
4. State the general formula of the alkenes. **CnH2n**
5. Describe how bromine water can be used to tell the difference between an alkane and an alkene. **Using bromine water, which would turn from orange to colourless when added to an alkene but remain orange when added to an alkane.**

Drill

1. Draw the structural formula for ethene. **Drawn out ethene**
2. Name the product formed when ethene reacts with hydrogen. **Ethane**
3. Describe a condition needed for ethene to react with hydrogen. **A catalyst is required**

Read Now:

Ethanol can be added to petrol for use as fuel for vehicles. This has become much more common since the 1990s, but particularly since 2005. Most petrol that you find at petrol stations is labelled 'E10', which means that it contains at least 10% ethanol. This is thought to slightly reduce the effects of burning fossil fuels on global warming, but only if the ethanol is produced through fermentation. This is when crops are grown as biofuels and therefore absorb carbon dioxide while they are growing. However, often ethanol is made from ethene, which is not a renewable resource as it is obtained from crude oil through fractional distillation and cracking.

1. Give a use of ethanol other than in alcoholic drinks. **Added to petrol as fuel for vehicles**
2. Explain what is meant by E10 petrol. **It contains at least 10 % ethanol**
3. Explain why ethanol obtained from fermentation is a renewable resource. **It is obtained from fermentation of crops, which can be regrown.**
4. Explain why ethanol obtained from ethene is not a renewable resource. **It is obtained from crude oil, which cannot be replenished.**

Conditions for Hydration

The conditions for hydration of ethene are:

- The reaction requires a high temperature (approximately **300** °C)
- There needs to be a **catalyst** for ethene → ethanol it is phosphoric acid
- The pressure needs to be **60-70** atmospheres

The word equation for the reaction is: **Ethene + steam → ethanol**

The reverse reaction is: **Ethanol → ethene + steam**

The catalyst for the reverse reaction is **aluminium oxide**

Drill

1. State the chemical formula of ethanol. **C2H5OH**
2. State the chemical formula of ethene. **C2H4**
3. Describe two methods of producing ethanol. **Hydration of ethene and fermentation**
4. Describe how ethene is obtained from crude oil. **Through fractional distillation of crude oil then cracking**
5. Explain whether ethene is a renewable or non-renewable resource. **Non-renewable, as it is obtained from crude oil, which is not replenished at the same rate that it is used**
6. Describe the conditions required for hydration of ethene. **A high temperature (around 300 °C), 60-70 atm of pressure, and a catalyst (phosphoric acid)**
7. State the word equation for the hydration of ethene. **Ethene + steam → ethanol**
8. State the chemical equation for the hydration of ethene. **$C_2H_4 + H_2O \rightarrow C_2H_5OH$**
9. State the general equation for the hydration of alkenes. **Alkene + water (steam) → alcohol**
10. Describe the conditions required for the hydration of alkenes. **High temperature and a catalyst**
11. Explain why the alkenes are unsaturated. **They contain a C=C double bond.**

You: Evaluating Methods of Ethanol Production

Evaluate which method of ethanol production is better for a company.

Method	Fermentation	Hydration of ethene
Rate of reaction	Low	High
Purity of ethanol produced	10-15%	>95%
Energy usage	Low	High
Raw material used	Sugar	Crude oil

Hydration has a higher rate of reaction than fermentation so ethanol can be produced faster. However, hydration uses more energy so is a more expensive process.

Hydration produces ethanol with higher purity than fermentation, which means it is less likely to need to be distilled. However, hydration uses crude oil, which is a non-renewable resource, unlike fermentation, which uses a renewable resource.

Overall, I think that hydration would be better for a company because although it uses non-renewable resources, it allows ethanol to be produced more quickly.

Exit Ticket

1. Choose the term for what happens when ethanol is made from ethene.
   - ❑ **A. Hydration**
   - ❑ B. Hydrogenation
   - ❑ C. Fermentation
2. What is a disadvantage of making ethanol from ethene?
   - ❑ A. Ethene is obtained from sugar cane so is renewable
   - ❑ **B. Ethene is obtained from crude oil so is non-renewable**
   - ❑ C. Ethene is obtained from biofuels so is renewable
3. What is an advantage of producing ethanol from ethene?
   - ❑ **A. It produces ethanol much more quickly than fermentation**
   - ❑ B. It is an energy intensive process
   - ❑ C. It requires high temperatures and a catalyst

Taking it Further: Carboxylic acids

Do Now:

1. Describe the two methods of producing ethanol. **Through fermentation or by hydration of ethene.**
2. Name the functional group found in alcohols. **Hydroxyl group (OH)**
3. Describe the conditions needed for the hydration of ethene. **A high temperature (300 °C), a catalyst (phosphoric acid), and 60-70 atm of pressure.**
4. State the general formula of the alkanes. **CnH2n+2**
5. State the pH range of an acid. **pH 1-7**

Drill

1. Describe three ways of determining if a substance is an acid or an alkali. (**universal) indicator, pH probe or litmus paper**
2. Name some common acids. **Hydrochloric acid, sulfuric acid, nitric acid, carbonic acid, ethanoic acid, citric acid**
3. Identify the ion that makes substances acidic. **Hydrogen (H+)**

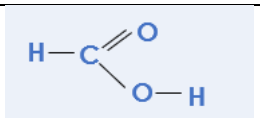
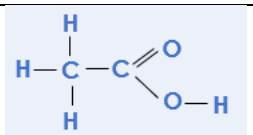
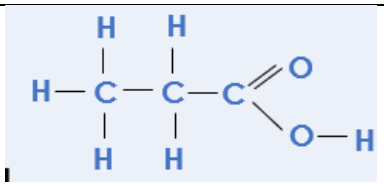
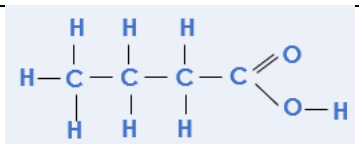
Read Now:

Carboxylic acids are another homologous series of organic (carbon-containing compounds). As with other organic compounds, the carboxylic acids have many different uses for humans and we use many of them without realising it. One of the most abundant carboxylic acids is ethanoic acid, which is sometimes also called acetic acid. This acid is the main component of vinegar (other than water), and is used to flavour different foods. Often ethanoic acid used in vinegar is made from a double fermentation process, where ethanol is made from plant sugars using yeast, then fermented again using bacteria to produce ethanoic acid.

1. Give an example of a carboxylic acid. **Ethanoic acid**
2. Give the other name for ethanoic acid. **Acetic acid**
3. Give one use for ethanoic acid. **Vinger in food flavourings**
4. Describe how ethanoic acid is made. **From a double fermentation process, where ethanol made from plant sugars using yeast is fermented again using bacteria.**

Carboxylic Acids

What is the functional group for carboxylic acids? _____

Name of alcohol	Formula	Displayed formula
Methanoic acid	HCOOH	
Ethanoic acid	**CH_3COOH**	
Propanoic Acid	C_2H_5COOH	
Butanoic acid	C_3H_7COOH	

Carboxylic acids are **weak** acids with a pH of **less than 7**

Acid + metal → **salt + hydrogen**

Acid + alkali → **salt + water**

Acid + base → **salt + water**

Acid + metal carbonate → **salt + water + carbon dioxide**

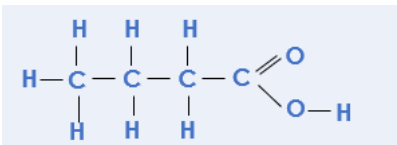
Drill

1. State the chemical formula of methanoic acid. **HCOOH**
2. State the chemical formula of ethanoic acid. **CH3COOH**
3. Name the functional group of the carboxylic acids. **Carboxyl group**
4. State the formula of the functional groups of the carboxylic acids. **-COOH**
5. State the pH values of solutions containing dissolved carboxylic acids**. Less than 7**
6. State whether carboxylic acids are strong or weak acids. **Weak acids**
7. State the products formed when a carboxylic acid reacts with a metal carbonate. **Salt, water, and carbon dioxide**
8. Write a general equation for the reactions between carboxylic acids and metal carbonates. **Carboxylic acid + metal carbonate → salt + water + carbon dioxide**

You: Reactions of Carboxylic Acids

Magnesium carbonate reacts with butanoic acid.

Draw the structural formula for butanoic acid.



State the chemical formula for butanoic acid ***C_3H_7COOH***

What products would be made in a reaction between a carboxylic acid and a metal carbonate? ***A salt, water and carbon dioxide***

Write a word equation for this reaction.

Magnesium carbonate + butanoic acid → magnesium ethanoate + water + carbon dioxide

Exit Ticket

1. Choose the functional group found in carboxylic acids.
    - ❑ A. Hydroxyl group
    - ❑ **B. Carboxyl group**
    - ❑ C. Carboxylate group
2. Which carboxylic acid has the formula CH_3COOH?
    - ❑ A. Methanoic acid
    - ❑ **B. Ethanoic acid**
    - ❑ C. Propanoic acid
3. What are the products of a reaction between a carboxylic acid and a metal carbonate?
    - ❑ **A. A salt, water and carbon dioxide**
    - ❑ B. A salt, water and hydrogen
    - ❑ C. A salt and water

Taking It Further: Esters

Do Now:

1. Name the functional group found in carboxylic acids. **Carboxyl group**
2. State the chemical formula of methanoic acid. **COOH**
3. Name the homologous series that contains a C=C double bond. **Alkenes**
4. Name the alcohol that contains two carbon atoms. **Ethanol**
5. Give a use of ethanol**. In alcoholic drinks, as a fuel or a solvent**

Drill:

1. Draw the structural formula of ethene**. Drawn out ethene**
2. Draw the structural formula of ethanol. **Drawn out ethanol**
3. Draw the structural formula of ethanoic acid. **Drawn out ethanoic acid.**

Read Now:

If you look on the ingredients lists on many scented cleaning products or fragrances, you may see compounds with names like methyl butanoate. Esters are organic compounds that usually have fruity smells and can be used as solvents, making them useful in scented products. Esters are formed through the chemical reaction between alcohols and carboxylic acids. In any chemical reaction, the properties of the new substance or compound formed is different to the substances or compounds it is formed from. We can use the names of the alcohols and the carboxylic acids that react to determine the name of the ester and the number of carbon atoms that would be found in a molecule.

1. Explain why esters are useful in scented products. **They have fruity smells and can be used as solvents.**
2. Describe how an ester is formed. **From the reaction between an alcohol and a carboxylic acid**
3. Compare the properties of the product of a chemical reaction with the properties of the reactants. **Esters have fruity smells, whereas carboxylic acids and alcohols do not.**
4. Describe how we can determine the name of an ester. **From the name of the alcohol and carboyxlic acid that reacted to make it.**

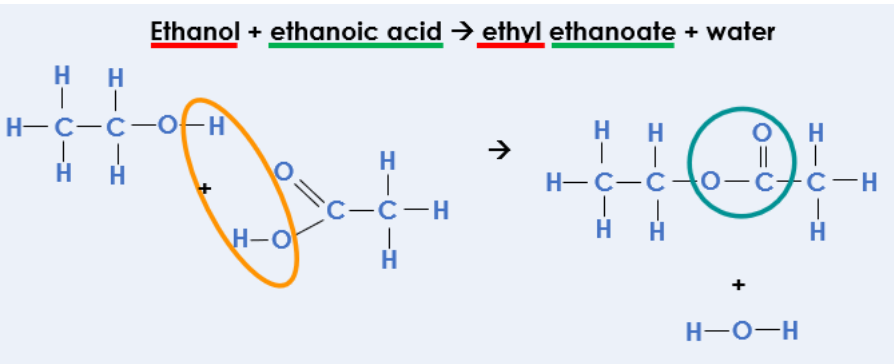
Esters

The functional group of an ester is **COO**

Alcohol + carboxylic acid → **ester + water**

Ethanol + ethanoic acid → **ethyl ethanoate + water**

This is called a **condensation** reaction because **water** (a small molecule) is formed



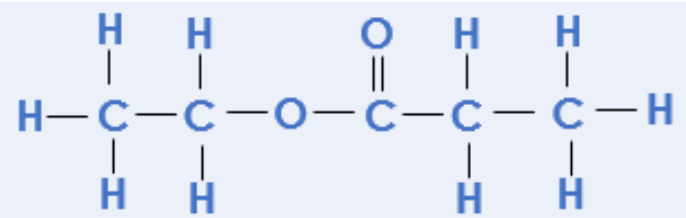
Esters all have different **scents/smells** (pineapple, apricot etc) so are used in **perfumes/diffusers/flavourings**

They are also used as **solvents**

Drill

1. State the function group found in esters. **COO**
2. Give a use of esters. **In scented products or as a solvent**
3. Name the type of reactants needed to form an ester. **An alcohol and a carboxylic acid**
4. Explain why the formation of an ester is a condensation reaction. **It produces water**
5. State the general equation for the formation of an ester. **Alcohol + carboxylic acid → ester + water**
6. Name the ester made from ethanol and ethanoic acid. **Ethyl ethanoate**

The displayed formula below shows an organic compound.



Identify the homologous series this compound belongs to. ***Esters***

Identify the functional group of this compound. ***COO***

Name the two types of organic compound that would have been used to make this compound. ***Alcohol and carboxylic acid***

Stretch: suggest the names of the reactants used to make this compound.

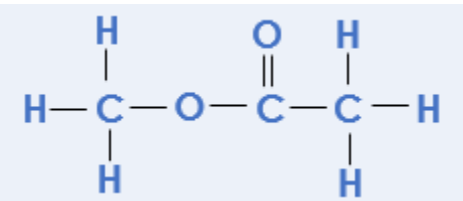
Ethanol and propanoic acid

Stretch: suggest the name of this compound.

Ethyl propanoate

We: Reactions of organic compounds

The displayed formula below shows an organic compound.



Identify the homologous series this compound belongs to. ***Esters***

Identify the functional group of this compound. ***COO***

Name the two types of organic compound that would have been used to make this compound. ***Alcohol and carboxylic acid***

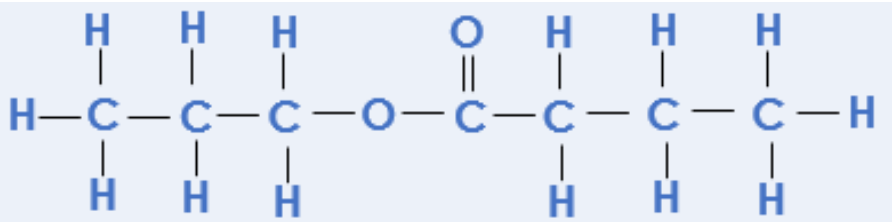
Stretch: suggest the names of the reactants used to make this compound.

Methanol and ethanoic acid

Stretch: suggest the name of this compound. ***Methyl Ethanoate***

You: Reactions of organic compounds

The displayed formula below shows an organic compound.



Identify the homologous series this compound belongs to. ***Esters***

Identify the functional group of this compound. ***COO***

Name the two types of organic compound that would have been used to make this compound. ***Alcohol and carboxylic acid***

Stretch: suggest the names of the reactants used to make this compound.

Propanol and butanoic acid

Stretch: suggest the name of this compound.

Propyl butanoate

Exit Ticket

1. What are the reactants needed to make an ester?
   - ❑ A. An alcohol and an alkene
   - ❑ B. A carboxylic acid and an alkene
   - ❑ **C. An alcohol and a carboxylic acid**
2. What is the name of the ester formed from ethanol and ethanoic acid?
   - ❑ A. Ethanol ethanoate
   - ❑ **B. Ethyl ethanoate**
   - ❑ C. Ethyl ethanoic
3. What is a use of esters?
   - ❑ A. As a fuel
   - ❑ B. In alcoholic drinks
   - ❑ **C. In scented products**

Polymers

Do Now:

1. Define a hydrocarbon. **A compound that contains carbon and hydrogen atoms only**.
2. Name the type of bonding found in hydrocarbons. **Covalent.**
3. State the general formula of the alkanes. **CnH2n+2.**
4. Describe how fractional distillation is used to separate crude oil. **Crude oil is heated and hydrocarbons are evaporated. Then condense at different temperatures depending on their boiling points.**
5. Explain the difference between reusing and recycling. **Reusing involves using the same product again, but recycling involves a process of making the materials from the product into something else.**

Drill

1. Describe the structure of diamond. **In diamond, each carbon atom is covalently bonded to four other carbon atoms in a giant covalent network.**
2. Describe the structure of graphite. **In graphite, each carbon atom is covalently bonded to three other carbon atoms in a giant covalent network, and arranged in layers, leaving a free electron from each carbon atom.**
3. Explain why graphite conducts electricity but diamond does not. **Graphite contains free electrons to carry the charge through the structure, but diamond does not.**

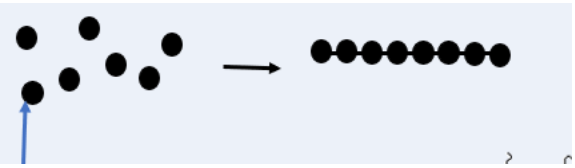
:

Read Now:

The word polymer comes from Greek and means 'many parts'. A polymer is a very long molecule made up of many units. Polymers can be naturally occurring or synthetic (man-made) and we use many examples in our daily lives. One of the most important naturally occurring polymers is DNA, which is found in the nuclei of all our cells. Other naturally occurring polymers are proteins and starch. These naturally occurring polymers make up an important part of our diet, but they must be digested into small soluble products before being absorbed into our blood stream. Products made from synthetic polymers are all around us, including plastic products, silicone products, nylon and polyester clothing.

1. Define a polymer. **A long molecule made up of many units**
2. Define synthetic. **Man-made**
3. Give three examples of naturally occurring polymers. **DNA, starch, proteins, cellulose**
4. Explain why naturally occurring polymers found in foods must be digested. **Polymers are too large and insoluble to be absorbed into the bloodstream.**
5. Give an example of a synthetic polymer. **Nylon, silicone, plastic, polyester**

Poly**mer**

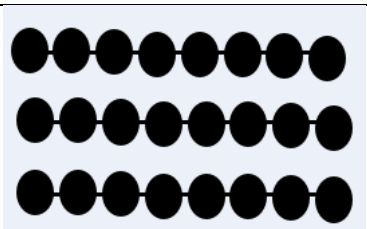
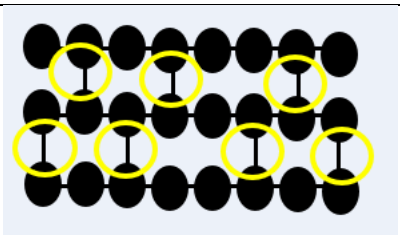


Properties of polymers

The properties of a polymer depend on two things:

- the -**monomer** it is made from
- the **conditions** that the polymer is made in

Complete the table for thermosetting sand thermosoftening plastics

		
Type of polymer	**Thermosoftening**	**Thermosetting**
What happens when heated?	**Melts**	**Do not melt**
Are there intermolecular forces between the polymer chains?	**Yes**	**Yes**
Are there crosslinks (covalnt bonds) between the chains when heated?	**No**	**Yes**
Are they suitable for recycling?	**Yes**	**No**

Drill

1. What is a polymer? **Long chain molecules made of many units**
2. What kind of bonding occurs between monomers in a polymer? **Covalent bonding**
3. What does the n represent in the general formula for a polymer? **n represents the number of repeating units of the polymer**
4. Name the forces that act between the polymer molecules. **Intermolecular forces act between the polymer molecules**
5. State whether these forces are weak or strong. **These forces are relatively strong**
6. Describe the state of polymers at room temperature. **Polymers are solids at room temperature**
7. What determines the properties of polymers? **The properties of polymers are determined by the monomers that make them up and the conditions that they are made in**
8. What happens to thermosetting polymers when heated? **Thermosetting polymers do not melt when heated**
9. What happens to thermosoftening polymers when heated? **Thermosoftening polymers melt when heated**
10. Explain why these polymers behave differently when heated. **Thermosetting polymers contain crosslinks, which are covalent bonds between molecules. These require much more energy to overcome, so they have much higher melting points**

We: Explain: ***to use scientific understanding to make something clear or state the reason for something happening***

Many recyclable plastic bottles are made from thermosoftening polymers.

Explain how the properties of a thermosoftening polymer make them suitable for recycling.

- **Thermosoftening polymers contain weak intermolecular forces between molecules**
- **These do not require a lot of energy to overcome, so thermosoftening polymers have low melting points and melt when heated**
- **This means they can be melted and reshaped to be recycled into other products**

You: Explain: ***to use scientific understanding to make something clear or state the reason for something happening***

Firefighters' helmets are made from thermosetting polymers.

Explain how the properties of a thermosetting polymer make them suitable for this purpose

- **Thermosetting polymers contain crosslinks, which are covalent bonds between molecules**
- **These require a lot of energy to overcome, so thermosetting polymers have high melting points and do not melt when heated**
- **<u>This means</u> they will not melt when exposed to high temperatures**

Exit Ticket

1. How many carbon atoms will the polymer represented by this diagram have?
   - ❑ A. 20
   - ❑ **B. 40**
   - ❑ C. 80
2. What is between polymer molecules?
   - ❑ A. Covalent bonds
   - ❑ **B. Intermolecular forces**
   - ❑ C. Electrostatic attraction
3. What is the difference between thermosetting and thermosoftening polymers?
   - ❑ **A. Thermosoftening polymers melt when heated**
   - ❑ B. Thermosetting polymers melt when heated
   - ❑ C. Thermosoftening polymers contain crosslinks

Taking it Further: Addition Polymerisation

Do Now:

1. State the general formula of alkenes. - **CnH2n**
2. Explain why alkenes are described as unsaturated. - **They contain a C=C double bond**
3. Describe how bromine water could be used to identify an alkene. - **Bromine water would turn from orange to colorless when added to an alkene.**
4. Define a polymer. - **A long molecule made up of many repeating units.**
5. Explain the difference between thermosetting and thermosoftening polymers. - **Thermosetting polymers contain crosslinks, so they do not melt when heated. Thermosoftening polymers melt when heated.**

Drill:

1. Draw the displayed formula for ethene. **- Drawn out ethene**
2. Draw the displayed formula for butene. - **Drawn out butene**
3. Compare the structure of butene and butane. - **Both contain 4 carbon atoms but butene contains 8 hydrogen atoms**

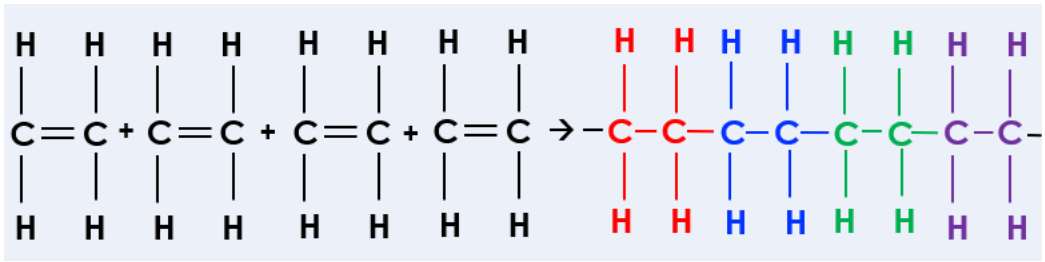
Read Now:

Polymers are long molecules made up of repeating units called monomers. One of the most common polymers used by humans is poly(ethene), which is made in both high-density and low density forms. Poly(ethene) is made through the joining of many ethene monomers, a reaction which is called addition polymerisation. The double bond of the ethene molecules is broken, allowing the carbon atoms to bond with neighbouring molecules. However, it is not just poly(ethene) that can be made through addition polymerisation. Other polymers such as poly(propene) or poly(chloroethene) are also made through addition polymerisation. In addition polymerisation, the only product is the polymer.

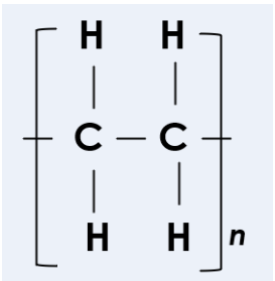
1. Define a polymer. **A long molecule made of repeating monomer units.**
2. Identify the monomer that makes up poly(ethene). **Ethene**
3. Describe how poly(ethene) is formed. **Joining of many ethene monomers by breaking their double bonds.**
4. Give an example of another polymer made through addition polymerisation. **Poly(propene), poly(chloroethene)**

Addition Polymerisation

Label on the diagram : Monomer, repeat unit, polymer

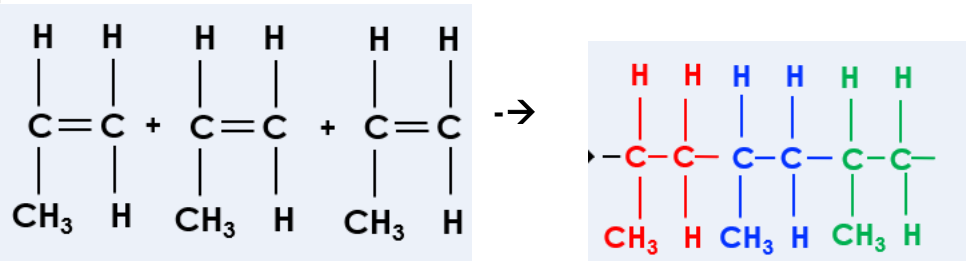


Monomer **Polymer**



Repeat unit

Draw the polymer for poly(propene) and the repeat unit with brackets and an n



When the double C=C bond **breaks/opens up**, the monomer molecules can **all bond** to each other in a long chain called a **polymer**

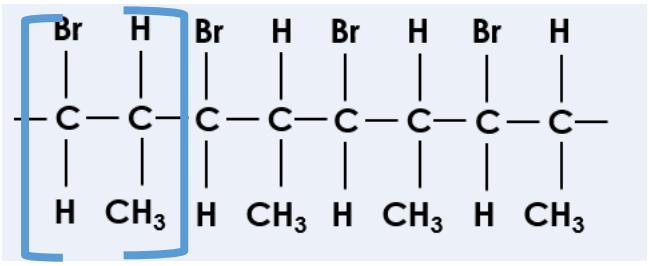
Drill

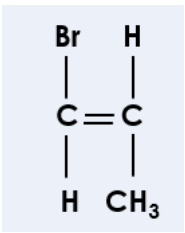
1. Define a polymer. - **Long chain molecules made of many units**
2. Define a monomer. - **Small molecules that can be joined together to make a polymer**.
3. Describe what happens during an addition polymerization reaction. - **Monomers are joined together when their double bonds are broken.**
4. Identify the product(s) that are formed in an addition polymerization reaction. **- Only a polymer is formed**
5. Ethene molecules join to form poly(ethene). Identify the monomer and the polymer. - **Ethene is the monomer and poly(ethene) is the polymer.**
6. Name the polymer that would be formed through addition polymerization of propene molecules. - **Poly(propene)**
7. Name the monomer that would have been used to form the polymer poly(butene). - **Butene**

.

We: Identifying monomers

The displayed formula below shows part of a polymer.



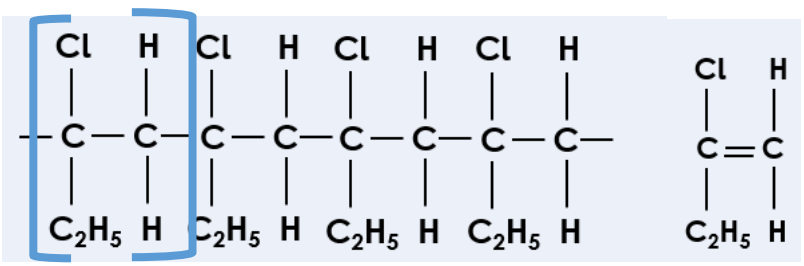


Draw the displayed formula of the monomer. → monomer

1. Identify the repeating unit by adding brackets to the diagam
2. Draw the structure of the repeating unit
3. Replace the double bond that was broken during polymerisation

You: Identifying monomers

The displayed formula below shows part of a polymer.



Draw the displayed formula of the monomer. → monomer

1. Identify the repeating unit by adding brackets to the diagam
2. Draw the structure of the repeating unit
3. Replace the double bond that was broken during polymerisation

Exit Ticket

1. What is the name of the polymer formed through the addition polymerisation of propene?
    - ❑ A. Poly(ethene)
    - ❑ **B. Poly(propene)**
    - ❑ C. Poly(propane)
2. What happens to the atoms of monomers in addition polymerisation?
    - ❑ A. Some atoms are lost
    - ❑ B. Extra atoms are produced
    - ❑ **C. Atoms are not lost or produced**
3. What is made during an addition polymerisation reaction?
    - ❑ A. A polymer and another product
    - ❑ B. A polymer and different monomers
    - ❑ **C. A polymer only**

Taking it Further: Condensation Polymerisation (HT only)

Do Now:

1. Define a polymer. **A long molecule made up of many repeating units.**
2. Describe what happens during addition polymerization. **The C=C double bonds of monomers are broken so monomers can join together to form a polymer.**
3. Explain why alkanes cannot be monomers. **They are saturated, so cannot make more bonds with other molecules.**
4. State the chemical formula of water. **H2O**
5. Describe the bonding in water. **An oxygen atom covalently bonds to two hydrogen atoms, so that each atom achieves a full outer shell.**

Drill

1. Name the functional group found in alcohols. **Hydroxyl group**
2. Name the functional group found in carboxylic acids. **Carboxyl group**
3. Name the type of compound formed when an alcohol reacts with a carboxylic acid. **Ester**

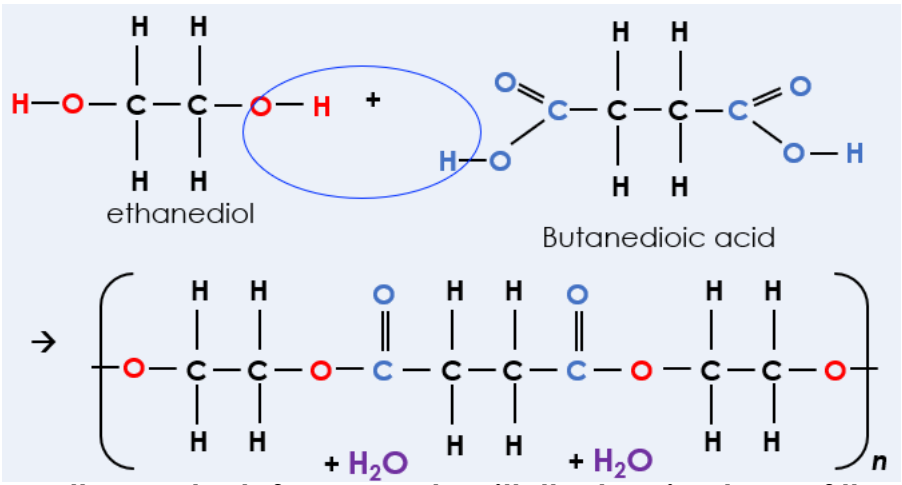
Read Now:

For addition polymerisation to take place, monomers must contain a C=C double bond. This double bond is broken open to allow the monomer to bond with other monomers to make the polymer chain. In condensation polymerisation, the monomers do not require a C=C double bond, but the monomers must each have two functional groups. Simple polymers can be made through condensation polymerisation reactions where two monomers contain two of the same functional group. This is how materials such as polyester are made. Condensation polymerisation is also the reaction through which proteins are synthesised from amino acids.

1. State what is required for monomers to undergo addition polymerisation. **Monomers must contain a C=C double bond**
2. State what is required for monomers to undergo condensation polymerisation. **Each monomer must have two functional groups.**
3. Give an example of a polymer made from condensation polymerisation. **Polyester**
4. Identify the monomers and polymers when proteins are synthesised from amino acids. **Polymer is protein, monomer is amino acids**

Condensation polymers

- Circle where the molecules will bond together
- Name the reactants
- Add in the second product
- What is the name of the large molecule produced? _**polyester**
- Why is it called a condensation reaction? **A small molecule (water) is lost**



Draw the products for example with the box in place of the carbon chain

Drill

1. Define a polymer. - **Long chain molecules made of many units**
2. Define a monomer. - **Small molecules that can be joined together to make a polymer**.
3. State what the monomers need for condensation polymerization to occur. **- Each monomer requires two functional groups.**
4. State the products of a condensation polymerization reaction. **- A polymer and a small molecule (usually water) are formed.**
5. Name the functional group found in alcohols. **- Hydroxyl group**
6. Name the functional group found in carboxylic acids. **- Carboxyl group**

We: Types of polymerisation

The formulae below show two monomers.

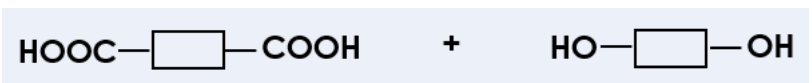
Explain what type of polymerisation would happen when many of the two monomers reacted.

- State how many functional groups there are
- Name the type of polymerisation
- Name the products

- **Both monomers contain a double bond.**
- **This means they would react in an addition polymerisation reaction.**
- **This would produce a polymer only. (polyethene)**

You: Types of polymerisation

The formulae below show two monomers.



Explain what type of polymerisation would happen when many of the two monomers reacted.

- State how many functional groups there are
- Name the type of polymerisation
- Name the products

- **Both monomers contain two functional groups.**
- **This means they would react in a condensation polymerisation reaction.**
- **This would produce a polymer and water.**

Exit Ticket

1. What is required for monomers to react in condensation polymerisation?
    - ❑ A. The monomers must contain a C=C double bond
    - ❑ B. The monomers must contain water
    - ❑ **C. The monomers must contain two functional groups**
2. What small molecule is usually produced through condensation polymerisation?
    - ❑ A. A polymer
    - ❑ **B. Water**
    - ❑ C. Carbon dioxide
3. Which of these is made through condensation polymerisation?
    - ❑ **A. Polyester**
    - ❑ B. Poly(ethene)
    - ❑ C. Amino acids

Taking it Further: Naturally Occuring Polymers

Do Now:

1. Name the functional group found in carboxylic acids. **Carboxyl group**
2. State what monomers require to be able to undergo condensation polymerisation. **Two functional groups**
3. Name the small molecule that is usually produced through condensation polymerisation. **Water**
4. Name the organelle that contains DNA in eukaryotic cells. **Nucleus**
5. Describe the structure of DNA. **Repeating nucleotides made of a base (A,C,T,G), a phosphate and a sugar. Two strands of DNA are wrapped in a double helix..**

Drill:

1. Name the organelles that are found in both plant and animal cells. **Nucleus, cell membrane, cytoplasm, mitochondria**
2. Explain the difference between eukaryotic and prokaryotic cells. **Eukaryotic cells contain membrane bound organelles, including the nucleus. Prokaryotic cells contain DNA in loops or a plasmid**
3. Give an example of a prokaryotic cell. **Bacteria, archaea**

Read Now:

DNA (deoxyribonucleic acid) is one of the most important naturally occurring polymers in the world as it contains the instructions needed for all living organisms (and viruses) to grow, survive and reproduce. DNA consists of a double helix structure, with two strands of DNA. Each strand contains repeating nucleotide units, each of which contains a base, a sugar and a phosphate group. There are four different bases found in DNA and they are complementary pairs. Cytosine always binds to guanine and adenine always binds to thymine. These repeating nucleotide units are the monomers that make up the polymer DNA.

1. Explain why DNA is important. **It contaisn the instructions needed for all living organisms to grow, survive and reproduce.**
2. Describe the structure of DNA. **A double helix structure, with two strands of DNA.**
3. Identify the complementary base pairs in DNA. **A+T, C+G**
4. Identify the monomers that make up the polymer DNA. **Nucleotides**

Naturally Occurring Polymers

Polymer	Name of the monomers it Is made of
Starch	**Glucose**
Cellulose	**Beta glucose**
Protein	**Amino acids**
DNA	**nucleotides**

The structure of DNA

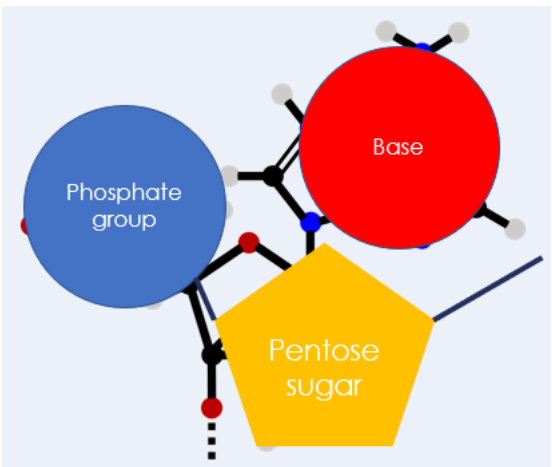
DNA is made of **two** polymer chains in a **double** helix shape

There are **hydrogen** bonds beytween the chains

Name the four possible bases in DNA **A, C, T and G**

A bonds with **T** and G bonds with **C**

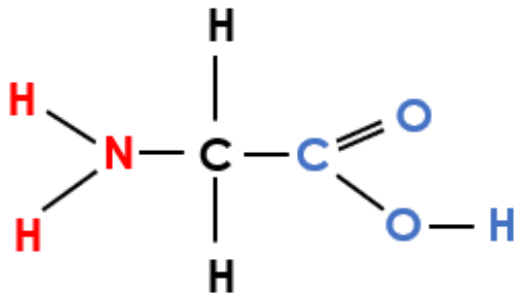
Label the parts of the nucleotide



Amino acids and polypeptides

Amino acids have **two** functional groups so can self polymerise to form polypeptides.

This is another example of **condensation** polymerisation



Drill

1. Describe the function of DNA**. It contains the genetic instructions for development and functioning of living organisms and viruses.**
2. Describe the structure of DNA. **Two polymer chains made up of nucleotides held in a double helix.**
3. Describe what makes up a nucleotide. **A base, a phosphate, and a sugar.**
4. State the complementary base pairs**. A and T, C and G.**
5. Give two other naturally occurring polymers. **Starch, cellulose, proteins.**
6. (HT) State whether the functional groups found in amino acid molecules are the same or different. **The functional groups are different.**
7. (HT) Name the type of reaction that produces a polypeptide from amino acids. **Condensation polymerisation.**
8. (HT) Name the other product of this reaction. **Water.**

We: Explain: ***to use scientific understanding to make something clear or state the reason for something happening***

Explain why polypeptides are described as polymers.

- **Polypeptides consists of amino acids in a chain**
- **This means that polypeptides are polymers because they consist of repeating subunits/monomers**

You: Explain: ***to use scientific understanding to make something clear or state the reason for something happening***

Explain why starch is described as a polymer.

- **Starch consists of glucose molecules in a chain**
- **This means that starch is a polymers because is consists of repeating subunits/monomers**

Exit Ticket

1. What are the monomers that make up DNA?
   - ❑ **A. Nucleotides**
   - ❑ B. Amino acids
   - ❑ C. Base pairs
2. Which of these is a naturally occurring polymer?
   - ❑ A. Poly(ethene)
   - ❑ **B. Cellulose**
   - ❑ C. Glucose
3. How can polypeptides be produced from amino acids?
   - ❑ **A. Amino acids contain two different functional groups so can undergo condensation polymerisation**
   - ❑ B. Amino acids contain two different functional groups so can undergo addition polymerisation
   - ❑ C. Amino acids contain two of the same functional group so can undergo condensation polymerisation

Independent Practice

Prior Knowledge Review

Section A

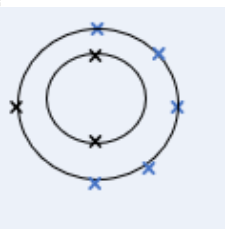
1. Choose the correct words from the box to complete the sentence.

You can use each work once, more than once or not at all.

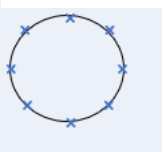
elements	metals	non-metals	ions

Covalent bonding occurs between **non-metals and non-metals**

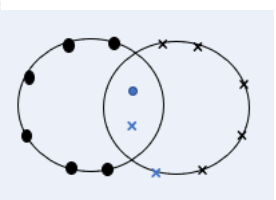
2. Complete the electronic configuration diagram below to show 6 electrons on the outer shell.



3. Redraw the electronic configuration from question 2 above, but this time
   - Only draw the valance shell electrons
   - Draw the atom with a full outer shell

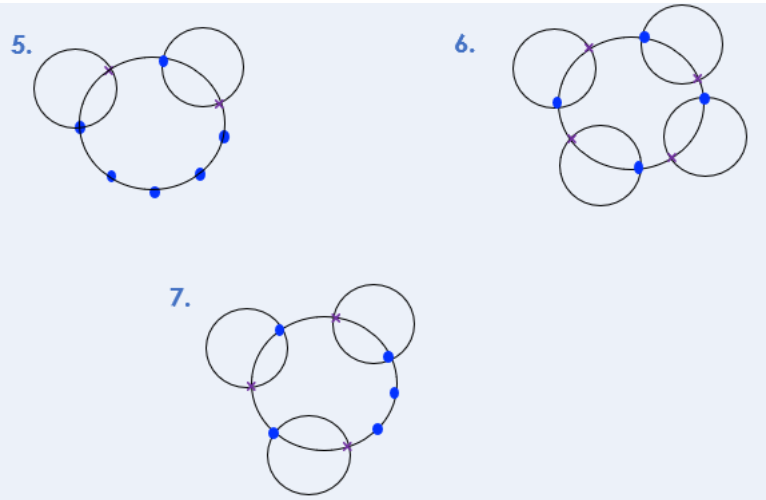


4. Complete the dot and cross diagram to show the bonding in a molecule of Chlorine gas, Cl_2.

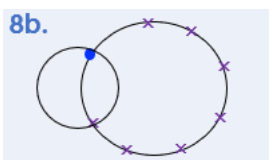


Section B

5. Draw a dot-and-cross diagram to show the bonding in a molecule of water, H_2O.
6. Draw a dot-and-cross diagram to show the bonding in a molecule of methane, CH_4.
7. Draw a dot-and-cross diagram to show the bonding in a molecule of ammonia, NH_3.



Section C



8. Hydrochloric acid has the chemical formula HCl.
   a. Identify the type of bonding present in HCl. **. Covalent bonding**
   b. Draw a dot-and-cross diagram to show the bonding in HCl.
   c. Calculate the relative formula mass of hydrochloric acid. **1+35.5 = 36.5**
   d. Calculate the percentage by mass of chlorine in HCl. **Mass of element/mass of compound x 100 = 35.5/36.5 x 100 = 97.26%**
   e. Write a word equation to show what happens in the reaction between hydrochloric acid and sodium hydroxide. **Hydrochloric acid + sodium hydroxide → sodium chloride + water**
   f. Write a balanced chemical equation for the reaction in Q5. **HCl + NaOH → NaCl + H_2O**
   g. Identify the type of bonding that would be present in each of the products of the reaction in Q5. **Water: covalent, sodium chloride: ionic**

Crude oil and hydrocarbons

Section A

1. Choose the correct words from the box to complete the sentences.

Crude oil is a finite resource found deep underground. It is made from the biomass of ancient plankton, which was buried under mud.

compound	**mixture**	**hydrocarbons**	**mud**	**plankton**	**rocks**	**finite**	**infinite**

2. Choose the correct definition of a hydrocarbon.

   Tick (✓) **one** box.

   A. A compound made of hydrogen and carbon atoms ☐

   B. A compound made of water and carbon atoms ☐

   C. A mixture made of hydrogen and carbon atoms ☐

   D. A mixture made of water and carbon atoms ☐

3. State the general formula of the alkanes. C_nH_{2n+2}

4. Choose the name of the alkane that contains three carbon atoms.

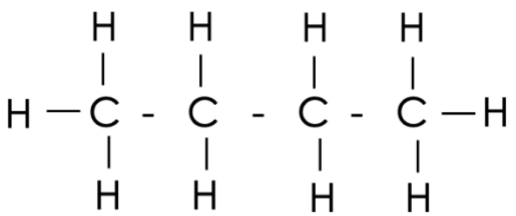
   Tick (✓) **one** box.

   A. Ethane ☐

   B. Propane ☐

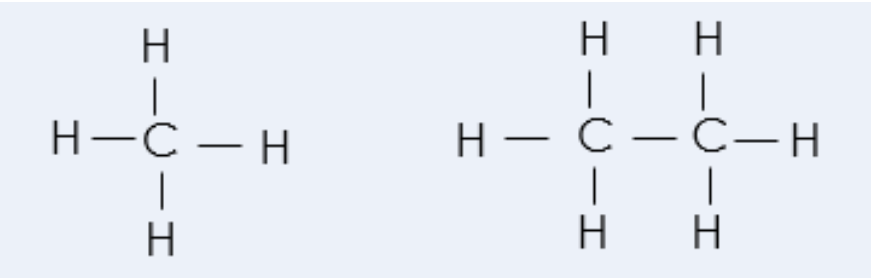
   C. Butane ☐

5. Name the alkane shown by the structural formula below. **butane**

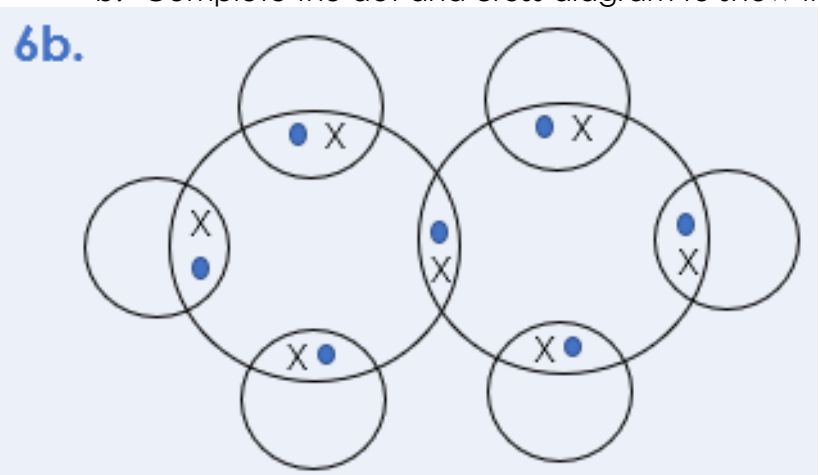


Section B

6. Methane and ethane are both alkanes.
   a. Draw the structural formulae for methane and ethane.



   b. Complete the dot and cross diagram to show the bonding in a molecule of ethane.

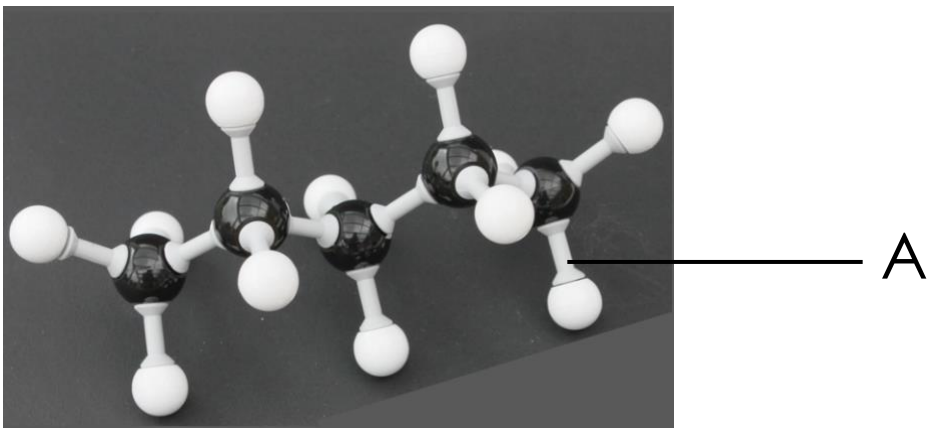


   c. Compare the structures of methane and ethane.

- **Both are alkanes**
- **Both are hydrocarbons/contain only carbon and hydrogen atoms**
- **Both contain covalent bonds**
- **Methane has 1 carbon atom, ethane has 2 carbon atoms**
- **Methane has 4 carbon atoms, ethane has 6 carbon atoms**
- **Ethane also contains a carbon-carbon bond, but methane only has carbon-hydrogen bonds**

   d. The alkanes is a large family of compounds.
   Determine the chemical formula of an alkane with:
      i. 8 carbons **C_8H_{18}**
      ii. 24 carbons **$C_{24}H_{50}$**
      iii. 36 hydrogens **$C_{17}H_{36}$**
      iv. 20 hydrogens **C_9H_{20}**

7. The image below shows a model of an alkane.



a. Determine the chemical formula of this alkane. **C_5H_{12}**

b. Give an advantage of this model.

It shows the shape of the molecule in 3D. The bonds are not really at 90° to each other.

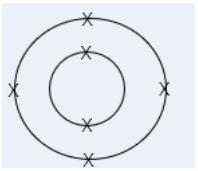
c. What is represented by the letter A? **A covalent bond**

d. Explain why this alkane is a compound and a molecule.

It contains two different types of atom (elements) chemically bonded together and the atoms are non-metals covalently bonded together

Section C

8. Carbon has an atomic number of 6 and a mass number of 12.



   h. State the number of protons, neutrons and electrons in an atom of carbon. **6 protons, 6 neutrons, 6 electrons**
   i. Draw the electronic configuration of a carbon atom.
   j. Explain why a carbon atom is neutral. **It contains the same number of (positively charged) protons and (negatively charged) electrons.**
   k. Carbon's mass number is usually rounded to 12 but the relative atomic mass is actually 12.02. Explain why this is not a whole number. **It contains the same number of (positively charged) protons and (negatively charged) electrons.**
   l. Compare the atomic structures of carbon-12 and carbon-14. **Both types of carbon atom contain 6 protons but carbon-12 contains 6 neutrons and carbon-14 contains 8 neutrons.**

Fractional Distillation

Section A

1. Explain why crude oil is described as a mixture.

. It is made up of different compounds, which are not chemically bonded together.

2. Choose the fraction of crude oil that has the lowest boiling point.

   Tick (✓) **one** box.

   A. Bitumen ☐

   B. Petrol ☐

   C. Liquefied petroleum gases ☐

3. Choose the option that correctly describes the pattern of viscosity in the fractions of crude oil.

   Tick (✓) **one** box.

   A. Viscosity increases as the size of molecules in a fraction increase ☐

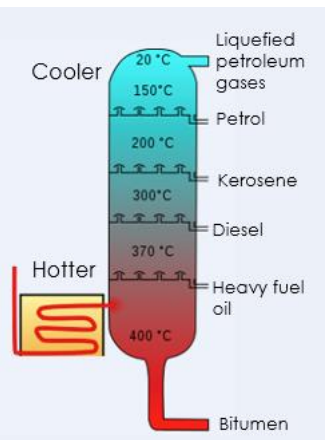
   B. Viscosity decreases as the size of molecules in a fraction increase ☐

   C. Viscosity increases as the size of molecules in a fraction decrease ☐

4. The image below shows a fractionating column.

   a. Add labels to the fractionating column to show where it is hottest and coolest.

   b. Add labels to the fractionating column to name each of the fractions collected at each condenser.



Section B

5. Fractional distillation is used to separate crude oil.
   a. Describe how fractional distillation separates crude oil.

- **Crude oil is heated**
- **Hydrocarbons evaporate**
- **The column is hotter at the top (so hydrocarbons cool as they get higher up)**
- **Fractions cool and condense**
- **Fractions condense at their boiling point (at different heights in the column)**

   b. Describe the relationship between the size of molecules in a fraction and boiling point.

Boiling point increases as the size of molecules in a fraction increases

   c. Explain the relationship between the size of molecules in a fraction and boiling point.

As molecules get larger, intermolecular forces increase so they require more energy to overcome.

6. The table below shows the boiling points of three alkanes.

Alkane	**Boiling point (°C)**
Pentane (C_5H_{12})	36
Decane ($C_{10}H_{22}$)	174
Pentadecane ($C_{15}H_{22}$)	271

   a. What is an alkane?

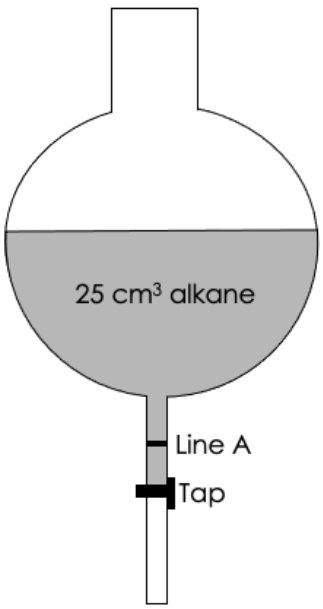
A compound that contains only hydrogen and carbon atoms, and only single bonds (is saturated)

   b. What is the general formula for alkanes? **C_nH_{2n+2}**

c. Determine which state of matter pentane would be at room temperature (22 °C). **Liquid**

A student used the following experiment to investigate a property of these alkanes:

- Add 25 cm^3 of pentane to a separating flask (as shown)
- Start the timer as the tap is opened
- Record the time taken for the level of pentane to reach line A
- Repeat for decane and pentadecane



d. What property is the student investigating with this experiment?
Viscosity

e. The student measured 5.2 seconds for pentane to reach line A. Predict how the time taken for decane and pentadecane would compare.
Explain your answer.

Decane would take longer than pentane and pentadecane would take longer than decane.
Because the larger the molecule, the more viscous the liquid and the longer it will take to be poured.

Section C

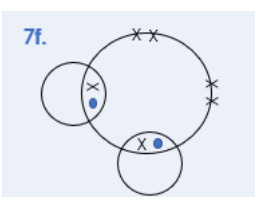
7. Fractional distillation is used to separate crude oil into fractions, but there are many other uses of distillation.

a) Describe how distillation is used in desalination. **7a. Saltwater is heated, so water is evaporated and condensed, leaving the salt behind.**
b) Give a disadvantage of using distillation for desalination. **7b. It requires a large volume of saltwater to be evaporated, which requires a lot of energy so would be very expensive.**
c) Give the name for water that is safe to drink. **7c. Potable water**

d) Explain the difference between water that is safe to drink and distilled water. **7d. Potable water may contain dissolved ions and other substances, but distilled water is pure water.**

e) Explain whether distilled water would conduct electricity. **7e. Pure water would not conduct electricity as it is covalently bonded so there are no free electrons (or dissolved ions) to carry charge.**

f) Draw a dot and cross diagram to show the bonding in water.



g) Calculate the percentage by mass of oxygen in water.

$$\%\ \textbf{by mass} = \frac{\textbf{mass of element}}{\textbf{mass of compound}} \times 100$$

$$\%\ \textbf{by mass} = \frac{16}{18} \times 100$$

$$\%\ \textbf{by mass} = 88.89\ \%$$

Combustion of Hydrocarbons

Section A

1. Choose the correct definition of a hydrocarbon.
   Tick (✓) **one** box.

   A. A molecule that contains carbon and water atoms only ☐

   B. A molecule that contains carbon and hydrogen atoms only ☐

   C. A molecule that contains a mixture of carbon and hydrogen atoms ☐

2. Complete the chemical formula for propane. **C_3H_8**
3. Choose the substance that hydrocarbons react with during combustion.
   Tick (✓) **one** box.

   A. Air ☐

   B. Oxygen ☐

   C. Carbon dioxide ☐

4. Complete the general equation for the complete combustion of alkanes:
   Alkane + oxygen → carbon dioxide + water
5. Describe what is needed for complete combustion of alkanes to take place.
   A good supply of oxygen/air

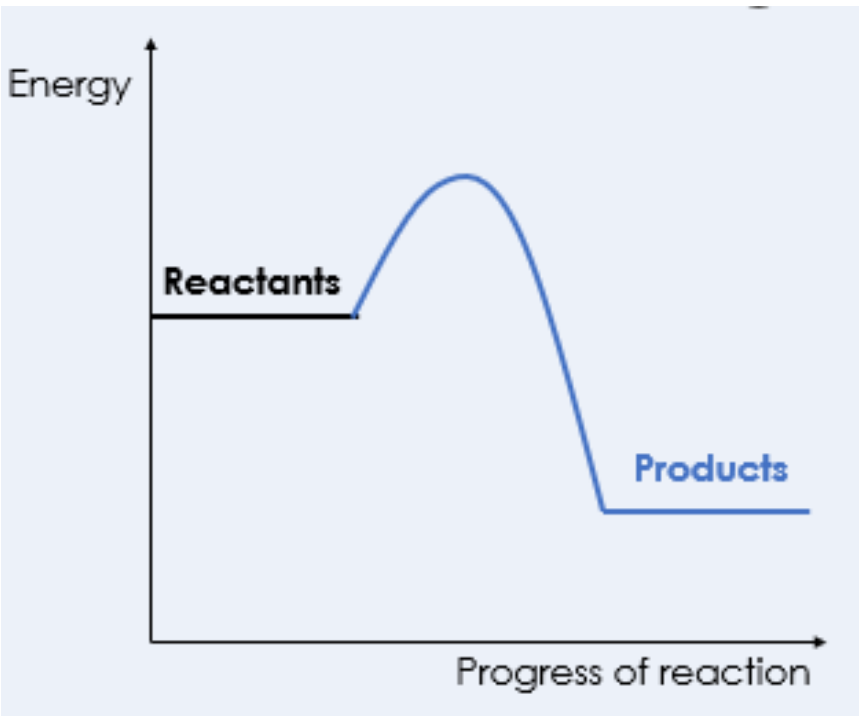
Section B

6. Methane is a common hydrocarbon that is used as a domestic fuel.

   a. Write a balanced symbol equation for the complete combustion of methane.
      $CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$

   b. Explain why the incomplete combustion of methane may be dangerous.
      It produces carbon monoxide, which is poisonous/toxic/stops oxygen binding to haemoglobin in blood.

   c. Complete the reaction profile for the combustion of methane.



   d. Explain your answer to question c.

It is exothermic, so the reactants have more energy than the products.

7. Petrol is used as a fuel in many cars. One of the compounds in petrol is octane (C_8H_{18}).

a. Complete the word equation for the reaction of octane that takes place in a car engine:

Octane + oxygen → carbon dioxide + water

b. Cars should use sulfur-free petrol. Explain why.

Sulfur impurities react with oxygen to form sulfur dioxide, which leads to acid rain.

c. Many scientists are concerned about one of the products of the complete combustion reaction of octane in car engines. Identify the product that is concerning scientists and explain why it is a concern.

Carbon dioxide, as it is contributing to global warming

The table below provides data on the composition of gases from the exhaust of a petrol engine.

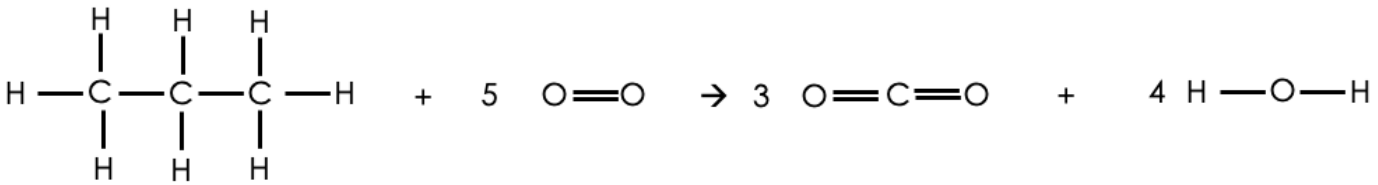
Gas	Percentage
Nitrogen	67
Carbon dioxide	16
Carbon monoxide	1.5
Oxygen	0.5
Nitrogen oxides	0.15
Sulfur dioxide	0.02
Other gases	

d. Calculate the percentage of other gases present. **14.83%**

e. Name the compound that makes up most of the other gases. **Water (vapour)/steam**

Section C

8. Below shows the reaction between propane and oxygen. This reaction is exothermic as 2018 kJ/mol more energy is released when forming the bonds than is taken in to break the bonds in the reactants.



Bond	Bond Energy (kJ/mol)
C-H	413
O=O	498
C=O	799
O-H	464

a. Use the information given to calculate the C-C bond energy.

Energy change = 2018 kJ/mol
Energy change = In-Out
In:
$2x$+(8x413)+(5x498) = 5794 + $2x$
Out:
(6x799)+(8x464) = 8506
Energy change = In-Out
2018 = In - 8506
In = (-)6488
5794 + $2x$ = 6488
$2x$ = 694
x = 347 (kJ/mol)

b. Calculate the mass of carbon dioxide that would be made when 100 g of propane burns in 600 g of oxygen.
Relative atomic masses:

Carbon = 12

Hydrogen = 1

Oxygen = 16

$$\textbf{Number of moles C3H8} = \frac{\textbf{mass}}{\textbf{Mr}} \quad \textbf{Number of moles C3H8} = \frac{100}{44} \quad \textbf{Number of moles} = 2.2727 \ldots \textbf{mol}$$

$$\textbf{Number of moles O2} = \frac{\textbf{mass}}{\textbf{Mr}} \quad \textbf{Number of moles O2} = \frac{600}{32} \quad \textbf{Number of moles} = 18.75 \ldots \textbf{mol}$$

Mole ratio = 1:5 $\textbf{number of moles of O2 needed to react with 2.2727 mol of C3H8} = 11..36 \textbf{ mol}$ **(possible)**

$\textbf{number of moles of C3H8 needed to react with 18.75 mol of O2} = 3.75 \textbf{ mol}$ **(not possible)**

Limiting reactant = C_3H_8

Mole ratio = 1:3 $\textbf{Number of moles CO2} = 6.8181 \ldots \textbf{ mol}$ $\textbf{Number of moles CO2} = \frac{\textbf{mass}}{\textbf{Mr}}$

$$6.8181 \ldots \textbf{ mol} = \frac{\textbf{mass}}{44} \quad \textbf{Mass} = 300 \textbf{ g}$$

Cracking

Section A

1. Describe what happens when large hydrocarbon molecules are cracked.
   They are broken down to form shorter chain hydrocarbons and alkenes.

2. Choose which of these is an alkene.

   Tick (✓) **one** box.

   A. Ethane ☐

   B. Ethene ☐

   C. Propane ☐

3. Give one difference between alkanes and alkenes.
   Any one from:

   - **Alkenes are unsaturated, alkanes are saturated**
   - **Alkenes contain a C=C double bond**
   - **Alkanes only contain C-C single bonds**
   - **Alkanes have the general formula C_nH_{2n+2}**
   - **Alkenes have the general formula C_nH_{2n}**

4. What type of reaction is cracking?

   Tick (✓) **one** box.

   A. Combustion ☐

   B. Neutralisation ☐

   C. Decomposition ☐

5. The chemical equations below show some of the reactants and products of different cracking reactions.

a. Determine the formula of the missing product in each case.

i. $C_{10}H_{22} \rightarrow C_6H_{14} + \mathbf{C_4H_8}$

ii. $C_6H_{14} \rightarrow C_2H_4 + \mathbf{C_4H_{10}}$

iii. $C_{14}H_{30} \rightarrow C_8H_{18} + \mathbf{C_6H_{12}}$

b. Highlight all alkanes in one colour and all alkenes in another colour.

Section B

6. Crude oil is fractionally distilled. Fractions with larger molecules can then be cracked. Describe two differences between fractional distillation and cracking.

Any two from:

- **cracking uses a catalyst, fractional distillation doesn't**
- **cracking breaks up molecules, fractional distillation separates them**
- **cracking is a chemical reaction, fractional distillation is a physical process**

7. Decane ($C_{10}H_{22}$) is commonly cracked.

a. Determine the formula of the other product formed when decane is cracked.

$C_{10}H_{22} \rightarrow C_2H_4 + \mathbf{C_8H_{18}}$

b. Name the product with the formula C_2H_4. **Ethene**

c. C_2H_4 is an alkene. Explain how this could be tested. **Bromine water could be added to it, which would turn colourless.**

d. Give two conditions used for cracking decane. **Any two from:**

High temperature
Steam
Catalyst (accept zeolite, aluminium oxide)

8. The table below gives some information about fractions of crude oil.

Fraction	**Approximate % of crude oil**	**Approximate % of total demand**
LPG	4	6
Petrol	10	25
Kerosene	16	14
Diesel	20	20
Heavy fuel oil	**22 %**	18
Bitumen/residue	28	17

a. What does LPG stand for? **Liquefied petroleum gases**

b. Complete the table by naming the missing fraction and calculating the approximate percentage of crude oil that is made up of heavy fuel oil.

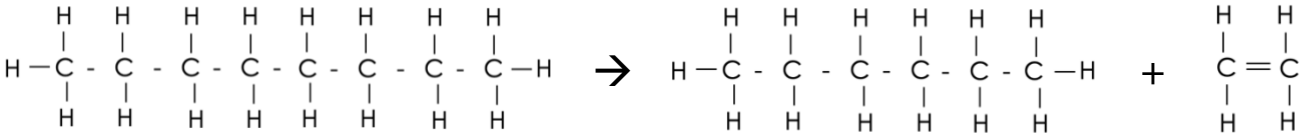
c. Identify which of these fractions is the most flammable. **LPG/liquefied petroleum gases**

d. Use the information in the table to explain why it is useful to crack hydrocarbons.

To break longer chains into smaller chains where the demand is higher. For example, only 10% of crude oil is petrol but the demand for petrol is 25% of the total.

9. The diagram below shows a chemical reaction.

Compound A Compound B Compound C



a. Compounds A, B and C are all what type of compound? **Hydrocarbons**
b. What type of chemical reaction is shown by this diagram? **Cracking**
c. Suggest one use for Compound B**Fuel/petrol**

d. Suggest one use for Compound C**Feedstock for petrochemical industry/chemical reactions, for making plastics/polymers**

Section C

10. Cracking is used to break long hydrocarbon chains into smaller hydrocarbon chains.
    a. Cracking takes place under high temperatures. Explain whether cracking is an exothermic or endothermic reaction. **It involves thermal decomposition, which is an endothermic reaction. More energy is taken in from the surroundings than is released through the reaction, which is why it has to take place at high temperatures.**
    b. (HT) $C_{20}H_{42}$ can be cracked. The equation for the reaction is:
    $C_{20}H_{42} \rightarrow C_{16}H_{34} + 2\ C_2H_4$
    Calculate the mass of $C_{20}H_{42}$ needed to produce 40 kg of ethene.
    Relative atomic masses:
    C=12
    H=1

$$\textbf{Number of moles C2H4} = \frac{\textbf{mass}}{\textbf{Mr}} \quad \textbf{Number of moles C2H4} = \frac{\textbf{40 000}}{\textbf{28}}$$

$\textbf{Number of moles} = \textbf{1 428.57 ... mol}$ **Mole ratio = 1:2**

$$\textbf{Number of moles C20H42} = \textbf{714.2857 ... mol} \quad \textbf{Number of moles C20H42} = \frac{\textbf{mass}}{\textbf{Mr}}$$

$\textbf{714.2857 ... mol} = \frac{\textbf{mass}}{\textbf{282}}$ $\textbf{Mass} = \textbf{201 428.57 g}$ **Mass = 201.43 kg**

Taking it Further: Alkenes

Section A

1. Complete the general formula of the alkenes. C_nH_2
2. Choose which of these is an alkene.

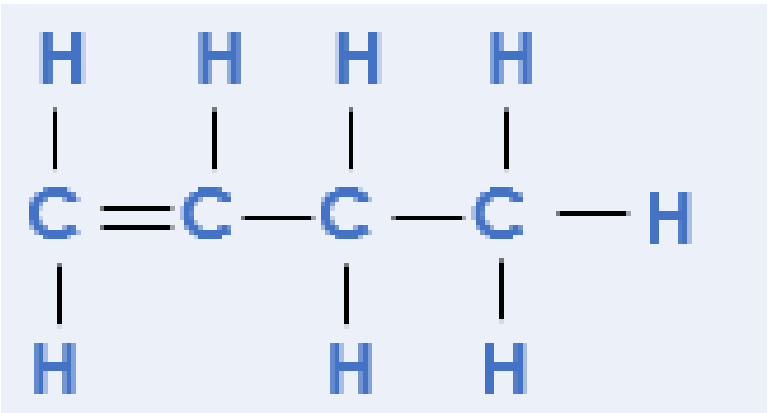
   Tick (✓) **one** box.

   A. Pentane ☐

   B. Hexene ☐

   C. Heptane ☐

3. Complete the structural formula for butene:



4. The alkenes are a large family of compounds.
   Determine the chemical formula of an alkene with:
   a. 8 carbons C_8H_{16}

   b. 24 carbons $C_{24}H_{48}$

   c. 36 hydrogens $C_{18}H_{36}$

   d. 20 hydrogens $C_{10}H_{20}$

5. What happens when bromine water is added to an alkene?

   Tick (✓) **one** box.

D. Bromine water turns cloudy ☐

E. Bromine water turns colourless ☐

F. Bromine water stays orange ☐

6. Which explains why alkenes are described as unsaturated?

Tick (✓) **one** box.

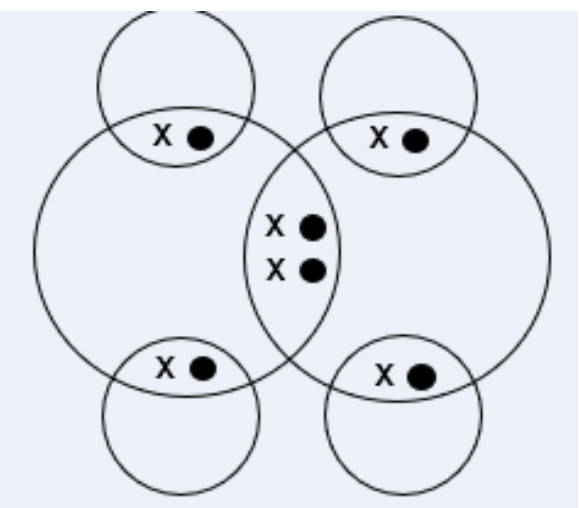
A. They contain a double bond between carbon atoms ☐

B. They contain a double bond between carbon and hydrogen atoms ☐

C. They contain only single bonds ☐

Section B

7. Complete the dot and cross diagram to show the bonding in ethene.



8. Predict the products of the following reactions.

a. Propene + hydrogen → **Propane**

b. pentene + hydrogen → **Pentane**

c. Hexene + hydrogen → **Hexane**

d. Propene + bromine → **Dibromopropane**

e. Pentene + chlorine → **Dichloropropane**

f. Hexene + iodine → **Diiodohexane**

9. Describe what is required for an alkene to react with hydrogen. **A catalyst is required**

10. Explain how alkenes are produced from crude oil using fractional distillation and cracking.

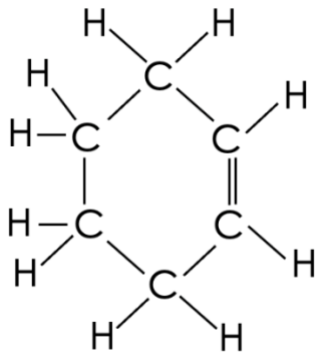
Suggested points:

- **During fractional distillation, crude oil is heated**
- **In a fractionating column**
- **The column is hotter at the bottom and cooler at the top**
- **The fractions have different boiling points**
- **The fractions condense at different temperatures**
- **Heavy fractions condense at the bottom, smaller fractions condense higher up**
- **Cracking is then used to break the larger hydrocarbons into smaller hydrocarbons**
- **It breaks alkanes into smaller alkanes and alkenes**
- **Cracking requires a catalyst/steam/high temperature**

11. Cycloalkenes are alkenes that are ring-shaped and contain a double bond between carbon atoms.
The chemical formulae of three cycloalkenes are given below.

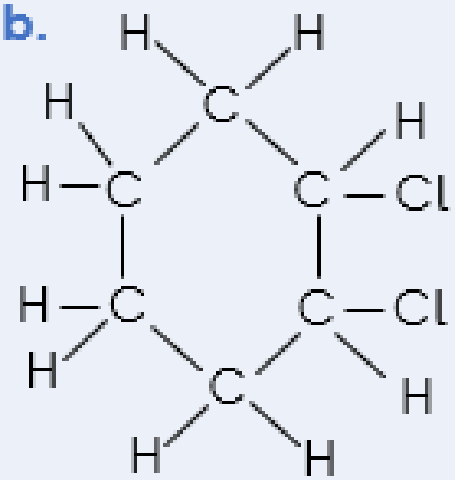
Name	Formula
Cyclobutene	C_4H_6
Cyclopentene	C_5H_8
Cyclohexene	C_6H_{10}

a. Use the information to determine the general formula of cycloalkenes. C_nH_{2n-2}
b. The structural formula of cyclohexene is shown below.



Cyclohexene reacts with chlorine. Complete the structural formula to show the compound formed when cyclohexene reacts with chlorine.

11b.



Section C

12. Alkenes are a homologous series of hydrocarbons.
    a. Define a homologous series. **A group of compounds with the same functional group**

b. Define a hydrocarbon. **A molecule that contains carbon and hydrogen atoms only.**
c. A scientist has a mixture of different alkenes. Describe and explain how they could separate them. **The boiling points vary with molecule size so distillation could be used to separate the alkenes as they would evaporate then condense at different temperatures.**
d. Identify the type of bonding in alkenes. **Covalent bonding**
e. Explain why the alkenes have relatively low melting and boiling points. **They are covalent molecules so there are weak intermolecular forces between them which require little energy to overcome.**
f. Hexene is an alkene that contains 6 carbon atoms. Describe what happens to the particles when hexene is heated past its boiling point. **The hexene molecules overcome the forces holding them together and spread apart, moving at random speeds in random directions.**
g. Hexene has a boiling point of 63 °C. What state is it in at room temperature? **Liquid**
h. Hexene has a specific heat capacity of 183 J/kg °C. Calculate how much energy is required to heat 100 g of hexene from room temperature (20 °C) to its boiling point.

$$\Delta E = mc\Delta\theta \quad \Delta E = 0.1 \times 183 \times 43 \quad \Delta E = 786.9\ J$$

Taking it Further: Alcohols

Section A

1. Choose which of these is an alcohol.

   Tick (✓) **one** box.

   D. Ethane ☐

   E. Ethene ☐

   F. Ethanol ☐

2. Choose the function groups of the alcohols.

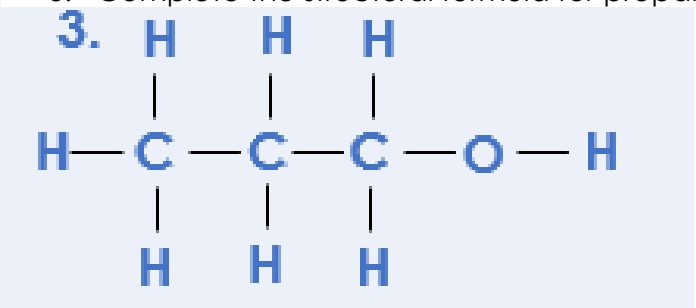
   Tick (✓) **one** box.

   A. Hydroxyl group ☐

   B. Hydroxide group ☐

   C. Hydrogen group ☐

3. Complete the structural formula for propanol:



4. The alcohols are a large family of compounds.
   Determine the chemical formula of an alcohol with:

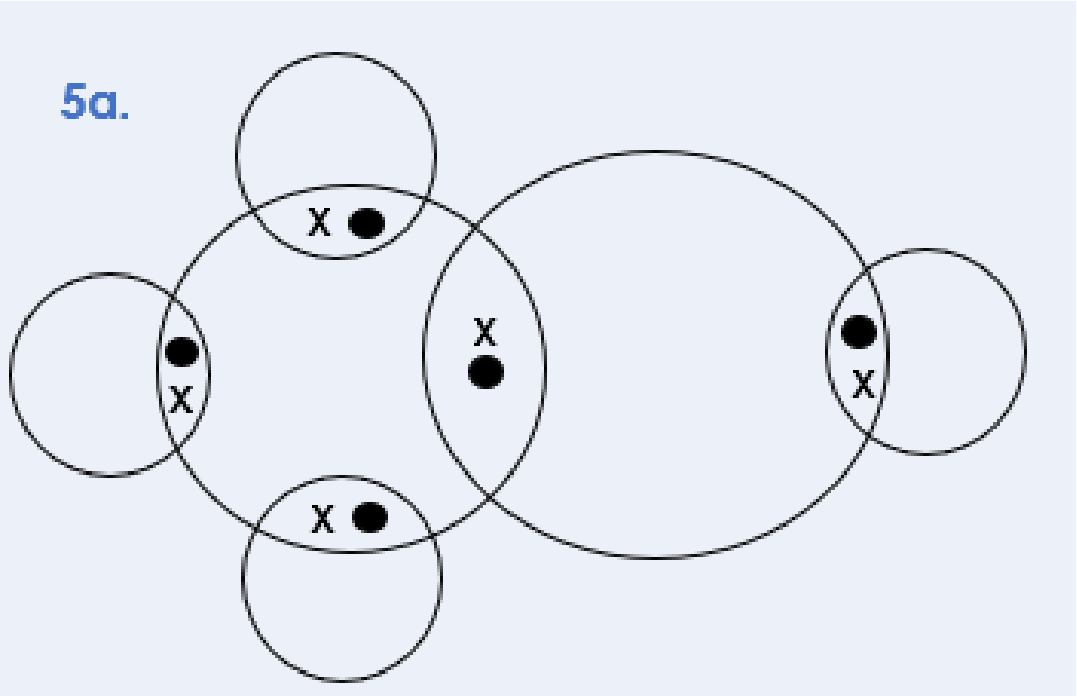
   e. 6 carbons **$C_6H_{11}OH$**

   f. 8 carbons **$C_8H_{15}OH$**

   g. 10 carbons**$C_{10}H_{19}OH$**

Section B

5. Methanol is an alcohol.
   a. Complete the dot and cross diagram to show the bonding in methanol.



   b. Give a use for methanol. **As a chemical feedstock**

   c. Complete the word equation to show the complete combustion of methanol.

      ethanol + oxygen → **Carbon dioxide + water**

   d. Compare the products that would be produced through complete and incomplete combustion of methanol. **Both types of combustion produce water but incomplete combustion produces carbon and carbon monoxide rather than carbon dioxide**.

   e. Predict the products of the following reactions.

i. Ethanol + sodium → **Sodium ethoxide + hydrogen**

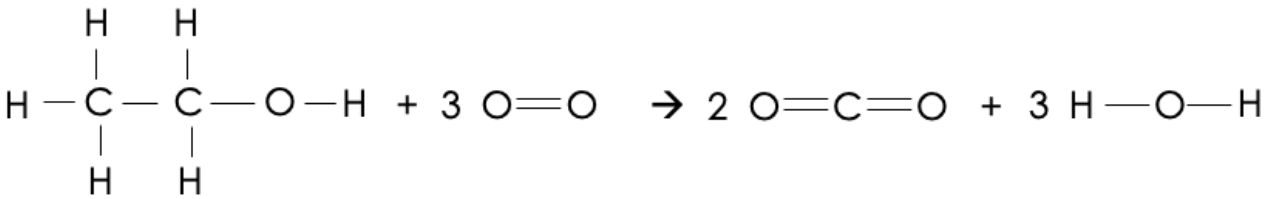
ii. Propanol + sodium → **Sodium propoxide + hydrogen**

iii. Butanol + sodium → **Sodium butoxide + hydrogen**

6. *This question is for higher tier students.*
Ethanol burns completely in air according to the following equation:

$C_2H_5OH + 3\ O_2 \rightarrow 2\ CO_2 + 3\ H_2O$

This reaction can be represented with structural formulae:



a. Use the bond energies given in the table to calculate the overall energy change of this reaction.

Bond	Bond energy (kJ/mol)
C-C	347
C-H	413
C-O	358
C=O	799
O-H	467
O=O	495

In:

(5x413)+347+358+467+(3x495) = 4722 kJ/mol

Out:

(4x799)+(6x467)= 5998

Energy change = In-Out

Energy change = 4722 - 5998

Energy change = -1276 kJ/mol

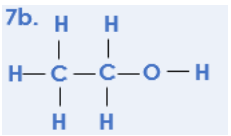
b. Use your answer to explain whether this reaction is exothermic or endothermic.

Exothermic as the overall energy change is negative. More energy is released when new bonds are formed than is taken in to break the bonds of the reactants.

Section C

7. Ethanol is an alcohol.
   a. State the chemical formula of ethanol. Draw the structural formula of ethanol. **C_2H_5OH**
   b. One use of ethanol is in alcoholic drinks. Give another use of ethanol. **As a solvent or a fuel**
   c. Describe some of the short term effects of alcohol on the body. **Delayed reaction times, impaired judgement, slurred speech, altered behaviour**
   d. Describe a simple experiment that could be used to estimate a person's reaction time. **Dropping a ruler from a given height and recording the distance the ruler fell before the person caught it. The further the ruler falls, the slower the reaction time is.**
   e. Drinking alcohol affects the stopping distance of a car. Does this affect the thinking distance or the braking distance? **. Thinking distance**
   f. Calculate the stopping distance of a car travelling at 10 m/s with a deceleration of 2.5 m/s^2. The diver's reaction time is 0.4 seconds.

7b.



Thinking distance: $\mathbf{s = vt \quad s = 10 \times 0.4 \quad s = 4\ m}$

Braking distance: $\mathbf{v^2 - u^2 = 2as \quad 0 - 10^2 = 2(-2.5)s \quad -100 = -5s \quad s = 20\ m}$

Stopping distance: $\mathbf{4 + 20 = 24\ m}$

Taking it Further: Producing Ethanol by Fermentation

Section A

1. Complete the word equation for fermentation.
   Glucose → **Ethanol + carbon dioxide**

2. Which explains why fermentation is an anaerobic process?
   Tick (✓) **one** box.

   A. It takes place in the presence of oxygen ☐

   B. It takes place in the absence of oxygen ☐

   C. It involves anaerobic respiration ☐

3. Choose the most suitable temperature for fermentation to take place.

   Tick (✓) **one** box.

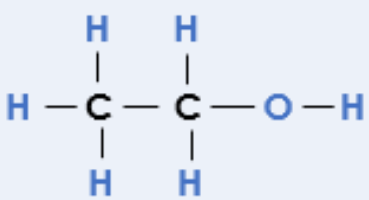
   A. 10 °C ☐

   B. 30 °C ☐

   C. 40 °C ☐

4. Complete the structural formula for ethanol:

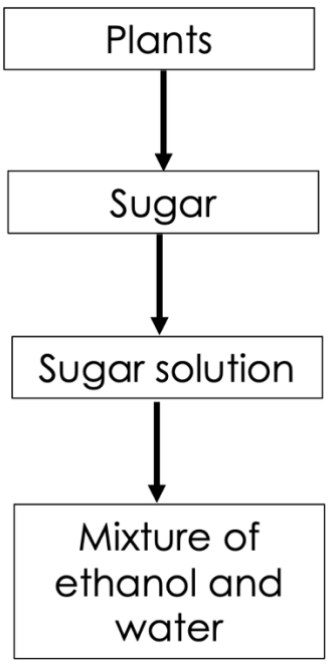
4.



5. Give a use for ethanol other than in alcoholic drinks. **As a fuel or a solvent**
6. Give a use for the other product of fermentation. **In baking, making dough rise**

Section B

7. The flowchart shows some of the substances involved in the production of ethanol.



   a. Name the process that can be used to make ethanol from plant sugars.

Fermentation

   b. Describe how the sugar solution is used to produce the mixture of ethanol and water.

Add yeast

Allow to ferment (leave at 25-35 °C with no oxygen)

   c. Describe the advantages and disadvantages of this method of producing ethanol.

Advantages

- **Low energy cost**
- **Raw material (sugar) is renewable**

Disadvantages

- **Low rate of reaction**
  Ethanol produced is low purity

   d. Describe how ethanol could be separated from the mixture of ethanol and water. Ethanol has a boiling point of 78 °C and water has a boiling point of 100 °C.

- **Heat the mixture**
- **Ethanol will vaporise first (as it has the lower boiling point)**
- **Then condense/cool**

   e. Ethanol made by this method can be used as a biofuel. Suggest the impact this may have on food security.

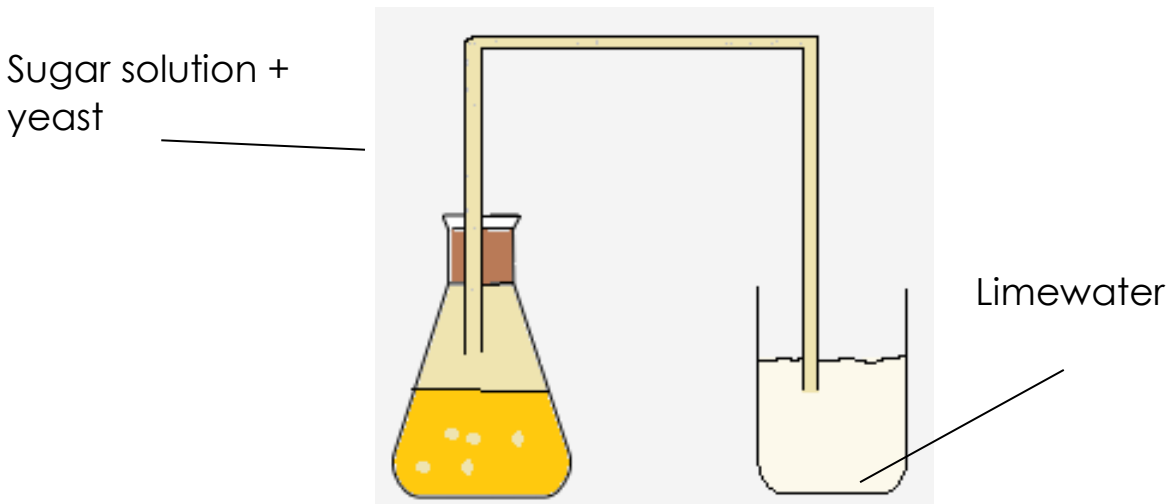
Land may be used to grow crops for biofuel production rather than food crops

This could decrease food security

f. Explain why burning biofuels contributes less to global warming than burning fossil fuels.

- **Burning ethanol still produces carbon dioxide (like burning fossil fuels)**
- **but carbon dioxide is taken in while the crops for biofuels are growing**
- **So net carbon dioxide emissions are lower**

g. The apparatus below shows how ethanol can be made from sugar solution and yeast.



a. Describe and explain the change that would be seen in the limewater.

- **Limewater would turn cloudy**
- **because the other product of fermentation is carbon dioxide**

b. Once the reaction has taken place, the solid yeast can be separated from the solution.
Describe how the solid yeast could be separated from the solution.

- **Using filtration**
- **The solid yeast would not pass through filter paper, but the solution/liquid would**

Section C

8. Ethanol can be produced by fermentation.
   a. Name the microorganism that is added to a sugar solution to produce ethanol. **Yeast**
   b. Enzymes in the microorganism increase the rate of reaction. Define an enzyme. **A biological catalyst.**
   c. Explain what is meant by the lock-and-key model of enzyme activity. **The active site of the enzyme fits with the substrate specifically.**
   d. Define the optimum temperature of an enzyme. **The temperature it works best at.**
   e. Describe what happens to an enzyme when it is heated too much. **It becomes denatured and the shape of the active site is destroyed.**

Taking it Further: Producing Ethanol from Ethene

Section A

1. Complete the word equation for hydration of ethene.
   Ethene + steam (water) → ethanol

2. What is the chemical formula of ethene?
   Tick (✓) **one** box.

   A. C_2H_6 ☐

   B. C_2H_5 ☐

   C. C_2H_4 ☐

3. Choose the required temperature for hydration of ethene to take place.

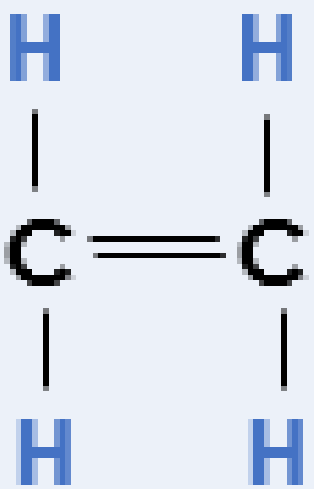
   Tick (✓) **one** box.

   A. 100 °C ☐

   B. 300 °C ☐

   C. 600 °C ☐

4. Complete the structural formula for ethene:



5. Compare the structure of ethene and ethanol.

- **Ethene and ethanol both contain 2 carbon atoms**
- **Ethene contains 4 hydrogen atoms, whereas ethanol contains 5 hydrogen atoms and a hydroxyl group**
- **Ethene contains a C=C double bond, whereas ethanol contains only single bonds**

Section B

6. Describe the steps involved in the production of ethanol from crude oil.
- **Crude oil is fractionally distilled to separate it into fractions**
- **Larger hydrocarbon fractions are broken up into smaller alkanes and alkenes (such as ethene) by cracking**
- **Ethene can then be reacted with steam/hydrated to produce ethanol**

7. E5 and E10 are both types of fuel used in cars. They both contain petrol and ethanol in different quantities. The table below shows some information about each fuel type.

Fuel type	**% of ethanol**	**% of petrol**
E5	5	95
E10	10	90

a. When filled, a car tank can hold 42 kg of E5 fuel. Calculate the mass of ethanol that would be found in 42 kg of E5 fuel.

5 % of 42 kg = 2.1 kg

b. The ethanol used in both these fuel types is made from sugar cane plants.

Suggest why E10 fuel is considered to be more environmentally friendly than E5 fuel.

It contains more ethanol, so more sugar cane is used. This means that more carbon dioxide is absorbed when the plants are growing.

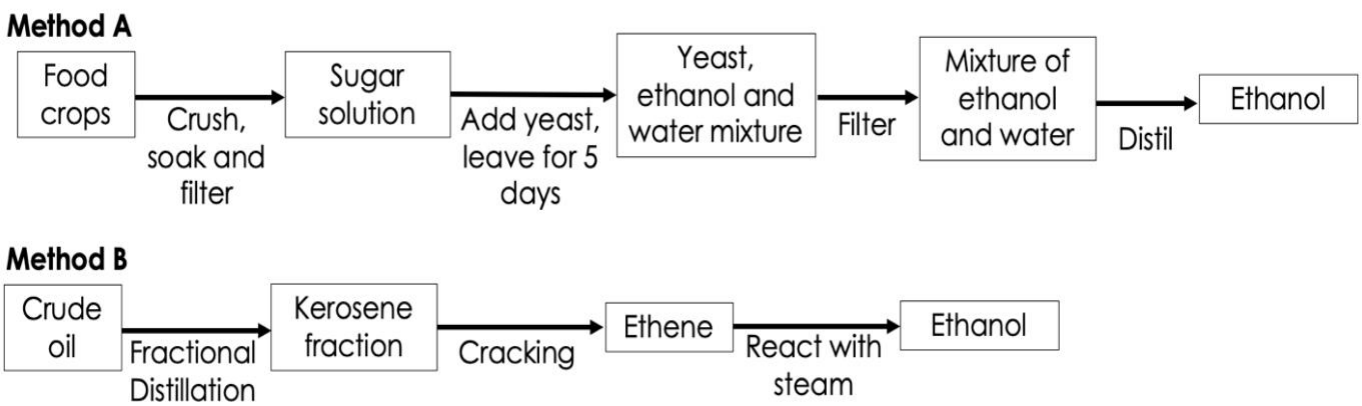
c. When ethanol is burned, it releases 28 MJ of energy per kg of ethanol. When petrol is burned, it releases 45 MJ of energy per kg of petrol.
Use this information to suggest one advantage of using E5 fuel instead of E10 fuel.

As E10 contains more ethanol, it would release less energy per kg of fuel, so a tank of fuel would not last as long/be able to travel as far.

d. Explain whether burning petrol and ethanol are exothermic or endothermic reactions.

They are both exothermic (combustion) reactions as they both transfer energy to the surroundings.

8. The flowcharts below show information about two different methods of producing ethanol.



Use information from the flow charts and your own knowledge to evaluate the two methods of producing ethanol.

Method A

Advantages:

- **renewable resource/raw material**
- **less energy required**
- **carbon dioxide absorbed when plants are growing**
- **low safety risk**
- **easy processes, less technology needed**

Disadvantages:

- **Process is slow**
- **More steps are involved**
- **Ethanol is impure**
- **More land used for growing crops for fuel instead of food**

Method B

Advantages:

- **fewer steps involved**
- **ethanol produced is pure**

Disadvantages:

- **non- renewable resource/raw material**
- **energy intensive (high temperatures required)**

Section C

9. Another use of ethanol is in antibacterial hand gels. This can help to prevent the spread of communicable diseases.
   a. Define a communicable disease. **Diseases caused by pathogens.**
   b. Give an example of a communicable disease. **Cholera, HIV, TMV, measles, salmonella, gonorrhoea, malaria, athlete's foot**
   c. Describe other methods of preventing the spread of communicable diseases. **Sterilising water with chemicals or UV light**
      Cooking food thoroughly
      Disinfecting surfaces
      Vaccinations
      Using barrier contraception methods

Taking it Further: Carboxylic acids

Section A

1. What is the functional group of the carboxylic acids?
   Tick (✓) **one** box.

   A. -COOH ☐

   B. -COH ☐

   C. -C=O ☐

2. Choose the chemical formula of methanoic acid?

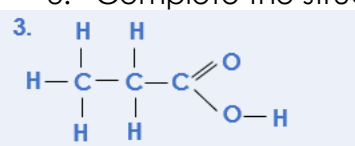
   Tick (✓) **one** box.

   D. CH_3COOH ☐

   E. HCOOH ☐

   F. COOH ☐

3. Complete the structural formula for propanoic acid:

3. 

4. Complete these word equations for reactions of carboxylic acids:

a. Methanoic acid + calcium → calcium methanoate + hydrogen

4b. Propanoic acid + sodium oxide → sodium propanoate + water

4c. Butanoic acid + potassium carbonate → potassium butanoate + water + carbon dioxide

Section B

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

Name	Chemical formula	pH (of 0.01 mol/dm^3) solution
Methanoic acid	**HCOOH**	2.9
Ethanoic acid	CH_3COOH	3.4
Propanoic acid	C_2H_5COOH	3.5

a. Complete the table above.

A student adds zinc carbonate powder to a solution of ethanoic acid in an open conical flask, placed on a mass balance.

b. Explain what would happen to the mass of the flask and contents during the reaction.

The mass would decrease because carbon dioxide gas is produced, which can escape the flask.

c. Explain how this would be different if the student had added zinc oxide powder instead of zinc carbonate.

he mass would not change if zinc oxide was added instead as only the salt and water would be produced, which would not leave the flask.

d. Calculate the relative formula mass of ethanoic acid.

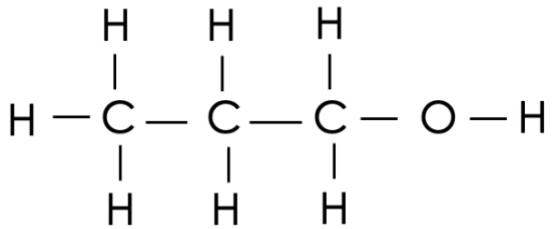
Mr = 12+(3x1)+12+16+16+1 = 60

e. Calculate the percentage by mass of carbon in ethanoic acid.

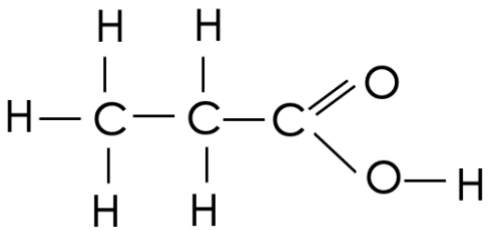
$$\% \text{ by mass} = \frac{\text{mass of element}}{\text{mass of compound}} \times 100 \quad \% \text{ by mass} = \frac{24}{60} \times 100 \quad \% \text{ by mass} = 40\ \%$$

6. The diagrams below show the structural (displayed) formulae of two organic compounds.

Compound A



Compound B



a. Explain what is meant by an organic compound.

A chemical compound that contains carbon atoms, chemically bonded to other atoms.

b. Name compounds A and B.
Compound A: Propanol Compound B: Propanoic acid

c. Both compounds are colourless liquids. Describe a simple chemical test that could be done in a test tube to determine which compound is which.

Any of the below tests:

- **Add a metal carbonate, compound B would cause effervescence**
- **Add a metal, compound B would cause effervescence**
- **Add an indicator (e.g. Universal Indicator), compound B would show an acidic pH/orange-red colour**

Section C

HT) Carboxylic acids are weak acids.

a) Define a weak acid. **An acid that only partially ionises/dissociates in solution**
b) Give an example of a strong acid. **Hydrochloric acid, nitric acid, sulfuric acid**
c) Compare the pH of a weak and strong acid with the same concentration. **If two acids had the same concentration, the stronger acid would have a lower pH**
d) Compare the pH of a dilute and concentrated sample of the same acid. **If two acids had the same concentration, the stronger acid would have a lower pH**
e) Calculate the concentration (in mol/dm^3) of 5 g of hydrochloric acid dissolved in 100 cm^3 of solution. Round your final answer to two decimal places. $\boldsymbol{number\ of\ moles = \frac{mass}{Mr}}$

$\boldsymbol{number\ of\ moles = \frac{5}{(35.5+1)}}$ $\boldsymbol{number\ of\ moles = 0.1369\ldots}$

$\boldsymbol{concentration = \frac{number\ of\ moles}{volume}}$ $\boldsymbol{concentration = \frac{0.1369\ldots}{0.1}}$ $\boldsymbol{concentration = 1.37\ mol/dm3}$

Taking it Further: Esters

Section A

1. What is the functional group of the esters?
   Tick (✓) **one** box.

   A. COOH ☐

   B. COO ☐

   C. COH ☐

2. What small molecule is made during the formation of an ester?

   Tick (✓) **one** box.

   G. Carbon dioxide ☐

   H. Oxygen ☐

   I. Water ☐

3. Complete the general equation for the reaction that forms an ester:

Alcohol + carboxylic acid → ester + water

4. What is the name of the ester formed through the reaction between ethanoic acid and ethanol?
   Tick (✓) **one** box.

   A. Ethanol ethanoicate ☐

   B. Ethane ethanolate ☐

   C. Ethyl ethanoate ☐

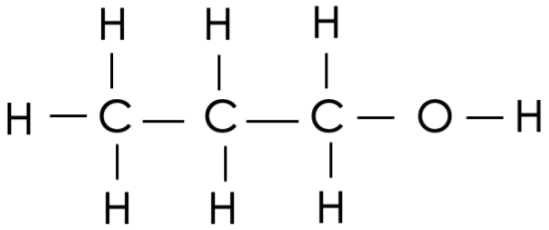
5. Give one use of esters.

In scented products or as a solvent

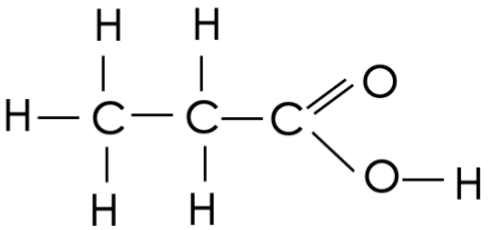
Section B

6. The displayed formulae below show two organic compounds.

Compound A



Compound B



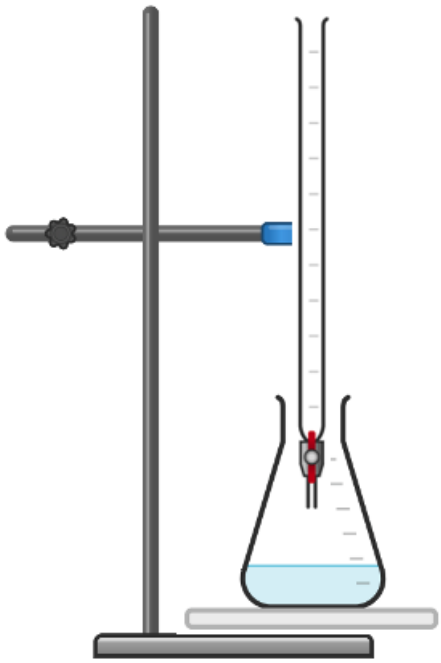
Compound A and Compound B react to form a product called propyl propanoate.

a. What type of organic compound is propyl propanoate? **An ester**
b. The reaction between Compound A and Compound B also forms another product. State the chemical formula of the other product. **H_2O**
c. Organic compounds such as propyl propanoate are useful in perfumes. Give **two** properties of these types of compounds that make them useful in perfumes.

They have fruity/pleasant smells, are highly volatile and are useful as solvents

7. A student has a solution of ethanoic acid. Ethanoic acid is a weak acid.
   a. Explain what is meant by a weak acid. **An acid that only partially ionises/dissociates in solution**
   b. Name the edible product that contains ethanoic acid. **Vinegar**

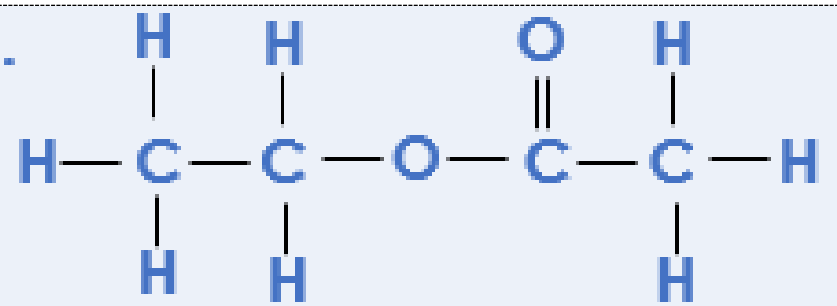
c. Describe how the apparatus shown below could be used to determine the concentration of the ethanoic acid solution.



Suggested points (for full credit, method must lead to a valid outcome)

- **Add a (named) alkali in burette**
- **alkali concentration should be known**
- **add known volume of acid to conical flask**
- **several drops of indicator should be added to acid**
- **on top of white tile**
- **add alkali to acid dropwise from burette**
- **swirl**
- **watch for colour change of indicator**
- **measure volume of alkali needed to neutralize acid**
- **calculate unknown concentration of acid**

d. Ethanoic acid can react with ethanol to form ethyl ethanoate. Draw the displayed formula of ethyl ethanoate.

7d. 

Section C

8. Naturally occurring fats and oils are complex esters.
   a. Describe the function of fats and oils in a balanced diet. **To provide energy (from storage)**
   b. Describe how to use qualitative reagents to test for the presence of fats. **Add ethanol to the food sample to dissolve the fat then add water. A positive result is that a white emulsion forms.**
   c. Describe where the digestion of fats takes place. **It begins in the stomach and continues in the small intestine**
   d. Explain why fats must be digested. **They are large insoluble molecules so must be broken down to form small soluble molecules so they can diffuse across the wall of the small intestine and into the bloodstream.**
   e. State the products of the digestion of fats. **. Glycerol and fatty acids**
   f. Name the type of enzyme that speeds up the digestion of fats. **Lipase**

Polymers

Section A

1. What is the definition of a polymer?
   Tick (✓) **one** box.

   A. Repeating units that join together to make a long chain ☐

   B. Small molecules held together by intermolecular forces ☐

   C. A long molecule made up of many repeating units ☐

2. Give the name for repeating units that polymers are made from. **Monomer(s)**

3. What polymer would be made from repeating units of ethene?

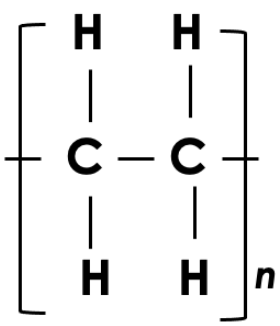
   Tick (✓) **one** box.

   A. poly(propene) ☐

   B. poly(ethene) ☐

   C. poly(ethane) ☐

4. Look at the diagram representing a polymer below.

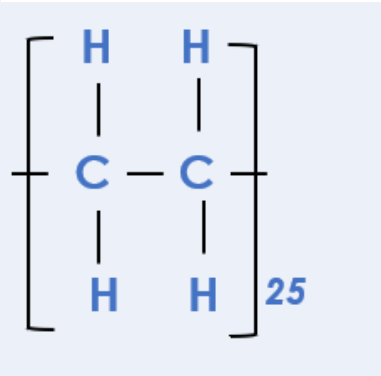


   a. What does the single straight line in between the H and C represent? **A covalent bond**
   b. What does the 'n' represent?**The number of repeating units in the polymer molecule**

Section B

5. What type of bonds are there in a polymer chain? **Covalent**

6. Describe the forces that occur between polymer chains. **There are (weak) intermolecular forces between polymer chains**
7. What type of polymers melt when heated? **Thermosoftening polymers**
8. Draw the molecular formula for a polymer molecule with 50 carbon atoms.



9. Explain why thermosetting polymers are suitable as a material for a saucepan handle.

Thermosetting polymers do not melt when they are heated, so when the saucepan heats up the handle would not melt.

10. Thermosoftening polymers are used to make plastic bottles and food packing. Explain why thermosoftening polymers would not be suitable for storing hot food.

Thermosoftening polymers melt when they are heated, so if hot food was placed in them, they would melt.

11. The diagrams below show models for the structures of a thermosetting polymer and a thermosoftening polymer. Identify which is which and explain why.

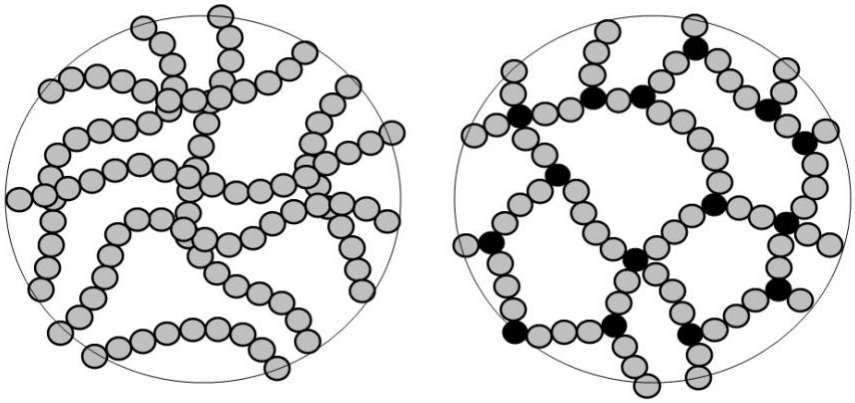


Image from Wikimedia

A is thermosoftening, B is thermosetting

B contains crosslinks, which are covalent bonds between the polymer chains

Section C

12. Carbon dioxide and diamond both contain carbon.

a. Describe the bonding in carbon dioxide. **In carbon dioxide, there is one carbon atom that makes two covalent bonds (a double bond) with each oxygen atom, sharing electrons so that all atoms have a full outer shell.**
b. Describe the bonding in diamond. **In diamond, each carbon atom is covalently bonded to four other carbon atoms in a giant covalent network.**
c. Explain why carbon dioxide is a gas at room temperature but diamond is a solid
There are weak intermolecular forces between molecules of carbon dioxide, which can be easily overcome, so it has a low melting and boiling point.

A great deal of energy would be needed to overcome the many strong covalent bonds in diamond, so it has a very high melting and boiling point.

Taking it Further: Addition Polymerisation

Section A

1. Poly(butene) is a polymer. What monomer would be used to make poly(butene)?
   Tick (✓) **one** box.

   A. Butane ☐

   B. Butene ☐

   C. Butanol ☐

2. Bromoethene molecules can be added together to make a polymer. What would this polymer be called?

   Tick (✓) **one** box.

   A. poly(ethene) ☐

   B. poly(bromoethane) ☐

   C. poly(bromoethene) ☐

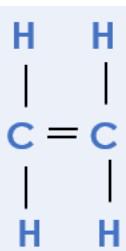
3. Describe what happens during addition polymerisation.

Double bonds in monomer units break open so they can join together to form a polymer

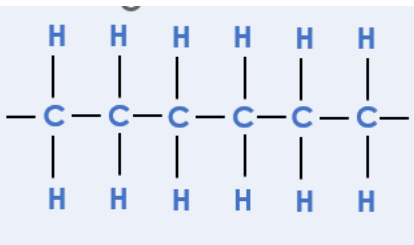
4. Poly(ethene) is made through addition polymerisation of ethene molecules.
   a. Complete the displayed formula for ethene.

   b. Complete the displayed formula for a section of poly(ethene).

4a.

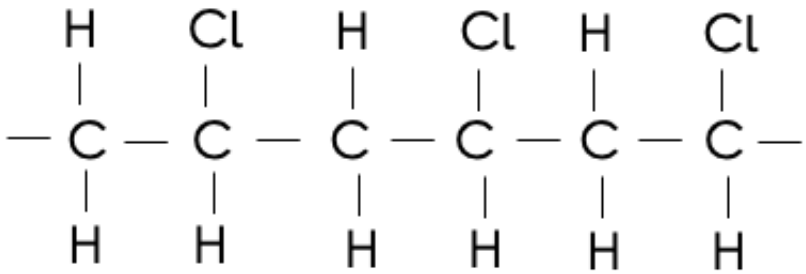


4b.

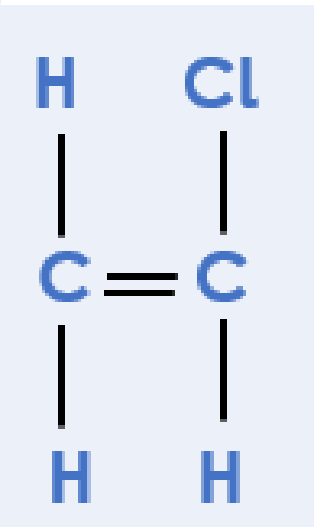


Section B

5. Polyvinyl chloride (PVC) is a non-biodegradable polymer. The displayed formula below shows a section of a PVC molecule.



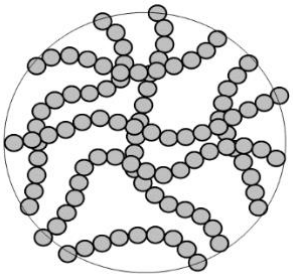
a. Draw the displayed structure of the monomer used to make PVC.



b. Explain why being non-biodegradable is a disadvantage of PVC.

Any one from:
Does not decompose
Would take up space in landfill
Takes up space of habitats
May be eaten/cause harm to animals

The diagram below represents some PVC molecules.



c. Suggest whether PVC is likely to melt when heated.

It would melt when heated as it is a thermosoftening polymer because it does not contain crosslinks (so little energy would be required to overcome the intermolecular forces).

6. Poly(chloroethene) and high-density polyethene (HDPE) are different polymers that can be used to make window frames. The table below gives some information about these polymers.

Polymer	**HDPE**	**Poly(chloroethene)**
Relative strength	70	24
Density (g/cm^3)	1.5	0.9

a. Use the table to give **one** advantage of using HDPE compared with poly(chloroethene) as a material for window frame.
Give a reason for your answer.

It is stronger, so it is less likely to be damaged (or more likely to last longer).

b. Use the table to give **one** advantage of using poly(chloroethene)compared with HDPE as a material for window frame.
Give a reason for your answer.

It has a lower density, so would be lighter/easier to install.

c. Polymers are used as an alternative material to wood for window frames.

Give **one advantage** and **one disadvantage** of using wood for window frames.

Advantage: Wood is renewable/can be replanted(polymers are not as they come from crude oil)

Disadvantage: Wood may not last as long as it may start to be broken down

d. HDPE is one form of poly(ethene). Explain how different forms of poly(ethene) can be produced from ethene.

Using different reaction conditions (different temperatures or pressures)

Section C

7. HDPE and LDPE are both types of poly(ethene) but they have different densities.
   a. Define density. **The mass per unit volume.**

b. HDPE has a density of 1.5 g/cm^3. Calculate the volume that 1.5 kg of HDPE would occupy. .

$\rho = \frac{m}{V}$ $1.5 = \frac{1500}{V}$ $V = 1000\ cm3$

c. Describe a method that could be used to calculate the density of an irregularly shaped piece of LDPE.

Measure the mass using a mass balance

Measure the volume using a displacement cylinder/Eureka can full of water

Add the object to the Eureka can and measure the volume of water displaced, which is the volume of the object Use mass/volume to calculate density

Taking it Further: Condensation Polymerisation

Section A

1. What is the name of the functional group found in carboxylic acids?
   Tick (✓) **one** box.

   A. Hydroxyl ☐

   B. Carboxyl ☐

   C. Ethanoxyl ☐

2. What is the formula of the functional group found in alcohols?

   Tick (✓) **one** box.

   A. OH ☐

   B. OCO ☐

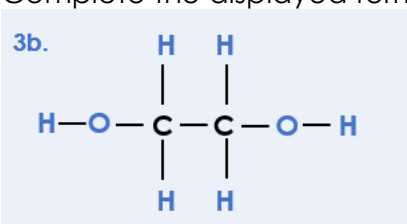
   C. COOH ☐

3. A polyester can be made from the reaction between molecules of ethandiol and hexanedioic acid.

   a. How many carbon atoms would be found in hexanedioic acid? **6**

   b. Complete the displayed formula for a molecule of ethandiol.

   3b.

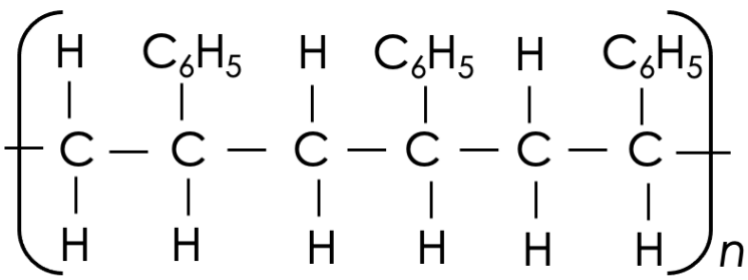


   c. Name the type of reaction that would occur when many molecules of ethandiol reacted with many molecules of hexanedioic acid. **Condensation polymerisation**
   d. Name the other product that would be formed in this reaction. **Water**

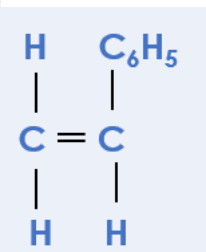
Section B

4. The picture below shows a surfboarder. Surfboards are made from different polymers.

The core of a surfboard is made from poly(styrene). A section of the displayed formula of poly(styrene) is shown below.

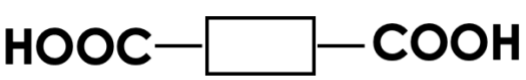


a. Complete the displayed formula to show the monomer that poly(styrene) is made from.

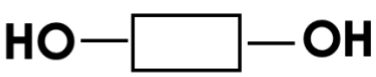


The outer layer of a surfboard is made from a polyester. This polyester is made from two different monomers, X and Y, which are shown in simplified forms below.

Monomer X



Monomer Y



b. Name the functional group in monomer Y. **Hydroxyl group**

c. The reaction between monomer X and monomer Y produces a polyester and a small molecule.

State the formula of this small molecule. **H_2O**

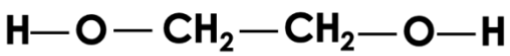
d. The polyester used for the outer layer is much more expensive than poly(styrene). Suggest **two** reasons why it is used.

Any two from:

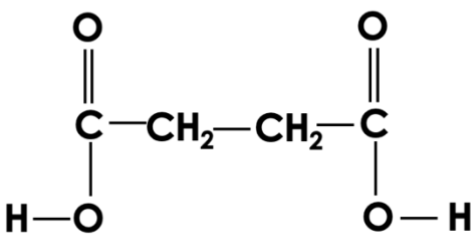
- **It is waterproof**
- **It is harder**
- **It is tougher**
- **It is more rigid**

5. The formulae below show different monomers; P, Q and R.

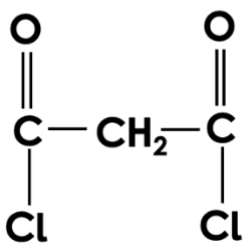
Monomer P



Monomer Q



Monomer R



Monomer P can react with either monomer Q or monomer R. In each case, a polymer is produced and a small molecule.

Complete the table to show the small molecules produced in these reactions.

Reactants	Formula of small molecule produced
P and Q	**H_2O**
P and R	**HCl**

Section C

6. Proteins are naturally occurring polymers formed from amino acids.
   a. Proteins are synthesised from amino acids through condensation polymerisation reactions. What does this show about the structure of amino acids? **Amino acids contain two functional groups.**
   b. Name the organelle where proteins are synthesised. **Ribosomes**
   c. Give two functions of proteins in the body. **Enzymes, antibodies, hormones, structures such as collagen etc**
   d. Explain the effect of a DNA mutation on protein synthesis. **Most mutations have no effect on protein synthesis but some mutations that cause a change in DNA structure, causing it to code for a protein with a different shape and affecting its function.**

Taking it Further: Naturally Occurring Polymers

Section A

1. Which of these is a naturally occurring polymer?
   Tick (✓) **one** box.

   A. Cellulose ☐

   B. Glucose ☐

   C. Amino acids ☐

2. What is the function of DNA?

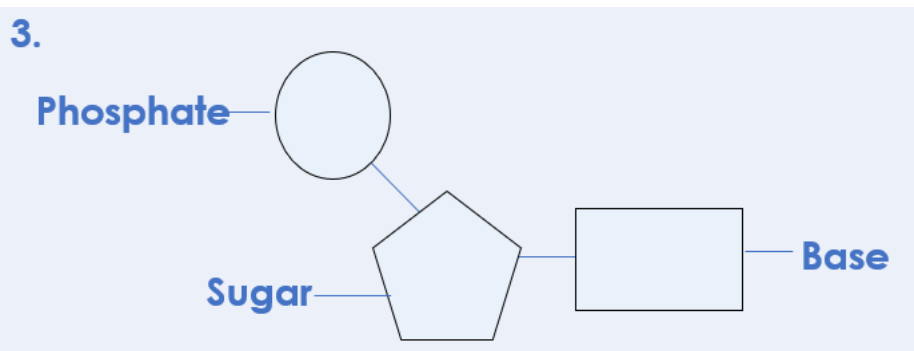
   Tick (✓) **one** box.

   A. To control the movement of substances into and out of cells ☐

   B. To provide genetic instructions for development and functioning ☐

   C. To act as the brains of a cell ☐

3. Label the three parts that make up the structure of DNA:



4. Name the term used to describe a unit containing one of each of these subunits.

Nucleotide

5. Explain why DNA is described as a polymer.

It is made up of repeating units (nucleotides).

6. State the complementary base pairs.

Adenine and thymine, cytosine and guanine

Section B

7. Starch and proteins are naturally occurring polymers. State the monomers that starch and proteins are made from:

   Starch: glucose

   Proteins: amino acids

8. Algae are photosynthetic organisms that live in aquatic environments.
   One of the products of photosynthesis is glucose.
   a. Name two naturally occurring polymers that are produced from glucose.

      Starch and cellulose

   b. Gas bubbles are produced when algae photosynthesise.
      Name the gas produced and describe a test that could be used to identify this gas.

      Gas: oxygen
      Test: relights a glowing splint

   c. The development and function of algae is controlled by another naturally occurring polymer.

Describe the shape and structure of this polymer.

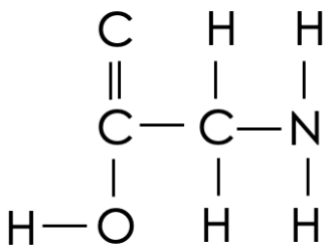
DNA is a polymer made up of repeating units called nucleotides.

Each nucleotide contains a phosphate group, a sugar and a base. T

he phosphate and sugar make up the backbone on the DNA.

There are four different bases, which are in complementary pairs, and these complementary pairs link the two strands of DNA together to form the double helix.

9. The displayed formula below shows a molecule of glycine, an amino acid.



a. How many functional groups are there in a molecule of glycine?
Tick (✓) **one** box.

A. 1 ☐

B. 2 ☐

C. 3 ☐

D. 4 ☐

b. Molecules of glycine can react to produce a polypeptide through condensation polymerisation. Name the other product made in this reaction.

Water

Section C

10. Starch is a naturally occurring polymer.
    a. Explain why starch is a polymer. **It is made up of repeating units of glucose**
    b. Starch must be digested before it can be absorbed into the small intestine. Explain why. **Starch is a large and insoluble molecule that cannot pass through the semipermeable membrane of cells in the small intestine.**
    c. Describe and explain how the small intestine is adapted for diffusion of nutrients into the bloodstream. **It is very long in length, which increases the time for absorption**
    It has villi and microvilli, which increase the surface are for more absorption
    The villi are very thin, so there is a short path for diffusion
    There is a good blood supply, so the concentration gradient can be maintained for diffusion