# Student Booklet

## C5.1 Carbon Chemistry

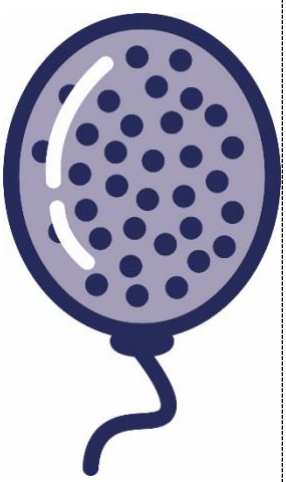
## Separate Science (Chemistry)

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'?

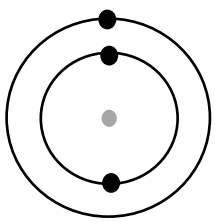
   _____

   _____

# 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.

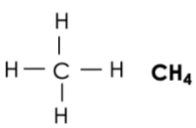
| Qu | Answer | Marks |
|---|---|---|
| 1 | C | 1 |
| 2 | B | 1 |
| 3 | C | 1 |
| 4 | A | 1 |
| 5 | B | 1 |
| 6 | A | 1 |
| 7 | C | 1 |
| 8 | A | 1 |
| 9 | B | 1 |
| 10 | B | 1 |

# Knowledge Organiser

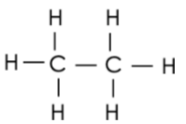
## Crude Oil and Hydrocarbons

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.

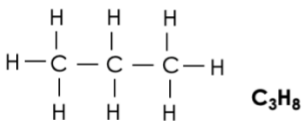
**Methane** Monkeys



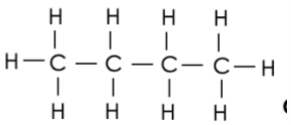

**Ethane** Eat

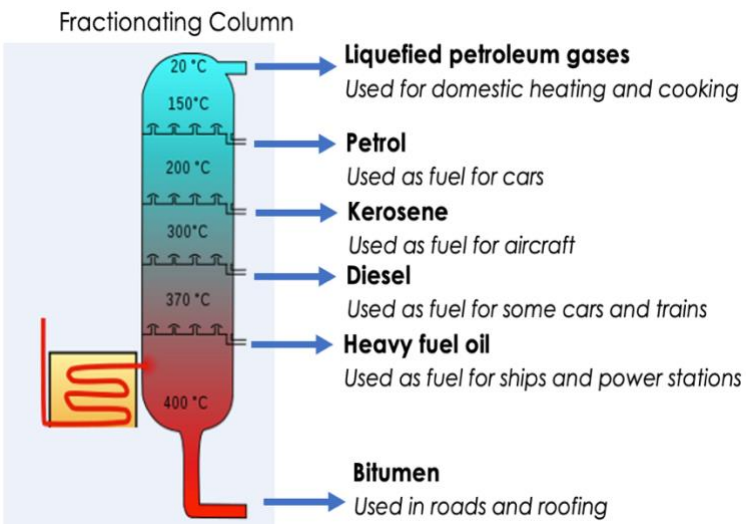



**Propane** Peanut




**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**. Its **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**

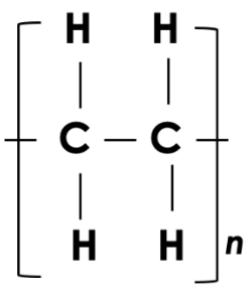
24. Complete combustion reactions of alkanes can be represented by balanced symbol equations, for example:
    **$CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$**
25. Incomplete combustion can occur if there is not enough oxygen. In this case, carbon, carbon monoxide is produced.

## 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:

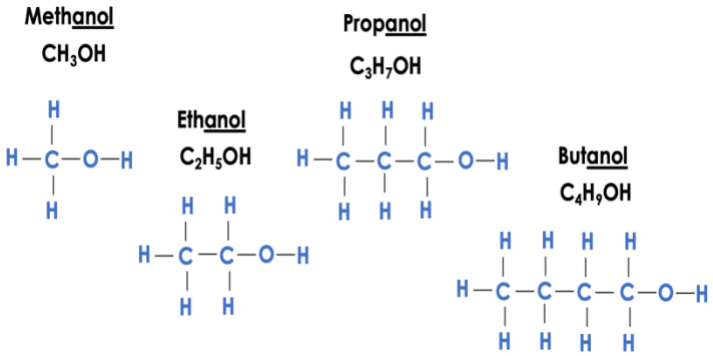


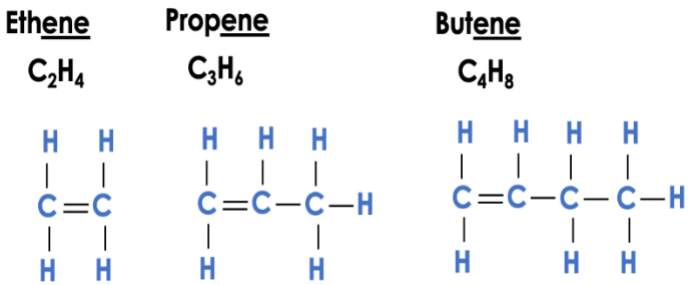

where n is a large number

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

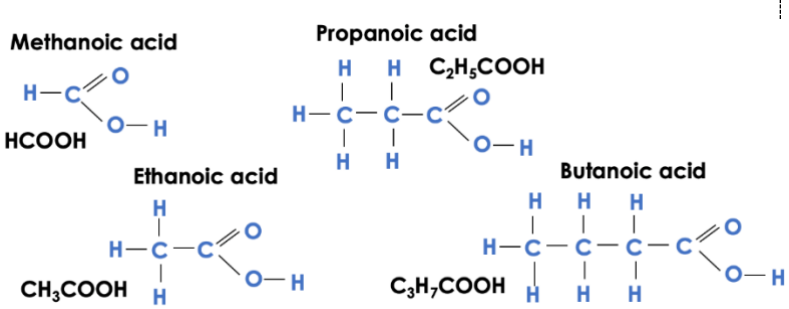
67. This is called hydration, and it needs a temperature of approximately 300°C and a catalyst.
68. For example: Butene + water → butanol
69. **Ethanol** can be manufactured by the hydration of **ethene**
70. The ethene for this reaction comes from **cracking crude oil** fractions
71. In this process, 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

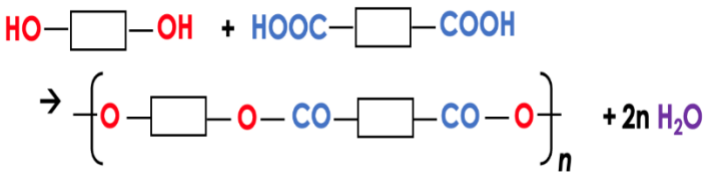
76. Ethanol is the only product of this reaction
77. This is a **continuous** reaction, which means that as long as ethene and steam are fed into the reaction, ethanol will be produced continually. This makes it an **efficient** process.
78. Ethene is made from crude oil which is a non-renewable resource.
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**

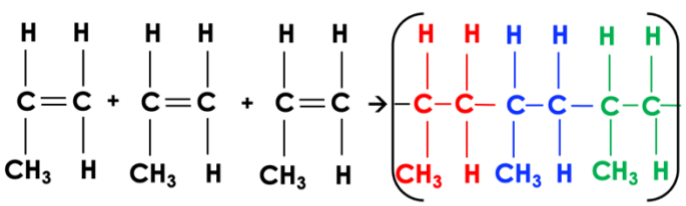
91. Carboxylic acids react with carbonates to form a salt, water and carbon dioxide
92. Because carboxylic acids are weak acids, their solutions do not contain many hydrogen ions compared to a strong acid of the same concentration
93. **Carboxylic acids** can react with **alcohols** to make **esters**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



Propene monomers  Poly(propene) polymer

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.<br>*Ethanol is the **alcohol** found in alcoholic drinks.* |
| **Alkane** | A hydrocarbon molecule with the general formula $C_nH_{2n+2}$.<br>*Methane, ethane and propane are all **alkanes**.* |
| **Alkene** | A hydrocarbon molecule with the general formula $C_nH_{2n}$.<br>***Alkenes** contain a carbon-carbon double bond.* |
| **Amino acid** | A naturally occurring monomer that contains two different functional groups.<br>***Amino acids** can be joined together to make polypeptides and proteins.* |
| **Carboxyl group** | The functional group found in carboxylic acids (-COOH).<br>*Ethanoic acid contains a **carboxyl group**.* |
| **Carboxylic acid** | An organic compound that contains a carboxyl (COOH) group.<br>*Ethanoic acid is a **carboxylic acid** found in vinegar.* |
| **Catalyst** | A substance that speeds up a chemical reaction without being used up.<br>*Ethanol can be made from ethene, but this requires a **catalyst**.* |
| **Combustion** | A reaction where a substance burns in oxygen.<br>***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.<br>***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.<br>***Cracking** produces an alkane and an alkene.* |

| | |
|---|---|
| **Crude oil** | A finite resource found in rocks made from the ancient biomass of plankton.<br>***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.<br>***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.<br>***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.<br>***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.<br>*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.<br>*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.<br>*The alkanes are a* ***homologous series*** *that all have the general formula* $C_nH_{2n+2}$*.* |
| **Hydration** | A process which adds water.<br>*Alcohols can be made from alkenes by* ***hydration****.* |

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

2. Carbon has an atomic number of 6. State its electron configuration.
3. State the type of bonding found in water.
4. Give an example of a giant covalent network.
5. Define a compound.

**Drill:**

1. State the chemical formula for carbon dioxide.
2. Name the type of bonding found in carbon dioxide.
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.
2. Explain why atoms make bonds.
3. Explain what is meant by a stable electron arrangement.
4. Define a molecule.
5. Give an example of a giant covalent structure.

**Covalent bonding**

What type of elements form covalent bonds? _____

What happens to the electrons in a covalent bond? _____

How many electrons are in one covalent bond? _____

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? _____

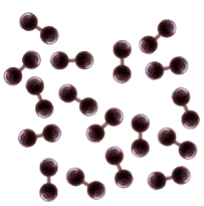
What holds the atoms together?_____

What holds the molecules together? _____

Give three names of simple covalent substances

**Properties of covalent substances**

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



A: _____ B _____

For each statement write A or B or both or neither

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

## Drill

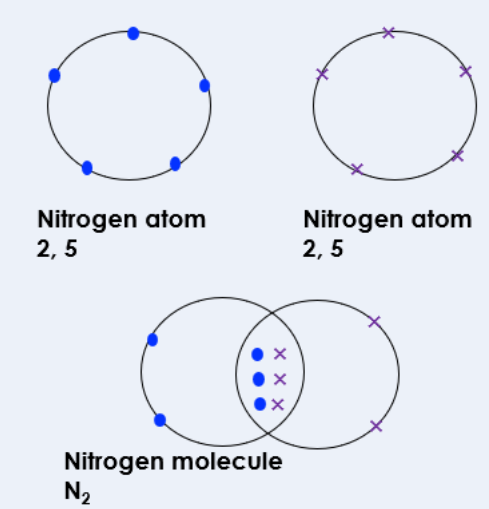
1. What type of elements are bonded during covalent bonding?
2. What happens during covalent bonding?
3. How is a single covalent bond represented?
4. How is a double covalent bond represented?
5. What is a double covalent bond?
6. What is the formula for methane?
7. State one example of a simple covalent substance.
8. What state of matter are simple covalent substances at room temperature?
9. Are covalent bonds weak or strong?
10. Name the forces that act between molecules in a simple covalent substance.
11. Explain the electrical conductivity of water.

**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

2. 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.
2. Describe what happens to electrons when a covalent bond is formed.

3. Define a compound.
4. Define a molecule.
5. Calculate the relative formula mass of methane ($CH_4$). C=12, H=1

**Drill:**

Here are some common chemical formulae: $CO_2$, $H_2O$, $O_2$, NaCl, $Ca(OH)_2$.

1. Identify which of these formulae represent elements.
2. Identify which of these formulae represent compounds.
3. Identify which of these formulae would form molecules.

**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.
2. Describe where crude oil is found.
3. Describe what crude oil is made from.
4. Explain whether crude oil is a renewable or non-renewable resource.
5. Name the countries that are the largest producers of crude oil.

**Crude Oil and Hydrocarbons**

Give two uses of crude oil

_____

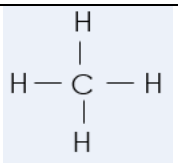
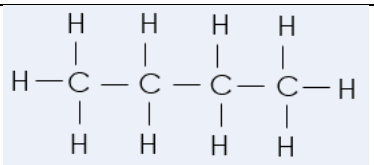
What type of resource is it? _____

Is crude oil an element, compound or mixture?_____

Define hydrocarbon

---

Complete the table below

| Name of alkane | Formula | Displayed formula |
|---|---|---|
| Methane | |  |
| | $C_2H_6$ | |
| propane | | |
| | |  |

## Drill

1. Describe where crude oil is found.
2. Describe what crude oil is made from.
3. Explain why crude oil is a mixture.
4. Define a hydrocarbon.
5. State the general formula of the alkanes.
6. Name the alkane with 1 carbon.
7. Name the alkane with 4 carbons.

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?*

*How many hydrogen atoms would there be in an alkane with 5 carbons?*

*How many carbon atoms would there be in an alkane with 14 hydrogens?*

**We do: Alkane Formulae**

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

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

**You do: Alkane Formulae**

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

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

## 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.
2. Name the alkane that contains four carbon atoms.
3. State the general formula of the alkanes.
4. Describe what happens when a covalent bond is formed.
5. Explain why covalent molecules have relatively low boiling points.

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

**Drill:**

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

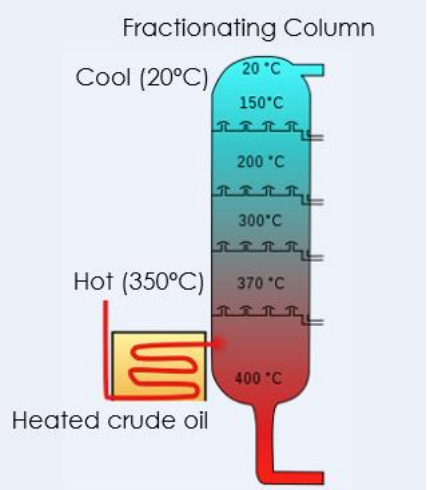
1. Identify which state of matter these alkanes would be at room temperature (20 °C).
2. Identify which state of matter these alkanes would be at -50°C.

**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.
2. Describe what happens during distillation.
3. Explain why crude oil is a mixture.
4. Explain what is meant by a 'fraction' of crude oil.
5. Give a use of the shorter hydrocarbon chains.

**Fractional Distillation**




**Fill in the key words in the method**

Crude oil is h_____and v_____

The column is h_____ at the bottoma and c_____ at the t_____.

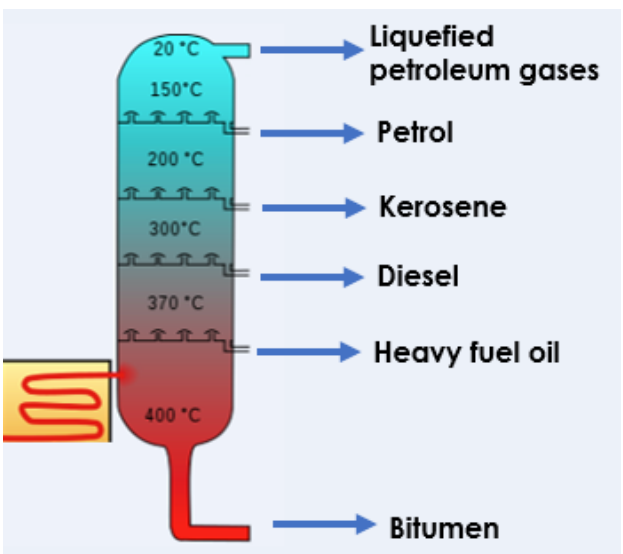
The smaller molecules have _____ boiling points, so they rise to the _____ of the column wheras larger molecules have a _____ boiling point so styay at the bottom.

As the mixture rises it c_____ and c_____.

The vapours will consense at different t_____ because the hydrocarbons have different b_____ p_____.

Give a use of each fraction

Label the column to show where larger molecules will be and where smaller moelcules will be



## Drill

1. Explain why crude oil is a mixture.
2. Name the piece of equipment used to separate crude oil into fractions.
3. State the physical property that fractions are separated based on.
4. Name the fraction with the smallest molecules.
5. Name the fraction with the largest molecules.
6. Give two fractions that are used as fuels for transport.
7. Describe the relationship between size of molecules and boiling point.
8. Explain the relationship between size of molecules and boiling point.

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

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

_____

_____

_____

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

_____

_____

_____

## 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.
2. Explain how this process separates crude oil.
3. Describe the pattern of viscosity as hydrocarbon chains get longer.
4. Name the alkane that contains two carbon atoms.
5. Explain the difference between an exothermic and an endothermic reaction.

**Drill:**

1. Name the compound with the formula $CH_4$.
2. Calculate the relatie formula mass of propane. C=12, H=1
3. Calculate the percentage by mass of carbon in ethane.

**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.
2. Explain what is meant by a combustion reaction.
3. Explain why combustion of hydrocarbons is a useful chemical reaction.
4. Give a disadvantage of burning hydrocarbons.
5. Describe two uses of hydrocarbons for humans.

**Complete Combustion**

Alkane + oxygen → _____ _____ + water

This reaction is e_____

**Incomplete Combustion**

Incomplete combustion occus where there is a limited supply of _____

Incomplete combustion produces water, c_____ m_____ and c_____

The toxic product of incomplete combustion is _____

Incomplete combustion is _____ exothermic than complete combustion

IIf sulfur is present you may also get _____ produced.

$$C_2H_6 + O_2 \rightarrow CO_2 + H_2O$$

**Balancing combustion equations**

Always balance C, then H then O!

$$C_2H_6 + O_2 \rightarrow CO_2 + H_2O$$

| Number of atoms | Element | Number of atoms |
|---|---|---|
| | C | |
| | H | |
| | O | |

## Drill

1. Name the substance that hydrocarbons react with during combustion.
2. State the two products of combustion of hydrocarbons.
3. Identify which product is linked to global warming.
4. Explain the difference between complete and incomplete combustion.
5. Describe how sulfur dioxide is formed.
6. State the environmental problem associated with sulfur dioxide.
7. Explain which fractions of crude oil can be burned most easily.

**I: Combustion Reactions**

*What is the chemical formula for methane?*

Methane burns in air.

*Draw the displayed formula for methane.*

*Write a word equation for the combustion of methane.*

*Write a symbol equation for the combustion of methane.*

*Balance the symbol equation.*

**We: Combustion Reactions**

*What is the chemical formula for propane?*

*propane* burns in air.

*Draw the displayed formula for propane.*

*Write a word equation for the combustion of propane.*

*Write a symbol equation for the combustion of propane.*

*Balance the symbol equation.*

**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.*

*Write a symbol equation for the combustion of pentane.*

*Balance the symbol equation.*

## 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.
2. Describe when incomplete combustion takes place.
3. Name the alkane with the chemical formula $C_2H_6$
4. Describe what short chain hydrocarbons are used for.
5. Draw the structural formula for methane.

**Drill:**

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

**Read Now:**

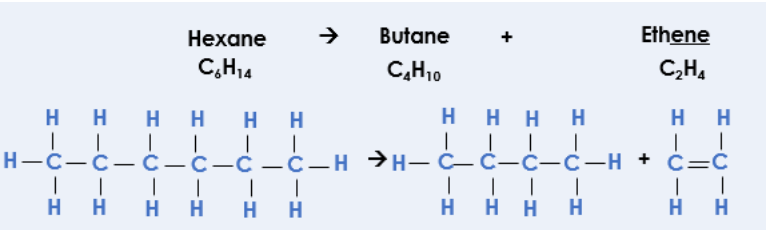
According to a survey from 2022, there are about 1.45 billion cars in the world. That means that over 17 % of the human population has a car, but the cars are not spread evenly as some cars have many more cars than others. Many of these cars have petrol engines, which burn petrol as the fuel. Petrol 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.
2. Name an alkane found in petrol.
3. Explain why there is high demand for petrol.
4. Describe what happens in a cracking reaction.
5. Name the other type of product from a cracking reaction.

**Cracking**

_____ molecules are in high demand as they are used as _____

Cracking is _____




Cracking produces both alkanes and _____. These are different to alkanes because they have at lease one _____. We say alkenes are u_____

To test for alkenes we can use _____ water.
If an alkene is present, it will turn from _____ to _____
The two types of cracking are _____ and _____

## Drill

1. Explain the difference between supply and demand.
2. Describe what happens during cracking.
3. Name the two types of product produced through cracking.
4. Give two reasons why cracking is useful.
5. Describe what happens when bromine water is added to alkanes.
6. Describe what happens when bromine water is added to alkenes.
7. Explain why alkenes are described as unsaturated.
8. Name two different methods of cracking.
9. Describe the conditions needed for catalytic cracking.
10. Describe the conditions needed for steam cracking.

**I: Determining the products of cracking**

Dodecane ($C_{12}H_{26}$) is cracked to produce octane ($C_8H_{18}$). **$C_{12}H_{26} \rightarrow C_8H_{18}$ +** _____

*What is the chemical formula for the other product formed? Write it on the lane*
*What homologous group does the other product belong to?*_____
*Explain how you could tell the difference between the two products once they were separated.*

_____
_____
_____

*Explain why it is useful to crack dodecane***.**

_____
_____

**We: Determining the products of cracking**

Dodecane ($C_{12}H_{26}$) is cracked to produce heptane ($C_7H_{16}$). **$C_{12}H_{26} \rightarrow C_7H_{16}$ +** _____

*What is the chemical formula for the other product formed? Write it on the lane*
*What homologous group does the other product belong to?*_____
*Explain how you could tell the difference between the two products once they were separated.*

_____
_____
_____

*Explain why it is useful to crack dodecane***.**

_____
_____

**You: Determining the products of cracking**

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

**$C_8H_{18} \rightarrow C_6H_{14}$ +** _____

*What is the chemical formula for the other product formed? Write it on the lane*
*What homologous group does the other product belong to?*_____
*Explain how you could tell the difference between the two products once they were separated.*

_____
_____
_____

*Explain why it is useful to crack dodecane***.**

_____
_____

**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.

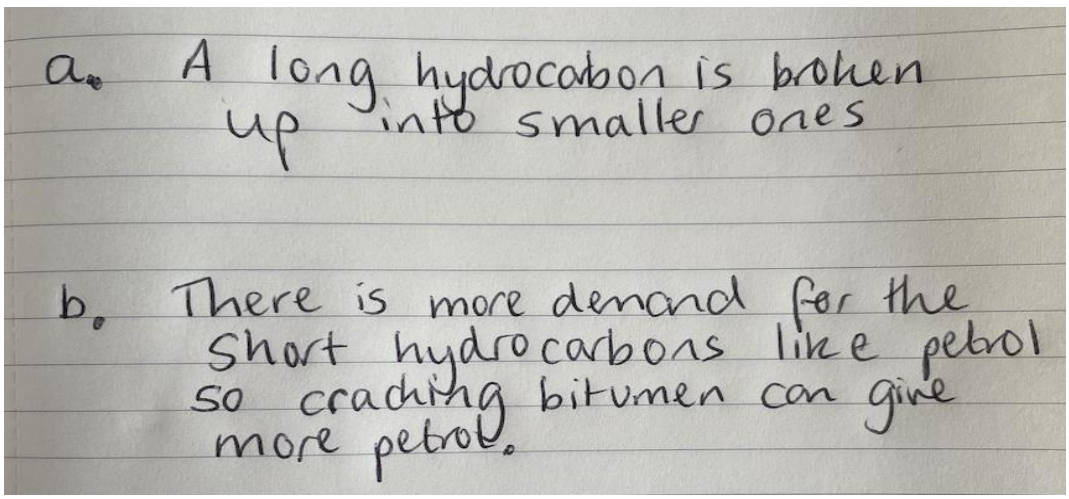
Stretch: Rewrite the answer to show how it should be done!

**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:**

**a.**

| **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 |

**b.**

| 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,<br><br>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.
2. Describe the difference between ethane and ethene.
3. Describe how to test for an alkene.
4. State the general formula for the alkanes.
5. State how many pairs of electrons are shared in a double covalent bond

**Drill:**

1. Draw the structural formula for ethane.
2. Draw the structural formula for ethene.
3. Name the type of compound that alkanes and alkenes are.

**Read Now:**

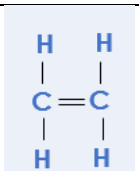
The alkenes are a homologous series of hydrocarbon compounds. Their functional group is a double bond between carbon atoms, which gives them their reactivity. Because of this double bond, alkenes are described as unsaturated. This also means that they are very useful in many chemical reactions in the 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.
2. Explain why the alkenes are described as unsaturated.
3. Identify the smallest alkene.
4. Explain why there is no such thing as methene.
5. Describe what alkenes are used for.

**Alkenes**

The general formula for an alkene is _____

Complete the table for the first three alkenes

| Name of alkene | Formula | Displayed formula |
|---|---|---|
| Ethene | |  |
| | $C_3H_6$ | |
| Butene | | |

**Reactions of Alkenes**

Alkenes are reactive because of the _____

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

**Addition reactions of alkenes**

Alkene + _____ → halogenalkane

Ethene +_____ → (1,2-)diiodethane

Alkenes will turn bromine water from _____ to _____ because of the formation of a _____

Ethene + hydrogen → _____

This reaction requires a _____ to speed it up

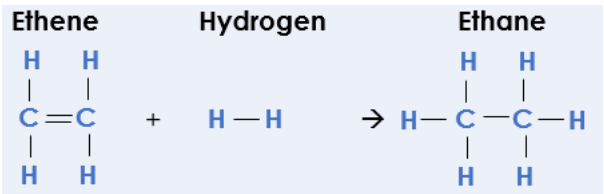
## Drill

1. State the general formula for alkenes.
2. State the chemical formula for ethene.
3. State the chemical formula for butene.
4. Identify the functional group of the alkenes.
5. Explain whether the alkenes are saturated or unsaturated.
6. Describe how to test for the presence of an alkene.
7. Predict the product formed when propene reacts with hydrogen.
8. Predict the product formed when ethene reacts with bromine.

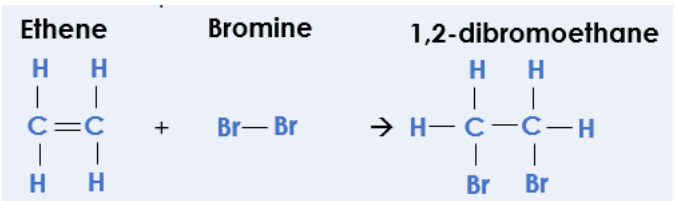
**I: Alkene reactions**

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.
2. State the general formula of the alkenes.
3. Explain how bromine water could be used to identify an alkane and an alkene.
4. Define a hydrocarbon.
5. Name the type of bonding present in alkanes and alkenes.

**Drill:**

Ethanol has the chemical formula $C_2H_5OH$.

1. Identify how many of each type of atom are present in a molecule of ethanol.
2. Calculate the relative formula mass of ethanol. C=12, H=1, O=16
3. Calculate the percentage by mass of hydrogen in ethanol

**Read Now:**

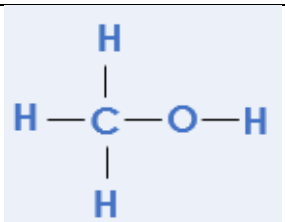
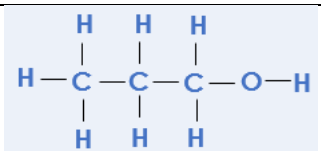
When the word alcohol is used, it generally means an alcoholic drink, such as wine or beer. However, alcohol is actually a homologous series of compounds so there is more than one type of alcohol. The type of alcohol in alcoholic drinks is ethanol, which as the prefix suggests, contains two carbon atoms. 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.
2. Identify how many carbon atoms are found in ethanol.
3. Explain why most alcoholic drinks only contain 2%-40% ethanol.
4. Describe some short term effects of drinking alcohol.
5. Describe some long term effects of excessive alcohol consumption.

**Alcohols**

The functional group for alcohols is _____

Complete the table about the first four alcohols

| **Name of alcohol** | **Formula** | **Displayed formula** | **Use** |
|---|---|---|---|
| Methanol | |  | |
| | $C_2H_5OH$ | | |
| | |  | |
| Butanol | $C_4H_9OH$ | | |

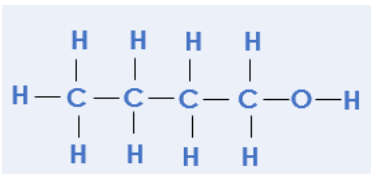
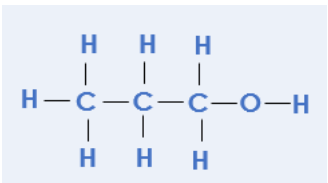
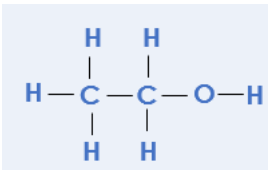
As you go down the series, the solubility _____

Alcohol + oxygen → _____ + _____

Alcohol + sodium → sodium _____ + _____

## Drill

1. State the names of the first four alcohols.
2. State the chemical formula for ethanol.
3. Give a use of methanol.
4. Give a use of ethanol.
5. Give a use of propanol.
6. State the products of the reaction between ethanol and sodium.
7. Describe the pattern of solubility of alcohols with size of molecules.

| | |
|---|---|
| **Steps to success** | 1. Determine the chemical formula of this compound.<br>2. Name this chemical compound.<br>3. Give a use of this chemical compound. |
| **I do**<br>  | |
| **We do**<br>  | |
| **You do**<br>  | |

## 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.
2. State the functional group of the alcohols.
3. Explain why alkenes are described as unsaturated.
4. Explain what is meant by the term anaerobic.
5. Name the process that takes place in cells to release energy.

**Drill:**

1. State the chemical formula of ethanol.
2. Compare the structures of ethene and ethanol.
3. Give a use of ethanol.

**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.
2. Give an example of a product that humans make from fermentation.
3. Give an example of a fermented food.
4. Describe the advantages of eating fermented food that microbiologists suggest.

**Fermentation**

Define fermentation

_____

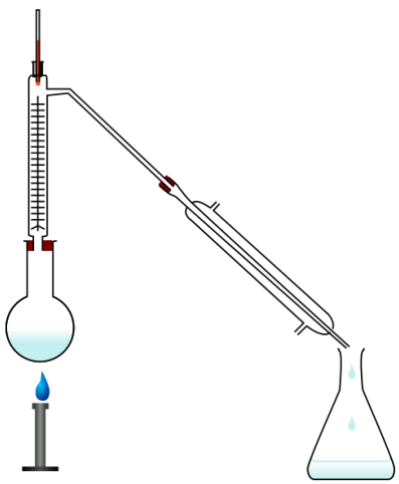
Write the equation for fermentation

_____ → _____ + _____

For fermentation to take place, there must be:

- A sugar _____ mixed with _____
- No _____ or _____ getting in (anaerobic)
- A warm temperature (_____ - _____ °C)

A solution of ethanol can be purified using _____



## Drill

1. Explain why fermentation is an anaerobic process.
2. State the reactant for fermentation.
3. State the products of fermentation.
4. Describe the conditions required for fermentation.
5. Give a use of ethanol produced through fermentation.
6. Give a use of carbon dioxide produced through fermentation.
7. Describe how ethanol produced through fermentation can be purified.

**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 |

## 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.
2. Explain why fermentation is an anaerobic process.
3. Describe the conditions needed for fermentation.
4. State the general formula of the alkenes.
5. Describe how bromine water can be used to tell the difference between an alkane and an alkene.

**Drill:**

1. Draw the structural formula for ethene.
2. Name the product formed when ethene reacts with hydrogen.
3. Describe a condition needed for ethene to react with hydrogen

**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.
2. Explain what is meant by E10 petrol.
3. Explain why ethanol obtained from fermentation is a renewable resource.
4. Explain why ethanol obtained from ethene is not a renewable resource.

**Conditions for Hydration**

The conditions for hydration of ethene are:

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

The word equation for the reaction is: ethene + _____ → _____

The reverse reaction is: ethanol → _____ + _____

The catalyst for the reverse reaction is _____

## Drill

1. State the chemical formula of ethanol.
2. State the chemical formula of ethene.
3. Describe two methods of producing ethanol.
4. Describe how ethene is obtained from crude oil.
5. Explain whether ethene is a renewable or non-renewable resource.
6. Describe the conditions required for hydration of ethene.
7. State the word equation for the hydration of ethene.
8. State the chemical equation for the hydration of ethene.
9. State the general equation for the hydration of alkenes.
10. Describe the conditions required for the hydration of alkenes.
11. Explain why the alkenes are unsaturated.

**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 |

## 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.
2. Name the functional group found in alcohols.
3. Describe the conditions needed for the hydration of ethene.
4. State the general formula of the alkanes
5. State the pH range of an acid.

**Drill:**

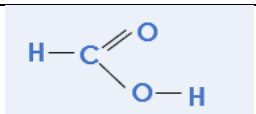
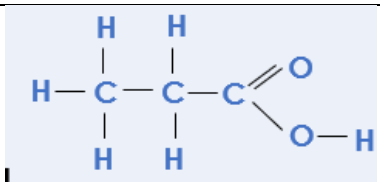
1. Describe three ways of determining if a substance is an acid or an alkali.
2. Name some common acids.
3. Identify the ion that makes substances acidic

**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.
2. Give the other name for ethanoic acid.
3. Give one use for ethanoic acid.
4. Describe how ethanoic acid is made.

What is the functional group for carboxylic acids? _____

| **Name of alcohol** | **Formula** | **Displayed formula** |
|---|---|---|
| Methanoic acid | |  |
| | **$CH_3COOH$** | |
| Propanoic Acid | |  |
| | | |

Carboxylic acids are _____ acids with a pH of _____

Acid + metal →

Acid + alkali →

Acid + base →

Acid + metal carbonate →

## Drill

1. State the chemical formula of methanoic acid.

2. State the chemical formula of ethanoic acid.
3. Name the functional group of the carboxylic acids.
4. State the formula of the functional groups of the carboxylic acids.
5. State the pH values of solutions containing dissolved carboxylic acids.
6. State whether carboxylic acids are strong or weak acids.
7. State the products formed when a carboxylic acid reacts with a metal carbonate.
8. Write a general equation for the reactions between carboxylic acids and metal carbonates.

**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.* _____

*What products would be made in a reaction between a carboxylic acid and a metal carbonate?* _____

*Write a word equation for this reaction.*

_____-->_____

## 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.
2. State the chemical formula of methanoic acid.
3. Name the homologous series that contain a C=C double bond.
4. Name the alcohol that contains two carbon atoms.
5. Give a use of ethanol.

**Drill:**

1. Draw the structural formula of ethene.
2. Draw the structural formula of ethanol.
3. Draw the structural formula of 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.
2. Describe how an ester is formed.
3. Compare the properties of the product of a chemical reaction with the properties of the reactants.
4. Describe how we can determine the name of an ester.

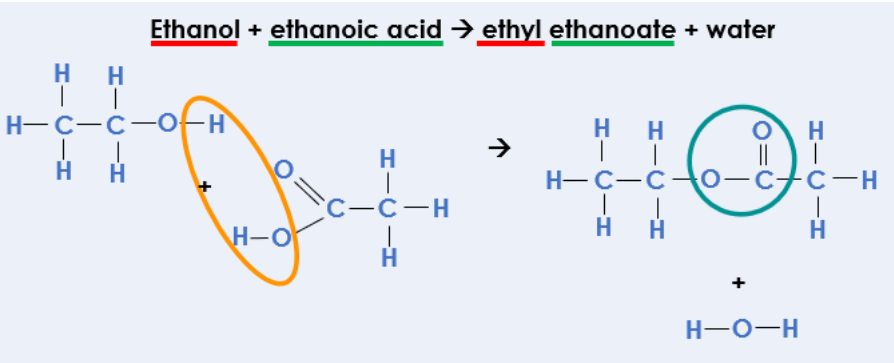
**Esters**

The functional group of an ester is _____

Alcohol + carboxylic acid → _____ + _____

Ethanol + ethanoic acid → _____ + _____

This is called a c_____ reaction because w_____ ( a small molecule) is formed




Esters all have different _____ (pineapple, apricot etc) so are used in _____

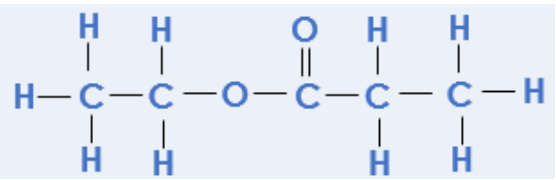
They are also used as s_____

## Drill

1. State the functional group found in esters.
2. Give a use of esters.
3. Name the type of reactants needed to form an ester.
4. Explain why the formation of an ester is a condensation reaction.
5. State the general equation for the formation of an ester.
6. Name the ester made from ethanol and ethanoic acid.

**I: Reactions of organic compounds**

The displayed formula below shows an organic compound.



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

*Identify the functional group of this compound.* _____

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

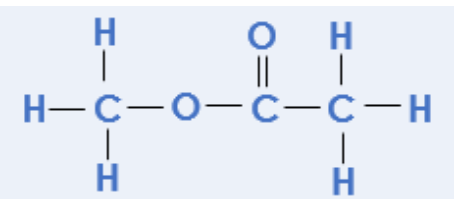
*Stretch: suggest the names of the reactants used to make this compound.*

_____ *and* _____

*Stretch: suggest the name of this compound.*

**We: Reactions of organic compounds**

The displayed formula below shows an organic compound.



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

*Identify the functional group of this compound.* _____

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

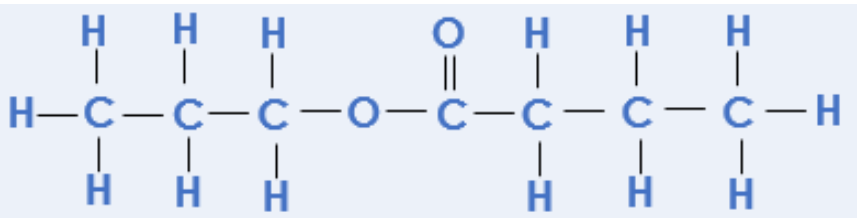
*Stretch: suggest the names of the reactants used to make this compound.*

_____ *and* _____

*Stretch: suggest the name of this compound.*

**You: Reactions of organic compounds**

The displayed formula below shows an organic compound.



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

*Identify the functional group of this compound.* _____

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

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

_____ *and* _____

*Stretch: suggest the name of this compound.*

## 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.
2. Name the type of bonding found in hydrocarbons.
3. State the general formula of the alkanes.
4. Describe how fractional distillation is used to separate crude oil.
5. Explain the difference between reusing and recycling.

**Drill:**

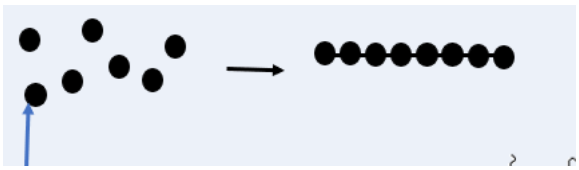
1. Describe the structure of diamond.
2. Describe the structure of graphite.
3. Explain why graphite conducts electricity but diamond does not.

**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.
2. Define synthetic.
3. Give three examples of naturally occurring polymers.
4. Explain why naturally occurring polymers found in foods must be digested.
5. Give an example of a synthetic polymer.

# Poly**mer**

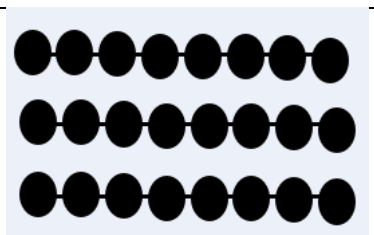
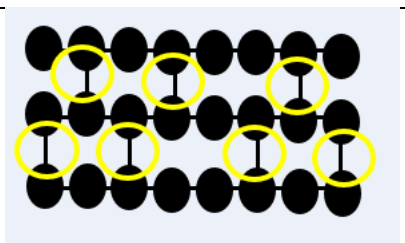


**Properties of polymers**

The properties of a polymer depend on two things:

- the -_____it is made from
- the _____ that the polymer is made in

**Complete the table for thermosetting sand thermosoftening plastics**

| |  |  |
|---|---|---|
| Type of polymer | | |
| What happens when heated? | | |
| Are there intermolecular forces between the polymer chains? | | |
| Are there crosslinks (covalnt bonds) between the chains when heated? | | |
| Are they suitable for recycling? | | |

## Drill

1. What is a polymer?
2. What kind of bonding occurs between monomers in a polymer?
3. What does the n represent in the general formula for a polymer?
4. Name the forces that act between the polymer molecules.
5. State whether these forces are weak or strong
6. Describe the state of polymers at room temperature
7. What determines the properties of polymers?
8. What happens to thermosetting polymers when heated?
9. What happens to thermosoftening polymers when heated?
10. Explain why these polymers behave differently when heated.

**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.

**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

## 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.
2. Explain why alkenes are described as unsaturated.
3. Describe how bromine water could be used to identify an alkene.
4. Define a polymer.
5. Explain the difference between thermosetting and thermosoftening polymers.

**Drill:**

1. Draw the displayed formula for ethene.
2. Draw the displayed formula for butene.
3. Compare the structure of butene and butane.

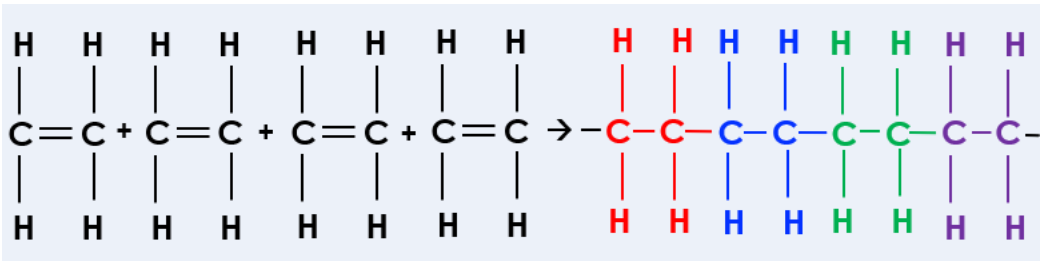
**Read Now:**

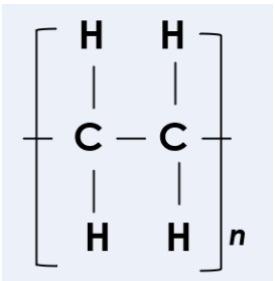
Polymers are long molecules made up of repeating units called monomers. One of the most common polymers used by humans is poly(ethene), which is made in both high-density and low density forms. Poly(ethene) is made through the joining of many ethene monomers, a reaction which is called addition polymerisation. 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.
2. Identify the monomer that makes up poly(ethene).
3. Describe how poly(ethene) is formed.
4. Give an example of another polymer made through addition polymerisation.

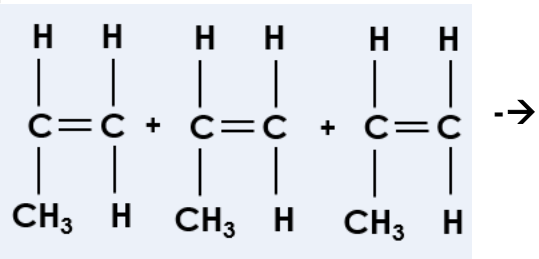
**Addition Polymerisation**

Label on the diagram : Monomer, repeat unit, polymer





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



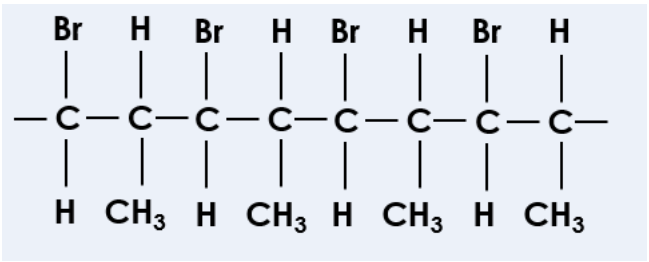
When the double C=C bond _____, the monomer molecules can all _____ to each other in a long chain called a _____

## Drill

1. Define a polymer.
2. Define a monomer.
3. Describe what happens during an addition polymerisation reaction.
4. Identify the product(s) that are formed in an addition polymerisation reaction.
5. Ethene molecules join to form poly(ethene). Identify the monomer and the polymer.
6. Name the polymer that would be formed through addition polymerisation of propene molecules.
7. Name the monomer that would have been used to form the polymer poly(butene).

**We: Identifying monomers**

The displayed formula below shows part of a polymer.

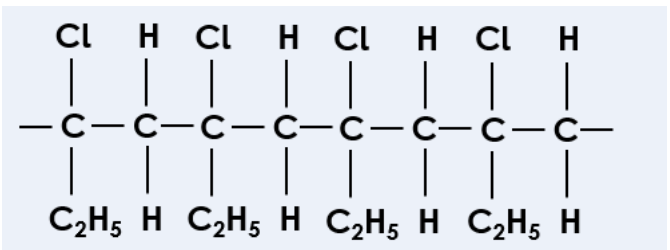


Draw the displayed formula of the monomer. → monomer

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.
2. Describe what happens during addition polymerisation.
3. Explain why alkanes cannot be monomers.
4. State the chemical formula of water.
5. Describe the bonding in water.

**Drill:**

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

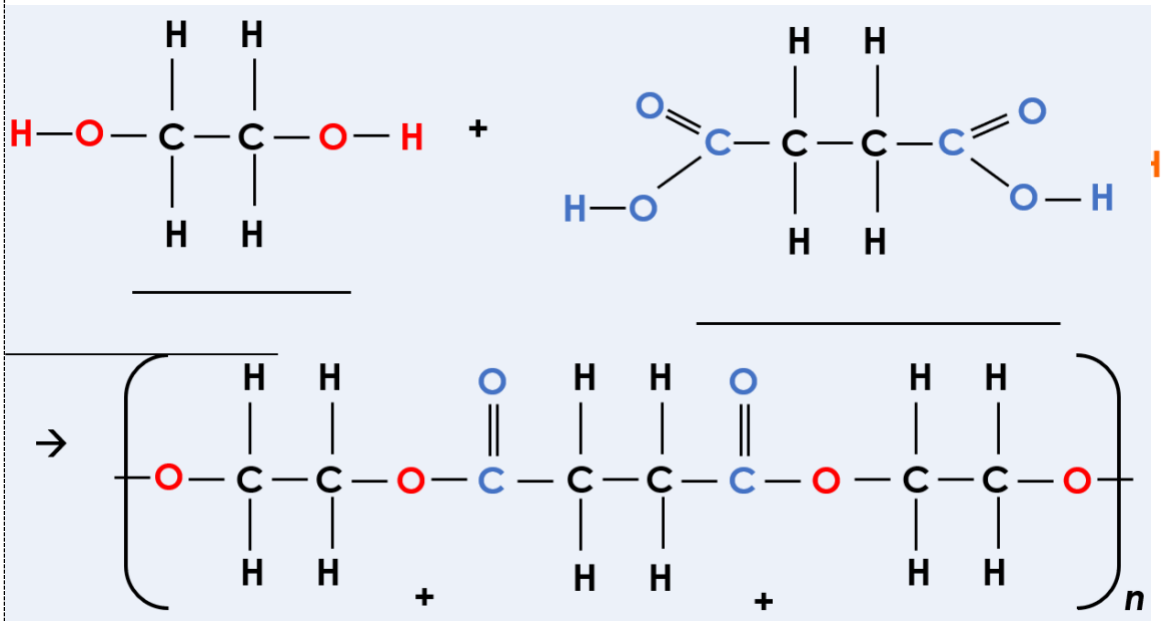
**Read Now:**

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.
2. State what is required for monomers to undergo condensation polymerisation.
3. Give an example of a polymer made from condensation polymerisation.
4. Identify the monomers and polymers when proteins are synthesised from 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? _____
- Why is it called a condensation reaction?_____



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

## Drill

1. Define a polymer.
2. Define a monomer.
3. State what the monomers need for condensation polymerisation to occur.
4. State the products of a condensation polymerisation reaction.
5. Name the functional group found in alcohols.
6. Name the functional group found in carboxylic acids.

**We: Types of polymerisation**

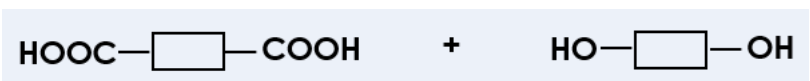
The formulae below show two monomers.

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

**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

## 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.
2. State what monomers require to be able to undergo condensation polymerisation.
3. Name the small molecule that is usually produced through condensation polymerisation.
4. Name the organelle that contains DNA in eukaryotic cells.
5. Describe the structure of DNA.

**Drill:**

1. Name the organelles that are found in both plant and animal cells.
2. Explain the difference between eukaryotic and prokaryotic cells.
3. Give an example of a prokaryotic cell.

**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.
2. Describe the structure of DNA.
3. Identify the complementary base pairs in DNA.
4. Identify the monomers that make up the polymer DNA.

**Naturally Occurring Polymers**

| Polymer | Name of the monomers it Is made of |
|---|---|
| Starch | |
| Cellulose | |
| Protein | |
| DNA | |

**The structure of DNA**

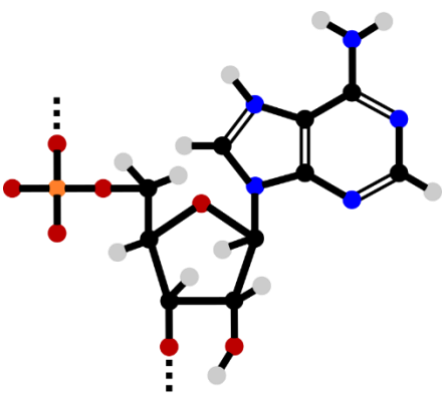
DNA is made of _____ polymer chains in a _____ helix shape

There are _____ bonds beytween the chains

Name the four possible bases in DNA _____

A bonds with _____ and G bonds with _____

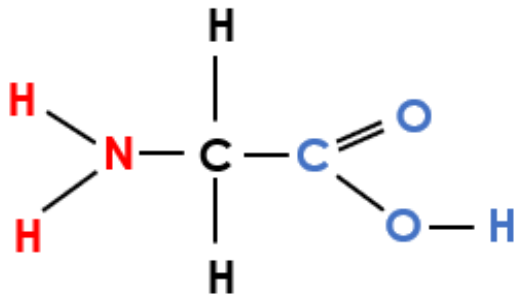
Label the parts of the nucleotide



**Amino acids and polypeptides**

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

This is another example of _____ polymerisation




## Drill

1. Describe the function of DNA.
2. Describe the structure of DNA.
3. Describe what makes up a nucleotide.
4. State the complementary base pairs.
5. Give two other naturally occurring polymers.
6. (HT) State whether the functional groups found in amino acid molecules are the same or different.
7. (HT) Name the type of reaction that produces a polypeptide from amino acids.
8. (HT) Name the other product of this reaction.

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

Explain why polypeptides are described as polymers.

**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.

## 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

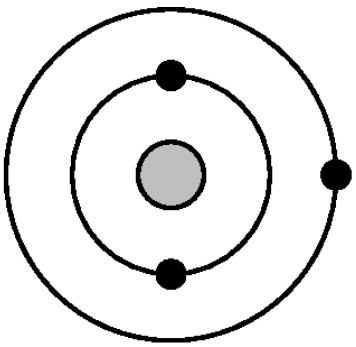
1. Choose the correct words from the box to complete the sentence.

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

| elements | metals | non-metals | ions |
|---|---|---|---|

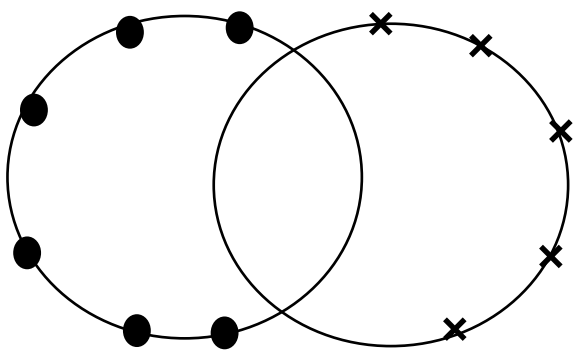
Covalent bonding occurs between _____ and _____.

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.
    b. Draw a dot-and-cross diagram to show the bonding in HCl.
    c. Calculate the relative formula mass of hydrochloric acid.
    d. Calculate the percentage by mass of chlorine in HCl.
    e. Write a word equation to show what happens in the reaction between hydrochloric acid and sodium hydroxide.
    f. Write a balanced chemical equation for the reaction in Q5.
    g. Identify the type of bonding that would be present in each of the products of the reaction in Q5.

## Crude Oil and Hydrocarbons

Section A

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

| compound | mixture | hydrocarbons | mud | plankton | rocks | finite | infinite |
|---|---|---|---|---|---|---|---|

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

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.

   _____

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

   Tick (✓) **one** box.

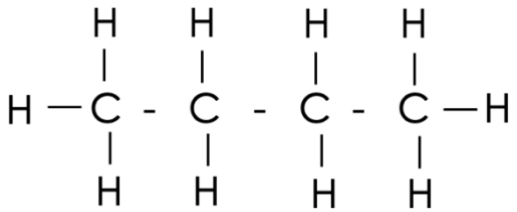
   A. Ethane ☐

   B. Propane ☐

   C. Butane ☐

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

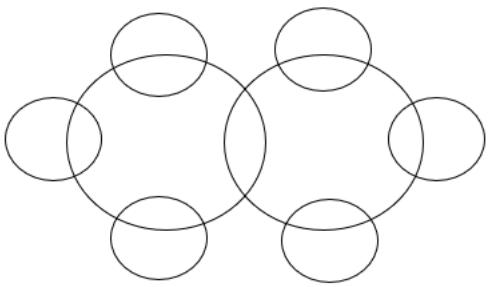
   _____



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.

_____

_____

_____

_____

   d. The alkanes is a large family of compounds.
      Determine the chemical formula of an alkane with:
      i. 8 carbons

_____

ii. 24 carbons

_____

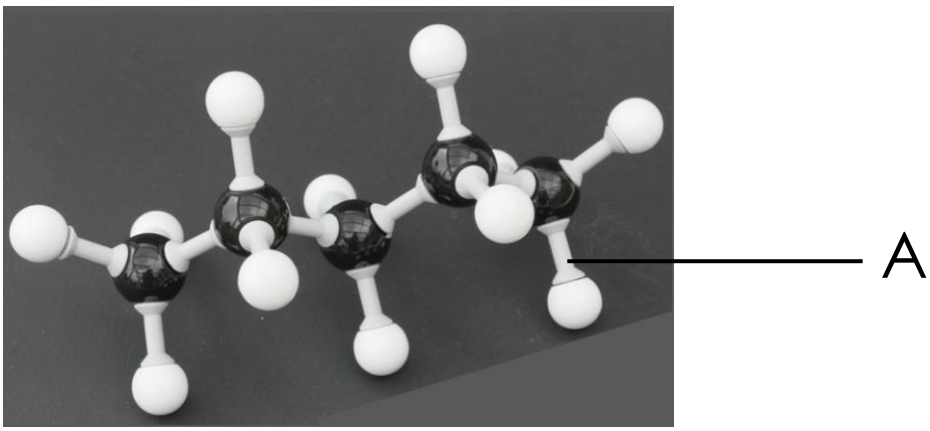
iii. 36 hydrogens

_____

iv. 20 hydrogens

_____

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




a. Determine the chemical formula of this alkane.

_____

b. Give an advantage of this model.

_____

_____

c. What is represented by the letter A?

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

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.
   i. Draw the electronic configuration of a carbon atom.
   j. Explain why a carbon atom is neutral.
   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.
   l. Compare the atomic structures of carbon-12 and carbon-14.

**Fractional Distillation**

Section A

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

_____

_____

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 ☐

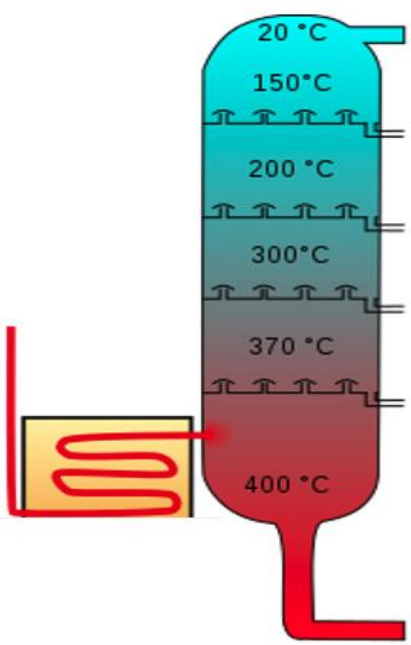
   B. Viscosity decreases as the size of molecules in a fraction increase ☐

   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.

_____

_____

_____

_____

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

_____

_____

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

_____

_____

_____

_____

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?

_____

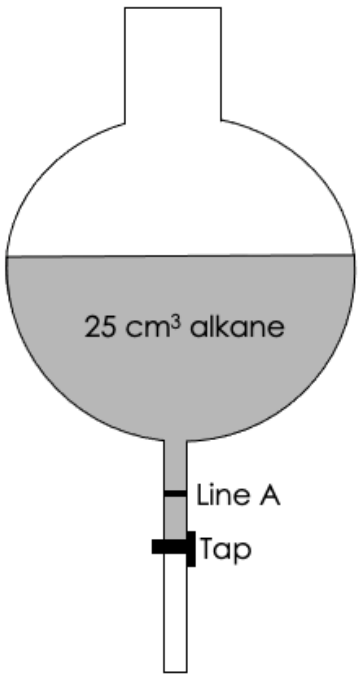
_____

b. What is the general formula for alkanes?

_____

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

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?

_____

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.

_____

_____

_____

_____

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.
   b. Give a disadvantage of using distillation for desalination.
   c. Give the name for water that is safe to drink.
   d. Explain the difference between water that is safe to drink and distilled water.
   e. Explain whether distilled water would conduct electricity.
   f. Draw a dot and cross diagram to show the bonding in water.
   g. Calculate the percentage by mass of oxygen in water.

**Combustion of Hydrocarbons**

Section A

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

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

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

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

2. Complete the chemical formula for propane.

   C__H___

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 + _____ → _____ _____ + _____

5. Describe what is needed for complete combustion of alkanes to take place.

   _____

   _____

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.

   _____ + _____ → _____ + _____

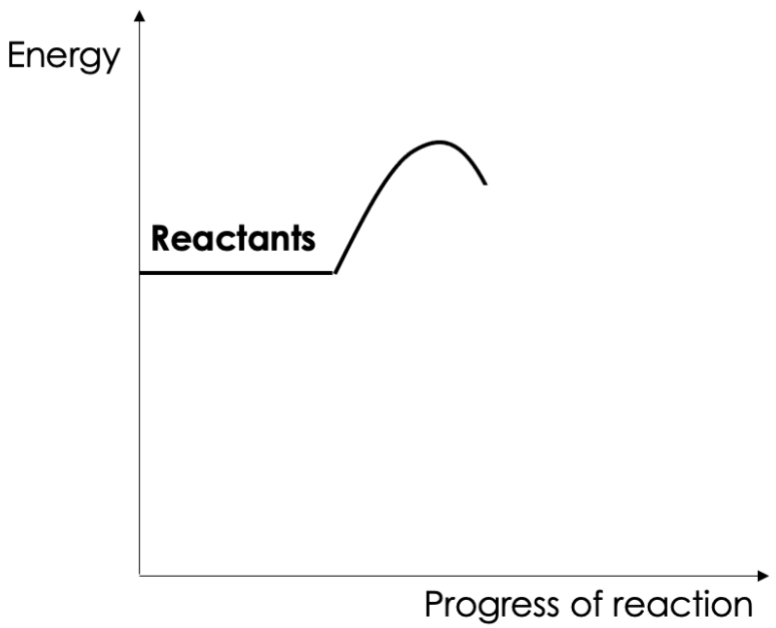
   b. Explain why the incomplete combustion of methane may be dangerous.

_____

_____

_____

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




   d. Explain your answer to question c.

_____

_____

_____

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 + _____ → _____ + _____

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

_____

_____

_____

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.

_____

_____

_____

_____

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.

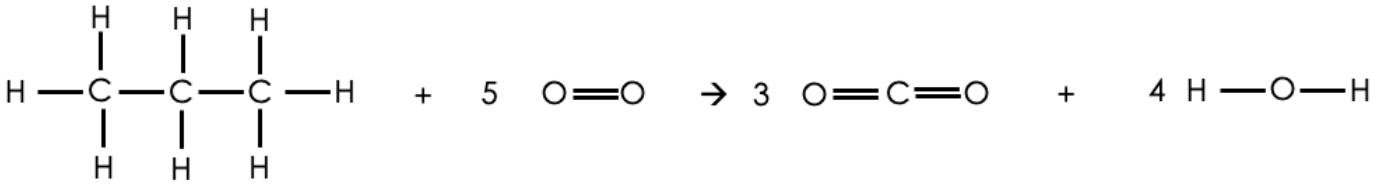
_____

e. Name the compound that makes up most of the other gases.

_____

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.
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

## Cracking

Section A

1. Describe what happens when large hydrocarbon molecules are cracked.

_____

_____

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.

_____

_____

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. $C_{10}H_{22} \rightarrow C_6H_{14}$ + _____

      ii. $C_6H_{14} \rightarrow C_2H_4$ + _____

      iii. $C_{14}H_{30} \rightarrow C_8H_{18}$ + _____

   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.

_____

_____

_____

_____

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

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

      $C_{10}H_{22} \rightarrow C_2H_4$ + _____

   b. Name the product with the formula $C_2H_4$.

_____

   c. $C_2H_4$ is an alkene. Explain how this could be tested.

_____

d. Give two conditions used for cracking decane.

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 | | 18 |
| | 28 | 17 |

a. What does LPG stand for?

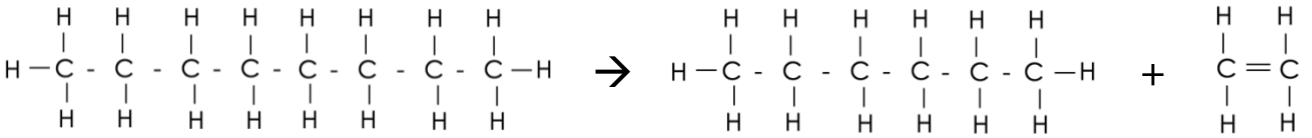
b. Complete the table by naming the missing fraction and calculating the approximate percentage of crude oil that is made up of heavy fuel oil.

c. Identify which of these fractions is the most flammable.

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

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?

_____

b. What type of chemical reaction is shown by this diagram?

_____

c. Suggest one use for Compound B.

_____

d. Suggest one use for Compound C.

_____

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.
    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

**Taking it Further: Alkenes**

Section A

1. Complete the general formula of the alkenes.

C___H____

2. Choose which of these is an alkene.

   Tick (✓) **one** box.

   A. Pentane ☐

   B. Hexene ☐

   C. Heptane ☐

3. Complete the structural formula for butene:

   C C C C

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

      _____

   b. 24 carbons

      _____

   c. 36 hydrogens

      _____

   d. 20 hydrogens

      _____

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

   Tick (✓) **one** box.

A. Bromine water turns cloudy ☐

B. Bromine water turns colourless ☐

C. Bromine water stays orange ☐

6. Which explains why alkenes are described as unsaturated?

Tick (✓) **one** box.

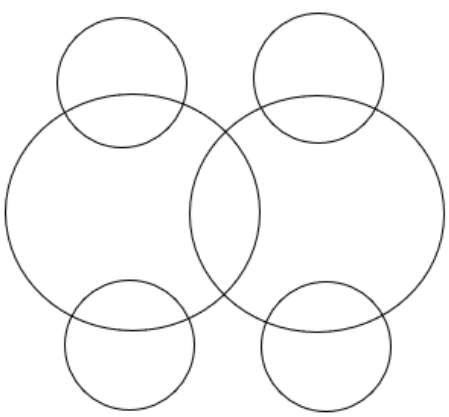
A. They contain a double bond between carbon atoms ☐

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 →

b. Pentene + hydrogen →

c. Hexene + hydrogen →

d. Propene + bromine →

e. Pentene + chlorine →

f. Hexene + iodine →

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

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

11. Cycloalkenes are alkenes that are ring-shaped and contain a double bond between carbon atoms.

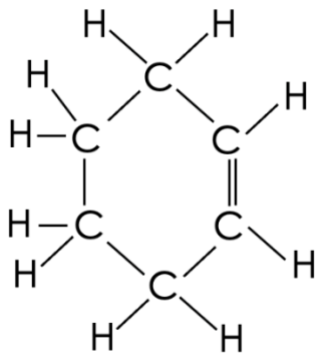
    The chemical formulae of three cycloalkenes are given below.

| Name | Formula |
|---|---|
| Cyclobutene | $C_4H_6$ |
| Cyclopentene | $C_5H_8$ |
| Cyclohexene | $C_6H_{10}$ |

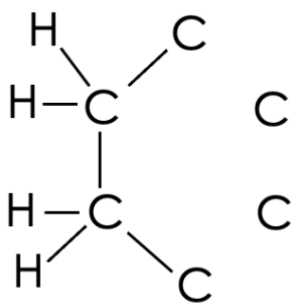
a. Use the information to determine the general formula of cycloalkenes.

_____

The structural formula of cyclohexene is shown below.



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



Section C

12. Alkenes are a homologous series of hydrocarbons.
    a. Define a homologous series.
    b. Define a hydrocarbon.
    c. A scientist has a mixture of different alkenes. Describe and explain how they could separate them.

d. Identify the type of bonding in alkenes.
e. Explain why the alkenes have relatively low melting and boiling points.
f. Hexene is an alkene that contains 6 carbon atoms. Describe what happens to the particles when hexene is heated past its boiling point.
g. Hexene has a boiling point of 63 °C. What state is it in at room temperature?
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.

**Taking it Further: Alcohols**

Section A

1. Choose which of these is an alcohol.

   Tick (✓) **one** box.

   A. Ethane ☐

   B. Ethene ☐

   C. 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:

   C C C

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

   e. 6 carbons

   _____

   f. 8 carbons

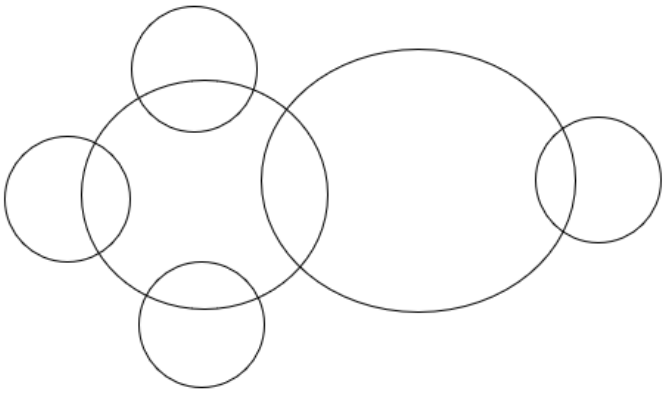
   _____

   g. 10 carbons

   _____

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.

_____

_____

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

      Methanol + oxygen → _____ + _____

   d. Compare the products that would be produced through complete and incomplete combustion of methanol.

_____

_____

_____

_____

   e. Predict the products of the following reactions.

i. Ethanol + sodium →

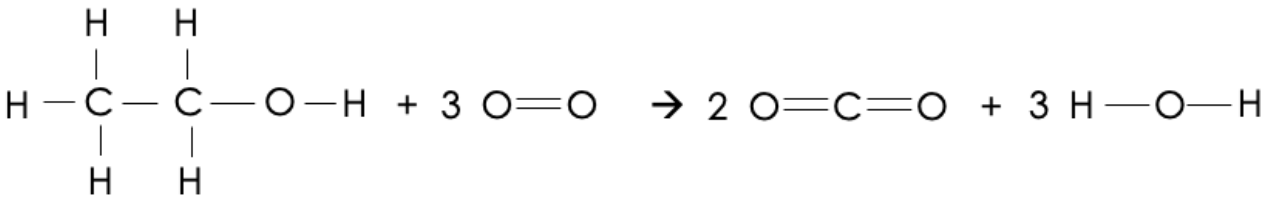
ii. Propanol + sodium →

iii. Butanol + sodium →

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 |

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

_____

_____

_____

_____

Section C

7. Ethanol is an alcohol.
   i. State the chemical formula of ethanol.
   j. Draw the structural formula of ethanol.
   k. One use of ethanol is in alcoholic drinks. Give another use of ethanol.
   l. Describe some of the short term effects of alcohol on the body.
   m. Describe a simple experiment that could be used to estimate a person's reaction time.
   n. Drinking alcohol affects the stopping distance of a car. Does this affect the thinking distance or the braking distance?
   o. 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.

**Taking it Further: Producing Ethanol by Fermentation**

Section A

1. Complete the word equation for fermentation.

   Glucose → _____ + _____

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:

   C C

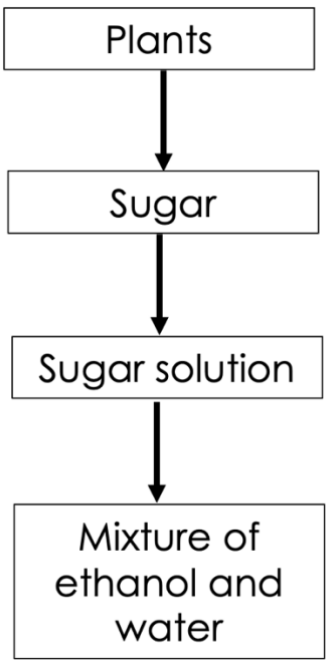
5. Give a use for ethanol other than in alcoholic drinks.

   _____

6. Give a use for the other product of fermentation.

   _____

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.

   _____

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

_____

_____

_____

_____

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

_____

_____

_____

_____

   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.

_____

_____

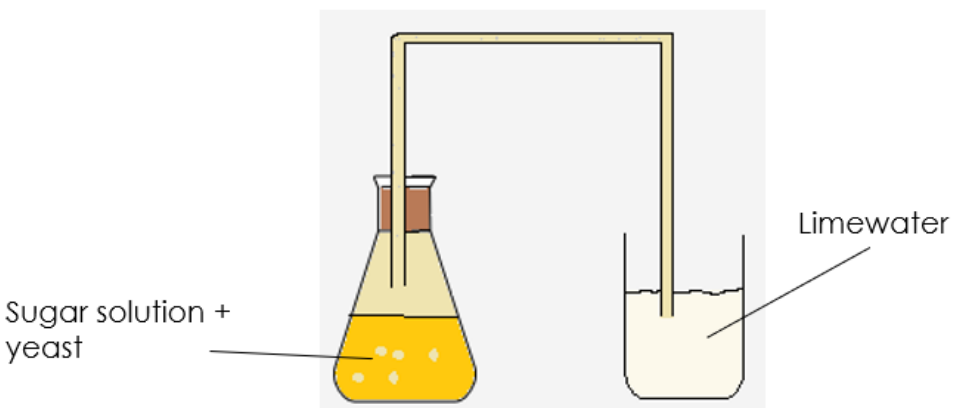
_____

_____

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

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

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.

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.

_____

_____

_____

Section C

8. Ethanol can be produced by fermentation.
   p. Name the microorganism that is added to a sugar solution to produce ethanol.
   q. Enzymes in the microorganism increase the rate of reaction. Define an enzyme.
   r. Explain what is meant by the lock-and-key model of enzyme activity.
   s. Define the optimum temperature of an enzyme.
   t. Describe what happens to an enzyme when it is heated too much.

**Taking it Further: Producing Ethanol from Ethene**

Section A

1. Complete the word equation for hydration of ethene.

   Ethene + _____ → _____

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:

   C C

5. Compare the structure of ethene and ethanol.

Section B

6. Describe the steps involved in the production of ethanol from crude oil.

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.

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.

_____
_____
_____
_____

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.

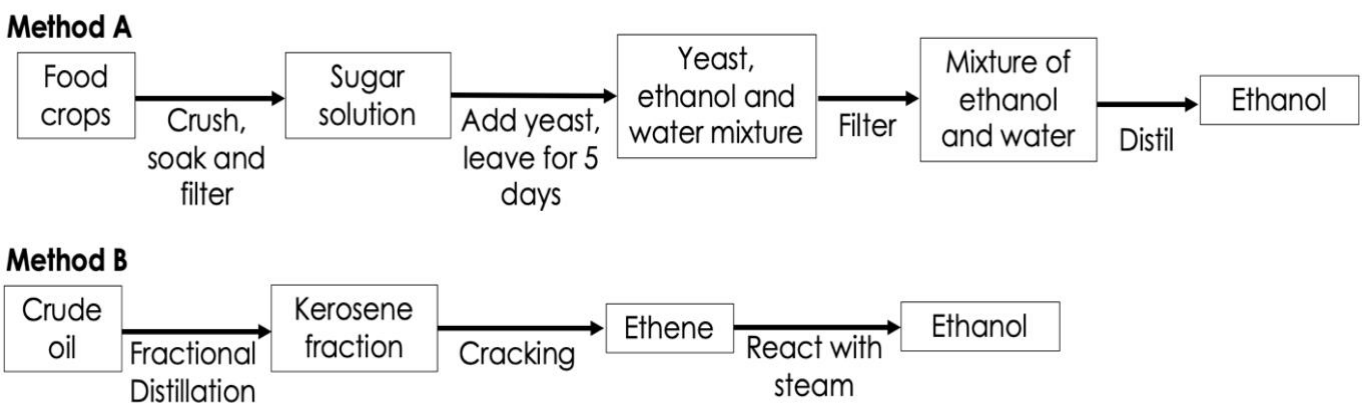
Use this information to suggest one advantage of using E5 fuel instead of E10 fuel.

_____
_____
_____

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

_____
_____
_____

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.

Section C

9. Another use of ethanol is in antibacterial hand gels. This can help to prevent the spread of communicable diseases.
   u. Define a communicable disease.
   v. Give an example of a communicable disease.
   w. Describe other methods of preventing the spread of communicable diseases.

**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.

   A. $CH_3COOH$ ☐

   B. HCOOH ☐

   C. COOH ☐

3. Complete the structural formula for propanoic acid:

   C C C

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

   a. _____ acid + calcium → calcium methanoate + _____

   b. Propanoic acid + _____ oxide → sodium propanoate + _____

   c. Butanoic acid + potassium carbonate → potassium butanoate + _____ + _____

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

| **Name** | **Chemical formula** | **pH (of 0.01 mol/dm$^3$) solution** |
|---|---|---|
| Methanoic acid | | 2.9 |
| Ethanoic acid | $CH_3COOH$ | 3.4 |
| | $C_2H_5COOH$ | 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.

_____
_____
_____
_____

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

_____
_____
_____
_____

d. Calculate the relative formula mass of ethanoic acid.

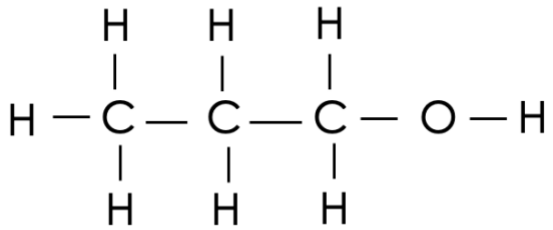
_____
_____

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

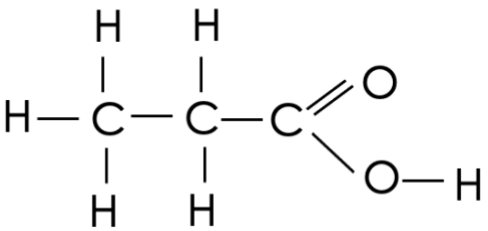
_____
_____

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.

_____
_____

b. Name compounds A and B.

_____
_____

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.

_____
_____
_____
_____

Section C

7. (HT) Carboxylic acids are weak acids.
   a. Define a weak acid.
   b. Give an example of a strong acid.
   c. Compare the pH of a weak and strong acid with the same concentration.
   d. Compare the pH of a dilute and concentrated sample of the same acid.
   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.

**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.

   A. Carbon dioxide ☐

   B. Oxygen ☐

   C. Water ☐

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

   _____ + _____ → ester + _____

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.

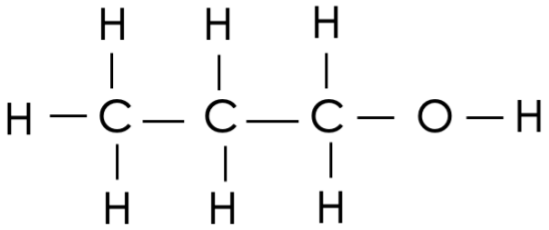
   _____

   _____

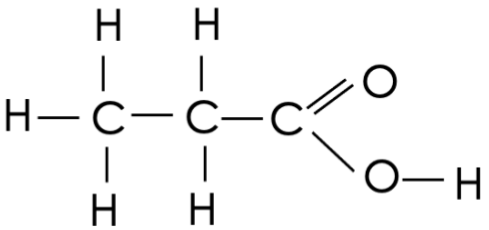
Section B

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?

_____

b. The reaction between Compound A and Compound B also forms another product. State the chemical formula of the other product.

_____

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.

_____

_____

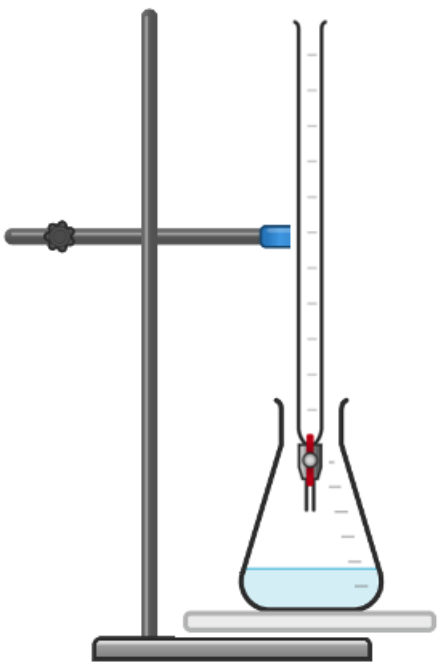
7. A student has a solution of ethanoic acid. Ethanoic acid is a weak acid.

   a. Explain what is meant by a weak acid.

_____

b. Name the edible product that contains ethanoic acid.

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



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

Section C

8. Naturally occurring fats and oils are complex esters.
    a. Describe the function of fats and oils in a balanced diet.
    b. Describe how to use qualitative reagents to test for the presence of fats.
    c. Describe where the digestion of fats takes place.
    d. Explain why fats must be digested.
    e. State the products of the digestion of fats.
    f. Name the type of enzyme that speeds up the digestion of fats.

**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.

   _____

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

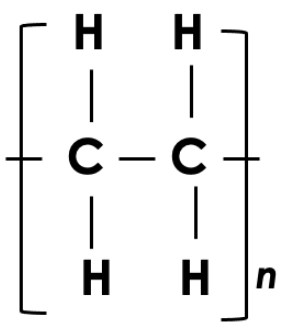
   Tick (✓) **one** box.

   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?

   _____

   b. What does the 'n' represent?

   _____

Section B

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

6. Describe the forces that occur <u>between</u> polymer chains.

7. What type of polymers melt when heated?

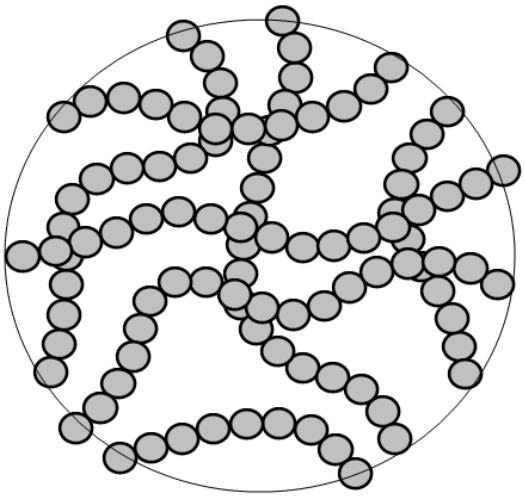
8. Draw the molecular formula for a polymer molecule with 50 carbon atoms.

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

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

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

**A**_____ **B**_____



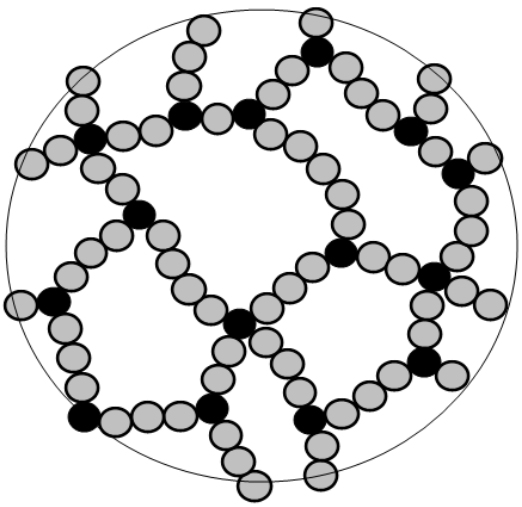


*Image from Wikimedia*

Section C

12. Carbon dioxide and diamond both contain carbon.

a. Describe the bonding in carbon dioxide.
b. Describe the bonding in diamond.
c. Explain why carbon dioxide is a gas at room temperature but diamond is a solid

**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.

4. Poly(ethene) is made through addition polymerisation of ethene molecules.

   a. Complete the displayed formula for ethene.

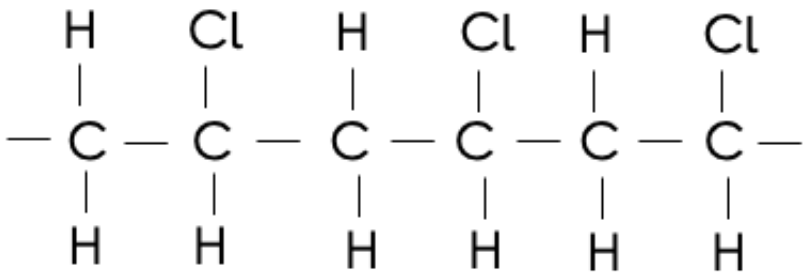
   C C

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

C C C C C C

Section B

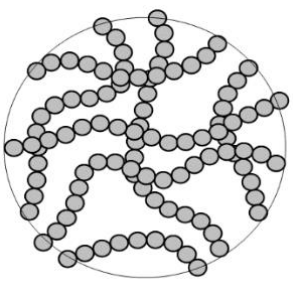
5. Polyvinyl chloride (PVC) is a non-biodegradable polymer. The displayed formula below shows a section of a PVC molecule.




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

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

The diagram below represents some PVC molecules.



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

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.

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.

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:

Disadvantage:

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

Section C

7. HDPE and LDPE are both types of poly(ethene) but they have different densities.
   a. Define density.
   b. HDPE has a density of 1.5 g/cm$^3$. Calculate the volume that 1.5 kg of HDPE would occupy.
   c. Describe a method that could be used to calculate the density of an irregularly shaped piece of LDPE.

**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?

   _____

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

   C C

   c. Name the type of reaction that would occur when many molecules of ethandiol reacted with many molecules of hexanedioic acid.

   _____

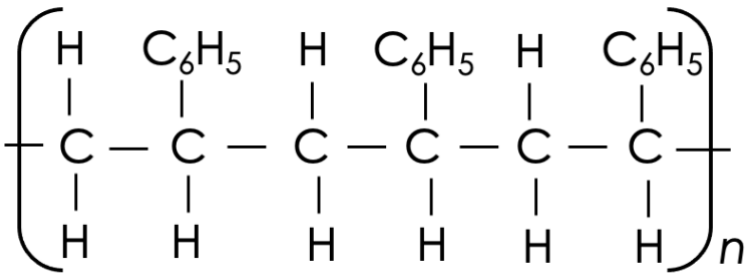
   d. Name the other product that would be formed in this reaction.

   _____

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.

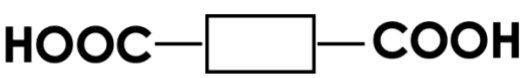


a. Complete the displayed formula to show the monomer that poly(styrene) is made from.

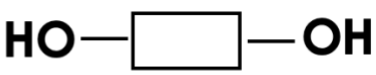
C C

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.

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

State the formula of this small molecule.

_____

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

_____

_____

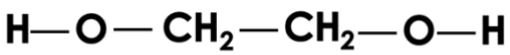
_____

_____

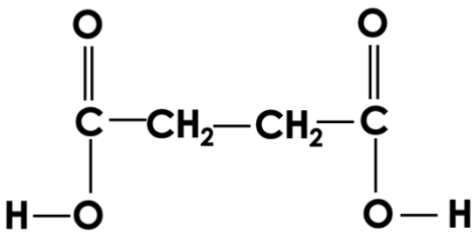
_____

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

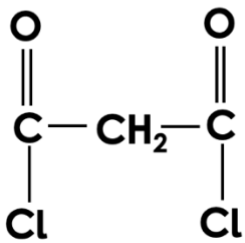
Monomer P



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 | |
| P and R | |

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?
   b. Name the organelle where proteins are synthesised.
   c. Give two functions of proteins in the body.
   d. Explain the effect of a DNA mutation on protein synthesis.

## 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?

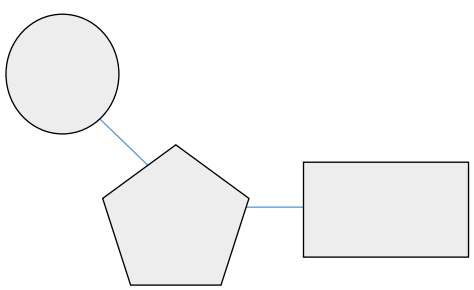
   Tick (✓) **one** box.

   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.

5. Explain why DNA is described as a polymer.

6. State the complementary base pairs.

Section B

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

   Starch: _____

   Proteins: _____

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.

   b. Gas bubbles are produced when algae photosynthesise.

      Name the gas produced and describe a test that could be used to identify this gas.

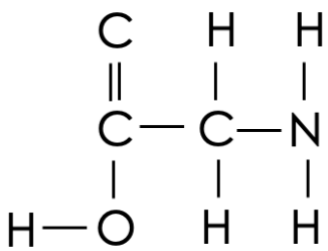
   Gas: _____

   Test:

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

Describe the shape and structure of this polymer.

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.

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Section C

10. Starch is a naturally occurring polymer.
    a. Explain why starch is a polymer.
    b. Starch must be digested before it can be absorbed into the small intestine. Explain why.
    c. Describe and explain how the small intestine is adapted for diffusion of nutrients into the bloodstream.