AQA GCSE Chemistry | 8462

SPECIFICATION POINT 4.7.1.2

Fractional distillation and petrochemicals

Past-paper questions

Tier	**Higher**
Question groups	**32**
Available paper years	**2007–2024**

Using this booklet

1. Answer the questions in order and show your working.
2. Original question numbers and marks are retained.
3. Print at actual size (100%) for measuring questions.
4. Use the companion answer booklet to check your work.

Name: _____ **Date:** _____

Whole questions are retained for context, so some parts assess other specification points. Current and legacy sources are labelled. Continue on extra paper if needed.

4.7.1.2 Fractional distillation and petrochemicals

Question 01

5 Crude oil is a mixture of mostly alkanes.

(a) Crude oil is separated into useful fractions by fractional distillation.

(i) Describe and explain how the mixture of alkanes is separated by fractional distillation.

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(3 marks)

(ii) The table gives the name and formula for each of the first three alkanes.

Complete the table to show the formula of butane.

Name of alkane	Formula
Methane	CH_4
Ethane	C_2H_6
Propane	C_3H_8
Butane	

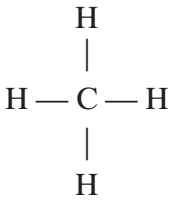
(1 mark)

4.7.1.2 Fractional distillation and petrochemicals

Question 01 · continued

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(b) The structural formula of methane, CH_4, is:



Draw the structural formula of propane, C_3H_8

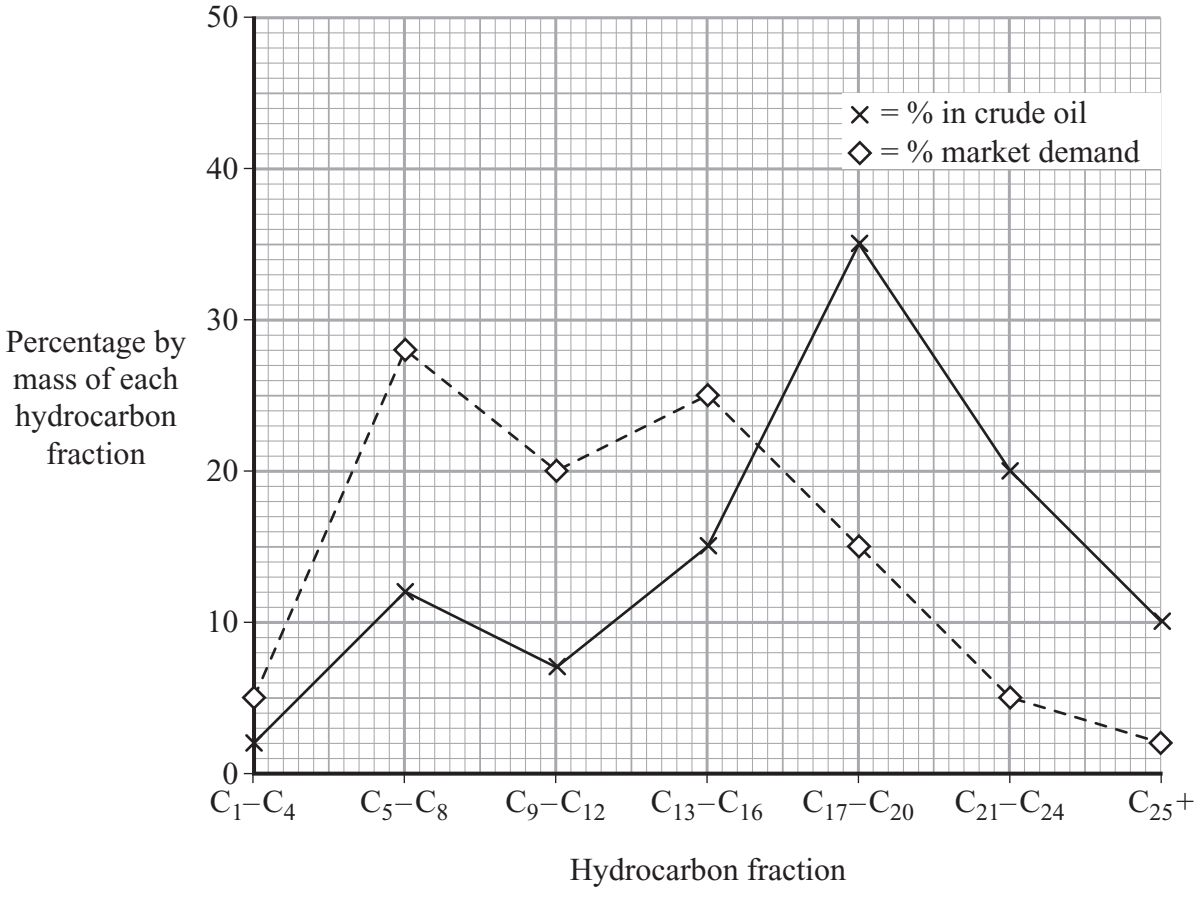
(1 mark)

Question 5 continues on the next page

Question 01 · continued

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(c) The relative amounts of and the market demand for some hydrocarbons from the fractional distillation of crude oil are shown in the graph.



(i) Why is the market demand for the $C_5–C_8$ fraction higher than the market demand for the $C_{21}–C_{24}$ fraction?

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(1 mark)

(ii) Cracking is used to break down large hydrocarbon molecules into smaller hydrocarbon molecules.

Complete the symbol equation by writing in the formula of the other hydrocarbon.

$C_{20}H_{42} \rightarrow C_{16}H_{34} + 2$ .....

(1 mark)

4.7.1.2 Fractional distillation and petrochemicals

Question 01 · continued

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(iii) The C_5-C_8 fraction has low supply and high market demand.

Suggest **three** ways in which the oil industry could overcome this problem.

1 .....

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2 .....

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3 .....

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(3 marks)

10

4.7.1.2 Fractional distillation and petrochemicals

Question 02

March 2007 | CHY1A | Original Q3 | Legacy

QUESTION THREE

Crude oil is a non-renewable energy source. Petrol is a fuel obtained from the fractional distillation of crude oil.

Gasohol is also a fuel. It is a mixture of 90 % petrol and 10 % ethanol. The ethanol can be produced from the waste stems and leaves when crops have been harvested. So ethanol is a renewable energy source.

	Mass in grams of gas produced by completely burning 10 cm^3 of fuel		
Fuel	Carbon dioxide from petrol	Carbon dioxide from ethanol	Water vapour
Petrol	26.4	0	12.6
Gasohol	23.8	1.5	12.2

3A What is the total mass of carbon dioxide produced when 10 cm^3 of gasohol is burned?

1 22.3 g

2 23.8 g

3 25.3 g

4 26.4 g

3B How much more carbon dioxide is produced when 10 cm^3 of petrol is burned than when 10 cm^3 of gasohol is burned?

1 0.4 g

2 1.1 g

3 1.6 g

4 24.9 g

4.7.1.2 Fractional distillation and petrochemicals

Question 02 · continued

3C Why is the water vapour produced by burning fuels not a problem?

1 It condenses to a liquid.

2 It does not cause corrosion.

3 It is not a pollutant.

4 Very little is produced.

3D Carbon dioxide causes environmental problems.

Why is carbon dioxide from burning ethanol thought to be less of a problem than carbon dioxide from burning petrol?

1 Not as much carbon dioxide is produced.

2 The carbon dioxide produced has different chemical properties.

3 It is just recycling carbon dioxide removed from the air by plants.

4 The ethanol is not produced from crude oil.

4.7.1.2 Fractional distillation and petrochemicals

Question 03

March 2007 | CHY1A | Original Q8 | Legacy

QUESTION EIGHT

This question is about crude oil.
Crude oil is separated into fractions by fractional distillation.

8A In the fractionating column, the crude oil separates into fractions because . . .

1 it evaporates.

2 the vapour condenses at 100 °C.

3 the vapour condenses at different temperatures.

4 thermal decomposition occurs.

8B Fractional distillation is possible because the hydrocarbons in the crude oil have . . .

1 different boiling points.

2 different chemical properties.

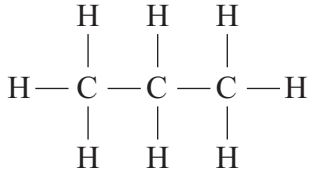
3 exactly the same boiling points.

4 the same ignition temperature.

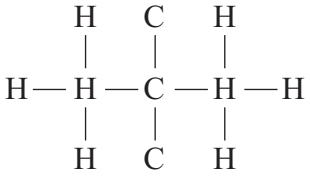
The simplest alkane in crude oil is methane, CH_4
Another alkane is propane, C_3H_8

8C A molecule of propane can be represented by . . .

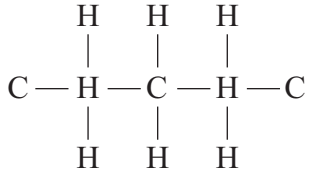
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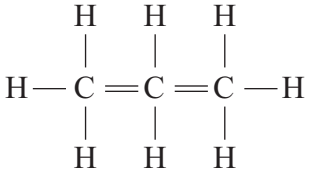
2



3



4



4.7.1.2 Fractional distillation and petrochemicals

Question 03 · continued

8D Compared with methane, propane will . . .

1 ignite more easily.

2 boil at a lower temperature.

3 have a higher boiling point.

4 be less saturated.

Turn over for the next question

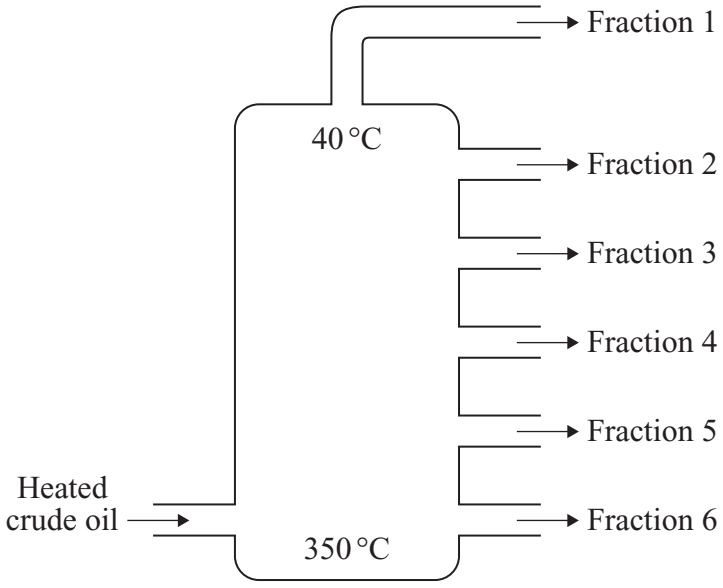
4.7.1.2 Fractional distillation and petrochemicals

Question 04

June 2007 | CHY1A | Original Q6 | Legacy

QUESTION SIX

In a fractionating column, crude oil is separated into a number of fractions.



6A Crude oil can be separated into fractions in this way because . . .

1 it contains liquid and gaseous hydrocarbons.

2 it vaporises at about 350 °C.

3 it is a mixture of only two elements.

4 it is a mixture of hydrocarbons.

6B Each fraction has a range of boiling points because . . .

1 a hydrocarbon does not have a fixed boiling point.

2 not all fractions contain the same number of hydrocarbons.

3 not all fractions contain solid hydrocarbons.

4 each fraction is a mixture of hydrocarbons.

4.7.1.2 Fractional distillation and petrochemicals

Question 04 · continued

6C Which row in the table correctly describes the hydrocarbons in Fraction 1?

1	molecules are large	ignite with difficulty
2	liquids at room temperature	ignite easily
3	molecules are small	ignite easily
4	molecules are small	ignite with difficulty

6D Which of these compounds will make up the largest percentage of Fraction 1?

1 C_2H_4

2 C_3H_6

3 C_3H_8

4 $C_{12}H_{26}$

Turn over for the next question

4.7.1.2 Fractional distillation and petrochemicals

Question 05

November 2007 | CHY1A | Original Q1 | Legacy

QUESTION ONE

This question is about fractional distillation of crude oil.

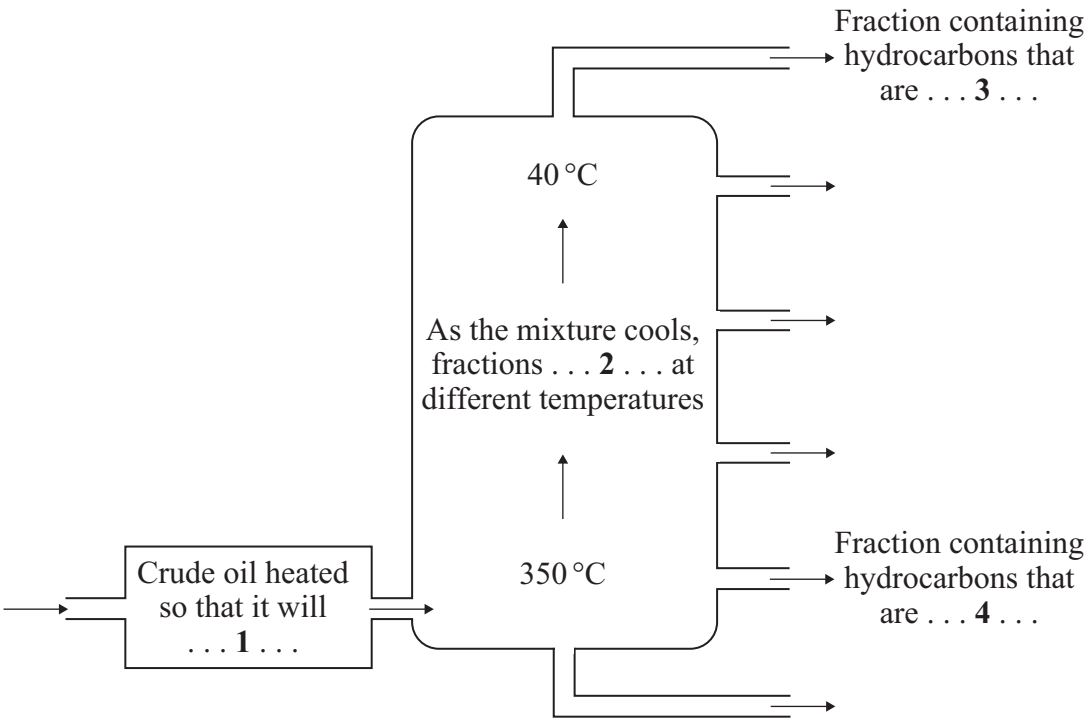
Match words, **A**, **B**, **C** and **D**, with the numbers **1–4** in the sentences on the diagram.

A condense

B vaporise

C viscous

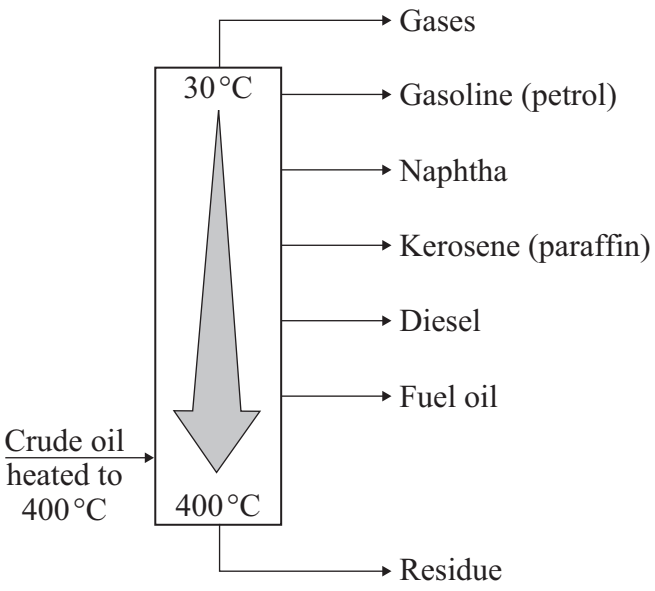
D volatile



4.7.1.2 Fractional distillation and petrochemicals

Question 06

6 Crude oil is the source of many useful materials. Crude oil is separated into fractions by fractional distillation.



(a) Describe how the naphtha fraction separates from the other fractions.

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(2 marks)

(b) The naphtha fraction is often used to make other useful materials.
This involves the cracking of hydrocarbons in the naphtha fraction.

For example:

decane → hexane + ethene

$C_{10}H_{22} \rightarrow C_6H_{14} + C_2H_4$

(i) Balance the symbol equation given above.

(1 mark)

4.7.1.2 Fractional distillation and petrochemicals

Question 06 · continued

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(ii) Describe how cracking is carried out.

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(2 marks)

(iii) Why does ethene have different chemical properties from decane and hexane?

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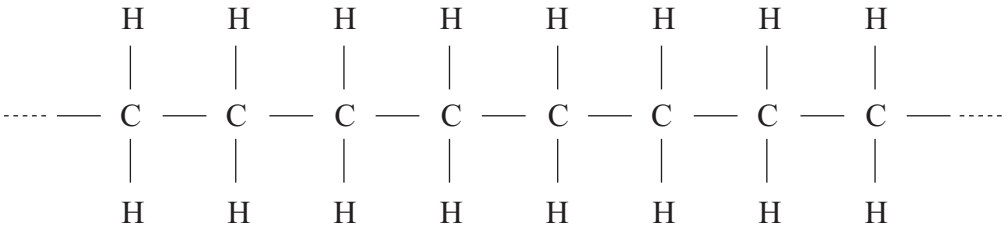
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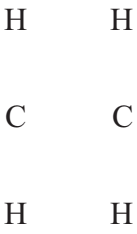
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(2 marks)

(c) Ethene is used as the starting material for many polymers. The most common polymer is poly(ethene). One hydrocarbon molecule in poly(ethene) will contain thousands of carbon atoms.



Complete the diagram to show the bonds in ethene.



(1 mark)

Question 6 continues on the next page

Question 06 · continued

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(d) Read the following information.

Landfill, Incineration, Recycling and Re-use of Poly(ethene)

People could be encouraged to re-use their poly(ethene) bags and containers.

Recycling poly(ethene) saves raw materials and energy needed to make new plastic. When polymers are recycled the plastics must be collected, transported, sorted into different types by hand and washed. This requires the use of fossil fuels and is expensive.

Poly(ethene) can be burnt in an incinerator with other household waste. The heat released could be used to make steam to drive an electric generator. Surplus heat could be used to heat greenhouses used for growing vegetables. Incineration at too low a temperature can produce harmful substances. The residue (ash) has to go to landfill.

Landfill is probably the easiest way to dispose of polymers and it is cheap. Polymers are often mixed in with other household rubbish. Household waste does not get sorted into different materials because it is disposed of in the same hole in the ground. When the hole is eventually full, the waste is covered by a layer of soil to stop it smelling. The waste gets compressed under its own weight. Most polymers, such as poly(ethene), are not biodegradable so will remain in the ground forever.

4.7.1.2 Fractional distillation and petrochemicals

Question 06 · continued

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You are asked to decide which option for the disposal of poly(ethene) will be put forward in your area. You decide that recycling is the best option.

Suggest **one** economic argument and **one** environmental argument that will be made against recycling.

For each argument made, how will you persuade those making the argument to accept your option?
(You must use only one sentence for each argument made against your decision and only one sentence for your response to it.)

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(4 marks)

12

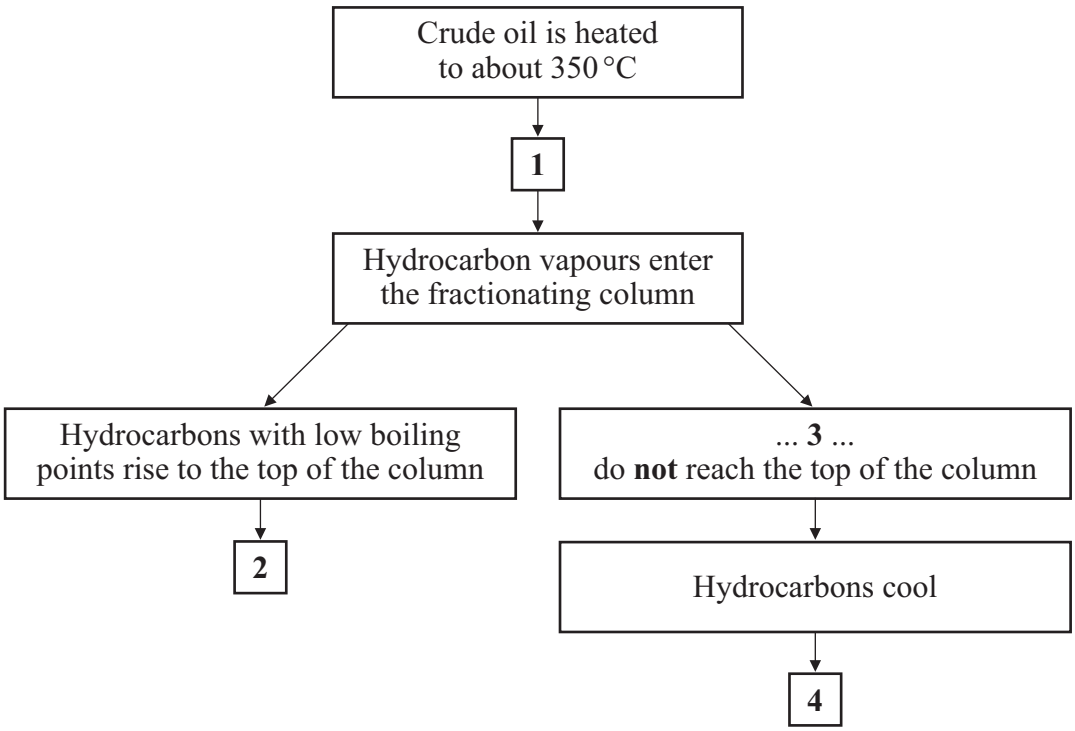
4.7.1.2 Fractional distillation and petrochemicals

Question 07

March 2008 | CHY1AP | Original Q2 | Legacy

QUESTION TWO

The flow chart shows stages in the fractional distillation of crude oil.



Match statements, **A**, **B**, **C** and **D**, with the numbers **1–4** in the flow chart.

A Hydrocarbons in the crude oil turn to vapour

B Hydrocarbons collected as gases

C Hydrocarbons with high boiling points

D Hydrocarbons condense to form liquids

4.7.1.2 Fractional distillation and petrochemicals

Question 08

March 2008 | CHY1AP | Original Q8 | Legacy

QUESTION EIGHT

The table gives some information about the boiling points and combustion products of the first six alkanes.

			When one molecule of the alkane is completely burned	
Name	**Formula**	**Boiling point in °C**	**Number of molecules of CO_2 formed**	**Number of molecules of H_2O formed**
Methane	CH_4	–168	1	2
Ethane	C_2H_6	– 89	2	3
Propane	C_3H_8	– 42	3	4
Butane	C_4H_{10}	– 0.5		
Pentane	C_5H_{12}	+ 36		
Hexane	C_6H_{14}	+ 69		

8A Which one of the following statements is true about the fractional distillation of a mixture of the alkanes in the table?

1 Each of the fractions collected would contain just **one** alkane.

2 Hexane would be in the fraction selected at the highest temperature.

3 The hottest part of the column would be at the top.

4 Methane would be separated out at the bottom of the column.

8B Which one of the following is true about burning the alkanes?

1 As the size of the alkane molecules increases, the ratio of $CO_2 : H_2O$ molecules formed will eventually be 1:1

2 As the size of the alkane molecules increases, more and more oxygen molecules will be required to completely burn one molecule of the alkane.

3 The amount of water and carbon dioxide formed suggests that the alkanes with larger molecules will ignite more easily.

4 Since only water and carbon dioxide are formed on burning, the alkanes are environmentally-friendly fuels.

4.7.1.2 Fractional distillation and petrochemicals

Question 08 · continued

8C Burning the alkanes that have larger molecules tends to produce carbon monoxide along with carbon dioxide and water.

This suggests that these alkanes . . .

1 do **not** undergo complete combustion.

2 would make better fuels.

3 contain dissolved carbon monoxide gas.

4 can never be made totally pure.

8D To estimate the boiling point of heptane (C_7H_{16}) it would be best to use the boiling points from the table to plot . . .

1 a line graph with the number of carbon atoms as the independent, discrete variable.

2 a line graph with the number of carbon atoms as the categoric variable.

3 a bar chart with the number of carbon atoms as the independent, discrete variable.

4 a bar chart with the number of carbon atoms as the categoric variable.

4.7.1.2 Fractional distillation and petrochemicals

Question 09

June 2008 | CHY1AP | Original Q6 | Legacy

QUESTION SIX

Crude oil contains a large number of alkanes, which have the general formula C_nH_{2n+2}

Crude oil can be separated into a number of fractions by fractional distillation.

6A Crude oil can be separated into fractions in this way because . . .

1 the alkanes it contains have different boiling points.

2 the alkanes it contains have different densities.

3 alkanes are compounds which are made up of more than one element.

4 all alkanes vaporise easily when they are heated.

6B Each fraction from the crude oil will contain . . .

1 a single alkane.

2 a mixture of several alkanes.

3 alkanes that have the same boiling point.

4 alkanes that have the same density.

The alkanes are a series of compounds.

The first ten alkanes in the series range from methane, CH_4 to decane, $C_{10}H_{22}$

6C The difference between the formulae of successive alkanes is . . .

1 C

2 H_2

3 CH

4 CH_2

4.7.1.2 Fractional distillation and petrochemicals

Question 09 · continued

6D Which of the following changes in the alkane series, from methane to decane?

1 the general formula

2 the number of bonds on each carbon atom

3 the ratio of carbon atoms to hydrogen atoms

4 the number of elements present

Turn over for the next question

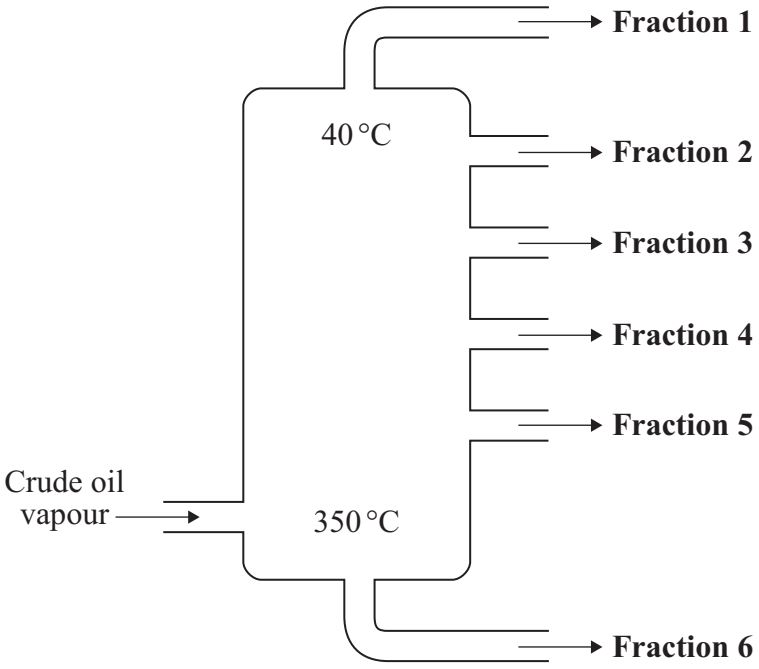
4.7.1.2 Fractional distillation and petrochemicals

Question 10

March 2009 | CHY1AP | Original Q6 | Legacy

QUESTION SIX

Crude oil vapour can be separated into a number of fractions.



6A Crude oil vapour enters the fractionating column.

What happens as the vapour cools?

1 The fractions separate because they have different densities.

2 The fractions condense at 40 °C.

3 The fractions condense at different temperatures.

4 The fractions condense at 350 °C.

6B **Fraction 6** will contain . . .

1 alkanes with high boiling points.

2 alkanes with a small number of carbon atoms in each molecule.

3 only hydrocarbons that are unsaturated.

4 only hydrocarbons with low boiling points.

4.7.1.2 Fractional distillation and petrochemicals

Question 10 · continued March 2009 | CHY1AP | Original Q6 | Legacy

6C **Fraction 1** contains the alkanes called methane, ethane, propane and butane.

By what process could pure methane be obtained from this fraction?

1 evaporation

2 electrolysis

3 thermal decomposition

4 fractional distillation

6D Which of these statements is correct for the alkanes?

1 They are a series of compounds with the general formula C_nH_{2n+1}

2 They are saturated compounds.

3 Most are gases at room temperature (20 °C), some are liquids, none are solids.

4 Their molecules have a carbon : hydrogen ratio of 1 : 4

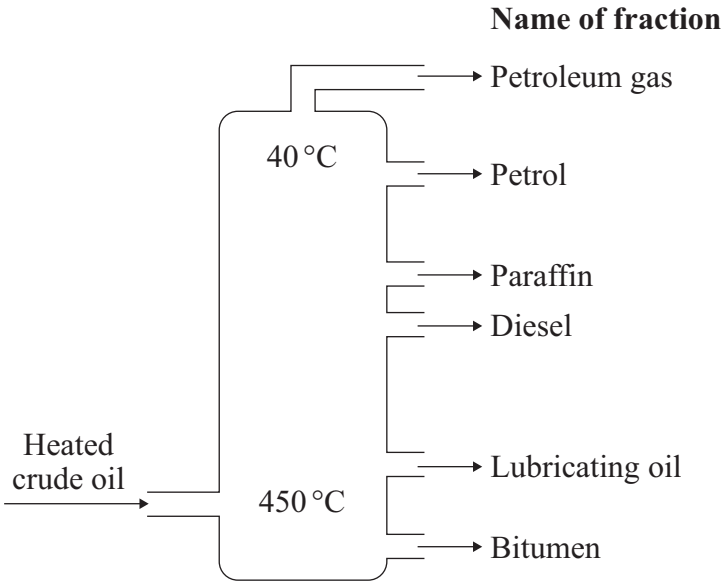
4.7.1.2 Fractional distillation and petrochemicals

Question 11

June 2009 | CHY1AP | Original Q5 | Legacy

QUESTION FIVE

In a fractionating column, crude oil is separated into a number of fractions.



5A The crude oil separates into fractions in the fractionating column because . . .

1 it changes from a liquid to a vapour.

2 crude oil vapour condenses at 100 °C.

3 crude oil vapour condenses at different temperatures.

4 decomposition of the crude oil occurs.

5B The diesel fraction boils over a range of temperatures from about 250 °C to 340 °C.

The fraction does **not** have a fixed boiling point because . . .

1 the temperature in the fractionating column is **not** constant.

2 the hydrocarbons in the fraction have different chemical properties.

3 the fraction contains a mixture of hydrocarbons.

4 liquid hydrocarbons boil at temperatures above 250 °C.

4.7.1.2 Fractional distillation and petrochemicals

Question 11 · continued

5C The hydrocarbons from the bitumen fraction will . . .

1 be difficult to ignite at room temperature.

2 have small molecules.

3 be gases or liquids at room temperature.

4 have a small number of carbon atoms in each molecule.

5D A hydrocarbon from the lubricating oil fraction burns, in air, with a smoky flame.

This suggests that . . .

1 the hydrocarbon contains sulfur as an impurity.

2 there is only partial combustion of the hydrocarbon.

3 the hydrocarbon has small molecules.

4 when the hydrocarbon burns, it is oxidised.

4.7.1.2 Fractional distillation and petrochemicals

Question 12

June 2009 | CHY1H | Original Q6 | Legacy

6 (a) PEX is a material that is used as an alternative to copper for hot water pipes. PEX is made from poly(ethene).

6 (a) (i) Describe how ethene forms poly(ethene).

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(2 marks)

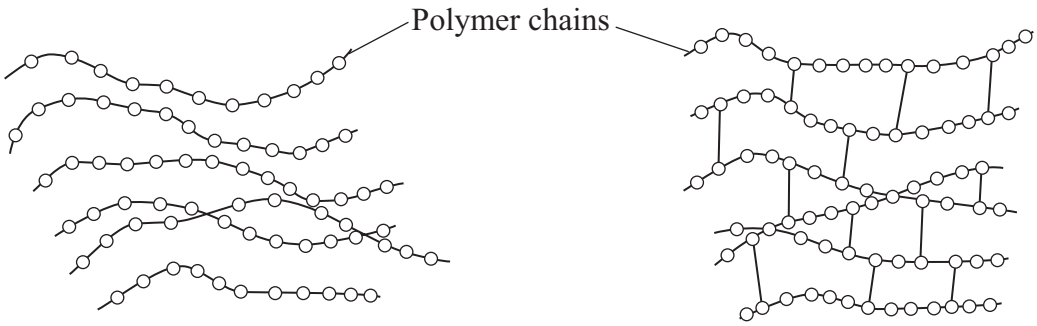
6 (a) (ii) PEX is a shape memory polymer. What property does a shape memory polymer have?

.....

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(1 mark)

6 (a) (iii) The simplified structures of poly(ethene) and PEX are shown.



Poly(ethene) **PEX**

Poly(ethene) is a thermoplastic that softens easily when heated.

Suggest and explain how the structure of PEX changes this property.

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(3 marks)

4.7.1.2 Fractional distillation and petrochemicals

Question 12 · continued

for mark

6 (b) Copper was considered to be the most suitable material to use for hot water pipes. PEX is now used as an alternative material for hot water pipes.

Copper is extracted from its ore by a series of processes.

1 The low-grade ore is powdered and concentrated.
2 Smelting is carried out in an oxygen flash furnace. This furnace is heated to 1100 °C using a hydrocarbon fuel. The copper ore is blown into the furnace with air, producing impure, molten copper.
3 Oxygen is blown into the impure, molten copper to remove any sulfur. The copper is cast into rectangular slabs.
4 The final purification of copper is done by electrolysis.

PEX is made from crude oil by a series of processes.

1 Fractional distillation
2 Cracking
3 Polymerisation
4 Conversion of poly(ethene) into PEX

Suggest the possible environmental advantages of using PEX instead of copper for hot water pipes.

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(4 marks)

10

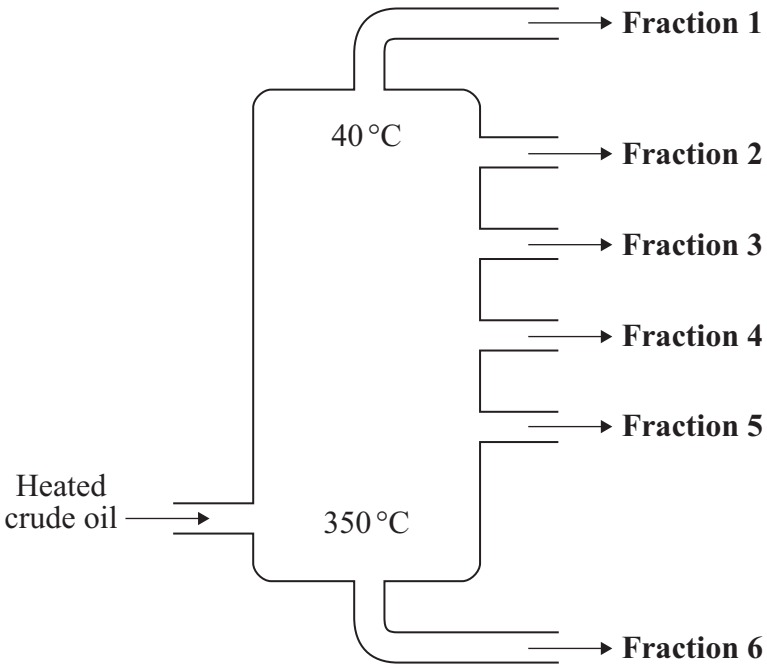
4.7.1.2 Fractional distillation and petrochemicals

Question 13

November 2009 | CHY1AP | Original Q3 | Legacy

QUESTION THREE

In a fractionating column, crude oil is separated into a number of fractions.



3A Each fraction contains . . .

1 only alkanes that are liquids.

2 only alkanes that condense at temperatures above 40 °C.

3 alkanes with similar boiling points.

4 alkanes with the same chemical formula.

4.7.1.2 Fractional distillation and petrochemicals

Question 13 · continued

3B Which statement is true for the alkanes in **Fraction 1**?

1 They burn to produce carbon dioxide and sulfur dioxide only.

2 They have the general formula C_nH_{2n-2}

3 They are saturated compounds.

4 They are compounds of carbon, hydrogen and oxygen.

3C When compared with the alkanes in **Fraction 6**, the alkanes in **Fraction 1** . . .

1 will ignite more easily.

2 will be more viscous.

3 will have higher boiling points.

4 will have larger molecules.

3D In a molecule of the alkane called propane, there are eight hydrogen atoms.

The formula for propane is . . .

1 C_2H_8

2 C_3H_8

3 C_4H_8

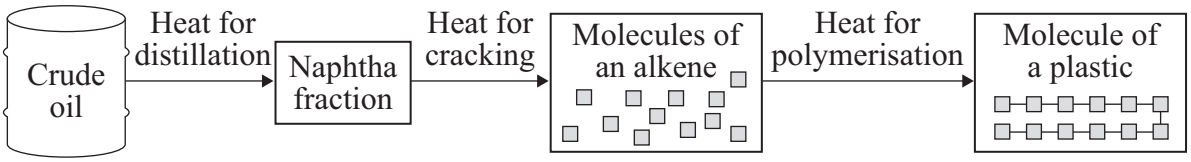
4 C_3H_8O

4.7.1.2 Fractional distillation and petrochemicals

Question 14

January 2010 | CHY1H | Original Q6 | Legacy

6 To make a plastic, such as poly(ethene), from crude oil involves many processes.



6 (a) Describe how crude oil is separated into fractions.

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(2 marks)

6 (b) Ethene is produced by cracking the hydrocarbons in the naphtha fraction.

6 (b) (i) Balance the symbol equation for this reaction.

$$\underset{\text{decane}}{C_{10}H_{22}} \rightarrow \underset{\text{butane}}{C_4H_{10}} + \underset{\text{ethene}}{C_2H_4}$$

(1 mark)

6 (b) (ii) Describe how cracking is carried out.

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(2 marks)

4.7.1.2 Fractional distillation and petrochemicals

Question 14 · continued

for mark

6 (c) Alkanes, such as butane (C_4H_{10}), do **not** form polymers.

Alkenes, such as ethene (C_2H_4), do form polymers.

Explain these statements.

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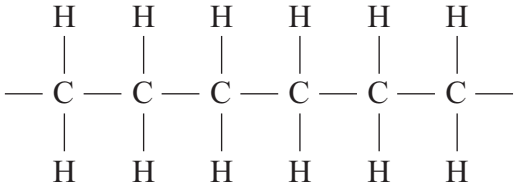
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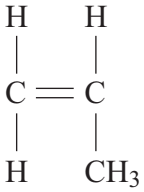
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(2 marks)

6 (d) Ethene molecules form the polymer poly(ethene). One molecule in poly(ethene) will contain thousands of carbon atoms. The diagram represents part of a poly(ethene) molecule.



Propene molecules form the polymer poly(propene).



Propene molecule

Draw a diagram to represent part of a poly(propene) molecule.

(2 marks)

9

4.7.1.2 Fractional distillation and petrochemicals

Question 15

March 2010 | CHY1AP | Original Q5 | Legacy

QUESTION FIVE

Fuel oil is a mixture of compounds, mainly hydrocarbons.

Fuel oil is obtained from crude oil by fractional distillation.

5A Which of the following hydrocarbons is an alkane?

1 CH_6

2 C_3H_6

3 C_2H_6

4 C_2H_4

5B Which of the following describes how fuel oil is obtained from crude oil during fractional distillation?

1 boiling followed by evaporation

2 evaporation followed by boiling

3 evaporation followed by condensation

4 condensation followed by evaporation

5C Which of the following is a correct list of gases that might be produced by burning fuel oil?

1 carbon dioxide, water vapour, sulfur dioxide, carbon monoxide

2 hydrogen, carbon dioxide, sulfur dioxide, carbon monoxide

3 sulfur dioxide, carbon dioxide, water vapour, hydrogen

4 carbon, water vapour, sulfur dioxide, carbon monoxide

4.7.1.2 Fractional distillation and petrochemicals

Question 15 · continued

5D Which row in the table correctly describes the type of combustion **and** a substance produced when fuel oil is burned?

	Type of combustion	Substance produced
1	Incomplete	Hydrogen
2	Complete	Carbon particles
3	Incomplete	Carbon particles
4	Complete	Carbon monoxide

Turn over for the next question

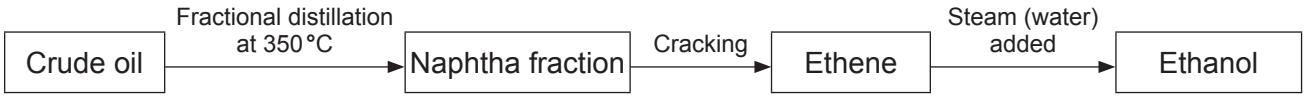
4.7.1.2 Fractional distillation and petrochemicals

Question 16

June 2010 | CHY1H | Original Q6 | Legacy

6 Petrol sold in most countries now contains at least 5% ethanol.
The production of ethanol, for use as a fuel, is being increased.

The flow diagram shows how ethanol can be produced from crude oil.



6 (a) Why does crude oil need to be fractionally distilled?

.....

.....

(1 mark)

6 (b) Hydrocarbons, such as decane, in the naphtha fraction are cracked to produce ethene.
The balanced chemical equation shows the cracking of decane.

$$\underset{\text{decane}}{C_{10}H_{22}} \rightarrow \underset{\text{octane}}{C_8H_{18}} + \underset{\text{ethene}}{C_2H_4}$$

6 (b) (i) Describe how cracking is done.

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(2 marks)

6 (b) (ii) Complete the structural formula of ethene by drawing lines to represent each covalent bond.

H H

C C

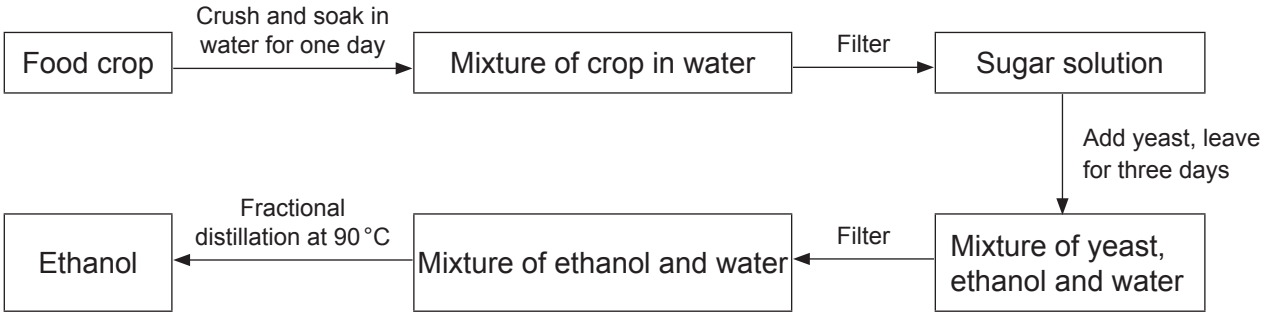
H H

(1 mark)

4.7.1.2 Fractional distillation and petrochemicals

Question 16 · continued

6 (c) The flow diagram below shows how ethanol, for use as a fuel, can also be produced from food crops.



Use the information in the two flow diagrams and your own knowledge and understanding to evaluate whether more of this ethanol should be produced from food crops or from crude oil.

Remember to give a conclusion to your evaluation.

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(5 marks)

9

4.7.1.2 Fractional distillation and petrochemicals

Question 17

November 2010 | CHY1AP | Original Q7 | Legacy

QUESTION SEVEN

This question is about crude oil and some of the alkanes that it contains.

The table shows information about four of the fractions obtained from the distillation of crude oil.

Fraction	Boiling point in °C	Number of carbon atoms in the molecules of the alkanes in the fraction
Gases	Lower than 25	1–4
Petrol	25–60	4–11
Naphtha	60–180	7–14
Kerosene	180–222	11–15

7A Which of the following is the likely boiling point for the alkane with twelve **hydrogen** atoms?

1 −16 °C

2 36 °C

3 76 °C

4 186 °C

7B Which of the following statements about the distillation of crude oil is correct?

1 It produces more alkanes than were in the original mixture.

2 It will not use up the world's fuel supplies.

3 It will contribute to global warming.

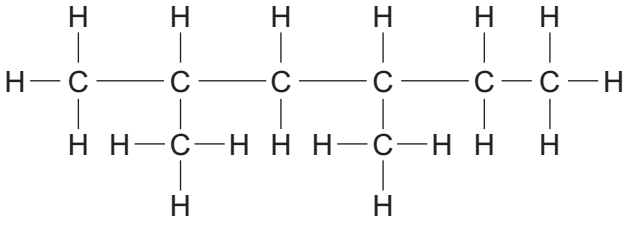
4 It is a continuous process that could go on for ever.

4.7.1.2 Fractional distillation and petrochemicals

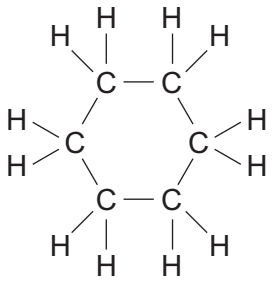
Question 17 · continued

7C Which of the following hydrocarbons would give the same number of molecules of carbon dioxide on complete combustion as octane C_8H_{18}?

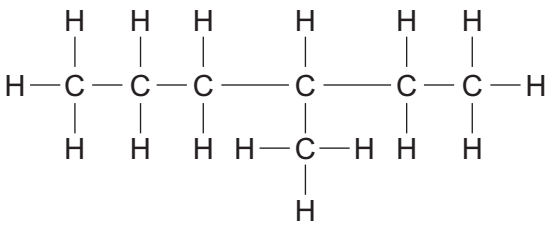
1



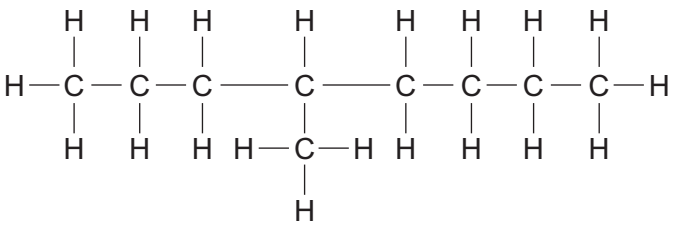
2



3



4



7D Hexane is the **sixth** member of the alkanes.

Which of the following could **not** be calculated from this information about its position in the alkane series?

1 its chemical formula

2 the number of water molecules produced by burning one molecule of hexane

3 the number of bonds in one molecule of hexane

4 the number of carbon monoxide molecules produced by the incomplete combustion of one molecule of hexane

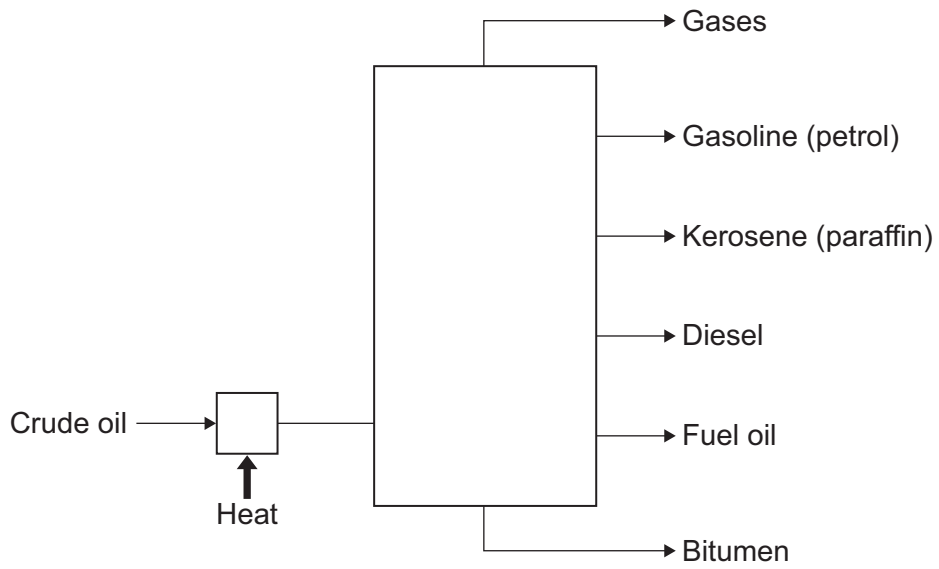
4.7.1.2 Fractional distillation and petrochemicals

Question 18

January 2011 | CHY1H | Original Q2 | Legacy

2 Crude oil is used to produce many useful materials.

2 (a) The diagram shows some of the fractions produced from crude oil by fractional distillation.



Use the diagram to help you to explain how crude oil is separated into fractions.

You should use the words evaporated and condensed in your answer.

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(3 marks)

4.7.1.2 Fractional distillation and petrochemicals

Question 18 · continued

2 (b) The table shows some information about four of the fractions from crude oil that are used as fuels.

Fraction	Boiling point in °C	Number of carbon atoms found in the molecules
Gasoline (petrol)	20 – 200	5 – 10
Kerosene (paraffin)	180 – 260	10 – 16
Diesel	260 – 340	14 – 20
Fuel oil	370 – 600	20 – 70

Use the information in the table to help you to answer these questions.

2 (b) (i) How can you tell that each of the fractions is a mixture?

.....

.....

(1 mark)

2 (b) (ii) How does the number of carbon atoms in a molecule affect its boiling point?

.....

.....

(1 mark)

2 (c) Fuels are substances that release energy.

2 (c) (i) Name the reaction that releases energy from a fuel such as gasoline (petrol).

.....

(1 mark)

2 (c) (ii) Describe how fuel oil is broken down into smaller, more useful molecules such as gasoline (petrol).

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(2 marks)

8

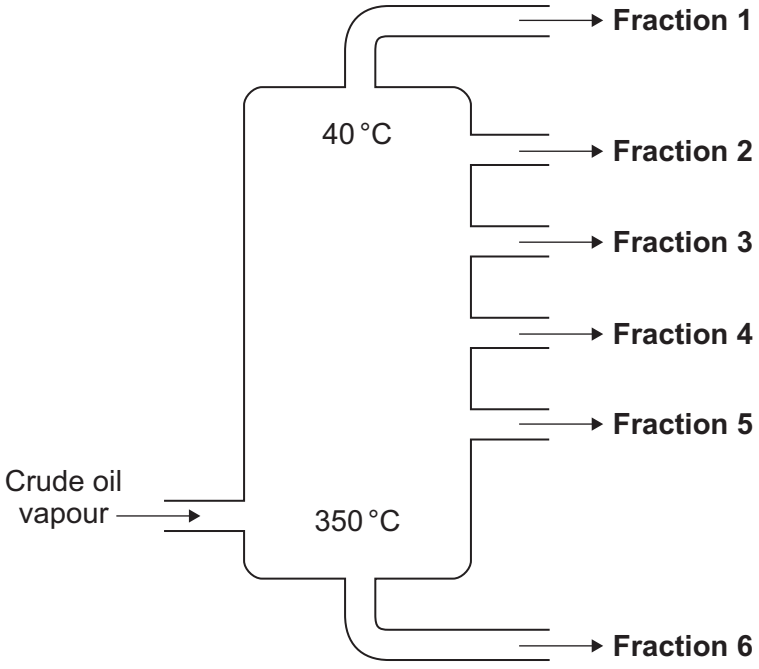
4.7.1.2 Fractional distillation and petrochemicals

Question 19

March 2011 | CHY1AP | Original Q5 | Legacy

QUESTION FIVE

Crude oil can be separated into fractions by fractional distillation.



5A The fractions can be separated in this way because the hydrocarbons in the crude oil . . .

1 have different chemical properties.

2 are compounds containing only two elements.

3 are gases, liquids and solids.

4 have different boiling points.

5B Each fraction will contain . . .

1 a single alkane.

2 alkanes with the same chemical formula.

3 a mixture of alkanes.

4 alkanes with the same number of carbon atoms in each molecule.

4.7.1.2 Fractional distillation and petrochemicals

Question 19 · continued

March 2011 | CHY1AP | Original Q5 | Legacy

5C When compared with **Fraction 5**, **Fraction 3** . . .

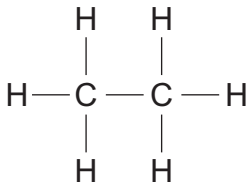
1 will be more difficult to ignite.

2 will be more volatile.

3 will be more viscous.

4 will have boiling points in a higher range.

5D The diagram shows a molecule of an alkane.



In which fraction will most of this alkane be found?

1 **Fraction 1**

2 **Fraction 2**

3 **Fraction 4**

4 **Fraction 6**

4.7.1.2 Fractional distillation and petrochemicals

Question 20

June 2011 | CHY1AP | Original Q4 | Legacy

QUESTION FOUR

Crude oil is a mixture made up mainly of alkanes.

4A The alkanes are a series of hydrocarbons . . .

1 all of which are gases at room temperature (20 °C).

2 that have the general formula C_nH_{2n}.

3 in which the molecules have a carbon : hydrogen ratio of 1 : 4.

4 that are saturated.

Crude oil can be separated into fractions by fractional distillation.

4B In the fractionating column, the crude oil separates into fractions because . . .

1 the crude oil changes from a liquid into a vapour.

2 the alkanes condense at different temperatures.

3 the crude oil decomposes when it is heated.

4 the alkanes have different densities.

4C The petrol fraction has a boiling range from 40 °C to 70 °C.

The fraction does not have a fixed boiling point because it . . .

1 contains only one alkane.

2 contains several alkanes.

3 collects near the top of the column.

4 decomposes at 40 °C.

4D The petrol fraction is used as a fuel. Ethanol (C_2H_5OH), made from plant material, can be used as a fuel instead of petrol.

One advantage of ethanol over petrol is that ethanol . . .

1 does not produce carbon dioxide when it burns.

2 is a renewable fuel.

3 produces only water when it burns.

4 is a compound, not a mixture.

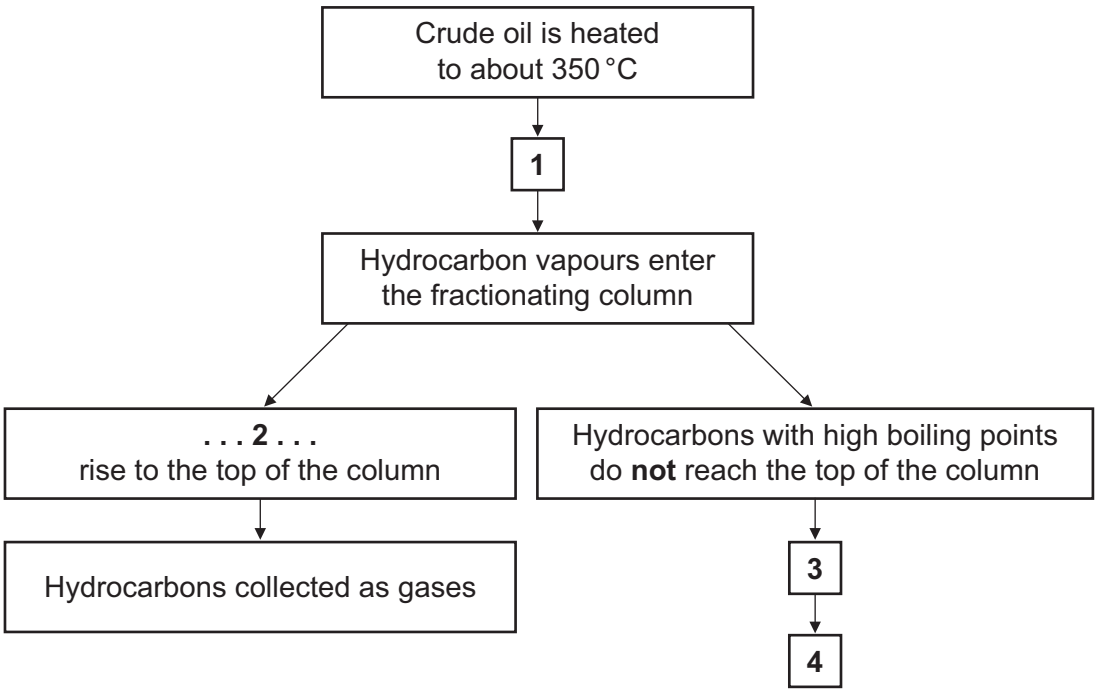
4.7.1.2 Fractional distillation and petrochemicals

Question 21

November 2011 | CHY1AP | Original Q2 | Legacy

QUESTION TWO

The flow chart shows stages in the fractional distillation of crude oil.



Match statements, **A**, **B**, **C** and **D**, with the numbers **1–4** in the flow chart.

A Hydrocarbons turn to vapour

B Hydrocarbons cool

C Hydrocarbons with low boiling points

D Hydrocarbons condense to form liquids

4.7.1.2 Fractional distillation and petrochemicals

Question 22

January 2012 | CH1HP | Original Q7 | Legacy

7 Ethene is used as a starting material for the production of many other substances, including ethanol.

7 (a) Ethene is produced when hydrocarbons are cracked. To do this hydrocarbons are heated to vaporise them. The vapours are then passed over a hot catalyst. The symbol equation shows the reaction for one hydrocarbon.

$$C_{28}H_{58} \rightarrow C_{11}H_{24} + C_{11}H_{22} + C_4H_8 + C_2H_4$$

7 (a) (i) One of the products is a different type of hydrocarbon to the other products.

Complete the sentences.

The formula of the product that is a different type of hydrocarbon is ..... .

The chemical structure of this product is different to the other products because

.....

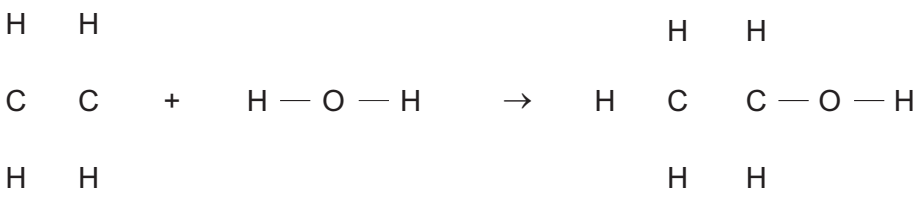
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(2 marks)

7 (a) (ii) Ethanol is produced when ethene reacts with steam in the presence of a hot catalyst.

Draw the missing bonds to complete the displayed structures in the equation.

ethene steam ethanol



(2 marks)

7 (b) *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.*

In 1970, the Brazilian Government had stated that all petrol must contain more than 25% ethanol. The reasons for this statement in 1970 were:

- the oilfields in Brazil at that time only supplied 20% of the crude oil needed to make petrol
- Brazil has a climate suitable for growing sugar cane.

To produce ethanol the sugar cane plants are crushed and soaked in water for one day. The sugar solution is separated from the plant material by filtration. Yeast is added to the sugar solution and fermented for three days. The yeast is separated from the solution of water and ethanol by filtration. Ethanol is separated from water by fractional distillation.

4.7.1.2 Fractional distillation and petrochemicals

Question 22 · continued

In 2011, the Brazilian Government decided to reduce the amount of ethanol in petrol to 18%. The reasons were that in 2011:

- the demand for ethanol and the price of ethanol had greatly increased
- very large offshore oilfields had been discovered. These offshore oilfields would make Brazil one of the biggest crude oil producers in the world.

Use the information above and your own knowledge and understanding to evaluate whether Brazil should in future produce ethanol from crude oil or produce ethanol from sugar cane.

You should include environmental and economic or social factors in your evaluation.

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(6 marks)

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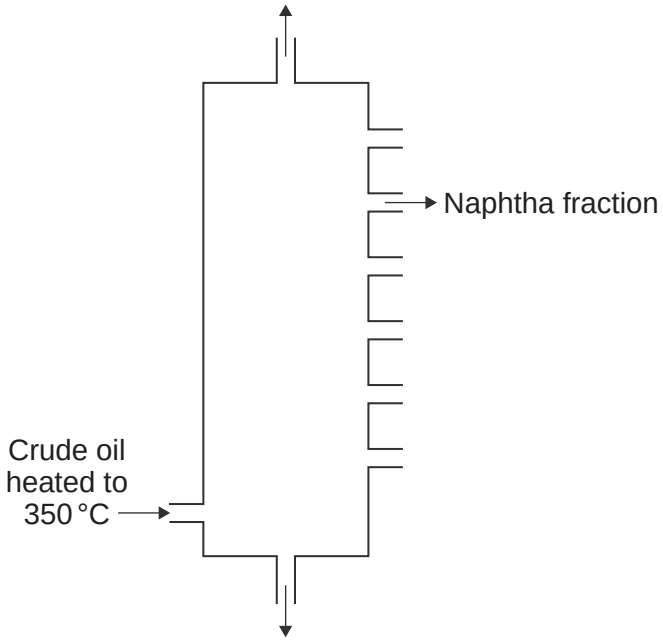
4.7.1.2 Fractional distillation and petrochemicals

Question 23

June 2012 | CH1HP | Original Q3 | Legacy

3 Crude oil is used to produce poly(ethene).

3 (a) Fractional distillation is used to separate crude oil into fractions.



3 (a) (i) Write a number, **2**, **3**, **4** or **5**, next to each stage so that the description of fractional distillation is in the correct order. Numbers **1** and **6** have been done for you.

Number	Stage
1	The crude oil is heated to 350 °C.
	When a fraction in the vapours cools to its boiling point, the fraction condenses.
	Any liquids flow down to the bottom of the column and the hot vapours rise up the column.
6	The condensed fraction is separated and flows out through a pipe.
	When the hot vapours rise up the column, the vapours cool.
	Most of the compounds in the crude oil evaporate.

(2 marks)

3 (a) (ii) The naphtha fraction is cracked to produce ethene (C_2H_4).
Ethene is used to make the polymer called poly(ethene).

Name **two** substances produced when poly(ethene) burns in air.

1 .....

2 .....

(2 marks)

4.7.1.2 Fractional distillation and petrochemicals

Question 23 · continued

3 (b) *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.*

Each year in the UK, billions of plastic bags are given free to shoppers. These bags are made from poly(ethene) and are often used only once.
After being used many of these plastic bags are either thrown away as litter or buried in landfill sites.

In 2006 over 10 billion of these plastic bags were given free to shoppers.
In 2009 the number of plastic bags given to shoppers had decreased to 6.1 billion.
One reason for the decrease was because some supermarkets made people pay for their plastic bags.

From 2011 a new type of plastic shopping bag made mainly from poly(ethene) had a use-by date of only one year printed on the bag.

Use the information above and your knowledge and understanding to describe advantages and disadvantages of using plastic shopping bags made from poly(ethene).

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(6 marks)

10

4.7.1.2 Fractional distillation and petrochemicals

Question 24

January 2013 | CH1HP | Original Q3 | Legacy

3 This question is about oil reserves.

3 (a) Diesel is separated from crude oil by fractional distillation.

Describe the steps involved in the fractional distillation of crude oil.

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(3 marks)

3 (b) Diesel is a mixture of lots of different *alkanes.*

What are *alkanes*?

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(2 marks)

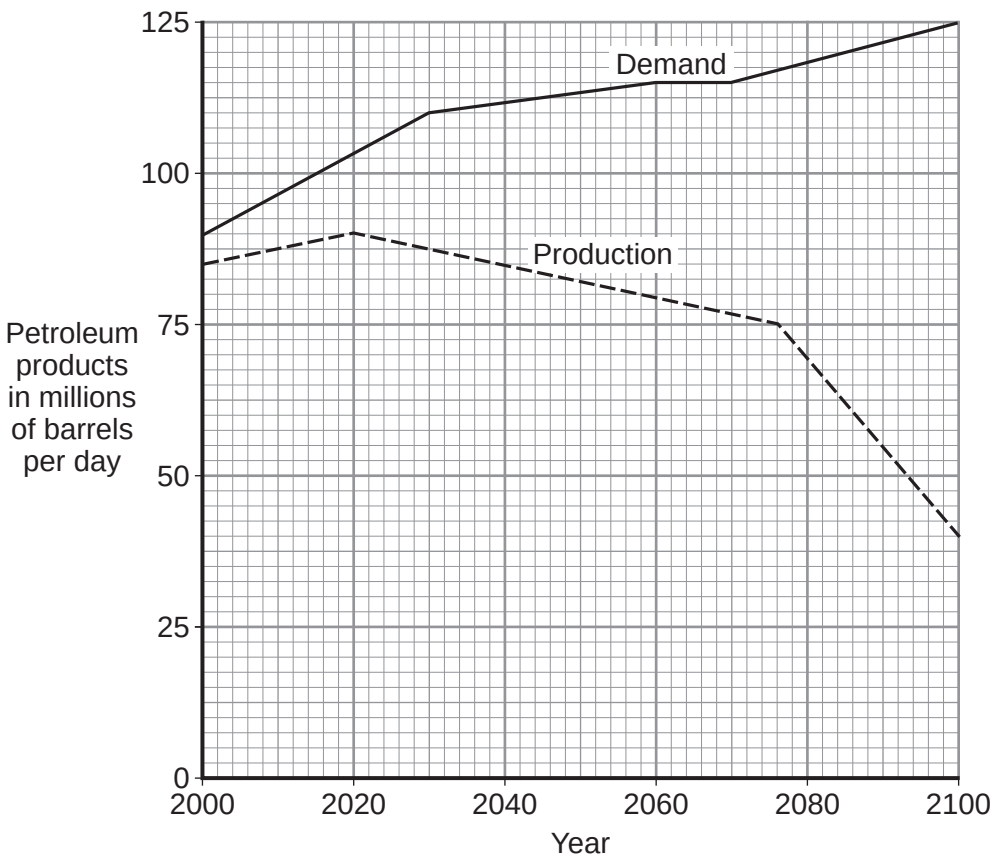
Question 3 continues on the next page

4.7.1.2 Fractional distillation and petrochemicals

Question 24 · continued

3 (c) *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.*

Petroleum products, such as petrol, are produced from crude oil.
The graph shows the possible future production of petroleum products from crude oil and the expected demand for petroleum products.



Canada's oil sands hold about 20% of the world's known crude oil reserves.

The oil sands contain between 10 to 15% of crude oil. This crude oil is mainly bitumen.

In Canada the oil sands are found in the ground underneath a very large area of forest. The trees are removed. Then large diggers and trucks remove 30 metres depth of soil and rock to reach the oil sands. The oil sands are quarried. Boiling water is mixed with the quarried oil sands to separate the bitumen from the sand. Methane (natural gas) is burned to heat the water.

The mixture can be separated because bitumen floats on water and the sand sinks to the bottom of the water. The bitumen is cracked and the products are separated by fractional distillation.

4.7.1.2 Fractional distillation and petrochemicals

Question 24 · continued

Use the information on page 8 and your knowledge and understanding to suggest the advantages and disadvantages of extracting petroleum products from oil sands.

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(6 marks)

11

4.7.1.2 Fractional distillation and petrochemicals

Question 25

June 2016 | CH1HP | Original Q2 | Legacy

2 This question is about hydrocarbons.

2 (a) Most of the hydrocarbons in crude oil are alkanes.

2 (a) (i) Large alkane molecules can be cracked to produce more useful molecules.

The equation shows the cracking of dodecane.

$$\underset{\text{dodecane}}{C_{12}H_{26}} \longrightarrow \underset{\text{butane}}{C_4H_{10}} + \underset{\text{hexene}}{C_6H_{12}} + \underset{\text{ethene}}{C_2H_4}$$

Give **two** conditions used to crack large alkane molecules.

[2 marks]

1 _____

2 _____

2 (a) (ii) The products hexene and ethene are alkenes.

Complete the sentence.

[1 mark]

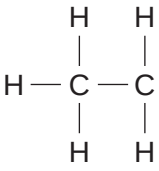
When alkenes react with bromine water the colour changes

from orange to _____ .

2 (a) (iii) Butane (C_4H_{10}) is an alkane.

Complete the displayed structure of butane.

[1 mark]



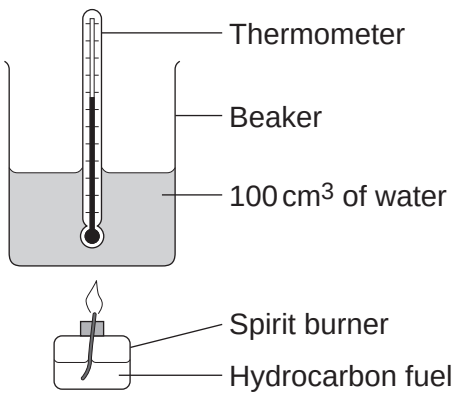
Question 2 continues on the next page

Question 25 · continued

2 (b) A group of students investigated the energy released by the combustion of four hydrocarbon fuels.

Figure 3 shows the apparatus used.

Figure 3



Each hydrocarbon fuel was burned for two minutes.

Table 1 shows the students' results.

Table 1

	After two minutes				
Name and formula of hydrocarbon fuel	**Mass of fuel used in g**	**Temperature increase of water in °C**	**Energy released by fuel in kJ**	**Energy released by 1.0 g of fuel in kJ**	**Relative amount of smoke in the flame**
Hexane, C_6H_{14}	0.81	40	16.80	20.74	very little smoke
Octane, C_8H_{18}	1.10	54	22.68	20.62	some smoke
Decane, $C_{10}H_{22}$	1.20	58	24.36		smoky
Dodecane, $C_{12}H_{26}$	1.41	67	28.14	19.96	very smoky

4.7.1.2 Fractional distillation and petrochemicals

Question 25 · continued

2 (b) (i) Calculate the energy released by 1.0 g of decane in kJ.

[2 marks]

Energy released = _____ kJ

2 (b) (ii) Suggest **one** improvement to the apparatus, or the use of the apparatus, that would make the temperature increase of the water for each fuel more accurate.

Give a reason why this is an improvement.

[2 marks]

2 (b) (iii) The students noticed that the bottom of the beaker became covered in a black substance when burning these fuels.

Name this black substance.

Suggest why it is produced.

[2 marks]

2 (b) (iv) A student concluded that hexane is the best of the four fuels.

Give **two** reasons why the results in **Table 1** support this conclusion.

[2 marks]

1 _____

2 _____

Question 2 continues on the next page

4.7.1.2 Fractional distillation and petrochemicals

Question 25 · continued

2 (c) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

Most car engines use petrol as a fuel.

- Petrol is produced from the fractional distillation of crude oil.
- Crude oil is a mixture of hydrocarbons.
- Sulfur is an impurity in crude oil.

Car engines could be developed to burn hydrogen as a fuel.

- Hydrogen is produced from natural gas.
- Natural gas is mainly methane.

Table 2 shows information about petrol and hydrogen.

Table 2

	Petrol	**Hydrogen**
State of fuel at room temperature	Liquid	Gas
Word equation for combustion of the fuel	petrol + oxygen ⟶ carbon dioxide + water	hydrogen + oxygen ⟶ water
Energy released from combustion of 1 g of the fuel	47 kJ	142 kJ

Describe the **advantages** and **disadvantages** of using hydrogen instead of petrol in car engines.

Use the information given and your knowledge and understanding to answer this question.

[6 marks]

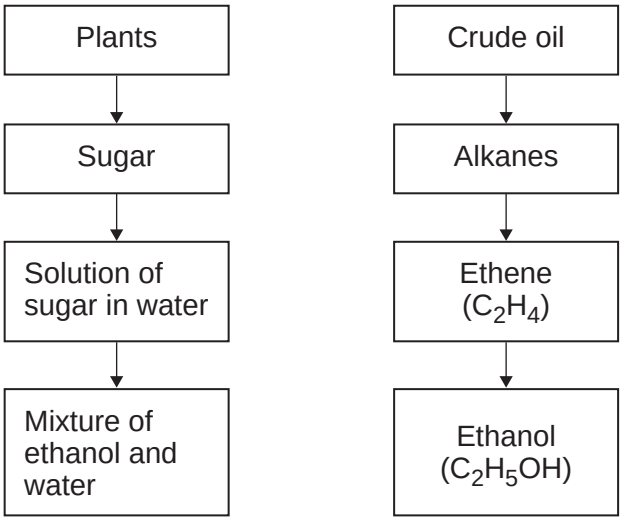
4.7.1.2 Fractional distillation and petrochemicals

Question 26

June 2016 | CH1HP | Original Q4 | Legacy

4 Ethanol can be made from plants and from crude oil as shown in **Figure 6.**

Figure 6



4 (a) (i) Describe how the solution of sugar in water is used to produce the mixture of ethanol and water.

[2 marks]

4 (a) (ii) Describe how ethanol is produced from ethene.

[2 marks]

4.7.1.2 Fractional distillation and petrochemicals

Question 26 · continued

4 (b) Explain **one** advantage and **one** disadvantage of using crude oil to make ethanol instead of using plants.

[4 marks]

4 (c) Ethanol has a boiling point of 78 °C.
Water has a boiling point of 100 °C.

Describe how distillation is used to separate a mixture of ethanol and water.

[3 marks]

11

4.7.1.2 Fractional distillation and petrochemicals

Question 27

June 2017 | CH1HP | Original Q5 | Legacy

5 This question is about the Earth's atmosphere.

5 (a) The Earth's early atmosphere was a mixture of gases.

One theory is that the Earth's early atmosphere had the composition shown in **Table 4**.

Table 4

Gas	Percentage in Earth's early atmosphere (%)
Carbon dioxide	96
Nitrogen	3.5
Oxygen	a trace
Other gases including methane, ammonia, hydrogen and water vapour	0.5

5 (a) (i) Amino acids are at the basis of all life processes.
The simplest amino acid is glycine, NH_2CH_2COOH

Two scientists, Miller and Urey, showed that they could produce glycine from a mixture of methane, ammonia, hydrogen and water.
Miller and Urey concluded that this is how life was formed on Earth.

Suggest **one** reason why this conclusion may **not** be correct.

[1 mark]

5 (a) (ii) Give **three** reasons why the percentage of carbon dioxide in the Earth's atmosphere today is less than the percentage of carbon dioxide in the Earth's early atmosphere.

[3 marks]

4.7.1.2 Fractional distillation and petrochemicals

Question 27 · continued

5 (b) **Table 5** shows the boiling points of some gases in the air.

Table 5

Gas	Boiling point in °C
Nitrogen	–196
Oxygen	–183
Carbon dioxide	–79*
Helium	–269
Neon	–246
Argon	–186

*freezes at this temperature

Oxygen from the air is separated by fractional distillation. To do this separation the air is cooled to –200 °C. Most of the gases condense.

5 (b) (i) Name the two gases that would **not** condense at –200 °C.

[1 mark]

_____ and _____

5 (b) (ii) Suggest why carbon dioxide is removed before the air is cooled.

[1 mark]

_____

_____

5 (b) (iii) The liquid at –200 °C is passed into a fractionating column.

Explain why one of the fractions is a mixture of oxygen and one other gas.

[2 marks]

_____

_____

_____

_____

4.7.1.2 Fractional distillation and petrochemicals

Question 27 · continued

5 (c) Oxygen is used in the production of steel.

Cast iron from a blast furnace contains 96% iron and 4% carbon.

The stages for the production of steel from cast iron are:

Stage 1 pass oxygen into molten cast iron

Stage 2 add small amounts of other metals.

Explain why each stage is needed in the production of steel.

[4 marks]

12

4.7.1.2 Fractional distillation and petrochemicals

Question 28

June 2019 | 8462/2H | Original Q1

0 1 This question is about crude oil and hydrocarbons.

Figure 1 shows a fractionating column used to separate crude oil into fractions.

Figure 1

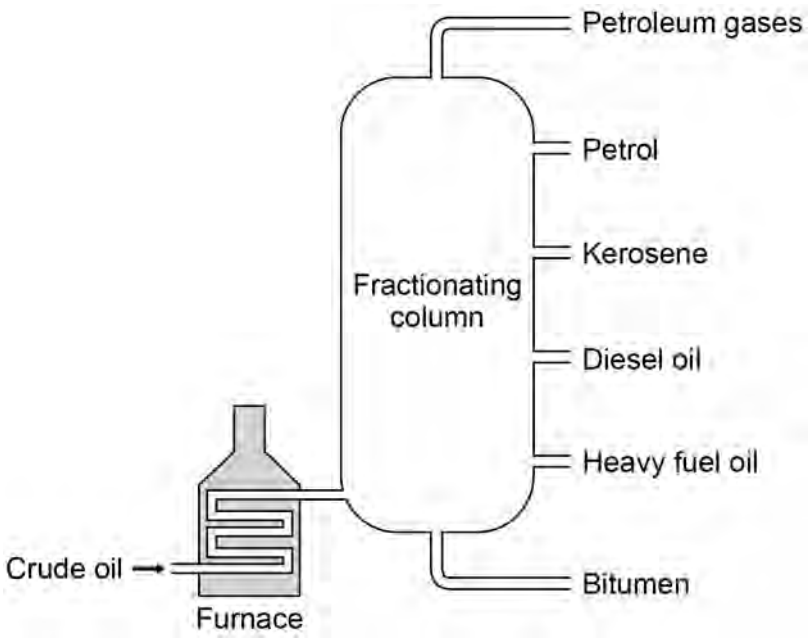


Table 1 gives information about some of the fractions.

Table 1

Fraction	Boiling point range in °C
Petroleum gases	Below 30
Petrol	40–110
Kerosene	180–260
Diesel oil	260–320
Heavy fuel oil	320–400
Bitumen	400–450

4.7.1.2 Fractional distillation and petrochemicals

Question 28 · continued

0 1 . 1 Suggest a suitable temperature for the furnace in **Figure 1**.

[1 mark]

_____ °C

0 1 . 2 Explain why diesel oil collects above heavy fuel oil but below kerosene in the fractionating column.

Use **Table 1**.

[2 marks]

_____

_____

_____

_____

0 1 . 3 Suggest **two** reasons why bitumen is **not** used as a fuel.

[2 marks]

1 _____

_____

2 _____

_____

Question 1 continues on the next page

4.7.1.2 Fractional distillation and petrochemicals

Question 28 · continued

0 1 . 4 Petrol contains mainly alkanes.

Which of the following compounds is an alkane?

[1 mark]

Tick (✓) **one** box.

C_2H_4 ☐

C_4H_8 ☐

C_6H_{14} ☐

C_8H_{16} ☐

Large hydrocarbon molecules in the diesel oil fraction are cracked to produce smaller hydrocarbon molecules.

0 1 . 5 Describe the conditions needed to crack hydrocarbon molecules from the diesel oil fraction.

[2 marks]

4.7.1.2 Fractional distillation and petrochemicals

Question 28 · continued

0 1 . 6 Explain why large hydrocarbon molecules in the diesel oil fraction are cracked to produce smaller hydrocarbon molecules.

[2 marks]

0 1 . 7 Complete the equation for the cracking of $C_{15}H_{32}$

[1 mark]

$$C_{15}H_{32} \rightarrow C_{12}H_{26} + _____$$

11

Turn over for the next question

4.7.1.2 Fractional distillation and petrochemicals

Question 29

November 2021 | 8462/2H | Original Q2

0 2 This question is about alkanes.

Table 1 shows information about some alkanes.

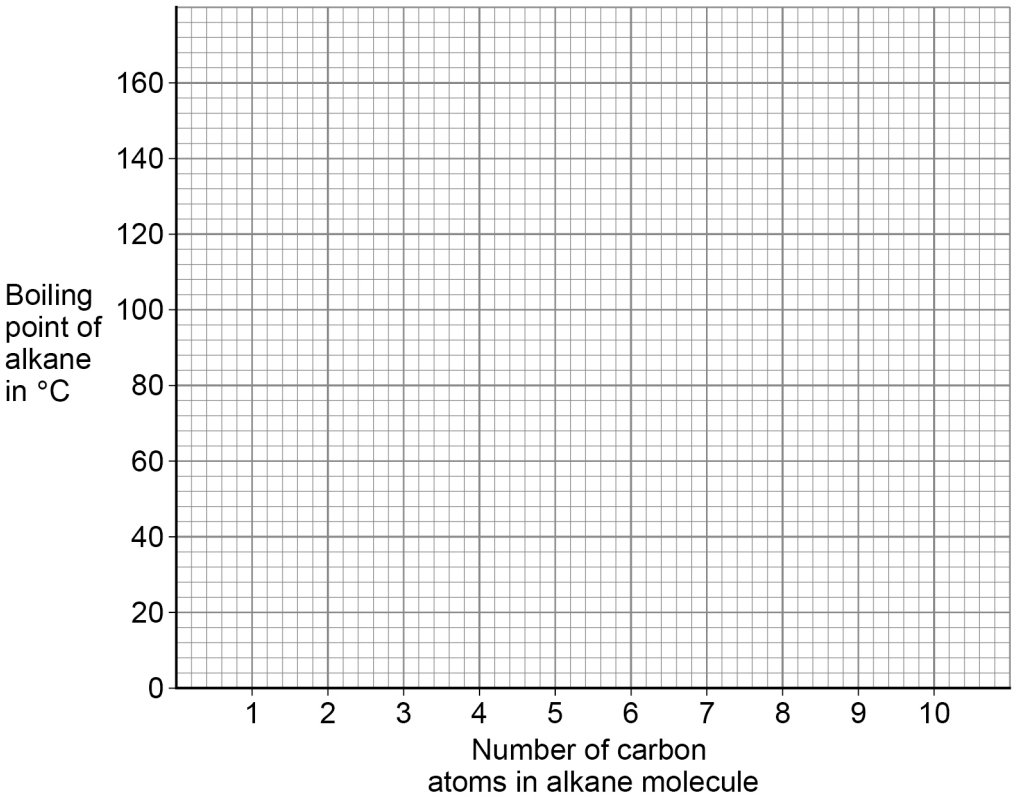
Table 1

Number of carbon atoms in alkane molecule	Boiling point of alkane in °C
4	0
5	36
6	69
7	**X**
8	126
9	151

0 2 . 1 Plot the data from **Table 1** on **Figure 2**.

[2 marks]

Figure 2



4.7.1.2 Fractional distillation and petrochemicals

Question 29 · continued

0 2 . 2 Predict the boiling point **X** of the alkane with seven carbon atoms in a molecule.

Use **Table 1** and **Figure 2**.

[1 mark]

X = _____ °C

0 2 . 3 **Figure 2** is **not** suitable to show the boiling point of the alkane with three carbon atoms in a molecule.

Suggest **one** reason why.

[1 mark]

_____

_____

0 2 . 4 What is the state at 20 °C of the alkane with four carbon atoms in a molecule?

Use **Table 1**.

[1 mark]

_____

Question 2 continues on the next page

Question 29 · continued

Table 1 is repeated below.

Table 1

Number of carbon atoms in alkane molecule	Boiling point of alkane in °C
4	0
5	36
6	69
7	**X**
8	126
9	151

The alkane with nine carbon atoms in a molecule is called nonane.

0 2 . 5 Complete the formula of nonane.

[1 mark]

C_9H____

0 2 . 6 Nonane will condense lower in a fractionating column during fractional distillation than the other alkanes in **Table 1**.

Explain why.

You should refer to the temperature gradient in the fractionating column.

[2 marks]

8

4.7.1.2 Fractional distillation and petrochemicals

Question 30

November 2021 | 8462/2H | Original Q10

1 0 This question is about alkenes and alcohols.

Ethene is an alkene produced from large hydrocarbon molecules.

Large hydrocarbon molecules are obtained from crude oil by fractional distillation.

1 0 . 1 Name the process used to produce ethene from large hydrocarbon molecules.

[1 mark]

1 0 . 2 Describe the conditions used to produce ethene from large hydrocarbon molecules.

[2 marks]

4.7.1.2 Fractional distillation and petrochemicals

Question 30 · continued

10.3 Ethanol can be produced from ethene and steam.

The equation for the reaction is:

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

The forward reaction is exothermic.

Explain how the conditions for this reaction should be chosen to produce ethanol as economically as possible.

[6 marks]

4.7.1.2 Fractional distillation and petrochemicals

Question 30 · continued

10.4 Ethanol can also be produced from sugar solution by adding yeast.

Name this process.

[1 mark]

10.5 Butanol can be produced from sugar solution by adding bacteria.

Sugar solution is broken down in similar ways by bacteria and by yeast.

Suggest the reaction conditions needed to produce butanol from sugar solution by adding bacteria.

[2 marks]

4.7.1.2 Fractional distillation and petrochemicals

Question 30 · continued

Ethanol and butanol can be used as fuels for cars.

10.6 A car needs an average of 1.95 kJ of energy to travel 1 m

Ethanol has an energy content of 1300 kilojoules per mole (kJ/mol).

Calculate the number of moles of ethanol needed by the car to travel 200 km

[3 marks]

Number of moles = _____ mol

10.7 When butanol is burned in a car engine, complete combustion takes place.

Write a balanced equation for the complete combustion of butanol.

You do **not** need to include state symbols.

[2 marks]

17

4.7.1.2 Fractional distillation and petrochemicals

Question 31

June 2022 | 8462/2H | Original Q4

0 4 This question is about the fractions obtained from crude oil.

0 4 . 1 Crude oil is separated into fractions by fractional distillation.

The fractions obtained from crude oil include:

- lubricating oil
- naphtha
- petroleum gases.

Table 3 shows the boiling point range of these fractions.

Table 3

Fraction	Boiling point range in °C
Lubricating oil	300–350
Naphtha	90–200
Petroleum gases	< 25

Explain how these fractions are obtained from crude oil by fractional distillation.

[4 marks]

Question 31 · continued

0 4 . 2 Fractions from crude oil can be processed to produce feedstock for the petrochemical industry.

Which **two** are useful materials produced from this feedstock?

[2 marks]

Tick (✓) **two** boxes.

- Alloys ☐
- Ceramics ☐
- Detergents ☐
- Fertilisers ☐
- Solvents ☐

Another fraction obtained from crude oil is petrol.

0 4 . 3 Petrol contains a hydrocarbon with the formula C_9H_{20}

Complete the equation for the complete combustion of C_9H_{20}

You should balance the equation.

[2 marks]

C_9H_{20} + _____ → _____ + _____

0 4 . 4 Petrol obtained from crude oil contains sulfur impurities.

Explain why sulfur impurities are removed before petrol is burned in car engines.

[2 marks]

0 4 . 5 **Table 4** shows information about two more fractions obtained from crude oil.

Table 4

Fraction	Range of number of carbon atoms in each molecule
Kerosene	11–15
Heavy fuel oil	20–40

A student predicted that heavy fuel oil is more viscous than kerosene.

The student's prediction was correct.

Justify the student's prediction.

[2 marks]

4.7.1.2 Fractional distillation and petrochemicals

Question 31 · continued

The heavy fuel oil fraction can be processed to produce smaller hydrocarbon molecules.

0 4 . 6 Name the process which produces smaller hydrocarbon molecules from heavy fuel oil.

Give the conditions used in this process.

[3 marks]

Name of process _____

Conditions _____

_____

_____

0 4 . 7 Hydrocarbon molecules containing seven and eight carbon atoms can be produced when heavy fuel oil is processed.

Which pair of hydrocarbon molecules would **both** turn bromine water colourless?

[1 mark]

Tick (✓) **one** box.

C_7H_{14} and C_8H_{16} ☐

C_7H_{14} and C_8H_{18} ☐

C_7H_{16} and C_8H_{16} ☐

C_7H_{16} and C_8H_{18} ☐

16

4.7.1.2 Fractional distillation and petrochemicals

Question 32

June 2024 | 8462/2H | Original Q5

0 5 This question is about burning fuels in central heating boilers.

In the future, gas central heating boilers may burn hydrogen rather than natural gas.

Table 2 shows information about these fuels when 1 dm^3 of the fuel is burned in a central heating boiler.

Table 2

	Fuel	
	Hydrogen	**Natural gas**
Energy released in kJ	11.9	37.1
Mass of carbon dioxide produced in grams	0.00	1.83
Mass of water vapour produced in grams	0.75	1.50
Mass of oxides of nitrogen produced in grams	6.6×10^{-4}	4.9×10^{-4}

0 5 . 1 Explain how oxides of nitrogen are produced when burning fuels.

[2 marks]

4.7.1.2 Fractional distillation and petrochemicals

Question 32 · continued

0 5 . 2 Explain **one** positive impact on the environment of burning hydrogen rather than natural gas as a fuel.

Use **Table 2**.

[2 marks]

0 5 . 3 Explain **one** negative impact on the environment of burning hydrogen rather than natural gas as a fuel.

Use **Table 2**.

[2 marks]

Question 5 continues on the next page

4.7.1.2 Fractional distillation and petrochemicals

Question 32 · continued

0 5 . 4 Air is 20% oxygen.

Calculate the volume of air needed to provide enough oxygen to react with 3.50 dm^3 of hydrogen gas.

The equation for the reaction is

$$2\ H_2 + O_2 \rightarrow 2\ H_2O$$

[3 marks]

Volume of air = _____ dm^3

0 5 . 5 Central heating boilers can also burn kerosene.

Kerosene is produced from crude oil in a fractionating column using fractional distillation.

In the first step, crude oil is heated and hydrocarbon vapours are formed.

Explain how kerosene is produced from these hydrocarbon vapours.

[3 marks]

12