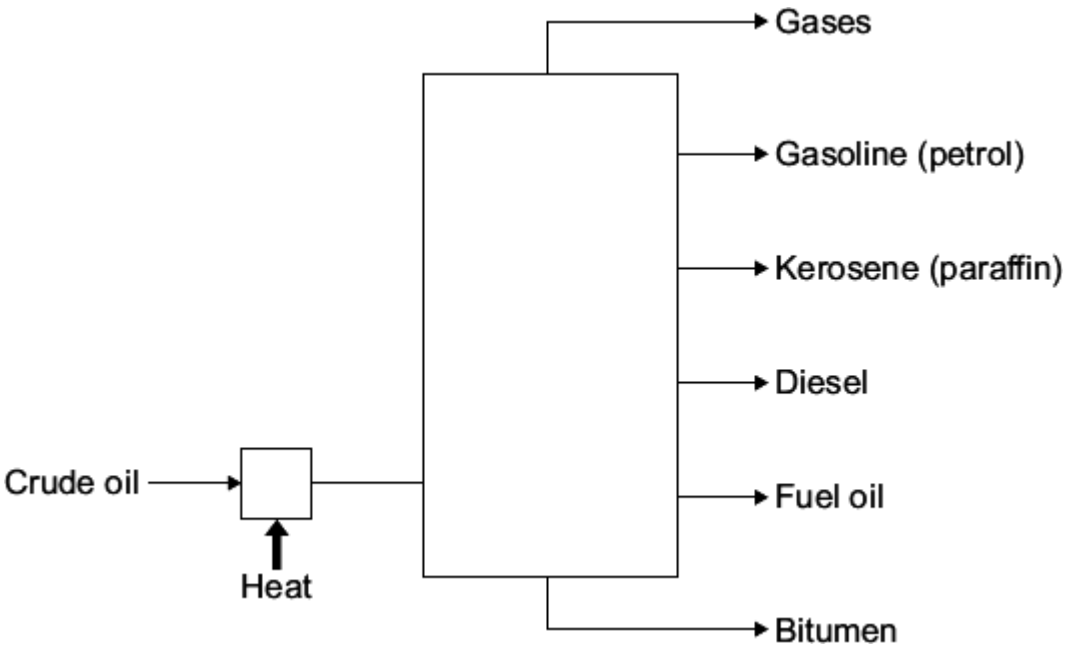
1 Crude oil is used to produce many useful materials.

(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.

(3)

(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.

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

_____

_____

(1)

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

_____

_____

(1)

(c) Fuels are substances that release energy.

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

_____

(1)

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

_____

_____

_____

_____

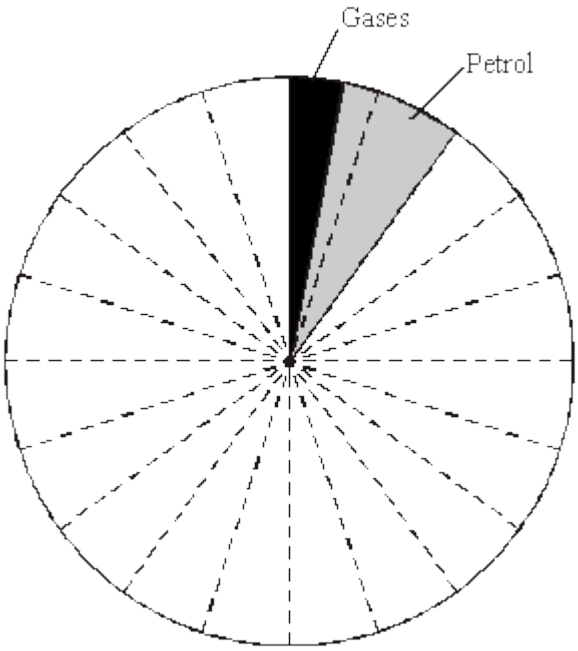
(2)

(Total 8 marks)

2 The table shows the composition of some crude oil.

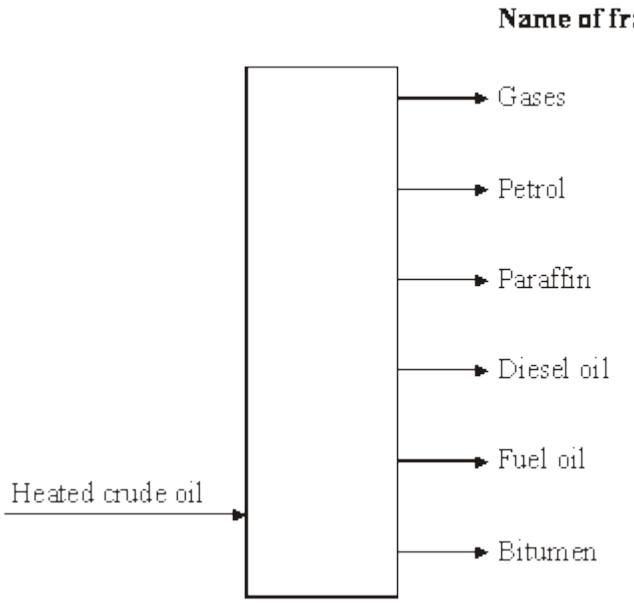
Fraction	Percentage in crude oil
Gases	3
Petrol	7
Naphtha	10
Kerosine	15
Gas oil	20
Fuel oil	45

(a) Complete the pie chart for the composition of this crude oil. Remember to label the chart.



(3)

(b) The diagram shows the process of separating a different sample of crude oil into fractions.



(i) What is the name given to this process?

_____

(1)

(ii) Which fraction has the lowest boiling point?

_____

(1)

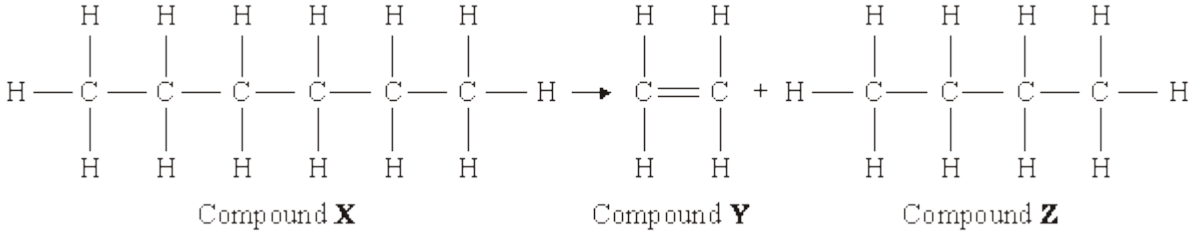
(iii) Which fraction is the least volatile?

_____

(1)

(Total 6 marks)

3 The diagram shows a reaction which takes place in an oil refinery.



(a) **X**, **Y** and **Z** are all examples of which type of compound?

_____

(1)

(b) What type of chemical reaction takes place when compound **X** is converted into compounds **Y** and **Z**?

_____

(1)

(c) Compounds **Y** and **Z** are both useful substances.

Compound **Y** is unsaturated. Compound **Z** is saturated.

(i) Suggest **one** use for compound **Y**.

_____

(1)

(ii) Suggest **one** use for compound **Z**.

_____

(1)

(Total 4 marks)

4 Crude oil and natural gas are mixtures of hydrocarbons. They are obtained from wells drilled into rocks where they are trapped.

(a) (i) What is the name of the process used to separate the different hydrocarbons in crude oil?

_____

(1)

(ii) Methane is one of the gases obtained when crude oil is separated.

Give the name of another hydrocarbon gas obtained from this process.

_____

(1)

(b) A fuel used in gas cookers is natural gas. It is mainly methane, CH_4.

(i) Complete the word equation for the complete combustion of methane.

methane + oxygen → _____ + _____

(2)

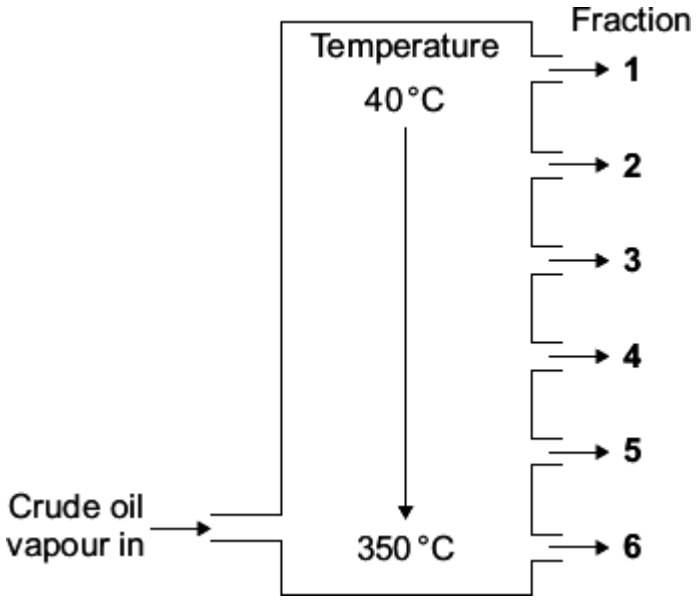
(ii) What different gas is produced by the incomplete combustion of methane?

_____

(1)

(Total 5 marks)

5 Crude oil is a mixture of hydrocarbons.
Crude oil can be separated into fractions.



(a) (i) Complete the sentence.

The process used to separate the crude oil into fractions is called

fractional _____ .

(1)

(ii) Why do the fractions separate at different temperatures?

_____

_____

(1)

(b) Tick (✓) **two** properties of fraction **6**.

Property	Tick (✓)
contains hydrocarbons	
has a small number of carbon atoms in each molecule	
is easy to ignite	
has a high boiling point	

(2)

(c) Fraction **1** contains hydrocarbons called alkanes.
The general formula of an alkane is: C_nH_{2n+2}

What is the formula of the alkane that has 5 carbon atoms in each molecule?

Draw a ring around the correct answer.

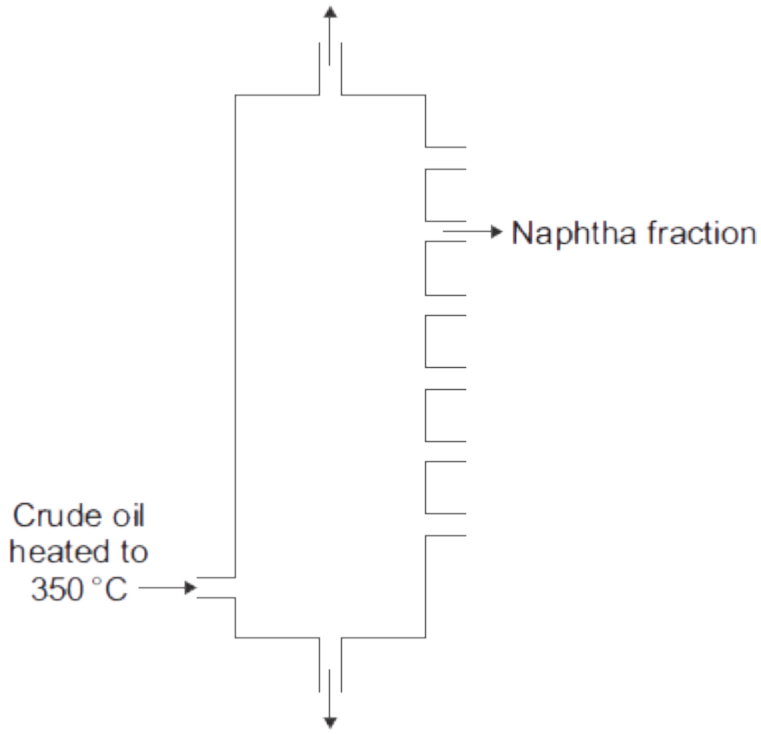
C_5H_9 **C_5H_{10}** **C_5H_{11}** **C_5H_{12}**

(1)

(Total 5 marks)

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

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



(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)

(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)

(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).

(6)

(Total 10 marks)

7 (a) Alkenes can be made by cracking large alkane molecules.

(i) Explain how the cracking process is carried out.

(2)

(ii) Give a chemical test which would show the difference between an alkene and an alkane.

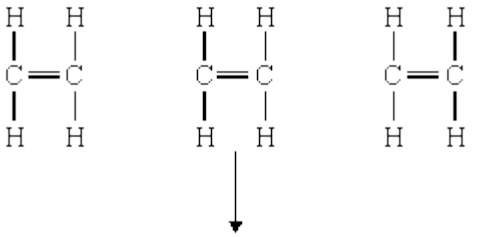
Test _____

Result of test _____

(2)

(b) Alkenes, such as ethene, can be made into polymers.

(i) Complete the following to show how the ethene molecules bond to form part of a polymer.



(1)

(ii) Name the polymer formed from ethene.

_____

(1)

(iii) Explain **one** important problem caused by the everyday use of this polymer.

_____

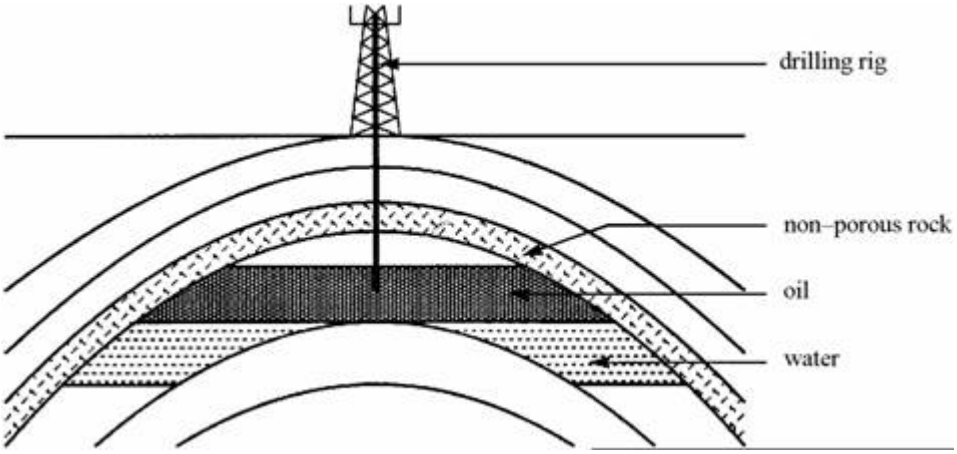
_____

_____

(2)

(Total 8 marks)

8 Crude oil is obtained by drilling into the Earth's crust. The diagram shows a section through the Earth's crust to show how this is done.

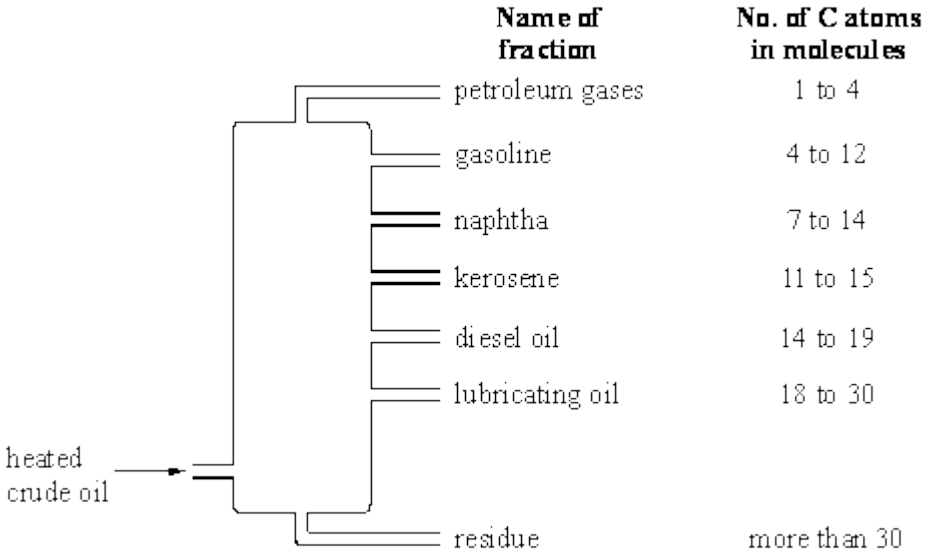


(a) Crude oil contains many hydrocarbons. Which elements do hydrocarbons contain?

_____

(1)

(b) The crude oil is separated by fractional distillation. The diagram shows a column used for this.



(i) Explain, as fully as you can, how fractional distillation works.

_____

_____

_____

_____

_____

(3)

(ii) Naphtha burns more easily than diesel oil. Explain why.

_____

_____

_____

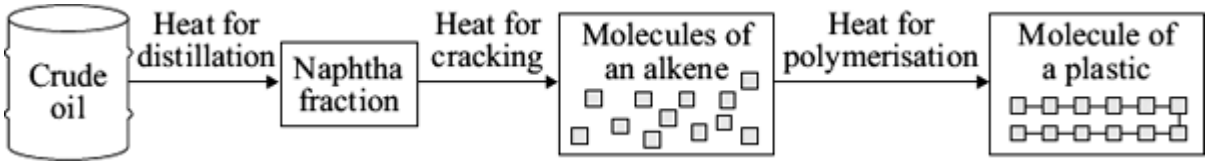
(1)

(iii) Naphtha contains a saturated hydrocarbon with the formula C_7H_{16} .
Draw the structural formula of this compound.

(2)

(Total 7 marks)

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



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

_____

_____

_____

_____

_____

(2)

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

(i) Balance the symbol equation for this reaction.

$C_{10}H_{22}$	→	C_4H_{10}	+	C_2H_4
decane		butane		ethene

(1)

(ii) Describe how cracking is carried out.

_____

_____

_____

_____

_____

(2)

(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.

_____

_____

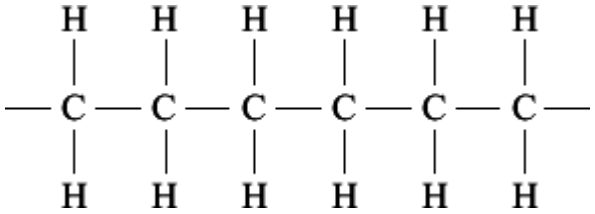
_____

_____

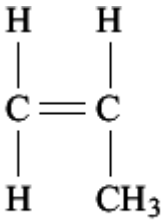
_____

(2)

(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).



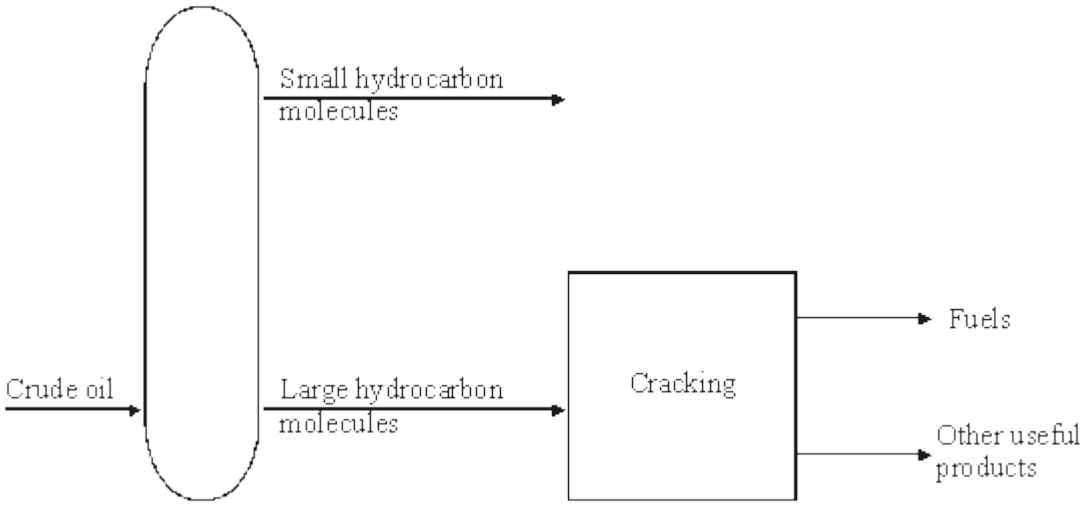
Propene molecule

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

(2)

(Total 9 marks)

10 Crude oil is a mixture of hydrocarbons. These hydrocarbons can be separated and some of them can be used to make other useful products.



(a) Complete the sentence.

Hydrocarbons are made up of _____ atoms and _____ atoms.

(2)

(b) How are the small and large hydrocarbon molecules in crude oil separated?

_____

_____

_____

_____

(2)

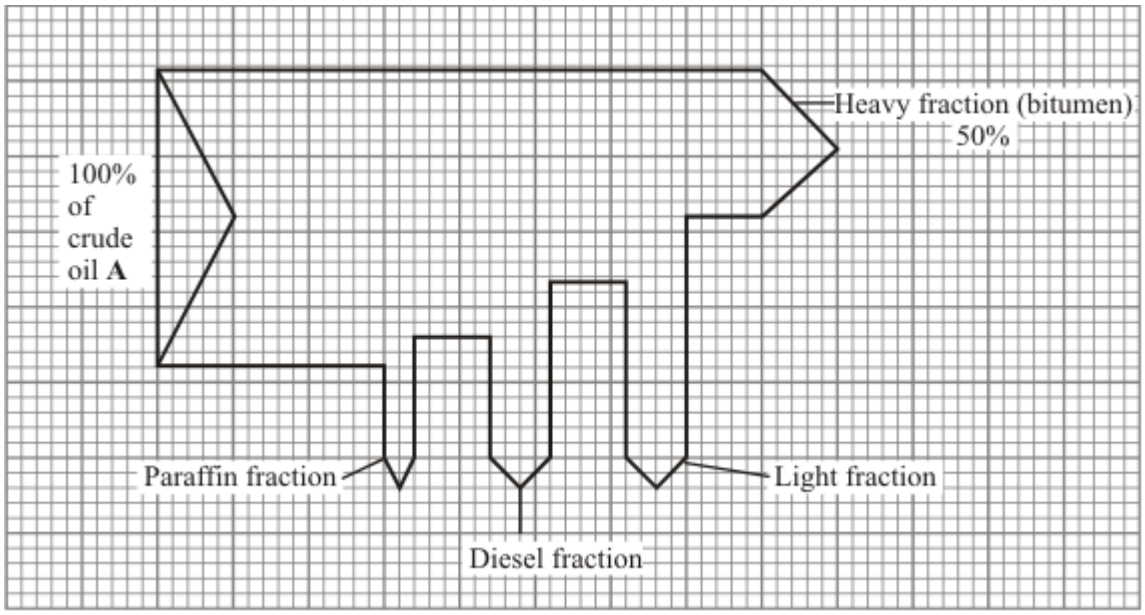
(c) The diagram shows that one useful product of cracking is fuels.
Name **one** of the other useful products.

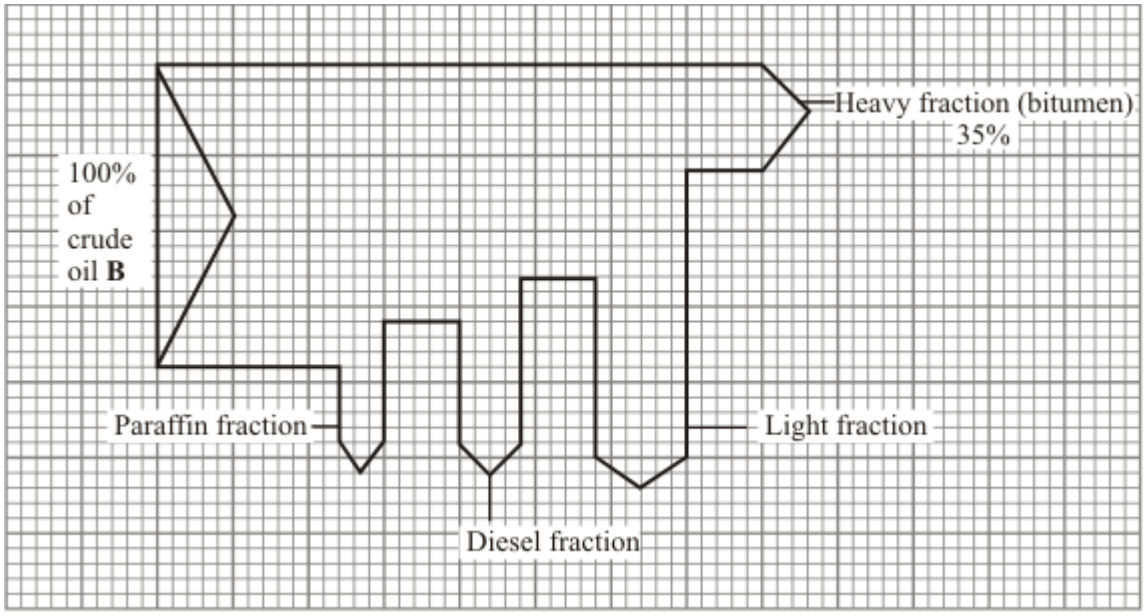
_____

(1)

(Total 5 marks)

11 The diagrams show the percentages of the four main fractions produced from two samples of crude oil, **A** and **B**.





(a) The light fraction contains hydrocarbons used for the manufacture of useful chemicals such as polymers. Which one of the samples, **A** or **B**, would be more useful for the manufacture of polymers? Explain your answer.

_____

_____

_____

_____

_____

_____

(2)

(b) Heptane (C_7H_{16}), is one of the hydrocarbons used for the manufacture of poly(ethene). The first stage of the process is the production of ethene and another hydrocarbon from heptane.

(i) In the box, draw the structural formula of the other hydrocarbon produced.

(1)

(ii) Describe how the reaction is carried out.

_____

_____

_____

_____

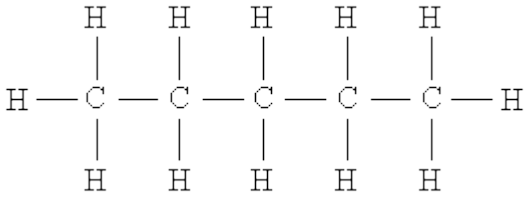
_____

_____

(2)

(Total 5 marks)

12 Crude oil is a mixture of a large number of compounds most of which are hydrocarbons such as the molecule shown below.



(a) What is a hydrocarbon?

_____

_____

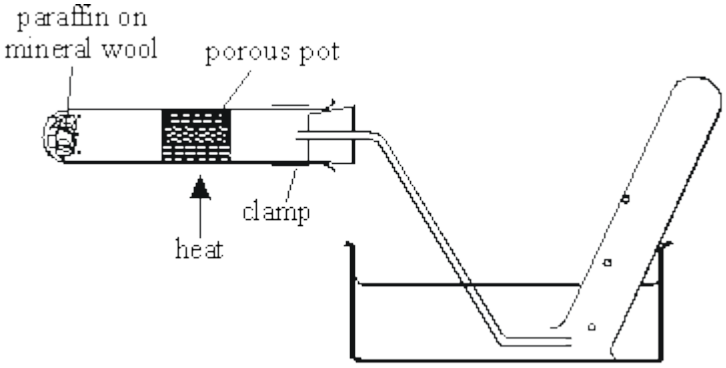
(1)

(b) What is the chemical formula of the molecule shown above?

_____

(1)

(e) The cracking of large molecules obtained from crude oil is one of the important processes in an oil refinery. Cracking involves the thermal decomposition of large molecules. The diagram below shows an apparatus that can be used to demonstrate cracking in the laboratory. The porous pot acts as a catalyst in the reaction.



(i) What happens during thermal decomposition?

_____

_____

_____

(2)

(ii) What effect does the porous pot catalyst have on the reaction?

_____

_____

(1)

(iii) Complete the equation below for the cracking of the molecule. $C_{20}H_{42}$.

$C_{20}H_{42} \rightarrow C_{12}H_{26} +$ _____

(1)

(Total 6 marks)

13 Alkanes are hydrocarbons found in crude oil.

(a) (i) Complete the sentence.

Hydrocarbons contain the elements _____ and _____ only.

(1)

(ii) Ethane is an alkane with the formula C_2H_6

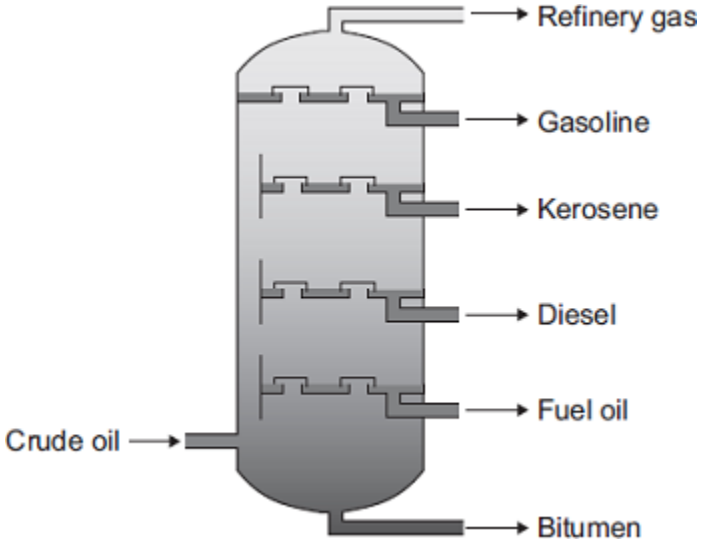
Draw a ring around the correct answer to complete the sentence.

Alkanes are hydrocarbons with the general formula

C_nH_n
C_nH_{2n}
C_nH_{2n+2}

(1)

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



Describe and explain how crude oil is separated into fractions by fractional distillation.

Use the diagram to help you answer the question.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(c) Dodecane ($C_{12}H_{26}$) from crude oil is cracked to produce ethene (C_2H_4).

(i) Complete the equation for this reaction.

$C_{12}H_{26} \longrightarrow 2\ C_2H_4 +$ _____

(1)

(ii) Give **two** conditions needed for cracking.

1. _____

2. _____

(2)

(Total 9 marks)

14 This question is about hydrocarbons.

(a) The names and formulae of three hydrocarbons in the same homologous series are:

Ethane	C_2H_6
Propane	C_3H_8
Butane	C_4H_{10}

The next member in the series is pentane.

What is the formula of pentane?

_____

(1)

(b) Which homologous series contains ethane, propane and butane?

Tick **one** box.

Alcohols ☐

Alkanes ☐

Alkenes ☐

Carboxylic acids ☐

(1)

(c) Propane (C_3H_8) is used as a fuel.

Complete the equation for the complete combustion of propane.

$C_3H_8 + 5O_2 \rightarrow 3$ _____ + 4 _____

(2)

(d) Octane (C_8H_{18}) is a hydrocarbon found in petrol.

Explain why octane is a hydrocarbon.

_____

_____

(2)

(e) The table below gives information about the pollutants produced by cars using diesel or petrol as a fuel.

Fuel	Relative amounts of pollutants		
	Oxides of Nitrogen	**Particulate matter**	**Carbon dioxide**
Diesel	31	100	85
Petrol	23	0	100

Compare the pollutants from cars using diesel with those from cars using petrol.

_____

_____

_____

_____

_____

_____

(3)

(f) Pollutants cause environmental impacts.

Draw **one** line from each pollutant to the environmental impact caused by the pollutant.

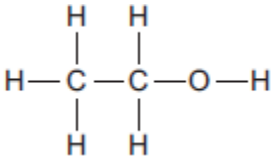
Pollutant	**Environmental impact caused by the pollutant**
	Acid rain
Oxides of nitrogen	Flooding
	Global dimming
Particulate matter	Global warming
	Photosynthesis

(2)

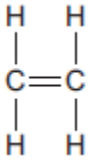
(Total 11 marks)

15 The figure below shows the displayed structures of five organic compounds, **A, B, C, D** and **E**.

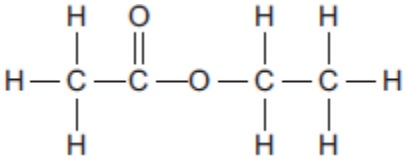
A



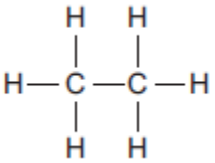
B



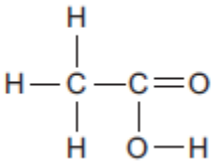
C



D



E



(a) Choose which organic compound, **A, B, C, D** or **E**, matches the descriptions.

You may choose each compound once, more than once or not at all.

Write the letter of the compound that:

(i) is a saturated hydrocarbon ☐ **(1)**

(ii) comes from a homologous series with the general formula C_nH_{2n} ☐ **(1)**

(iii) has the empirical formula C_2H_6O ☐ **(1)**

(iv) reacts with calcium carbonate to produce carbon dioxide ☐ **(1)**

(v) reacts with compound **A** to produce compound **C**. ☐ **(1)**

(b) Compound **B** (C_2H_4) and C_8H_{18} are produced by cracking $C_{14}H_{30}$

$$C_{14}H_{30} \longrightarrow 3C_2H_4 + C_8H_{18}$$

(i) Give **two** conditions for cracking.

_____

_____

(2)

(ii) Explain why C_8H_{18} has a lower boiling point than $C_{14}H_{30}$

_____

_____

_____

_____

(2)

(c) Compound **B** is a colourless gas.

Give a chemical test and its result to show that compound **B** is unsaturated.

Test _____

_____

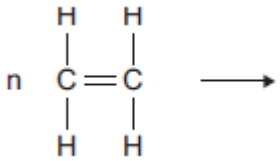
Result _____

_____

(2)

(d) Compound **B** is ethene.

Complete the equation to show the formation of poly(ethene) from ethene.



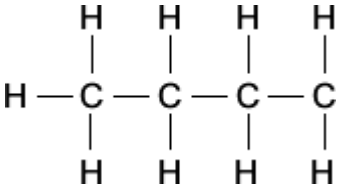
(3)

(Total 14 marks)

16 Crude oil is a mixture of hydrocarbons. Most of these hydrocarbons are alkanes.

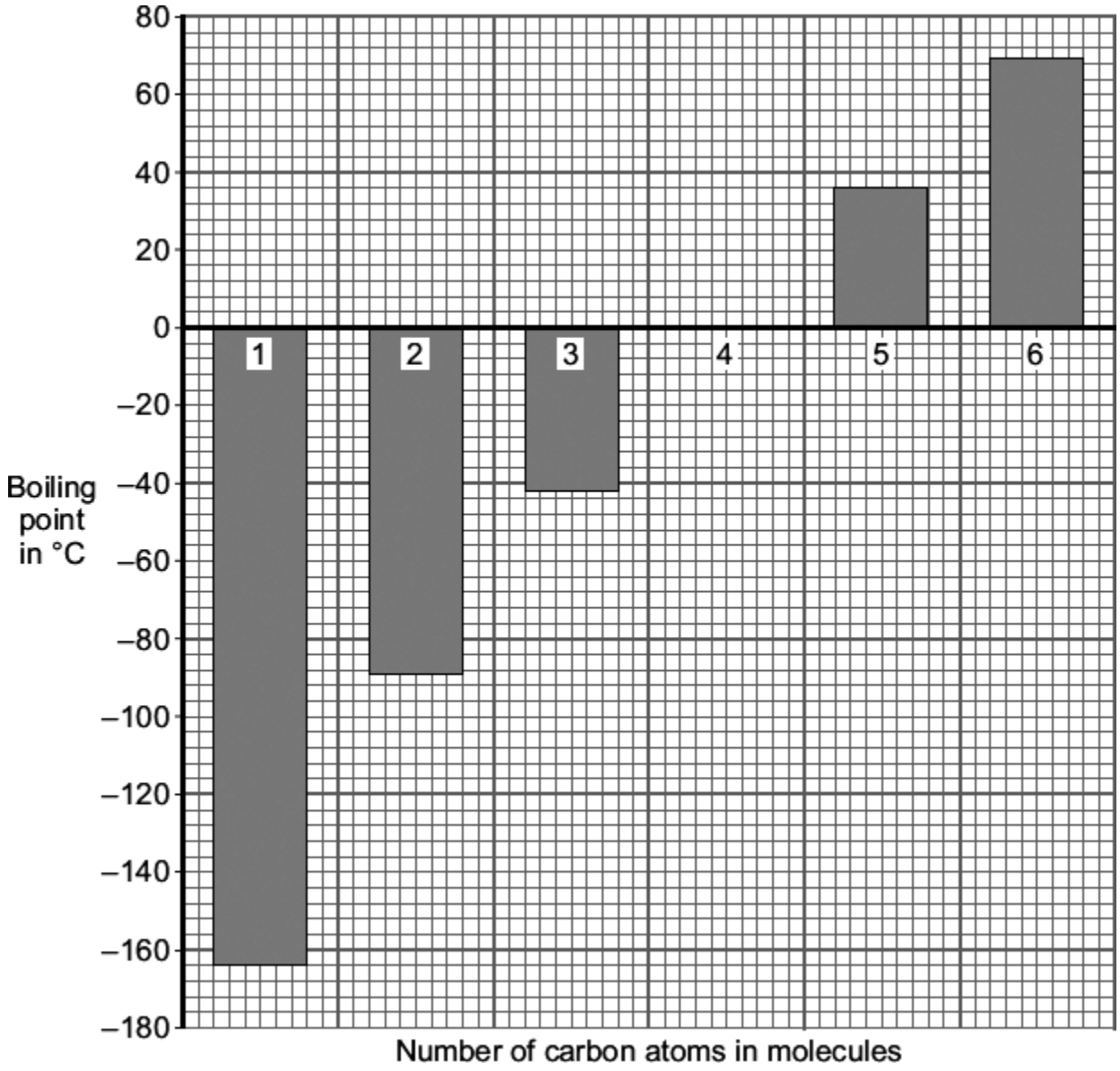
(a) The general formula of an alkane is C_nH_{2n+2}

Complete the structural formula for the alkane that has **six** carbon atoms in its molecules.



(1)

(b) The boiling points of alkanes are linked to the number of carbon atoms in their molecules.



(i) Describe the link between the number of carbon atoms in an alkane molecule and its boiling point.

_____

_____

(1)

(ii) Suggest **two** reasons why all of the alkanes in the bar chart are better fuels than the alkane with the formula $C_{30}H_{62}$

1. _____

_____

2. _____

_____

(2)

(c) During the last 200 million years the carbon cycle has maintained the percentage of carbon dioxide in the atmosphere at about 0.03 %.
Over the last 100 years the percentage of carbon dioxide in the atmosphere has increased to about 0.04 %.
Most of this increase is caused by burning fossil fuels to heat buildings, to generate electricity and to power our transport.
Fossil fuels contain carbon that has been locked up for millions of years.

(i) Burning fossil fuels, such as petrol, releases this locked up carbon. Balance the chemical equation for the combustion of one of the alkanes in petrol.

$$2\ C_8H_{18} + 25\ O_2 \longrightarrow \_\_\_\_\ CO_2 + \_\_\_\_\ H_2O$$

(1)

(ii) Where did the carbon that is locked up in fossil fuels come from?

_____

_____

(1)

(iii) The burning of fossil fuels has caused the percentage of carbon dioxide in the atmosphere to increase to above 0.03 %.
Explain why.

_____

_____

_____

_____

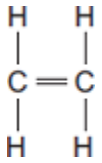
_____

_____

(2)

(Total 8 marks)

17 A molecule of ethene (C_2H_4) is represented as:



(a) A sample of ethene is shaken with bromine water.

Complete the sentence.

The bromine water turns from orange to _____ .

(1)

(b) Most ethene is produced by the process of cracking.

(i) Complete the sentence.

Cracking is a type of thermal _____ .

(1)

(ii) Decane ($C_{10}H_{22}$) can be cracked to produce ethene (C_2H_4) and **one** other product.

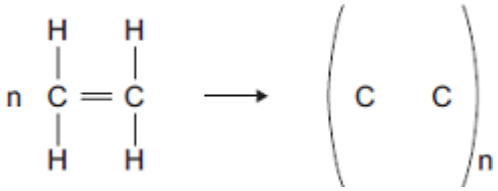
Complete the equation to show the formula of the other product.

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

(1)

(c) Many molecules of ethene join together to produce poly(ethene).

(i) Complete the structure of the polymer in the equation.



(2)

(ii) Some carrier bags are made from poly(ethene). Some carrier bags are made from cornstarch.

Suggest **two** benefits of using cornstarch instead of poly(ethene) to make carrier bags.

_____

_____

_____

_____

(2)

(Total 7 marks)

18 The table shows some information about alkanes.

Name	Formula	Relative formula mass	Boiling point in °C
methane	CH_4	16	–160
ethane	C_2H_6	30	–90
propane		44	–40
butane	C_4H_{10}	58	
pentane	C_5H_{12}	72	36
hexane	C_6H_{14}	86	68

(a) Give the formula of propane.

_____

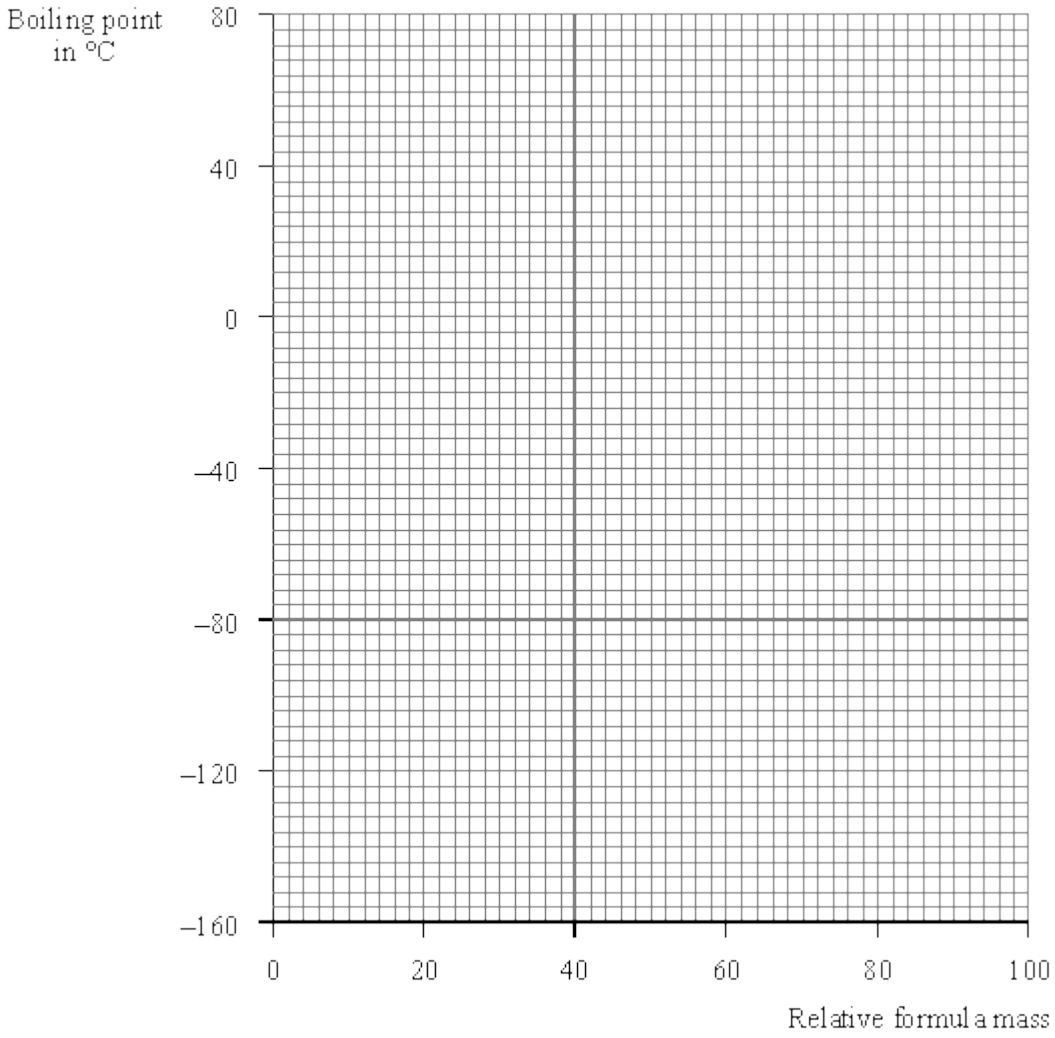
(1)

(b) (i) What happens to the boiling points of the alkanes as the relative formula mass increases?

_____

(1)

(ii) Draw a graph. Plot the points and draw a best fit line.



(3)

(iii) What is the boiling point of butane?

_____

(1)

(iv) Show clearly on the graph how you found the boiling point of butane.

(1)

(c) Circle which of the following is **not** an alkane.

$C_7 11_{16}$ C_9H_{18} $C_{11}H_{24}$ $C_{24}H_{50}$

(1)

(Total 8 marks)

19 Crude oil is a complex mixture of hydrocarbons, mainly alkanes. The number of carbon atoms in the molecules ranges from 1 to over 100.

(a) How does the boiling point change as the number of carbon atoms in the molecules increases?

_____

_____

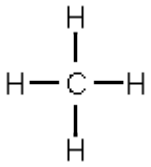
(1)

(b) Name the method used to separate petroleum into fractions.

_____

(1)

(c) The simplest hydrocarbon is methane, CH_4. Its structure can be represented:



Draw the structure of ethane, C_2H_6.

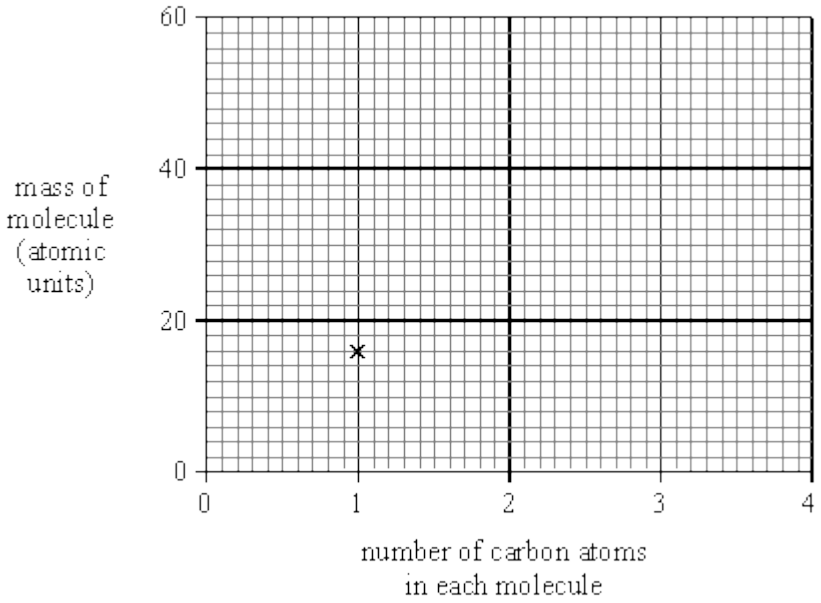
(1)

(Total 3 marks)

20 The table gives some information about a family of molecules in crude oil.

NUMBER OF CARBON ATOMS IN MOLECULE	MASS OF MOLECULE (atomic units)
1	16
2	30
4	58

(a) Show information from the table in the most appropriate way on the grid.



(3)

(b) What is the mass of a molecule with three carbon atoms?

_____

(1)

(c) The other atoms in each molecule are all hydrogen atoms.
What family of substances do all the molecules belong to?

_____

(1)

(d) The mass of a carbon atom is 12 atomic units.
The mass of a hydrogen atom is 1 atomic unit.

So the molecule with one carbon atom has four hydrogen atoms.
Its formula is CH_4.

Write down the formula:

(i) of the molecule with two carbon atoms _____

(ii) of a molecule from the same family with five carbon atoms _____

(2)

(Total 7 marks)

21 This question is about organic compounds.

Hydrocarbons can be cracked to produce smaller molecules.

The equation shows the reaction for a hydrocarbon, $C_{18}H_{38}$

$$C_{18}H_{38} \rightarrow C_6H_{14} + C_4H_8 + 2\,C_3H_6 + C_2H_4$$

(a) Which product of the reaction shown is an alkane?

Tick **one** box.

C_2H_4 ☐

C_3H_6 ☐

C_4H_8 ☐

C_6H_{14} ☐

(1)

(b) The table below shows the boiling point, flammability and viscosity of $C_{18}H_{38}$ compared with the other hydrocarbons shown in the equation.

	Boiling point	**Flammability**	**Viscosity**
A	highest	lowest	highest
B	highest	lowest	lowest
C	lowest	highest	highest
D	lowest	highest	lowest

Which letter, **A**, **B**, **C** or **D**, shows how the properties of $C_{18}H_{38}$ compare with the properties of C_2H_4, C_3H_6, C_4H_8 and C_6H_{14}?

Tick **one** box.

A ☐

B ☐

C ☐

D ☐

(1)

(c) The hydrocarbon C_4H_8 was burnt in air.

Incomplete combustion occurred.

Which equation, **A**, **B**, **C** or **D**, correctly represents the incomplete combustion reaction?

A $C_4H_8 + 4O \rightarrow 4CO + 4H_2$

B $C_4H_8 + 4O_2 \rightarrow 4CO + 4H_2O$

C $C_4H_8 + 6O_2 \rightarrow 4CO_2 + 4H_2O$

D $C_4H_8 + 8O \rightarrow 4CO_2 + 4H_2$

Tick **one** box.

A ☐

B ☐

C ☐

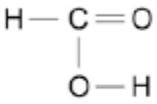
D ☐

(1)

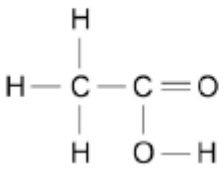
(d) Propanoic acid is a carboxylic acid.

Which structure, **A**, **B**, **C** or **D**, shows propanoic acid?

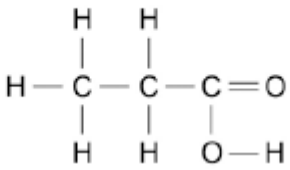
A



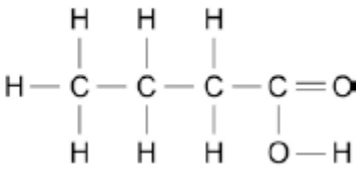
B



C



D



Tick **one** box.

A ☐

B ☐

C ☐

D ☐

(1)

(e) Propanoic acid is formed by the oxidation of which organic compound?

Tick **one** box.

Propane ☐

Propene ☐

Propanol ☐

Polyester ☐

(1)

(Total 5 marks)

22 This question is about hydrocarbons.

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

(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.

1. _____

2. _____

(2)

(ii) The products hexene and ethene are alkenes.

Complete the sentence.

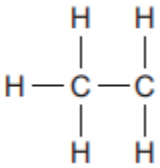
When alkenes react with bromine water the colour changes

from orange to _____ .

(1)

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

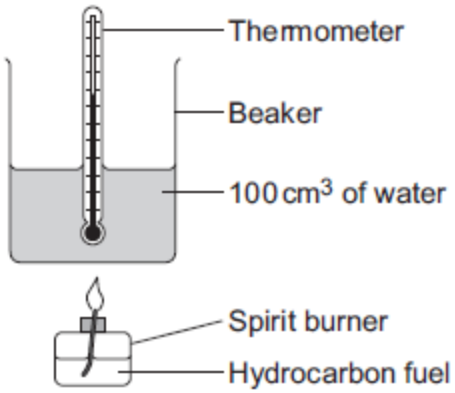
Complete the displayed structure of butane.



(1)

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

The diagram below shows the apparatus used.



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

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

_____

_____

Energy released = _____ kJ

(2)

(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)

(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)

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

Give **two** reasons why the results in **Table 2** support this conclusion.

1. _____

_____

2. _____

_____

(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)

(Total 18 marks)

1

(a) crude oil / it is evaporated / vaporised

ignore heated

1

vapours / gases / fractions <u>cool and condense</u>

accept named fraction(s)

1

(different) vapours / gases / fractions (condense) at different temperatures

accept (different) vapours / gases / fractions have different boiling points

*max **2** marks for description of laboratory method **or** mention of cracking*

1

(b) (i) any **one** from:

- range of boiling points
- range of carbon atoms

1

(ii) greater the number (of carbon atoms) the higher the boiling point

*do **not** accept molecules / particles*

1

(c) (i) burning / combustion

allow oxidation / redox

1

(ii) any **two** from:

*reaction with hydrogen gains max of **1** mark only*

- cracking / (thermal) decomposition
- heat / vaporise
- catalyst / aluminium oxide

allow porous pot

ignore names of other catalysts

2

[8]

2

(a) all plots correct

*3 **or** 2 plots correct gains 1 mark*

2

all sectors correctly labelled

1

(b) (i) (fractional) distillation

1

(ii) gases

1

(iii) bitumen

1

[6]

3 (a) hydrocarbon

1

(b) thermal decomposition / cracking

1

(c) (i) making polymers / poly(e)thene

accept plastic (bags)

1

(ii) fuel

1

[4]

4 (a) (i) fractional distillation

both words required

accept fractionation

1

(ii) any **one** from

ethane

propane

butane

1

(b) (i) carbon dioxide

1

water (vapour)

accept steam

do not credit symbols

1

(ii) carbon monoxide

accept CO

*do not credit soot **or** carbon oxide*

1

[5]

5 (a) (i) distillation

1

(ii) condense (at different temperatures)

accept they / fractions / hydrocarbons have different boiling points

ignore melting point / size of molecule

1

(b) contains hydrocarbons

1

has a high boiling point

1

(c) C_5H_{12}

1

[5]

6 (a) (i) (1)

5

3

(6)

4

2

all numbers in the correct order gains both marks

*any two numbers in the correct position gains **1** mark*

2

(ii) Water

ignore formula if correct name given

accept hydrogen oxide

allow H_2O

1

carbon dioxide

allow CO_2

*accept carbon monoxide / CO **or** carbon / C*

1

(b) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also apply a 'best-fit' approach to the marking.

0 marks
No relevant content.

Level 1 (1-2 marks)
There is a **basic** description of at least one advantage **or** one disadvantage caused by using plastic shopping bags made from poly(ethene)

Level 2 (3-4 marks)
There is a **clear** description of both an advantage **and** a disadvantage, caused by using plastic shopping bags made from poly(ethene).

Level 3 (5-6 marks)
There is a **detailed** description of both advantages **and** disadvantages caused by using plastic shopping bags made from poly(ethene)

examples of the chemistry/social points made in the response:
ignore cost unqualified

Advantages:

- Simple properties eg strong / low density / water resistant
- Bags can be reused (for shopping) **or** another specified use eg bin liners
- Money charged for bags can go to good causes **or** encourage reuse
- Poly(ethene) bags can be recycled eg made into milk bottle crates
- Poly(ethene) bags can be burned to provide heat for buildings/generation of electricity
- New bags are now made that can biodegrade

Disadvantages:

- (Older) bags can take many years to biodegrade
- There is a shortage of landfill space
- Bags are made from (crude) oil which is a non-renewable resource/running out
- Large amounts of energy/fuel are used for the production of poly(ethene)
- Production of poly(ethene) releases carbon dioxide/causes global warming
- Specified issue caused by litter eg visual pollution or effect on wildlife
- Burning bags release carbon dioxide / causes global warming

6

[10]

7

(a) (i) by heating

pressure is neutral

using a catalyst/pot/ceramic/porcelain/aluminium oxide

1

(ii) use bromine water/(alkaline) permanganate

accept bromine

1

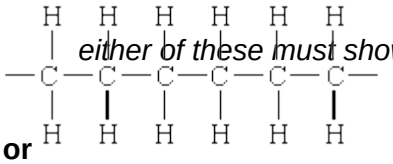
alkene makes bromine go colourless or lose its colour

accept alkane does not change the red/orange colour of bromine

***not** change colour/goes clear*

1

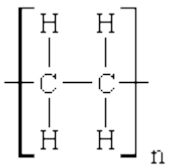
(b) (i)



either of these must show bonds at end

1

or



***not** H on ends*

*allow 3 instead of n **not** any other number*

(ii) poly(ethene) – brackets not essential

accept polythene

1

(iii) **large amount** of waste polymer/poly(ethene)/polythene/litter

*accept large amount of crude oil **or** finite resource used*

1

it is not biodegradable

accept it does not

decompose/decay/break down

it causes pollution/it creates toxic

fumes when burnt are neutral

***not** it is not recyclable*

2

[8]

8

(a) hydrogen and carbon

for 1 mark

1

(b) (i) the oil is evaporated / boiled / liquid converted to gas / vaporised

oil is condensed/changed back to liquid/cooled below boiling point (not just cooled)

liquids of different boiling points condense at different levels /
fractions with lower boiling points form near the top /
boiling point linked to chain length or Mr

each for 1 mark

3

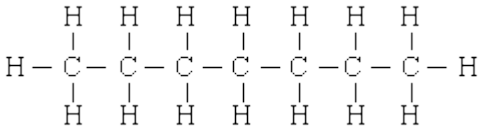
(ii) Assume they mean naphtha unless they say otherwise.
smaller molecules
/contains less atoms
/lower boiling point
/more volatile
/less bonds to break
/lower activation energy

If the answer is given the opposite way around then diesel must be specified.

any one for 1 mark

1

(iii)



correct number of atoms = 1
correct number of bonds (attached to correct atoms) = 1
Accept diagrams which show electrons correctly.
$CH_3CH_2CH_2CH_2CH_2CH_2CH_3$ = 1

for 2 marks

2

[7]

9 (a) vaporise / evaporate

allow boil for vaporise

1

different condensing points / temperatures

accept condense at different levels

ignore different size molecules or different densities

*mention of cracking = max **1***

*allow boils at different temperatures and condenses for **2** marks*

if no other marks awarded allow

*fractional distillation for **1** mark*

1

(b) (i) 3 (C_2H_4)

accept $+C_4H_8$

1

(ii) (decane / naphtha / hydrocarbon) vaporise / evaporate

allow crude oil

allow boil for vaporise

1

(passed over) a catalyst / alumina / porous pot

ignore other names of catalysts

1

(c) any **two** from:

'they' must be clarified

- alkanes / butane (molecules) do not have a (carbon carbon) double bond / are saturated / have (carbon carbon) single bonds
- alkenes / ethene (molecules) have (carbon carbon) double bonds

or

are unsaturated

- alkenes / ethene molecules are able to bond to other molecules

2

(d) single bonds between carbon atoms

– C - C –

1

the $-CH_3$ group appears on each pair of carbons on the 'chain'

NB any double bonds = ***0*** *marks*

1

[9]

10 (a) carbon

1

hydrogen

any order

1

(b) fractional

1

distillation

accept description

- *heat* ***or*** *evaporate / boil (1mark)*
- *separated when they condense* ***or*** *by boiling points (1 mark)*

1

(c) alkenes

*accept names **or** unsaturated hydrocarbons*

1

[5]

11

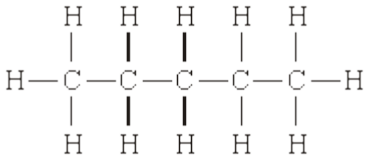
(a) **B** because it contains more of the light fraction)

1

Quantitative answer e.g. **B** has 30%,
A has 20% / 10% more / 1.5 times more

1

(b) (i)



1

(ii) heat

1

catalyst

if neither mark gained allow cracking for 1 mark

1

[5]

12

(a) A compound made from carbon and hydrogen (not mixture etc.)

1

(b) C_5H_{12}

1

(e) (i) Break down

by heat

(ii) Speeds up reaction

(iii) C_8H_{16}

each for 1 mark

4

[6]

13

(a) (i) hydrogen / H and carbon / C

answers can be in either order

if letters given, must be capital H

1

(ii) C_nH_{2n+2}

1

(b) (most) crude oil vaporises / evaporates **or** crude oil enters as a vapour

1

(vapour) cools as it rises up the tower / column **or** tower / column cooler at the top **or** negative temperature gradient

1

the fractions have different boiling / condensation points / ranges

accept the larger the molecules, the higher the boiling point / condensation point

1

so they will condense at different levels in the tower

allow will collect at different levels if condensation mentioned

allow will condense to give different fractions

*if no other mark is gained allow **1** mark for mention of heating*

1

(c) (i) C_8H_{18}

if one answer is given C_8H_{18} is the only acceptable answer

credit any correct combination of alkanes and alkenes, eg C_5H_{12} and C_3H_6

1

(ii) hot / high temperature

accept any temperature in the range 300 − 900 °C

'heat' is insufficient

1

catalyst

*accept a named catalyst − alumina **or** zeolites **or** aluminosilicates **or** broken pot*

ignore other named catalysts

allow (mixing with) steam as an alternative to second marking point

ignore pressure

1

[9]

14 (a) C_5H_{12}

1

(b) Alkanes

1

(c) (3) CO_2

1

(4) H_2O

1

*allow for **1** mark*

4 CO_2 + 3 H_2O

(d) contains hydrogen and carbon

1

(hydrogen and carbon) <u>only</u>

1

(e) *(diesel)*
produces more oxides of nitrogen

allow converse answers in terms of petrol

1

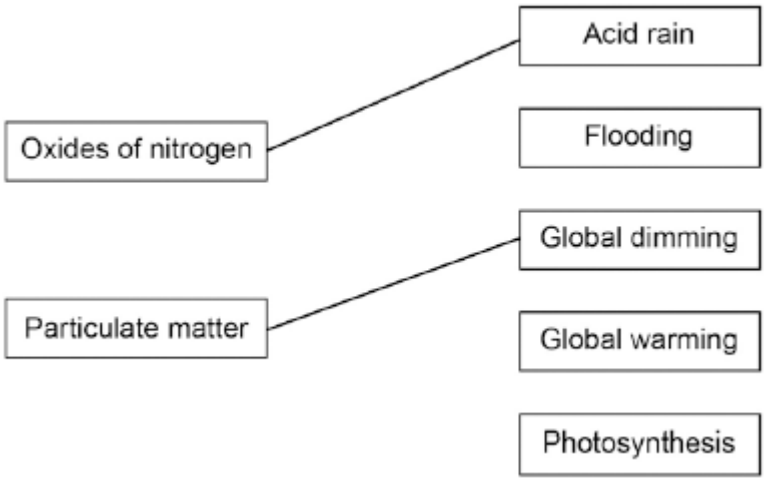
produces (more) particulate matter

1

produces less carbon dioxide

1

(f)



2

[11]

15 (a) (i) D

1

(ii) B

1

(iii) A

1

(iv) E

1

(v) E

1

(b) (i) high temperature

ignore hot / heat

allow temperature quoted (range 300-900 °C)

1

catalyst **or** steam

1

(ii) C_8H_{18} smaller molecule

It = C_8H_{18}

1

therefore there are weaker intermolecular forces

allow intermolecular bonds

*do **not** accept breaking covalent bonds / bonds*

or

weaker intermolecular forces in C_8H_{18} (1)

allow intermolecular bonds

so less energy to break (1)

1

(c) add bromine water

1

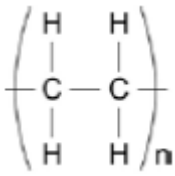
turns (from orange / yellow / red / brown) to colourless **or** decolourises

do not accept discoloured

*ignore clear incorrect test = **0** marks*

1

(d)



single C – C bond

1

four carbon-hydrogen bonds in place and two trailing bonds

1

structure in brackets and n at bottom right

1

[14]

16 (a) complete diagram with 2 carbon atoms and 5 hydrogen atoms each C–C and each C–H linked by a single line (bond)

1

(b) (i) the greater the number of (carbon) atoms (in an alkane molecule) the greater its boiling point **or** vice versa

allow as the (carbon) chain gets longer the boiling point increases

ignore melting points

*do **not** accept reference to greater number of molecules*

1

(ii) *they = hydrocarbons from the graph*

it = $C_{30}H_{62}$

any **two** from:

- low boiling point / volatile
  accept they are gases or liquids
- low viscosity
- high flammability
  accept easier to burn / ignite
- small molecules
  accept short chains
  ignore number of carbon atoms
- burn completely
  ignore speed of burning

2

(c) (i) 16 (CO_2) + 18 (H_2O)

1

(ii) (carbon dioxide in the Earth's early) atmosphere

accept from volcanoes (millions of years ago)

***or** from <u>dead</u> plants / animals*

allow dead sea creatures

ignore shells

1

(iii) <u>increase</u> in burning / use of fossil fuels

1

locked up carbon (carbon dioxide) is released

allow carbon / carbon dioxide from millions of years ago is released

accept extra carbon dioxide is not 'absorbed' (by the carbon cycle)

1

[8]

17 (a) colourless

ignore clear

1

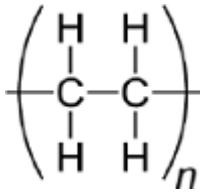
(b) (i) decomposition

1

(ii) C_8H_{18}

1

(c) (i)



two single trailing bonds extending from the carbons (through the brackets) ***1*** *mark*

five single bonds (1 C–C bond and 4 C–H bonds) ***1*** *mark*

2

(ii) any **two** from:

- (polymers made from) cornstarch are biodegradable
- less space needed in landfill sites
- polymers from cornstarch come from a renewable source.

allow converse for poly(ethene)

2

[7]

18 (a) C_3H_8

1

(b) (i) increases / gets larger

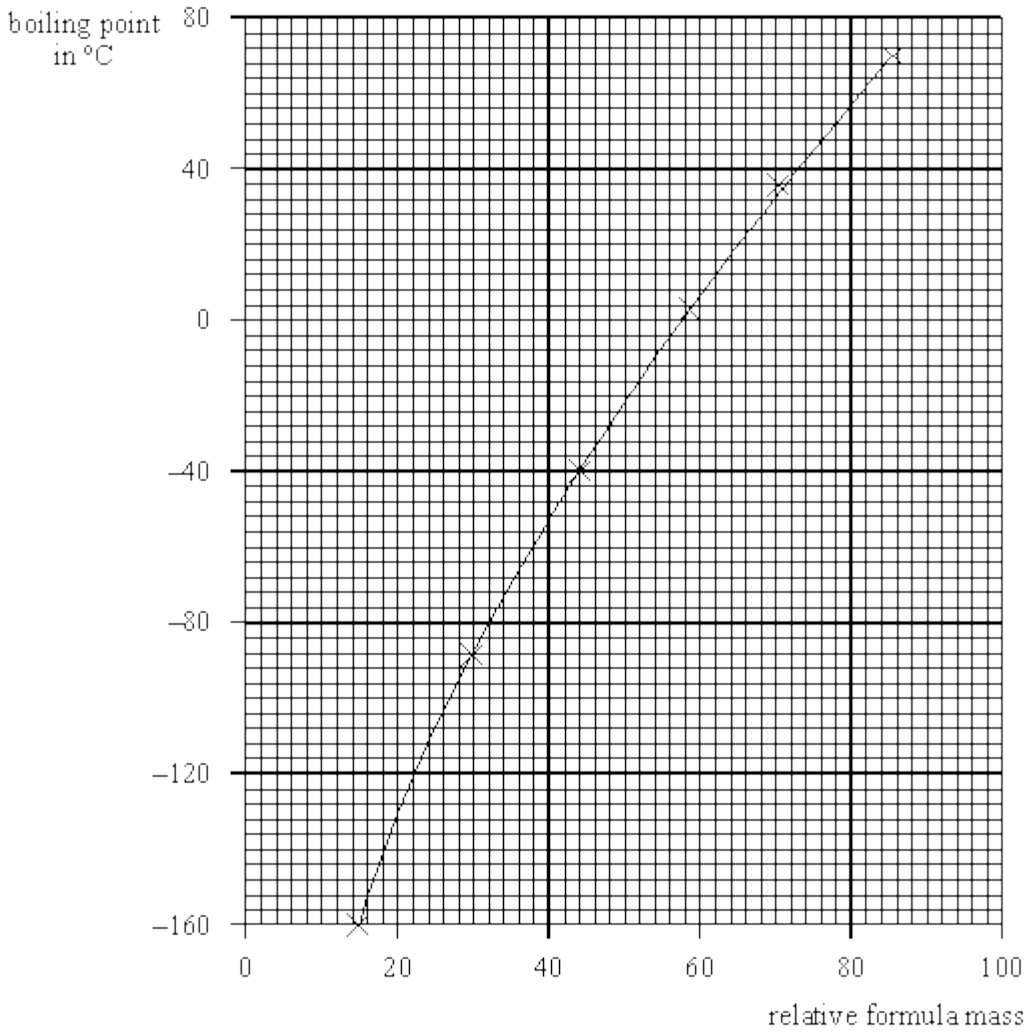
1

(ii) all 5 points plotted correctly

deduct 1 mark for each incorrectly plotted point
*but **ignore** –90, 30*
allow error of one square in any direction

2

smooth line graph



1

(iii) boiling point estimate from their graph

allow ± 2 °C

1

(iv) shown clearly on graph

allow just one construction line drawn

1

(c) C_9H_{18}

1

[8]

19 (a) the more C atoms the higher the b.pt./temperature
Allow just higher. **Not** answer based on melting point

for 1 mark

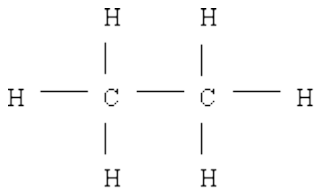
1

(b) (fractional) distillation/fractionation

for 1 mark

1

(c)



must include H atoms and lines **not** $CH_3 – CH_3$

for 1 mark

1

[3]

20 (a)
- vertical axis appropriately scaled

  [i.e. using more than half the grid]
- all three points correctly plotted* (to < ½ a square)
- reasonably straight line drawn through points (to < half a square)*
  [*credit both these marks for bars correctly drawn since discontinuous variable]

  each • for 1 mark

x [If points incorrectly plotted credit 1 mark for the best fit straight line or curve but not point-to-point]

3

(b) 44 (atomic units)

for 1 mark
(e.c.f. i.e. credit consistent with candidate's graph)

1

(c) hydrocarbons / alkanes

for 1 mark

1

(d) C_2H_6
C_5H_{12}

each for 1 mark

[NB figures must be subscripted]

2

[7]

21 (a) C_6H_{14}

1

(b) **A**

1

(c) **B**

1

(d) **C**

1

(e) Propanol

1

[5]

22 (a) (i) high temperature

allow heating / hot / 250-900 °C

1

catalyst or steam

allow named catalyst eg zeolite, Al_2O_3, silica, ceramic

allow in the absence of air / oxygen

1

ignore any references to pressure

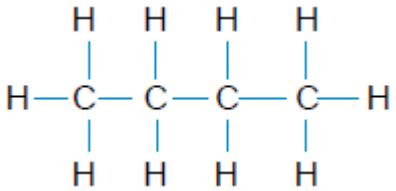
(ii) colourless

allow decolourised

ignore clear / discoloured

1

(iii)



1

(b) (i) 20.3(0) (kJ)

*if answer incorrect allow **1** mark for 24.36/1.2*

2

(ii) use a lid

allow insulate beaker or use draught shield

1

reduce energy / heat loss

ignore references to thermometer or repeats or distance of flame or loss of water vapour

allow stir (1) to distribute energy / heat (1)

allow use a metal can (1) as it's a better conductor (1)

1

(iii) carbon/soot

ignore tar, smoke

1

(produced by) incomplete combustion

allow from a limited supply of oxygen/air

1

(iv) hexane gives out the greatest energy (per 1.0 g)

ignore more energy

1

hexane produces the least smoke / carbon / soot

allow has the cleanest flame

ignore less smoke / carbon / soot

1

(c) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also apply a 'best-fit' approach to the marking.

Level 3 (5 – 6 marks):
Descriptions of advantages **and** disadvantages that are linked to their own knowledge.

Level 2 (3 – 4 marks):
Descriptions of an advantage **and** a disadvantage with some use of their knowledge to add value.

Level 1 (1 – 2 marks):
Statements made from the information that indicate whether at least one statement is an advantage **or** a disadvantage
or a linked advantage or disadvantage

0 marks:
No relevant content

Examples of the added value statements and links made in the response could include:
Note that link words are in bold; links can be either way round.
Accept reverse arguments and ignore cost throughout.

Advantages of using hydrogen:
- Combustion only produces water **so** causes no pollution
- Combustion does not produce carbon dioxide **so** this does not contribute to global warming or climate change
- Combustion does not produce sulfur dioxide **so** this does not contribute to acid rain
- Incomplete combustion of petrol produces carbon monoxide **that is** toxic
- Incomplete combustion of petrol produces particulates **that** contribute to global dimming
- Petrol comes from a non-renewable resource **but** there are renewable/other methods of producing hydrogen
- Hydrogen releases more energy **so** less fuel needed or more efficient

Disadvantages of using hydrogen:
- Hydrogen is a gas **so** is difficult to store or transfer to vehicles
- Hydrogen gas is very flammable **so** leaks cause a greater risk of explosion
- Most hydrogen is produced from fossil fuels **which** are running out
- Cannot be used in existing car engines **so** modification / development or replacement is needed
- Lack of filling stations **so** difficult to refuel your vehicle

6

[18]

Examiner reports

1

(a) This part was poorly answered with very few candidates gaining three marks. Candidates were told to use the words ‘evaporated’ and ‘condensed’ but often there was confusion as to where or when the evaporation process and condensation process occurred. Several candidates thought that ‘the gases evaporated’ and ‘the liquids condensed’ when the crude oil was heated. Many candidates realised that the different fractions boil/condense at different temperatures but very few linked this to the idea that the fractions had to be cooled in order to condense. Other candidates contradicted themselves, when they tried to use the words ‘evaporated’ and ‘condensed’ for example ‘heat causes crude oil to evaporate and heat causes crude oil to condense’. A few candidates thought that the crude oil ‘burns’ to form the fractions.

(b) (i) Answers were often confused because candidates did not make clear whether they were referring to one fraction or to all four fractions. Many candidates had great difficulty in expressing themselves clearly and made statements such as, ‘they have a large number of carbon atoms’ or ‘they have more than one carbon atom’. A few candidates also stated melting point instead of boiling point.

(ii) This question was well answered with a majority of candidates realising that as the number of carbon atoms increases the boiling point increases or vice versa. There was confusion between the terms ‘atoms and molecules’ and ‘heat and temperature’. Candidates did not gain credit if they wrote that ‘the more carbon atoms in a molecule then the longer it takes to boil’. A few candidates just stated ‘it got higher’ or ‘it increases it’ but without giving any explanation of what ‘it’ is.

(c) (i) This question was poorly answered by most candidates. Common incorrect answers were ‘heat reaction’, ‘thermal decomposition’, ‘distillation’ and ‘evaporation’.

(ii) Many candidates managed to get one mark for mentioning that fuel oil was ‘heated’. A few candidates who stated that it was ‘catalytic cracking’ got both marks. The most common incorrect answer was one based on a description of fractional distillation.

2

(a) Relatively few candidates completed the pie chart correctly. Common mistakes were to forget to label the sectors and to make the shading of one component indistinguishable from another.

(b) Part (i) was quite well answered. Few candidates understood relative boiling points, so bitumen was the most common answer in (ii). Only a minority understood the meaning of the term volatile.

3

Only the strongest candidates scored well on this question.

(a) Only a minority were able to state that X, Y and Z were hydrocarbons.

(b) Most candidates gave (fractional) distillation or displacement.

(c) Few gave polymers or plastics.

4

Many examiners reported that this was the one question on the whole paper that produced the poorest answers.

Some candidates were able to suggest distillation as the name of the separation process, but very few offered the required answer of ‘fractional distillation’. Hardly any candidates could suggest another hydrocarbon gas.

It was disappointing to see so few candidates realising that carbon dioxide and water are the products of combustion. ‘Methane oxide’ was suggested by a fairly large number. There were equally few correct answers giving carbon monoxide as being a product of incomplete combustion.

5

(a) (i) Most candidates gained the mark. The word ‘distillation’ presented many candidates with a spelling problem.

(ii) The word ‘condense’ was not well known, so most candidates who gained the mark here did so for mentioning that the fractions have different boiling points. Many candidates stated incorrectly that the fractions ‘have different melting points’, ‘have different reactivities’, ‘burn at different temperatures’, or ‘heat at different rates’.

(b) A few candidates ticked only one property. Generally this part was well answered. Almost half of the candidates correctly ticked both ‘contains hydrocarbons’ and ‘has a high boiling point’. The majority of candidates gained at least one mark.

(c) A slight majority of candidates were able to use the general formula C_nH_{2n+2} to identify that the correct formula of the alkane with five carbon atoms is C_5H_{12}.

6

(a) (i) Most students do not fully understand the process of the fractional distillation of crude oil. Most students did attempt this question but only a few students managed to gain both marks.

(ii) Most students only gained one mark here for stating carbon dioxide, carbon or carbon monoxide. Often the mark given for the product water was not awarded because most students stated hydrogen instead of water.

(b) This is the QWC question and as such it was marked holistically. Many students gained no credit because they did not add to the information given in the stem of the question. Students found difficulty not only in expressing themselves clearly and organising the information but also in using scientific terms correctly. Most were poor quality level 1 answers. Usually there was no expansion of the points made by the students which meant that the vast majority did not reach level 2. The most common answers were reusing and recycling of the plastic bags but there was no detail of what the bags could be reused for or recycled into. It was not clear from the answers whether many knew the difference between reuse and recycle. Many students focused on employment of people to make plastic bags and profit for the shops. Only rarely did students give examples of specified problems caused by litter. Vague expressions such as 'cause pollution' and 'environmental damage', should be avoided.

7 **Double and Single Award**

The majority of candidates knew that bromine was used in the test for an alkene, although this mark was sometimes lost by writing bromide. For the result of the test ‘clear’ was often used instead of ‘colourless’. However, a number then rescued this mark by writing that the alkene had no effect on bromine water. In (c) (i) many candidates left out the bond at each end or attached hydrogen atoms to them. The polymer, poly(ethene), was well known. The non-biodegradable property of the polymer was known by the majority of candidates. The fact that large quantities of this polymer are used and remain as waste was appreciated by very few candidates.

9 (a) The description of how crude oil is separated into fractions produced a wide range of responses. Although most candidates gained at least one mark, this mark was quite often for a reference to fractional distillation. This fall-back mark was often credited because candidates could not be precise enough to gain marks in any other way. Candidates referred to both the industrial and laboratory versions of this process. The first marking point in the industrial process, the vaporisation of the crude oil, was the mark that was often missed out, while the more difficult idea of separation by differing boiling or condensing points was often included and credited. Many candidates spoilt their responses by including references to cracking, some giving an excellent, but non-credit worthy, description of the cracking process. Surprisingly some candidates still managed to include electrolysis, chromatography and the blast furnace in their explanations.

(b) (i) It was disappointing that more than half of the candidates could not balance the symbol equation for cracking.

(ii) Many candidates correctly named alumina as the catalyst, although a nickel catalyst at 60°C was often mentioned. Some candidates lost the marks because they explained the meaning of the term cracking rather than describing how cracking is carried out.

(c) The difference in the structure between alkanes and alkenes was very well known, although it was not always explained very well. Most candidates could explain the relevance of the structure of these hydrocarbons to the formation of polymers. Some candidates had problems explaining the way in which alkene monomers bonded to each other to form a polymer and often lost that mark because of a mixture of weak scientific and poor English.

(d) Drawing the diagram to represent part of a poly(propene) molecule was difficult for many candidates. Common incorrect answers were to just copy the structure of propene or the structure of poly(ethene).

10 (a) The more able candidates correctly identified a hydrocarbon as being made up of carbon atoms and hydrogen atoms.

(b) Most candidates did not use the term ‘fractional distillation’. Many did gain credit for stating that the crude oil was heated but several of these candidates were confused between the terms ‘cracking’ and ‘fractional distillation’.

(c) There were very few candidates who understood that cracking produces alkenes.

11

(a) Most candidates could identify that sample A was the most useful as it contained more of the light fraction. However, few went on to gain the second mark by giving a quantitative explanation.

(b) There was a variety of wrong answers. Many candidates drew a correct pentane molecule but then lost the mark by adding double bonds between the carbon atoms. Very few candidates gained both marks by specifying the use of heat and a catalyst. Most often a mark was gained by mentioning cracking. Some candidates confused the process with fractional distillation.

13

(a) (i) The vast majority of students knew that hydrocarbons contain hydrogen and carbon only.

(ii) The example of C_2H_6 as the formula of ethane helped most students to correctly identify the general formula of an alkane as C_nH_{2n+2}

(b) Students showed a very good understanding of the process of fractional distillation with the majority of students scoring 3 or 4 marks. The most common mark missed was the idea of most of the fractions of crude oil being vaporised. Most students understood the concept of the negative temperature gradient in the column and could relate this to fractions with different boiling points condensing at different levels in the column. Some students confused the process with cracking.

(c) (i) Most students could balance the equation for cracking by answering C_8H_{18} or by choosing a correct combination of alkanes and alkenes. The most common incorrect answer was 2 moles of C_4H_9. Some students did not appreciate that there were 2 moles of ethene already present and gave $C_{10}H_{22}$ as an answer. Some confused the process with combustion and gave CO_2 and H_2O as products.

(ii) This question discriminated well – some students scored 2 marks with a very succinct reference to high temperature and a catalyst. Many students lost a mark by stating ‘heat’ without an indication of the intensity – high pressure was also a common answer. Very few students identified the catalyst by name, although incorrect catalysts were often quoted. Some students scored 2 marks by mentioning high temperature and steam.

15

(a) (i) The majority of students correctly identified D as the only saturated hydrocarbon.

(ii) The idea of general formula was well understood, with most students identifying B as having the general formula CnH2n

(iii) Students understood the concept of empirical formula and displayed structure with almost all students giving the correct answer of A.

(iv) This question proved to be demanding, with students having to recognise E as an acid and know that an acid reacts with metal carbonates to produce carbon dioxide. Only about half scored this mark.

(v) There were only three real options here, as A and C were mentioned in the question. Almost all students correctly identified E as the answer.

(b) (i) About half of students gained two marks, although many included vague statements such as ‘heat’ or ‘hot’, while ‘high pressure’ was a common incorrect answer. Some students quoted values of temperature, which in some cases related to other industrial processes they had studied.

(ii) Good answers gaining two marks were few. Students often could not distinguish between bonds within the alkane and intermolecular forces. Many students identified that octane was a smaller hydrocarbon and scored one mark but then went on to refer to the breaking of bonds, often quoting that it was the bonds between carbon and hydrogen in the molecule, rather than to intermolecular forces.

(c) The majority of students gained two marks, quoting bromine water and the correct colour change or that it was decolourised. Some incorrect tests were given, most commonly using limewater or a burning spill. Some confusion between saturated and unsaturated was evident.

(d) This question was generally well answered, with most students gaining full marks. The most common error was to retain the double bond between the carbon atoms.

16

(a) Most answers were correct, but a surprising number of scripts were left blank. Possibly, candidates did not realise that they had to do something to the structural formula of the alkane. A common error was only the addition of one single H on the right hand side. Candidates who adopted the strategy of writing down the formula C_6H_{14} for the alkane nearly always drew the correct structure.

(b) (i) There were many excellent descriptions of the link between the number of carbon atoms in an alkane molecule and its boiling point. As always, a number of candidates did not read the question carefully and wrote about melting points.

(ii) Candidates gave 'flammability', 'small molecules', 'low viscosity' and 'low boiling point' as the most common correct reasons why all the alkanes in the bar chart are better fuels than triacontane. Viscosity was not always clearly understood, often it was used to mean runny. Many candidates used the word 'gloopy' as a synonym for viscous.

(c) (i) There were a reasonable number of correct answers, but a surprising number of scripts were left blank. Possibly, candidates did not realise that they had to do something to the chemical equation.

(ii) This part was well answered with the most common answers referring to the carbon that is locked up in fossil fuels coming from the atmosphere or dead animals or plants.

(iii) Surprisingly, most candidates failed to appreciate the increasing use of fossil fuels is causing the percentage of carbon dioxide to rise above 0.03 %. Often candidates just mentioned that carbon dioxide came from burning fossil fuels. The second marking point for locked-up carbon or for the inability of the carbon cycle to absorb all the additional carbon dioxide was the more common scoring point. Many candidates used the formula for carbon dioxide in their explanations and there were too many who wrote 'CO2'.

18

Despite candidates' problems in drawing the graph correctly, this question was quite high scoring. The scale proved to be awkward for some students but the plotting was mainly satisfactory. The instruction to 'draw a line of best fit', however, was the signal for a straight line to be drawn through the points which were obviously on a curve. The 'transferred error' principle was applied and so no further penalties were imposed for that mistake. The boiling point of butane was not always read accurately from the graph.

19

This question was usually answered very well.

22

Foundation

(a) (i) A large number of students did not answer this question. Students often appeared not to understand what was meant by 'conditions' because there were numerous types of processes, such as fractional distillation and electrolysis or the products of cracking given as answers. Most of the correct responses mentioned the high temperature but very few stated that a catalyst or steam was needed for this reaction.

(ii) This was not well answered. Many incorrect responses were suggested with blue and green being the most common and discolour was a popular attempt. Most students did not know that alkenes turn bromine water colourless. A common error here was that students confused 'clear' and 'colourless.'

(iii) Several students did not attempt this question. The structure of butane using the formula C_4H_{10} was well known. The most common errors were to draw ethane or include a double bond.

(b) (i) A large number of students did not attempt this question or did not show how to work out the answer. Most students made the error of calculating a mean or using data from the table incorrectly.

(ii) A large number of students did not answer this question and overall this question was poorly answered. However, the small number who did get the first mark, using a lid or cover, usually gained the second mark for the reason that is to reduce heat loss. Common answers that did not gain credit were to use a digital thermometer, which would improve precision or to perform repeats. Many thought that an improvement would be to increase the temperature of the water so wrote heat for longer, use less water, move the flame closer, use a Bunsen burner or change the fuel. Several misunderstood the question and started their answer with 'this is an improvement because …' suggesting that they had not read the stem of the question.

(iii) A large number of students did not answer this question. Although carbon or soot was recognised by a few students as the black solid, most of these students did not explain that incomplete combustion was the reason for its formation. A number of students incorrectly named carbon monoxide as the black solid. Others believed that the glass turned black because it was burning.

(iv) Several students did not attempt this question and the majority of students did not gain any credit. The main reason was that the students' answers were often expressed in terms such as 'more energy' or 'less smoke'. Most students failed to appreciate that when comparing more than two sets of results statements such as 'most energy' and 'least smoke' should have been used.

(c) This was the quality of written communication (QWC) question. A large number of students either did not answer this question or gained no credit because they simply repeated information given in the stem of the question. The question gave a wide range of answers and marks. Students often had trouble describing the advantages and disadvantages, and gave a series of brief statements that gained little credit. Several students did not understand that hydrogen is made from methane not that hydrogen contains methane. Often students displayed the following misunderstanding of the word equations, 'hydrogen is only made from oxygen and water whereas petrol is made from oxygen, water and carbon dioxide'. A significant number of students thought that if more energy is released this means that it is wasted, so they concluded that this was a disadvantage of hydrogen. A common incorrect designation was 'an advantage of hydrogen is that it is a gas and not a liquid'. It was good to see students using their own knowledge especially for the problems of using hydrogen as a fuel. Most students who did not achieve level 2 often just stated advantages and gave no disadvantage which was required by the question.

Higher

(a) (i) Students scored well on this question with many gaining both marks. Students often quoted the name of a suitable catalyst, usually aluminium oxide, and a few correct responses mentioned the anaerobic conditions that are used in this reaction.

(ii) This was well answered with most knowing that alkenes turn bromine water colourless. The most common error here was that some students confused ‘clear’ and ‘colourless.’

(iii) The structure of butane was very well known.

(b) (i) This was answered correctly by a large number of students. A significant minority did not attempt this calculation.

(ii) This question was poorly answered. However, those who did get the first mark, using a lid or cover, usually gained the second mark for the reason that is to reduce heat loss. A common answer that did not gain credit was to use a digital thermometer.

(iii) Although carbon or soot was often recognised as the black solid, most responses failed to explain that incomplete combustion was the reason for its formation. A number of students incorrectly named carbon monoxide as the black solid but often went on to gain a mark for incomplete combustion.

(iv) The majority of students scored one mark, usually the energy mark, whereas only a few got both marks. The main reason was that the students’ answers were often expressed in terms such as ‘more energy’ or ‘less smoke’. Many students did not appreciate that when comparing more than two sets of results statements such as ‘most energy’ and ‘least smoke’ should have been used.

(c) This was the quality of written communication (QWC) question and it gave a wide range of answers and marks. Some students had trouble describing the advantages and disadvantages, and gave a series of brief statements that gained little credit. Students tended to give mainly advantages of hydrogen compared with petrol, such as reference to carbon dioxide and global warming, hydrogen producing more energy, sulfur dioxide and acid rain and the non-renewable nature of crude oil. The disadvantages were less well explained, although the idea of the difficulty of storing hydrogen because it was a gas was often seen.