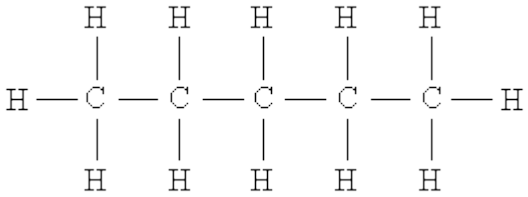
1 Crude oil is a mixture of a large number of compounds most of which are hydrocarbons such as the molecule shown below.



(a) What is a hydrocarbon?

_____

_____

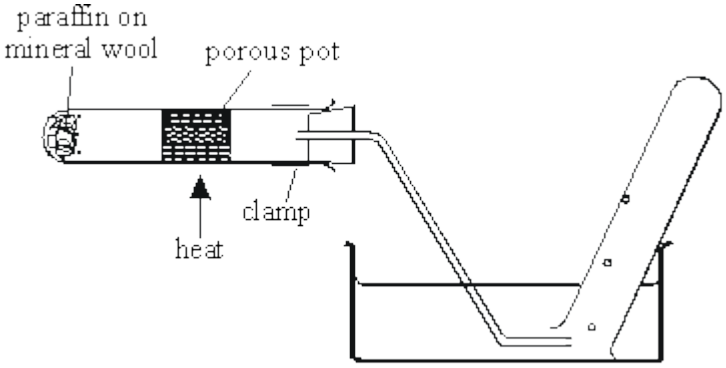
(1)

(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)

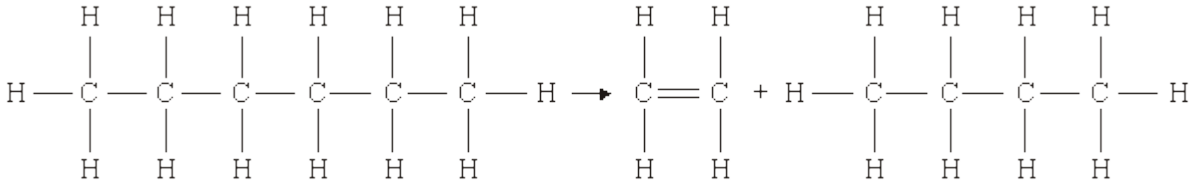
(iii) Complete the equation below for the cracking of the molecule. $C_{20}H_{42}$.

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

(1)

(Total 6 marks)

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



Compound **X** Compound **Y** Compound **Z**

(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)

3 (a) The hydrocarbon $C_{16}H_{34}$ was heated strongly in the absence of air.

This is one of the reactions which took place:

$$C_{16}H_{34} \longrightarrow C_6H_{14} + C_6H_{12} + 2C_2H_4$$

This type of reaction is carried out because there is a greater demand for the products than for the original hydrocarbon.

Suggest **two** reasons for this.

1. _____

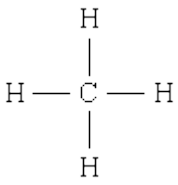
_____

2. _____

_____

(2)

(b) A molecule of the compound methane, CH_4, can be shown like this:

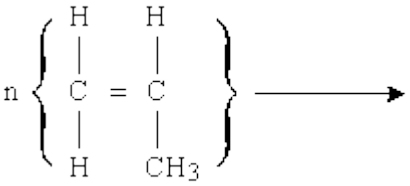


Draw a molecule of the compound ethene, C_2H_4.

(2)

(c) Small molecules of substances called monomers can be joined together in polymerisation, eg. ethene poly $\longrightarrow$ (ethene).

(i) COMPLETE THE EQUATION BELOW TO SHOW FORMATION OF THE POLYMER FROM THE MONOMER PROPENE.



(1)

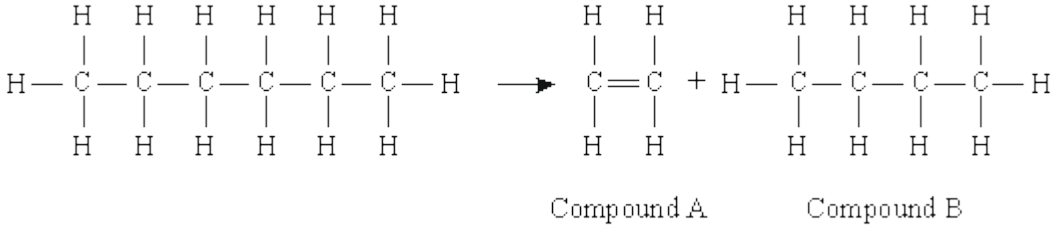
(ii) Suggest the name of the polymer formed.

_____

(1)

(Total 6 marks)

4 The equation below shows the cracking of a hydrocarbon compound into two different compounds, A and B.



(a) State **two** differences between the structures of compounds A and B.

_____

_____

_____

_____

(2)

(b) Why is compound A useful in industry?

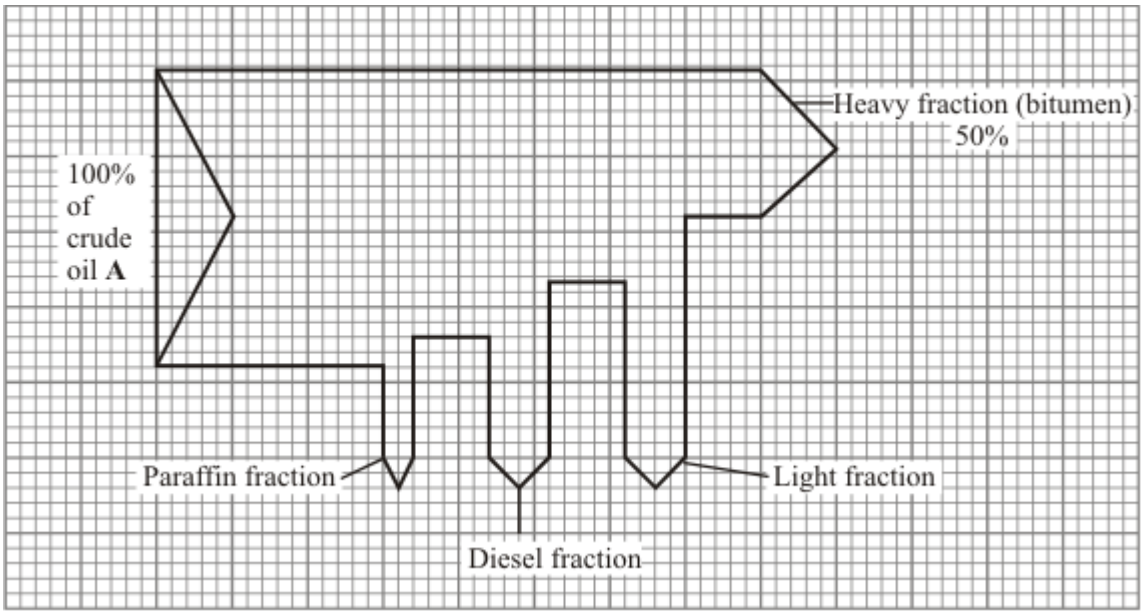
_____

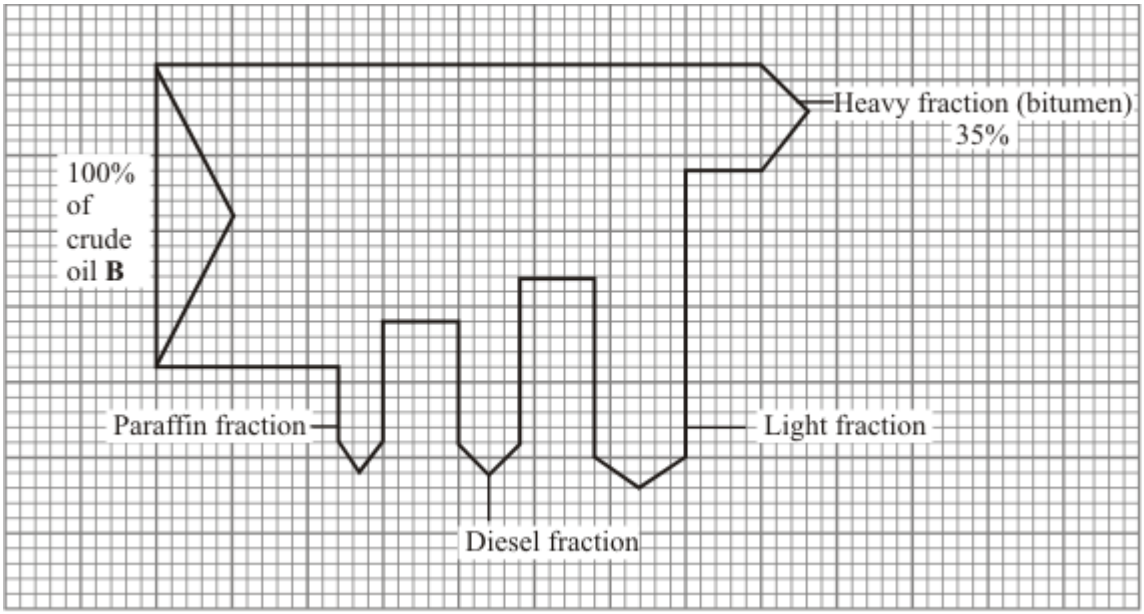
_____

(1)

(Total 3 marks)

5 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)

6 (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 _____

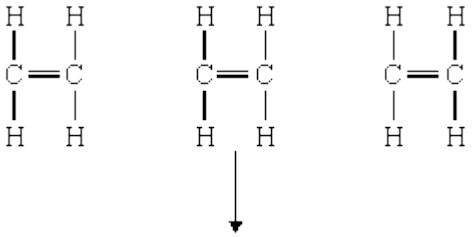
Result of test _____

_____

(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)

7 One reason the oil industry is important is that it uses crude oil to produce many of the plastic materials we use in everyday life.

(a) The first stage in the formation of a plastic material is called cracking. Butane (C_4H_{10}), a hydrocarbon in crude oil, can be cracked to produce two different hydrocarbons, ethane ($C_2.4$) and ethene (C_2H_4)

(i) For cracking to happen what needs to be done to the hydrocarbon?

_____

_____

(2)

(ii) Complete the equation for the cracking of butane using displayed formulae.

(2)

(iii) Complete the balanced chemical equation far the complete combustion of ethane in oxygen.

_____$C_2.4(g)$ + _____(g) → _____(g) + _____(l)

(3)

(b) The second stage is the formation of the plastic material by polymerisation.

Describe how ethene (C_2H_4) forms poly(ethene). You do not need to give the reaction conditions or the names of catalysts.

_____

_____

_____

_____

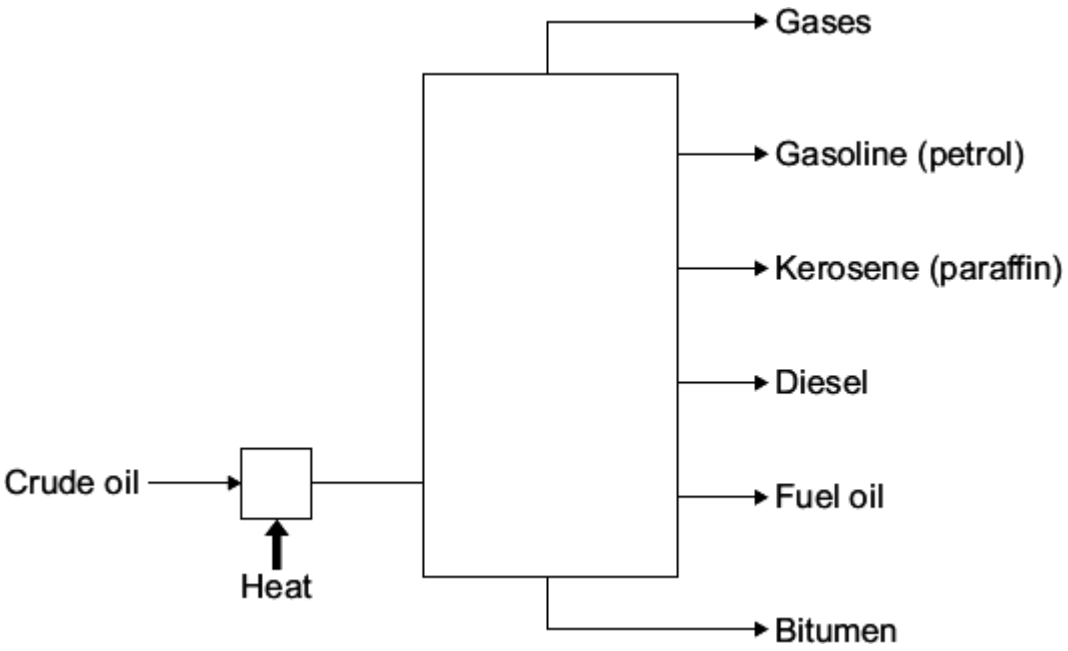
_____

(3)

(Total 10 marks)

8 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)

9 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 ☐

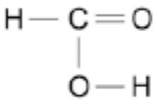
D ☐

(1)

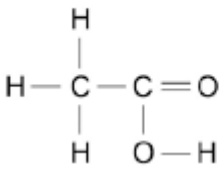
(d) Propanoic acid is a carboxylic acid.

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

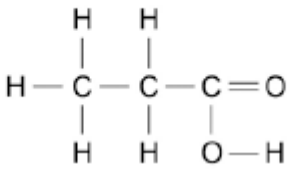
A



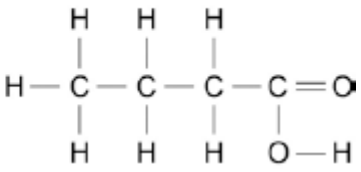
B



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 ☐

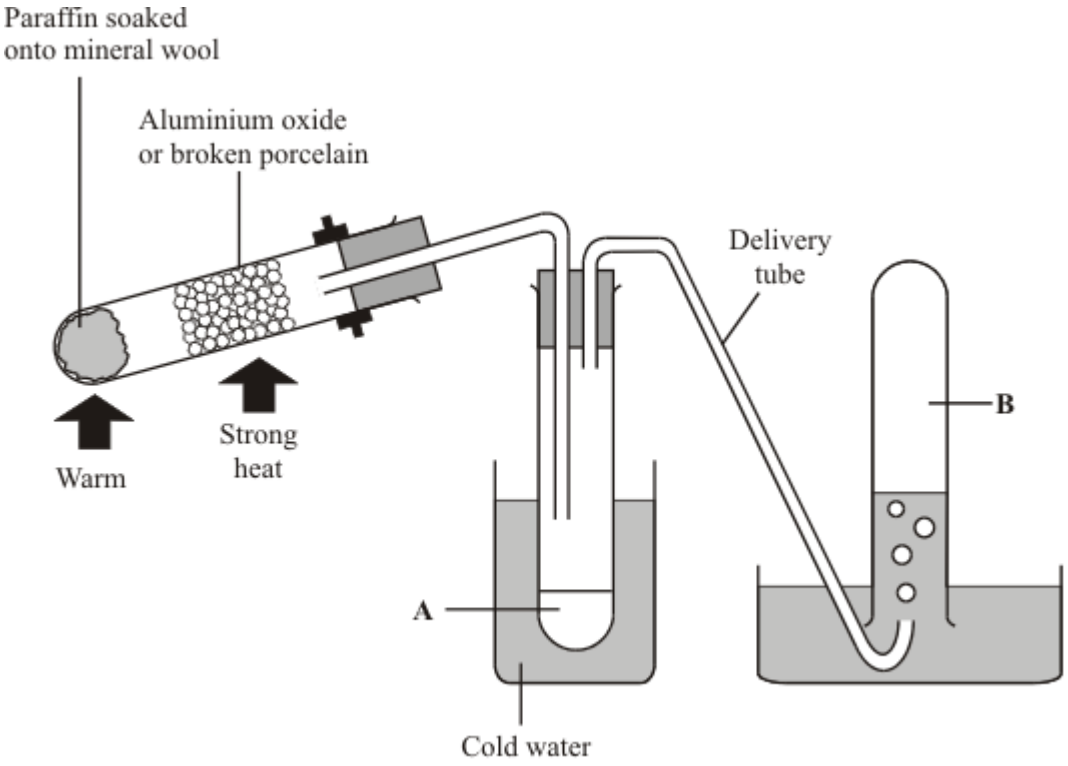
Propanol ☐

Polyester ☐

(1)

(Total 5 marks)

10 The diagram shows an apparatus that can be used to carry out cracking reactions in a laboratory.



(a) Why is aluminium oxide or broken porcelain used?

_____

_____

(1)

(b) Paraffin contains decane. The cracking of decane can be represented by the equation below. A decane molecule is split into two smaller molecules.

Complete the equation by adding the formula of the other product.

$C_{10}H_{22}$ (l) → _____ (l) + C_2H_4 (g)
decane

(1)

(c) Would you expect C_2H_4 molecules to collect at position **A** or **B** shown on the diagram?

Position _____

Explain your answer.

_____

_____

(1)

(d) Cracking reactions involve *thermal decomposition*.

What is meant by thermal decomposition?

_____

_____

_____

_____

(2)

(e) Explain, as fully as you can, why cracking is used in the oil industry.

To gain full marks in this question you should write your ideas in good English. Put them into a sensible order and use the correct scientific words.

_____

_____

_____

_____

_____

_____

_____

(3)

(f) The cracking reaction produces a mixture of products. The mixture contains hydrocarbons with different boiling points.

Suggest a method of separating this mixture.

_____

_____

(1)

(Total 9 marks)

11 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

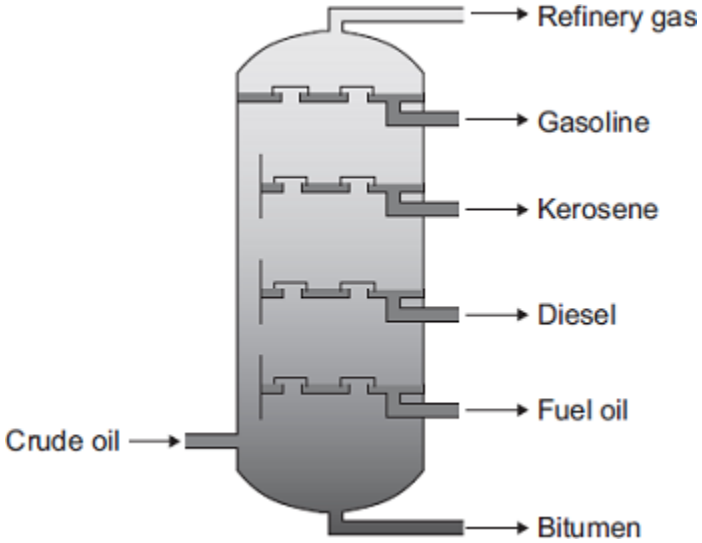
Draw a ring around the correct answer to complete the sentence.

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. _____

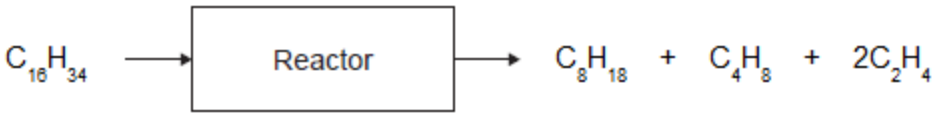
2. _____

(2)

(Total 9 marks)

12 Poly(butene) is a polymer made from crude oil in two stages.

(a) The first stage in making poly(butene) is to break down large hydrocarbon molecules from crude oil into smaller hydrocarbon molecules, as shown in the figure below.



(i) The products contain two types of hydrocarbon with different general formulae.

Name the two types of hydrocarbon.

_____

(1)

(ii) Describe the conditions in the reactor.

_____

_____

_____

_____

(2)

(iii) Suggest why air must **not** enter the reactor.

_____

_____

(1)

(iv) Suggest a method that can be used to separate butene (C_4H_8) from the other hydrocarbons.

_____

(1)

(b) The second stage is to use butene (C_4H_8) to produce poly(butene).

(i) Draw the displayed structure of a butene (C_4H_8) molecule.

(1)

(ii) Describe how molecules of butene (C_4H_8) form poly(butene).

_____

_____

_____

_____

(2)

(Total 8 marks)

13 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.

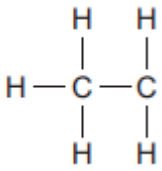
When alkenes react with bromine water the colour changes

from orange to _____ .

(1)

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

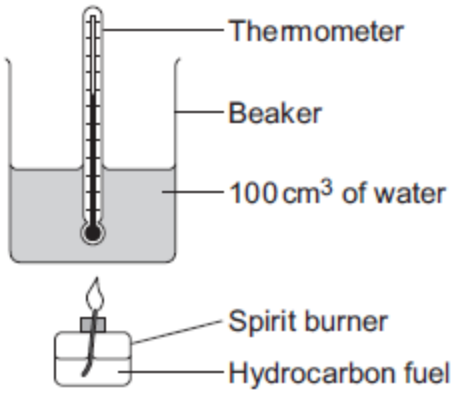
Complete the displayed structure of butane.



(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.

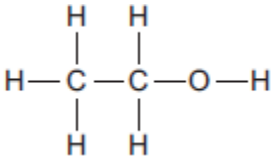
Use the information given and your knowledge and understanding to answer this question.

(6)

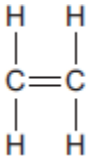
(Total 18 marks)

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

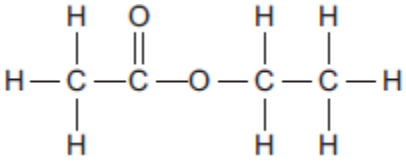
A



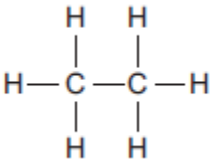
B



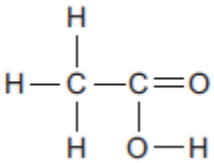
C



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 _____

_____

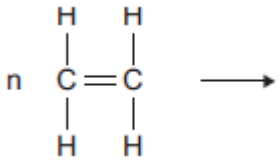
Result _____

_____

(2)

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

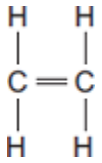
Complete the equation to show the formation of poly(ethene) from ethene.



(3)

(Total 14 marks)

15 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.

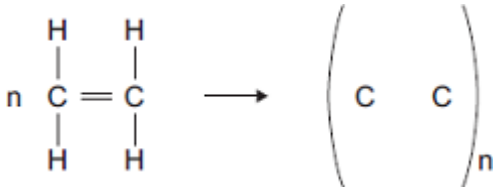
Complete the equation to show the formula of the other product.

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

(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)

Mark schemes

1

(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]

2

(a) hydrocarbon

1

(b) thermal decomposition / cracking

1

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

accept plastic (bags)

1

(ii) fuel

1

[4]

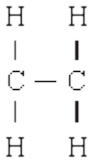
3

(a) smaller, more useful molecules more reactive (molecules)/(molecules) used to make plastics more easily ignited/better fuels produces unsaturated compounds/alkenes

any two for 1 mark each

2

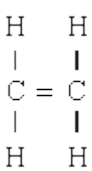
(b)



gains 1 mark

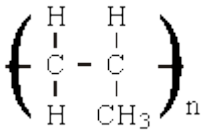
2

but



gains 2 marks

(c) (i)



for 1 mark

1

(ii) poly(propene)
(N.B. brackets not required; *allow* "polypropylene")

for 1 mark

1

[6]

4

(a) Compound A has fewer C atoms
or Compound B has fewer H atoms

Compound A has C = C/double bond
or Compound A is unsaturated

each for 1 mark
(accept converse i.e compound B has not ...)

2

(b) Compound A is reactive
or can be used to make many substances
or can be used in polymerisation/making plastics/named plastic
or can be used as a fuel

any one for 1 mark

1

[3]

5

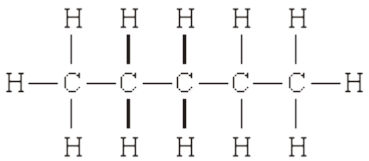
(a) **B** because it contains more of the light fraction)

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]

6 (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

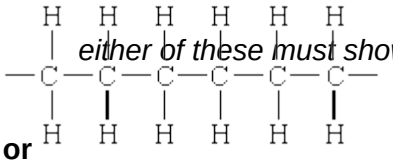
alkene makes bromine go colourless or lose its colour

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

not *change colour/goes clear*

1

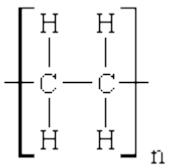
(b) (i)



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]

7 (a) (i) heat

accept increase temperature ignore pressure

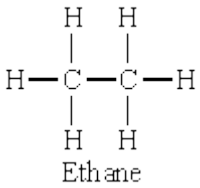
1

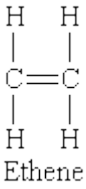
with a catalyst

1

(ii)

1





accept displayed formulae only

1

(iii) O_2

1

$CO_2 + H_2O$

ignore state symbols

1

correct balancing
$2 + 7 \rightarrow 4 + 6$

accept $1 + 3\frac{1}{2} \rightarrow 2 + 3$ *only if reactants and products correct*

1

(b) double bond breaks

1

many (ethene) molecules

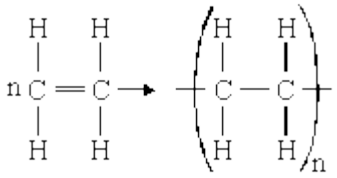
accept many monomers

1

bond together

*accept join **or** combine for bond*

accept



*for first **2** marks ignore unsaturated becomes saturated*

1

[10]

8 (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]

9

(a) C_6H_{14}

1

(b) **A**

1

(c) **B**

1

(d) **C**

1

(e) Propanol

1

[5]

10

(a) catalyst **or** speeds up the reaction (owtte)

*accept lowers activation energy **not** just helps reaction to take place*

ignore increased surface area

1

(b) C_8H_{18}

allow $H_{18}C_8$

must be upper case

*do **not** accept powers*

1

(c) B

because it is a gas **or** because it has small molecules **or** because <u>they</u> are small

*position **and** reason for mark*

*allow it has a lower / <u>very</u> low boiling point than **A***

ignore references to solubility

accept does not condense

*do **not** accept light molecules **or** bubbles into B*

*do **not** accept <u>it</u> is small*

1

(d) breakdown of a substance (owtte)

*do **not** accept decompose unqualified*

1

by the action of heat (owtte)

1

(e) **Quality of written communication**

if the written communication makes sense and it is in context then award Q mark

Q ✓ *Q* ✗

1

large to small molecules **or** scientific word that implies smaller,
e.g. alkene / ethane / petrol

any name or formula of alkane / alkene smaller than decane

1

either advantages of smaller molecules **or** disadvantages of larger molecules
e.g. hydrocarbons with large molecules are limited in their usefulness

***or** converse for smaller molecules*

1

large hydrocarbon molecules do not ignite easily / do not flow easily /
are not very volatile

***or** converse for smaller molecules*

more large hydrocarbon molecules are produced than are needed

***or** converse for smaller molecules*

smaller molecules are useful as fuels

alkenes / products can be used to make polymers

(f) (fractional) distillation

accept fractionation
accept good description
*do **not** accept just diagram*

1

[9]

11 (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 <u>vaporises / evaporates</u> **or** crude oil enters as a <u>vapour</u>

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]

12 (a) (i) alkanes **and** alkenes

any order

*allow saturated **and** unsaturated (hydrocarbons)*

1

(ii) high temperature

allow temperatures from 300 – 900 °C

allow vapours

*ignore heat / hot **or** pressure*

1

catalyst **or** steam

allow zeolite / aluminium oxide

ignore names of other catalysts

1

(iii) *oxygen* could react / *burn* with the hydrocarbons

allow oxygen could cause an explosion

1

(iv) *(fractional)* distillation

1

(b) (i) displayed structure of butene drawn

1

(ii) many monomers **or** many butene molecules

1

*form chains **or** very large molecules*

*if no other mark awarded allow double bond breaks / opens up **or** double bond forms a single bond for **1** mark*

1

[8]

13 (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

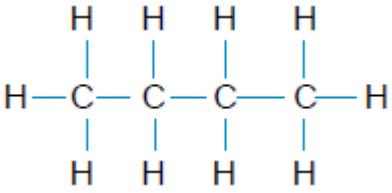
(ii) colourless

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]

14 (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

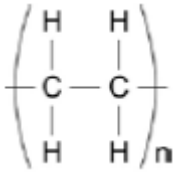
turns (from orange / yellow / red / brown) to colourless **or** decolourises

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]

15 (a) colourless

ignore clear

1

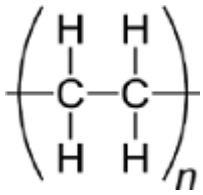
(b) (i) decomposition

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]

Examiner reports

2 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.

3 (a) A majority of candidates gained one mark for this item, identifying shorter-chain hydrocarbons with greater flammability: rather fewer referred to the greater reactivity of unsaturated molecules (alkenes).

(b) The formula for ethene was correctly shown by a minority of (usually more able) candidates. A common error amongst those who attempted an answer was to show the molecule with a **single** (rather than a double) carbon-carbon bond.

(c) Neither part of this question was well answered. Where the formula was attempted at all, the double bond was often retained and/or a subscripted “n” was not included. Surprisingly few H-tier candidates were able to extend the idea of ethene → poly(ethene) to the related polymerisation, propene → poly(propene).

4 **Paper 4 Option Q**

This question was poorly answered. Only good candidates picked out double bonds and different proportions of hydrogen atoms.

Paper 6 Option R

This question was generally well answered.

5 (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.

6 **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.

7 **Double and Single Award**

In (a)(i) many candidates knew the conditions needed for cracking, although some omitted the use of a catalyst. Most were able to draw displayed formulae for ethane and ethene. The common error was to draw a single covalent bond between the carbon atoms of ethene. Part (iii) saw the correct completion of the chemical equation for the combustion of ethane although several candidates struggled to balance the equation. Most candidates knew that poly(ethene) was formed from ethene but many could not describe precisely what happens to the double covalent bonds in the many ethene molecules during polymerisation. The prevention of corrosion was generally missed, or the mark was not awarded on account of reference to aluminium rusting.

8

(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.

10

Foundation Tier

(a) Few candidates knew that the aluminium oxide or broken porcelain acted as a catalyst. Incorrect responses included unqualified references to surface area and the idea that it acts as a filter.

(b) A few candidates made arithmetical errors in calculating the number of carbon and hydrogen atoms. Other candidates gave the formula incorrectly written, such as C^8H^{18} or C_8h_{18}.

(c) The answer **B** was often given with an incorrect explanation. The necessary point to make was that **B** is a gas.

(d) Few good definitions of thermal decomposition were seen. Many candidates referred to decomposing instead of breaking down.

(e) This part was often poorly answered. Many candidates confused cracking with fractional distillation and gave detailed descriptions of fractionation. The mark for 'good English' could still be gained even when the chemistry was incorrect.

(f) The method given in this part was frequently incorrect.

Higher Tier

This question was usually well answered by the candidates and allowed them to gain in confidence.

(a) Most candidates realised the catalytic nature of the material but some thought that it acted as a filter.

(b) This part was almost always answered correctly. The popular incorrect formulae were H_2O, C_6H_{18} and C_8H_{16}.

(c) This part was well answered, and those candidates who correctly chose **B** usually went on to give a correct explanation.

(d) Thermal decomposition was usually correctly described. It is not the breaking down of atoms.

(e) Overall this was quite a well answered question, and the majority of candidates had no problems conveying the general idea that there is limited use for the higher boiling point fractions (bigger molecules) and that cracking produces the more useful smaller molecules. Some candidates only scored the quality of written communication mark and that was for just describing fractional distillation rather than cracking. Cracking does not involve splitting crude oil to produce bitumen.

(f) Most candidates knew that fractional distillation is used to separate hydrocarbons based on boiling point differences. Some described the process instead, and gained credit for mentioning the key ideas of boiling followed by condensing at different temperatures.

11

(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.

12

(a) (i) About half of the students knew the two types of hydrocarbon with different general formulae.

(ii) Most students knew at least one of the conditions needed to crack large hydrocarbon molecules into smaller hydrocarbon molecules. Better answers gave catalyst, often correctly named, with a specific temperature in the range 300 to 900 °C. Weaker students tended to incorrectly name the catalyst as nickel, however, 'catalyst' gained the mark because the name of the catalyst was ignored. Vague answers, such as hot instead of high temperature, were not credited.

(iii) This question was poorly answered. The majority of students had the correct idea of something reacting with the hydrocarbons. Only a few students specified that it was oxygen in the air that would react with the hydrocarbons.

(iv) This question was correctly answered by nearly half of the students. Cracking was the most common incorrect response followed closely by polymerisation as the process to separate a hydrocarbon from other hydrocarbons. Some students stated two methods, one correct and one incorrect, thus losing the mark because of the list principle.

(b) (i) Less than a quarter of the students managed to correctly draw the displayed structure of a butene (C_4H_8) molecule. Most students managed to show four carbons and eight hydrogens, however, many of displayed structures had more than one carbon-carbon double bond or none at all.

(ii) Many students managed to score one mark, but few got both. Most students mentioned 'monomers' but did not state 'many'. 'Monomers join together to form polymers or poly(butene)' was a very common response which did not gain any credit. Some students described cracking instead of polymerisation.

13 **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.

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(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.