Write your name, centre number and candidate number in the boxes below.

Surname	Other names

Centre number | | | | | |

Candidate number | | | | |

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Petrochemicals and polymers

Time allowed: 1 hour 25 minutes

Subject code **0620**

Chemistry

Questions from Paper 3 and Paper 4

You must have: a ruler marked in centimetres and millimetres, a protractor, compasses, a pen, an HB pencil and an eraser.

Total marks

/ 87

Instructions

- Answer every question in the space provided on this paper.
- Write in black or dark blue ink. Pencil may be used for diagrams and graphs.
- Fill in your name, centre number and candidate number above.
- Show your working: a correct method can earn marks even if the answer is wrong.

Information

- This paper has 10 questions worth 87 marks in total.
- The marks for each question or part are shown in brackets, for example [3].

Advice

- Read every question through once before you write anything.
- Use the marks in brackets to judge how long to spend on each part.
- If you finish early, go back and check your working.

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Print at 100% (Actual size) so diagrams keep their real measurements.

1 Hydrocarbons are compounds of carbon and hydrogen.

(a) State the meaning of the term compound.

.....

..... [2]

(b) Fig. 2.1 shows a fractionating column for separating petroleum into different hydrocarbon fractions.

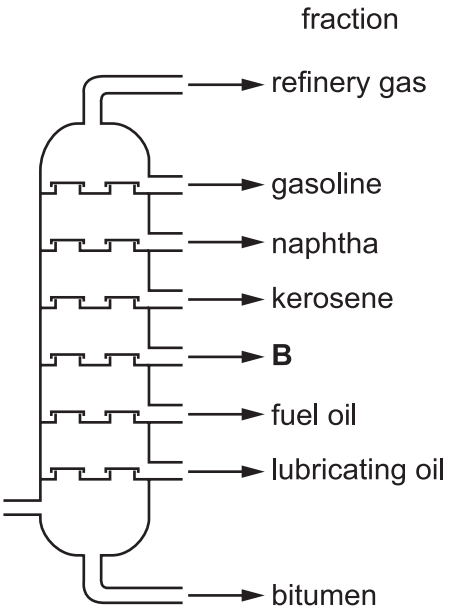


Fig. 2.1

(i) On Fig. 2.1, draw an **X** inside the column to show where the hydrocarbon with the highest boiling point collects. [1]

(ii) Name the fraction labelled **B** in Fig. 2.1.

..... [1]

(iii) State the name of the fraction which has hydrocarbons with the shortest chain length.

..... [1]

(iv) State **one** use of the naphtha fraction.

..... [1]

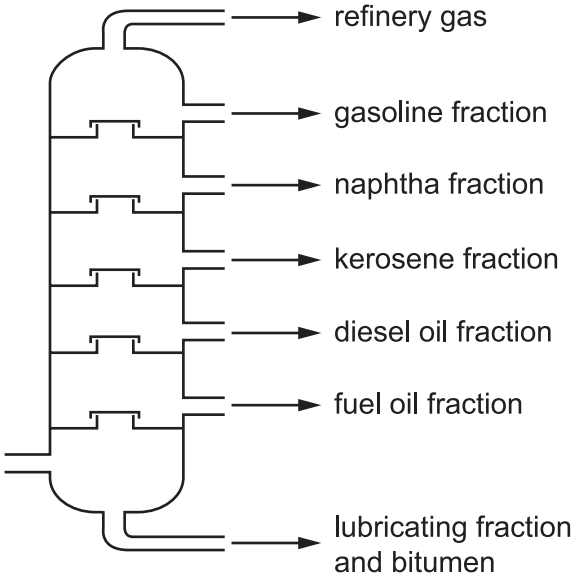
[Total: 6]

Elements, compounds and mixtures Click for more variations

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1(a)	one mark each for any two of: • (substance containing) atoms / ions of two or more (different) elements • (atoms) bonded / chemically combined • cannot be separated (into its components by physical means)	**2**
1(b)(i)	X in lowest section of the column / X in the tube where bitumen collects	**1**
1(b)(ii)	diesel (oil) / gas oil	**1**
1(b)(iii)	refinery gas	**1**
1(b)(iv)	chemical feedstock / making chemicals	**1**

2 The diagram shows a fractionating column used for the fractional distillation of petroleum.



(a) Describe the fractional distillation of petroleum.

In your answer, include
- where the petroleum enters the fractionating column,
- the relative temperatures in the fractionating column (higher or lower),
- the relative boiling points of the fractions (higher or lower),
- the changes in physical state which occur.

.....

.....

.....

.....

.....

.....

..... [4]

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(b) Alkenes can be made by cracking the kerosene fraction.

(i) What is meant by the term *cracking*?

.....

..... [2]

(ii) When butane is cracked, ethene and gas **X** are produced.

$$C_4H_{10} \rightarrow 2C_2H_4 + \mathbf{X}$$

State the name of gas **X**.

..... [1]

(c) Complete the sentence about the bonding in butane.

All the bonds in butane are single ..... chemical bonds. [1]

(d) Ethene is used to make poly(ethene).

Which **one** of the following words describes poly(ethene)?
Put a circle around the correct answer.

gas **monomer** **polymer** **solvent**

[1]

[Total: 9]

Fuels, petroleum and cracking Click for more variations

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2(a)	any 4 from: • petroleum vaporised / heated • petroleum enters the fractionating column at the bottom • vapours move up the fractionating column • column is hotter at the bottom / cooler at the top • idea of vapours condensing in different parts of the fractionating column • idea of different fractions having different boiling ranges • fractions (condensing) higher up have lower boiling points **ORA**	**4**
2(b)(i)	breaking down / decomposing / splitting hydrocarbons	**1**
	into smaller hydrocarbons / into alkanes and alkenes / by heating / using a high temperature	**1**
2(b)(ii)	hydrogen	**1**
2(c)	covalent	**1**
2(d)	polymer	**1**

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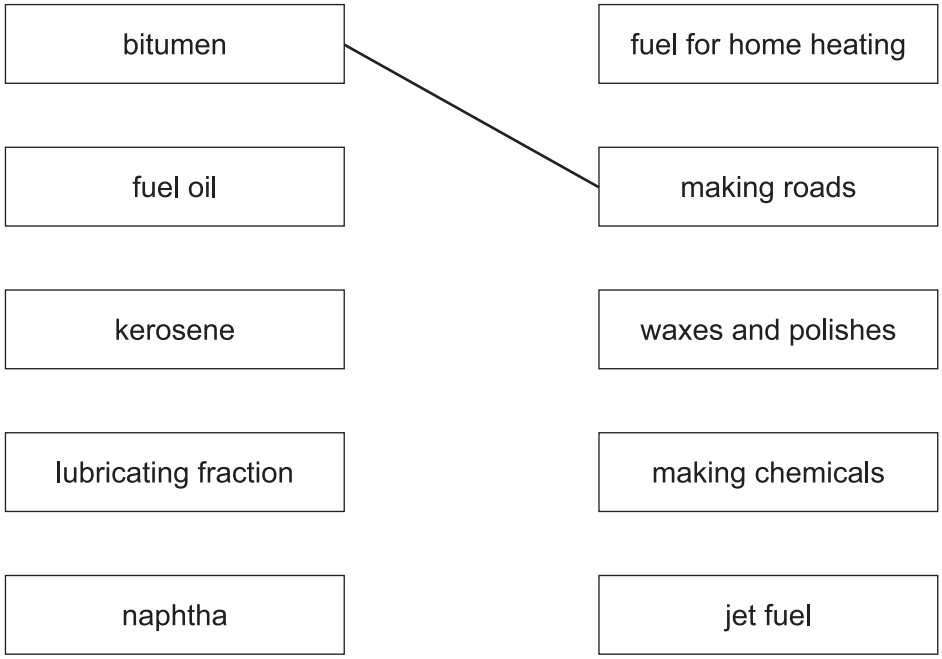
3 Petroleum is a mixture of hydrocarbons.
Two of the processes carried out in an oil refinery are fractional distillation of petroleum and cracking of hydrocarbon fractions.

(a) Which property of hydrocarbons is used to separate petroleum into fractions?
Tick **one** box.

boiling point	☐
chemical reactivity	☐
electrical conductivity	☐
melting point	☐

[1]

(b) Match the fractions on the left with their uses on the right.
The first one has been done for you.



[4]

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(c) Cracking is used to break down long chained alkanes into shorter chained alkanes and alkenes.

(i) State two conditions needed for cracking.

1. .....

2. ..... [2]

(ii) The hydrocarbon, $C_{14}H_{30}$, can be cracked to make ethene and one other hydrocarbon.
Complete the equation for this reaction.

$$C_{14}H_{30} \rightarrow C_2H_4 + ...$$

[1]

(iii) Draw the full structure of ethene showing all atoms and bonds.

[1]

(d) State the name of the polymer formed from ethene.

..... [1]

(e) Ethene is used to make ethanol.

(i) Which substance is needed for this reaction?
Put a ring around the correct answer.

ammonia **hydrogen** **oxygen** **steam**

[1]

(ii) Phosphoric acid is a catalyst in this reaction.
What do you understand by the term *catalyst*?

.....

..... [1]

[Total: 12]

Fuels, petroleum and cracking Click for more variations

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3 **(a)** boiling point / first box down ticked [1]

(b) fuel oil: fuel for home heating;
kerosene: jet fuel;
lubricating fraction: waxes and polishes;
naphtha: making chemicals; [4]

(c) **(i)** high temperature; catalyst; [2]

(ii) $C_{12}H_{26}$ [1]

(iii) correct structure showing all atoms and bonds [1]

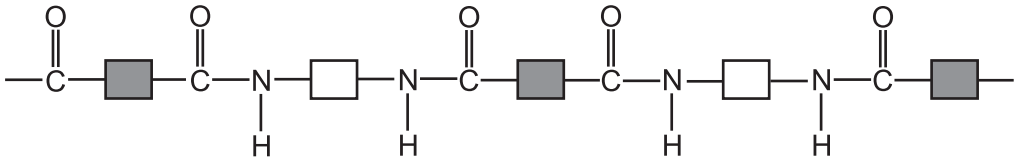
(d) poly(ethene) **allow:** polythene [1]

(e) **(i)** steam [1]

(ii) substance which speeds up rate / speed of reaction [1]

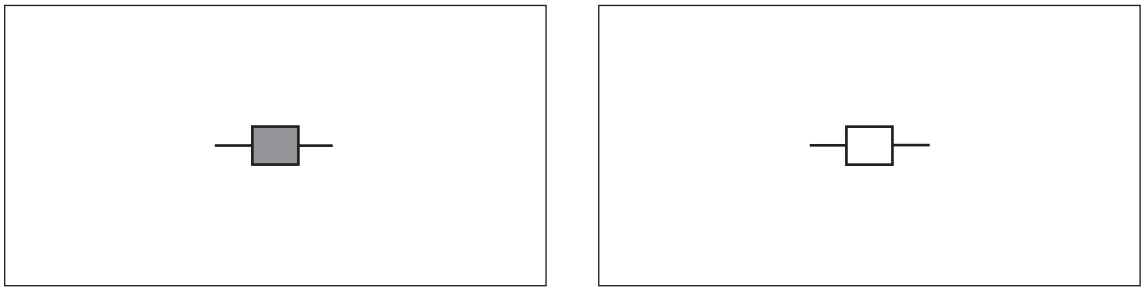
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4 **(a)** Part of the synthetic polymer, nylon, is shown in the diagram.



(i) Circle **one** amide linkage **on the diagram**. [1]

(ii) Complete the structures of the **two** monomers that react to form nylon.



[2]

(iii) Name the other product formed when nylon is produced.

..... [1]

(b) Items made from nylon are often disposed of by burying them in the ground. This is called landfill.

Why is the disposal of nylon using landfill a problem?

.....

..... [1]

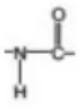
(c) Give the name of a natural polymer.

..... [1]

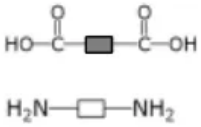
[Total: 6]

Polymers Click for more variations

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4(a)(i)		1

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(a)(ii) 4	 	2
4(a)(iii)	water	1
4(b)	non-biodegradable / running out of space / toxic / leaching	1
4(c)	(complex) carbohydrate / protein	1

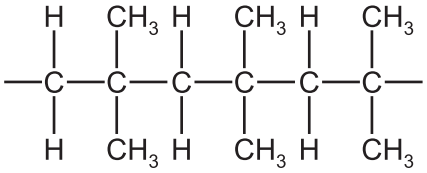
5 There are two types of polymers.

(a) Addition polymers are made from many identical small units.

(i) What is the term used to describe these small units?

..... [1]

(ii) A section of an addition polymer is shown.



Draw the structure of the small unit used to make this addition polymer.

Show all of the atoms and all of the bonds.

[2]

(b) Polyamides are condensation polymers.

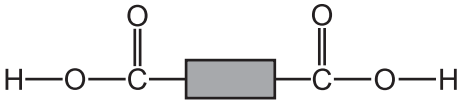
What does the term *condensation* mean when used to describe this type of polymer?

..... [1]

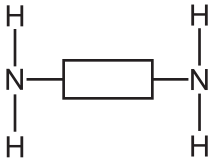
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(c) A polyamide can be made from two different molecules.

A simplified structure of octanedioic acid is shown.



A simplified structure of 1,6-diaminohexane is shown.



(i) Complete the diagram to show a section of polyamide manufactured from octanedioic acid and 1,6-diaminohexane. Include all of the atoms and all of the bonds in the linkages.



[3]

(ii) State the name of a synthetic polyamide.

..... [1]

[Total: 8]

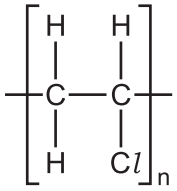
Polymers Click for more variations

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5(a)(i)	monomer	1
5(a)(ii)	any **hydrocarbon** with one C=C bond (with both C atoms having 4 bonds) (1) structure of methylpropene (1)	2
5(b)	water is a product (when polymer is made)	1
5(c)(i)	any correct amide link between any two blocks showing all atoms and all bonds (1) correct orientation of 3 inter-block amide links (1) continuation bonds (1)	3
5(c)(ii)	nylon	1

6 Many monomer molecules react together to form one molecule of a polymer. This reaction is called polymerisation.

(a) The structural formula of the polymer, poly(chloroethene), is given below. This polymer is also known as PVC.



(i) A major use of PVC is insulation of electric cables. PVC is a poor conductor of electricity.
Suggest another property which makes it suitable for this use.

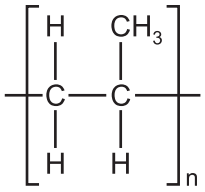
..... [1]

(ii) One way of disposing of waste PVC is by burning it. This method has the disadvantage that poisonous gases are formed.
Suggest **two** poisonous gases which could be formed by the combustion of PVC.

..... [2]

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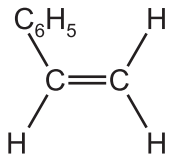
(b) (i) Deduce the structural formula of the monomer from that of the polymer.



structural formula of monomer

[1]

(ii) Deduce the structural formula of the polymer, poly(phenylethene), from the formula of its monomer, phenylethene.



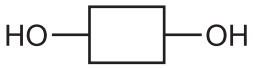
structural formula of polymer

[2]

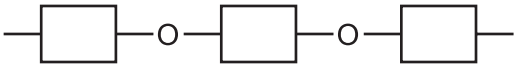
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(c) The carbohydrate, glucose, polymerises to form the more complex carbohydrate starch.

If glucose is represented by



then the structural formula of starch is as drawn below.



How does the polymerisation of glucose differ from that of an alkene such as phenylethene?

.....

.....

..... [2]

[Total: 8]

Polymers Click for more variations

6 **(a)** **(i)** does not decay **or** non-biodegradable **or** flexible **or** bendable **or** easily moulded **or** low density / light / lightweight **or** waterproof / insoluble in water **or** does not corrode **or** durable [1]

(ii) any two from: [2]
chlorine
hydrogen chloride
carbon monoxide

(b) **(i)** CH_3—$CH = CH_2$ [1]
note: can be fully or semi-displayed, C = C must be shown

(ii) correct repeat unit [1]
–$CH(C_6H_5)$–CH_2–

continuation shown [1]

(c) glucose two products (polymer and water) / condensation (polymerisation) / (small) molecules removed [1]

phenylethene one product (polymer) / addition (polymerisation) [1]

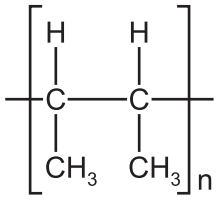
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7 Polymers are large molecules built up from small molecules.

(a) State the name given to the small molecules from which polymers are made.

..... [1]

(b) The formula of a polymer is shown.



(i) Draw the structure of the small molecule from which this polymer is made. Show all of the atoms and all of the bonds.

[2]

(ii) State the type of polymerisation used to make this polymer.

..... [1]

(c) Three amino acids are shown. They combine to form part of a natural polymer.



(i) Name the type of natural polymer formed when amino acids combine.

..... [1]

(ii) Complete the diagram to show part of the structure of the natural polymer that forms when these three amino acids combine. Show all of the bonds in the linkages.



[3]

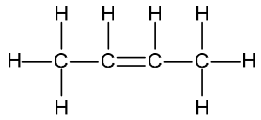
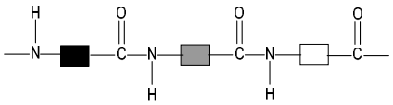
(iii) Name the type of chemical reaction that takes place when this natural polymer is converted back to amino acids.

..... [1]

[Total: 9]

Polymers Click for more variations

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7(a)	monomers	**1**
7(b)(i)	any **hydrocarbon** with one C=C bond (with both C atoms having 4 bonds) (1) structure of but-2-ene (1) 	**2**
7(b)(ii)	addition	**1**
7(c)(i)	protein	**1**
7(c)(ii)	 any correct amide link between any two blocks showing all atoms and all bonds (1) identical orientation of both inter-block amide links including terminal groups with correct orientation (if shown) (1) continuation bonds on polymer (1)	**3**
7(c)(iii)	hydrolysis (1)	**1**

8 Nylon, *Terylene* and proteins are all polymers.

(a) What is a polymer?

.....

.....

..... [2]

(b) Proteins are natural polymers. Proteins are biodegradable.

(i) Name the type of linkage in proteins.

..... [1]

(ii) What is meant by the term *biodegradable*?

.....

.....

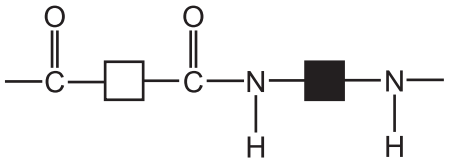
..... [2]

(iii) Name another natural polymer.

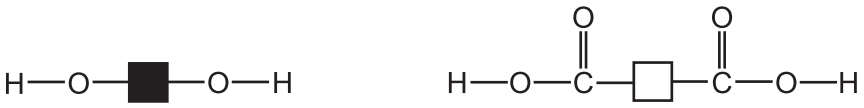
..... [1]

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(c) Nylon and *Terylene* are synthetic polymers.
The repeat unit of nylon can be shown as



Terylene can be made from the monomers shown.



Draw a diagram to show the repeat unit of *Terylene*.

[3]

[Total: 9]

Polymers Click for more variations

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8(a)	large / big molecule made from (many) monomers (joined together)	**1** **1**
8(b)(i)	amide / peptide	**1**
8(b)(ii)	(can be) broken down by microbes / bacteria	**1** **1**
8(b)(iii)	starch / cellulose / DNA / RNA / polysaccharides /	**1**

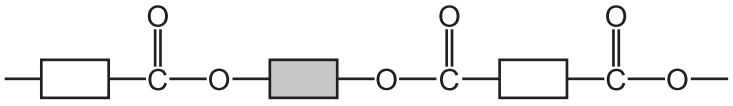
8(c)(i)	**M1** at least one correct ester linkage between boxes **M2** at least two boxes shown and sufficient correct C and O atoms to make **two correct** ester linkages **M3** continuation bond(s) **AND** if more than one repeat unit is shown, the repeat unit must be correctly identified	**1** **1** **1**

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9 This question is about polymers.

(a) Polymer **X** is a condensation polymer.

Part of the structure of polymer **X** is shown.



(i) How many molecules of water are produced when this part of polymer **X** is formed from its monomers?

..... [1]

(ii) Complete the structures of the **two** monomers used to make polymer **X**.

Show all of the atoms and all of the bonds in the functional groups.



and

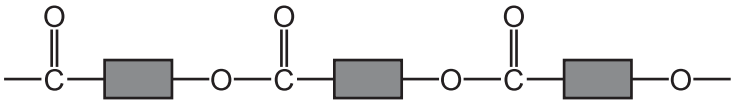


[2]

(iii) What type of condensation polymer is **X**?

..... [1]

(b) Part of polymer **Y** has the structure shown.

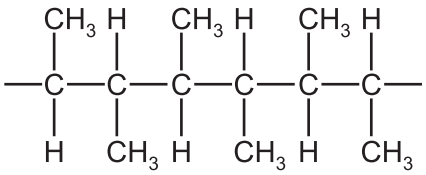


State the number of different types of monomer needed to make polymer **Y**.

..... [1]

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(c) Part of polymer **Z** has the structure shown.



(i) Draw and name the structure of the monomer which forms polymer **Z**.

Show all of the atoms and all of the bonds.

name .....

[3]

(ii) Name the chemical process used to make the monomer that forms polymer **Z**.

..... [1]

[Total: 9]

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9(a)(i)	3	**1**
9(a)(ii)	diagram of dioic acid showing two fully displayed carboxylic acid groups on unshaded block diagram of diol showing two fully displayed hydroxyl groups on shaded block	**2**
9(a)(iii)	polyester	**1**
9(b)	one	**1**
9(c)(i)	any hydrocarbon with one C=C bond (with both C atoms having 4 bonds) (1) structure of but-2-ene (1) but-2-ene	**3**
9(c)(ii)	cracking	**1**

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10 Alkenes are manufactured by cracking larger alkane molecules.

(a) State the source of the large alkane molecules used in cracking.

..... [1]

(b) State **two** conditions needed for cracking large alkane molecules.

1 .....

2 .....

[2]

(c) When one molecule of dodecane, $C_{12}H_{26}$, is cracked, three molecules of but-1-ene and one other product are formed.

(i) Use molecular formulae to complete the symbol equation for this reaction.

$C_{12}H_{26} \rightarrow$ ..... + ...

[2]

(ii) Suggest the type of chemical reaction which happens during cracking.

..... [1]

(d) Propene will undergo polymerisation.

(i) Suggest the name of the polymer formed from propene.

..... [1]

(ii) Draw part of this polymer molecule to show **three** repeat units.

[3]

(iii) State the type of polymerisation propene undergoes.

..... [1]

[Total: 11]

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Fuels, petroleum and cracking Click for more variations

10(a)	petroleum	**1**
10(b)	**M1** high temperature **M2** catalyst	**2**
10(c)(i)	$C_{12}H_{26} \rightarrow 3C_4H_8 + H_2$ **M1** C_4H_8 **M2** correct equation	**2**
10(c)(ii)	thermal decomposition	**1**
10(d)(i)	poly(propene)	**1**
10(d)(ii)	**M1** chain of six C atoms joined by single bonds in a chain **M2** three correctly placed CH_3 groups **M3** correct structure **AND** continuation bonds	**3**
10(d)(iii)	addition	**1**

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