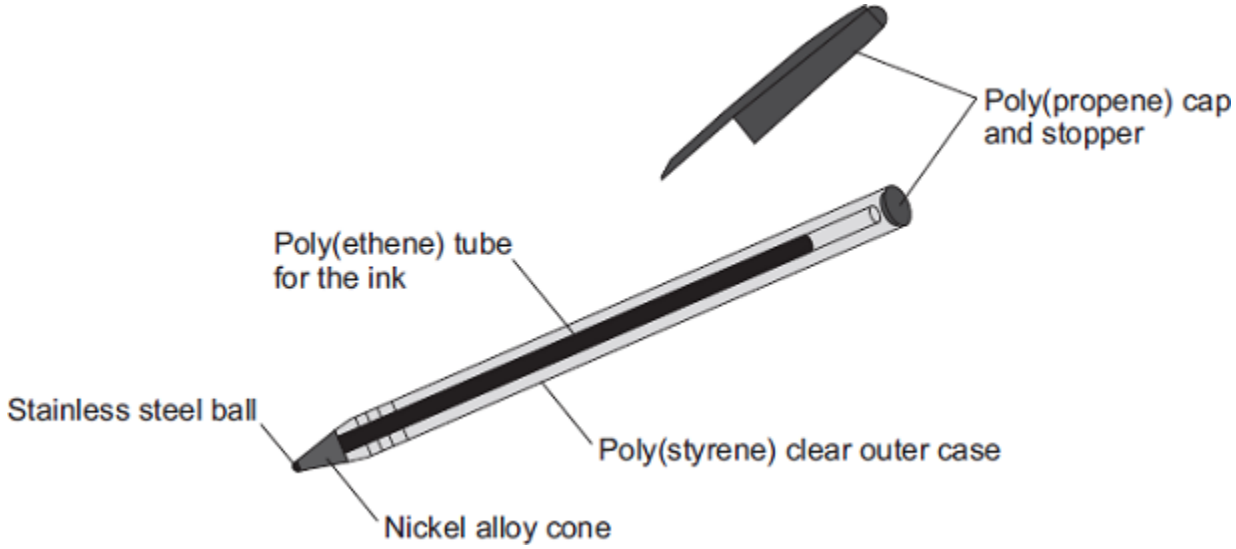
1 The diagram shows a ballpoint pen.



(a) Give **one** advantage and **one** disadvantage of recycling the materials from this type of ballpoint pen.

_____

_____

_____

_____

(2)

(b) Alloys are used to make the ballpoint pen.

Give **two** reasons why alloys are used in the ballpoint pen.

_____

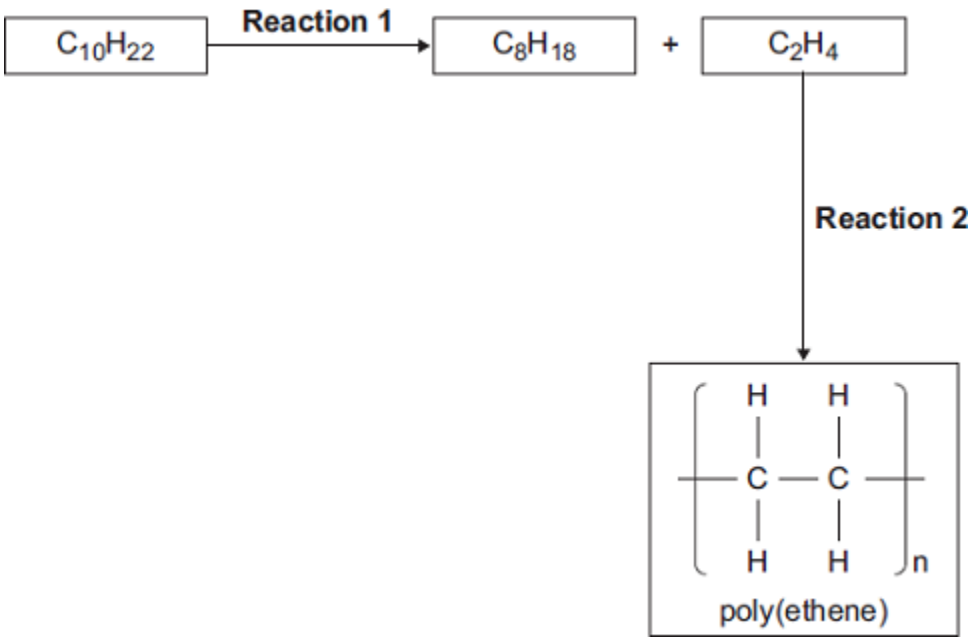
_____

_____

_____

(2)

(c) Decane ($C_{10}H_{22}$) can be used to produce poly(ethene).



(i) Describe the conditions needed for **Reaction 1**.

_____

_____

_____

_____

(2)

(ii) Describe, in terms of molecules, how poly(ethene) is produced in **Reaction 2**.

_____

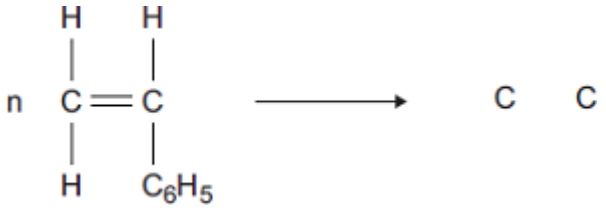
_____

_____

_____

(2)

(d) Complete the displayed structure of the product in the equation.

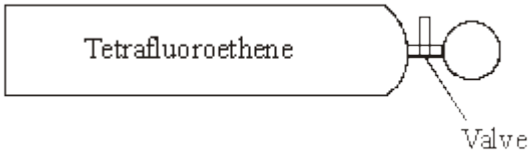


styrene poly(styrene)

(2)

(Total 10 marks)

2 In 1939 Roy Plunkett opened the valve on a new cylinder of tetrafluoroethene gas. No gas came out!



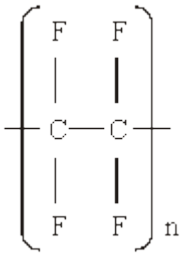
He cut the cylinder open and found that the gas had changed into a white solid. This solid was an addition polymer.

(a) Give the name of the addition polymer that formed inside the cylinder.

_____

(1)

(b) The structure of this polymer can be represented by the diagram below.



Draw the structure of the monomer, tetrafluoroethene, from which it is formed.

(2)

(c) Describe how this addition polymer forms from monomers.

_____

_____

_____

_____

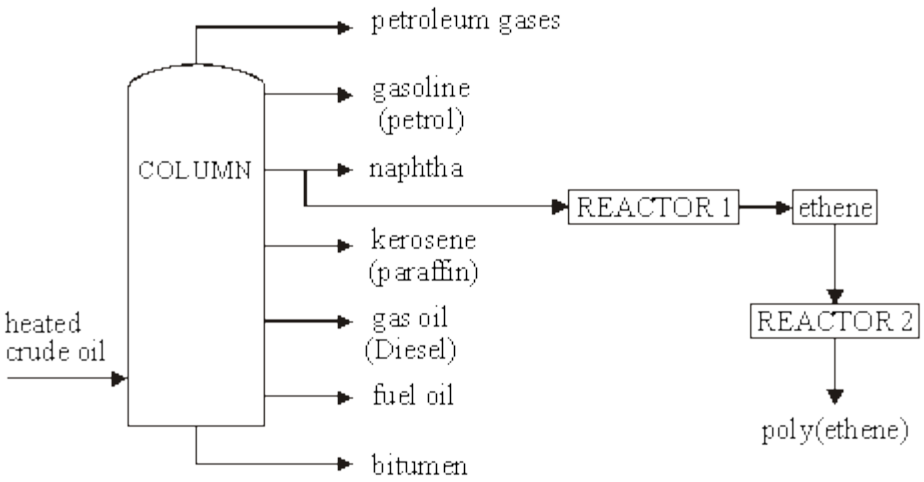
_____

_____

(3)

(Total 6 marks)

3 Crude oil is a mixture of many compounds. The diagram below shows some of the processes that take place in a petrochemical plant.



(a) Name the process which takes place in the COLUMN.

_____

(1)

(b) Name the type of reactions which take place in:

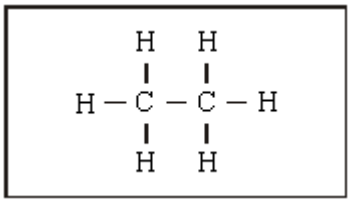
(i) REACTOR 1 _____

(ii) REACTOR 2 _____

(2)

(c) The petroleum gases contain ethane, C_2H_6 and propane, C_3H_8.

The structure of a molecule of ethane can be represented as:



ethane

Draw the structure of a molecule of propane in the space below.

propane

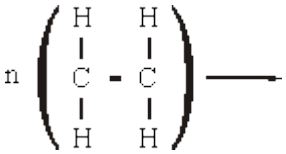
(1)

(d) Ethane and propane are said to be *saturated* hydrocarbons.
What does *saturated* mean when used to describe hydrocarbons?

(1)

(e) Many molecules of ethene join together to form poly(ethene) in REACTOR 2.

Complete the diagram below to show the formation of poly(ethene).



(2)
(Total 7 marks)

4 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)

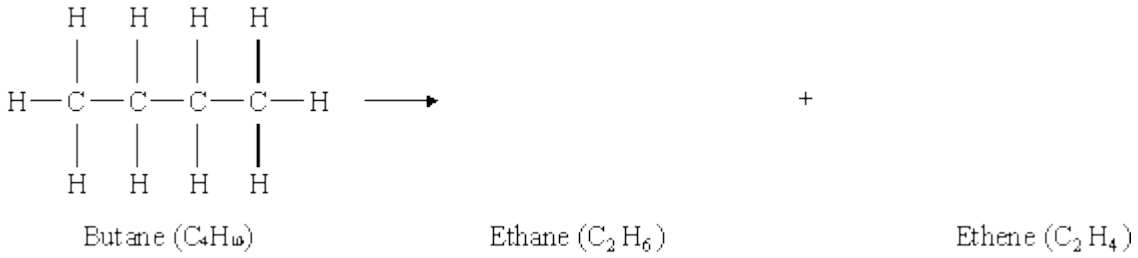
(i) For cracking to happen what needs to be done to the hydrocarbon?

_____

_____

(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.

_____

_____

_____

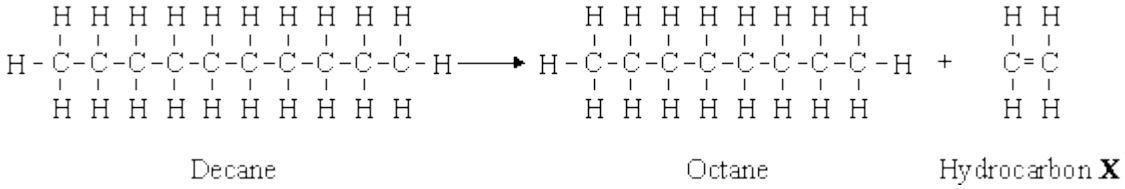
_____

_____

(3)

(Total 10 marks)

5 The high demand for petrol (octane) can be met by breaking down longer hydrocarbons, such as decane, by a process known as cracking.



(a) Apart from heat, what is used to make the rate of this reaction faster?

_____

(1)

(b) Octane is a *hydrocarbon.*

(i) What does *hydrocarbon* mean?

_____

_____

(1)

(ii) Give the molecular formula of octane.

_____

(1)

(c) The hydrocarbon **X** is used to make poly(ethene).

(i) What is the name of **X**?

_____

(1)

(ii) What is the name of the process in which **X** is changed into poly(ethene)?

_____

(1)

(Total 5 marks)

6 Modem window frames are often made from uPVC which contains the plastic poly(chloroethene).

(a) State why plastic window frames need no painting or maintenance.

_____

_____

(1)

(b) Poly(chloroethene) is a polymer formed by the *addition polymerisation* of chloroethene.

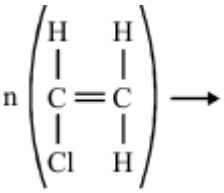
(i) Chloroethene is an unsaturated molecule. Why is this molecule said to be unsaturated?

_____

_____

(1)

(ii) Complete the diagram to represent how poly(chloroethene) is formed from chloroethene.



(3)

(iii) Explain what is meant by the term *polymerisation*.

_____

_____

_____

_____

(2)

(iv) Why is this an *addition polymerisation*?

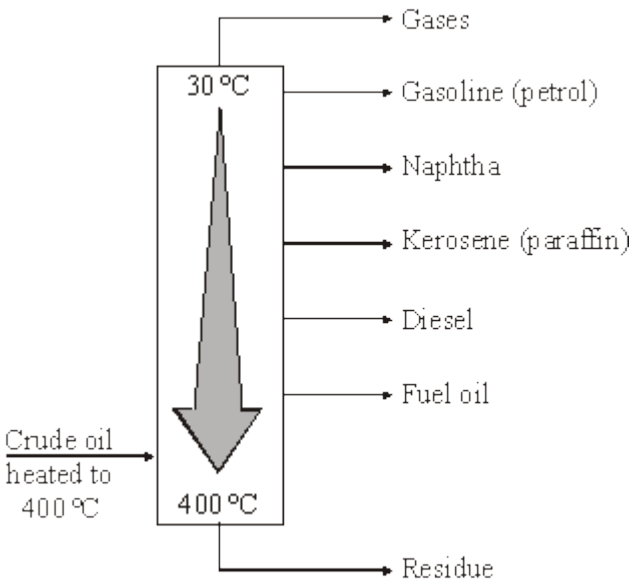
_____

_____

(1)

(Total 8 marks)

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



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

_____

_____

_____

_____

(2)

(b) The naphtha fraction is often used to make other useful materials.

This involves the cracking of hydrocarbons in the naphtha fraction.

For example:

decane → hexane + ethene

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

(i) Balance the symbol equation given above.

(1)

(ii) Describe how cracking is carried out.

_____

_____

_____

(2)

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

_____

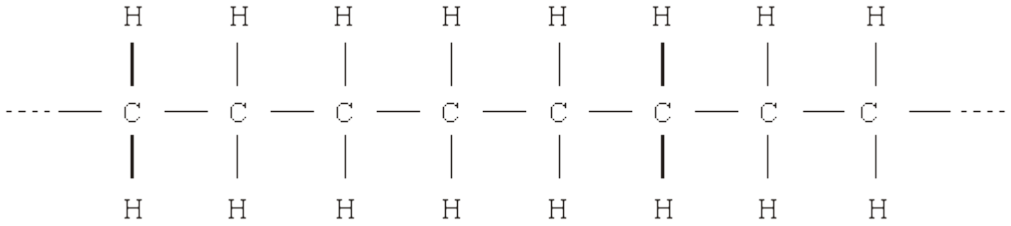
_____

_____

_____

(2)

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



Complete the diagram to show the bonds in ethene.

H H

C C

H H

(1)

(d) Read the following information.

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

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

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

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

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

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

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

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

_____

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 12 marks)

8 Polymers are used to make many materials that people need.

(a) Plastic bags are used to carry, protect and store food. Plastic bags are made from polymers.

Plastic bag made from a polymer

(i) Ethene is the small molecule (the monomer) used to make the polymer for this plastic bag.

Name the polymer that is made from ethene.

_____

(1)

(ii) Use the correct word from the box to complete the sentence about ethene.

condensing	corroding	cracking

Ethene is made by breaking down large hydrocarbon molecules into smaller hydrocarbon molecules by a process called _____

(1)

(iii) The hydrocarbon ethene has the formula C_2H_4

Complete the sentence about ethene.

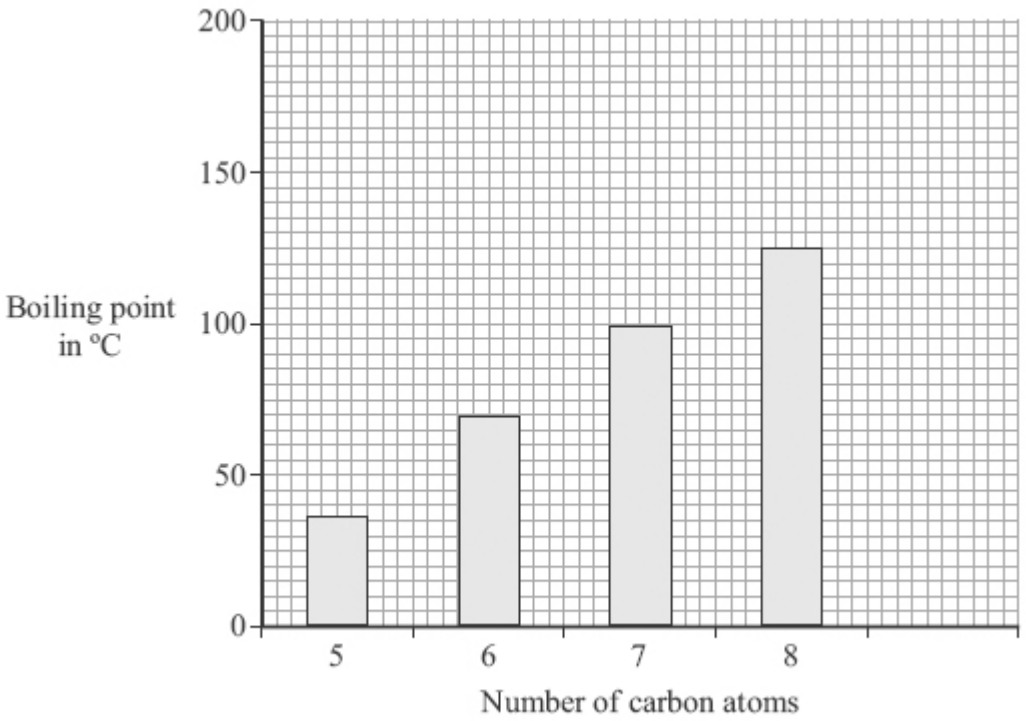
Ethene is a hydrocarbon made up of carbon and _____ atoms.

(1)

(b) The hydrocarbons used to make ethene come from crude oil. The properties of hydrocarbons are linked to the number of carbon atoms in their molecules.

Number of carbon atoms	5	6	7	8	9
Boiling point in °C	36	69	99	125	151

(i) Use the data in the table to complete the bar chart.



(2)

(ii) What happens to the boiling point of a hydrocarbon as the number of carbon atoms increases?

_____

(1)

(iii) All the hydrocarbons in the table are found in petrol. Petrol is one of the fractions separated from crude oil.

Describe how the fractions are separated from crude oil.

_____

_____

_____

_____

_____

(2)

(c) Most plastic bags that are made of hydrocarbons are not biodegradable.

Used plastic bags can be:

- dumped into large holes, which is called landfill
- burned to give out heat energy, which would produce large amounts of gases.

Would burning used plastic bags be better for the environment than dumping them in landfill?

Explain your answer.

_____

_____

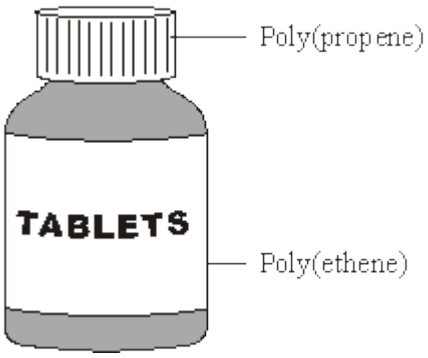
_____

_____

(2)

(Total 10 marks)

9 Tablet containers are often made from two different polymers.



(a) Ethene, C_2H_4, and propene, C_3H_6, can be made from crude oil.

(i) Complete the following sentence.

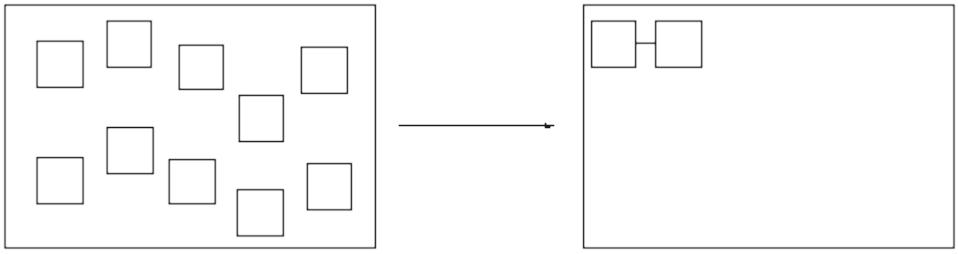
Ethene and propene are called hydrocarbons because they are made up of carbon and _____ atoms only.

(1)

(ii) Ethene molecules are used to form poly(ethene) molecules.

Complete the diagram to show the poly(ethene) molecule.

Ethene molecules **Poly(ethene) molecule**



(2)

(b) The tablet containers could be disposed of in a landfill site or could be recycled.

(i) Suggest **two** reasons why disposing of the tablet containers in a landfill site could cause problems.

1. _____

_____

2. _____

_____

(2)

(ii) Suggest **one** reason why recycling the tablet containers would be difficult.

_____

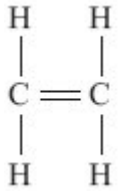
_____

(1)

(Total 6 marks)

10 Crude oil is used to make useful substances such as alkenes and plastics.

(a) The alkene shown is ethene.



(i) Tick (✓) the correct formula for ethene.

Formula	(✓)
CH_4	
C_2H_4	
C_2H_6	

(1)

(ii) Tick (✓) the name of the plastic formed when many ethene molecules join together.

Name of plastic	(✓)
Poly(ethene)	
Poly(ethanol)	
Poly(propene)	

(1)

(b) Read the article about plastics and then answer the questions.

THE PROBLEM WITH PLASTIC WASTE

The UK produces about 3 million tonnes of plastics from crude oil every year.

Most of the litter found on UK beaches is plastic waste.

80% of the plastics produced end up in landfill sites.

The UK recycles only 7% of plastic waste.

(i) Draw a ring around the correct answer in the box to complete the sentence.

Litter that is plastic waste needs to be removed from beaches

because it

decomposes
is flammable
is not biodegradable

.

(1)

(ii) Suggest a problem caused by 80% of the plastics going to landfill sites.

_____

_____

(1)

(iii) The UK government has set a target to recycle 30% of plastic waste.

How are resources saved by recycling more plastics?

_____

_____

(1)

(Total 5 marks)

11 Water sold in plastic bottles has a high 'carbon cost'.

The 'carbon cost' depends on the amount of carbon dioxide emitted in making and transporting the product.

The more carbon dioxide emitted, the higher the 'carbon cost'.

(a) Plastic water bottles are made from a polymer.
The polymer is made from ethene.
Ethene is made by cracking hydrocarbons.

(i) Name the polymer made from ethene.

_____

(1)

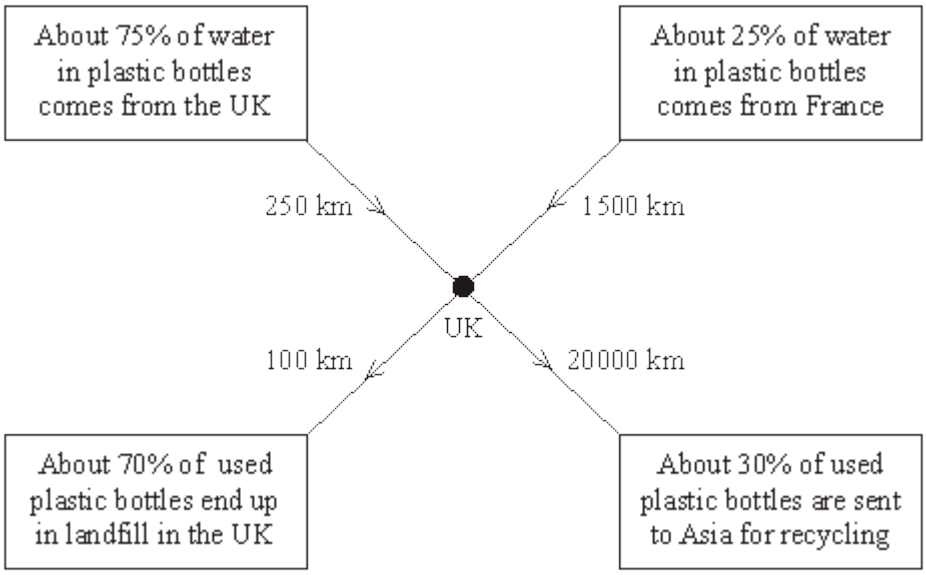
(ii) Ethene can be made by cracking the hydrocarbon pentane, C_5H_{12}.

$$C_5H_{12} \rightarrow C_2H_4 + C_3H_8$$

Explain why there is a 'carbon cost' for the process of cracking a hydrocarbon.

(2)

(b) The diagram shows information about water sold in plastic bottles in the UK.
The diagram also shows the average distances that water and plastic bottles are transported.

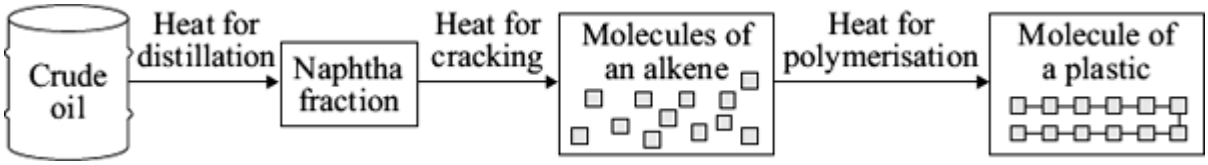


Suggest how the high 'carbon cost' of water sold in plastic bottles could be reduced.

(3)

(Total 6 marks)

12 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.

_____

_____

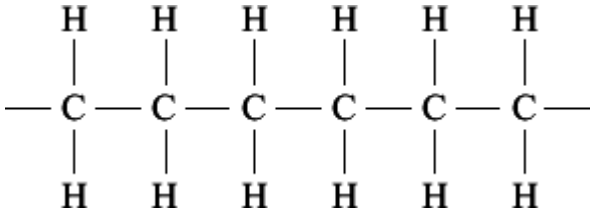
_____

_____

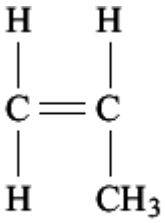
_____

(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

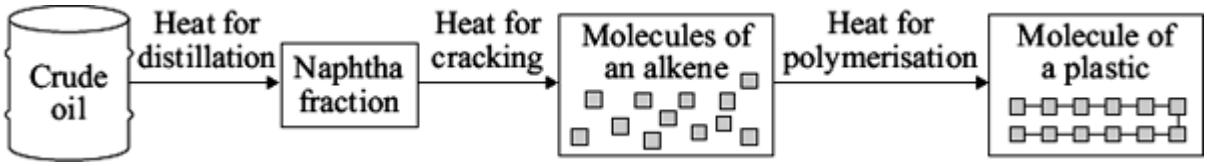
Draw a diagram to represent part of a poly(propene) molecule.

(2)

(Total 9 marks)

13 Crude oil is used to make plastics.

(a) To make a plastic from crude oil involves many processes.



(i) How do alkene molecules form a molecule of a plastic?

_____

_____

(1)

(ii) Suggest **one** of the main costs of making a plastic from crude oil.

_____

_____

(1)

(iii) Suggest **two** problems caused by the disposal of plastics in landfill sites.

1. _____

_____

2. _____

_____

(2)

(b) Some companies are using bio-plastics made from plants such as corn.
Less fossil fuel is used to make bio-plastics than is used to make plastics from crude oil.

Plastics made from plants would be more environmentally friendly than plastics made from crude oil.

Explain why.

_____

_____

_____

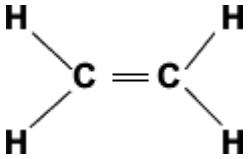
_____

(2)

(Total 6 marks)

14 Supermarkets in the UK have been advised by the Government to stop giving plastic bags to customers.
Plastic bags are made from a polymer.
The polymer is made from ethene.

The structural formula of ethene is shown.



Ethene is made by cracking hydrocarbons.
These hydrocarbons come from crude oil.

(a) Complete these sentences about ethene.

(i) Ethene is a hydrocarbon because it contains only _____ and

_____

(2)

(ii) Ethene is unsaturated because it has a _____ bond.

(1)

(b) Tick (✓) the name of the polymer formed when many ethene molecules join together.

Name of polymer	Tick (✓)
poly(chloroprene)	
poly(ethene)	
poly(propene)	

(1)

(c) Suggest **two** reasons why supermarkets should stop giving plastic bags to customers.

1. _____

_____

2. _____

_____

(2)

(Total 6 marks)

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

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

_____

_____

_____

_____

(2)

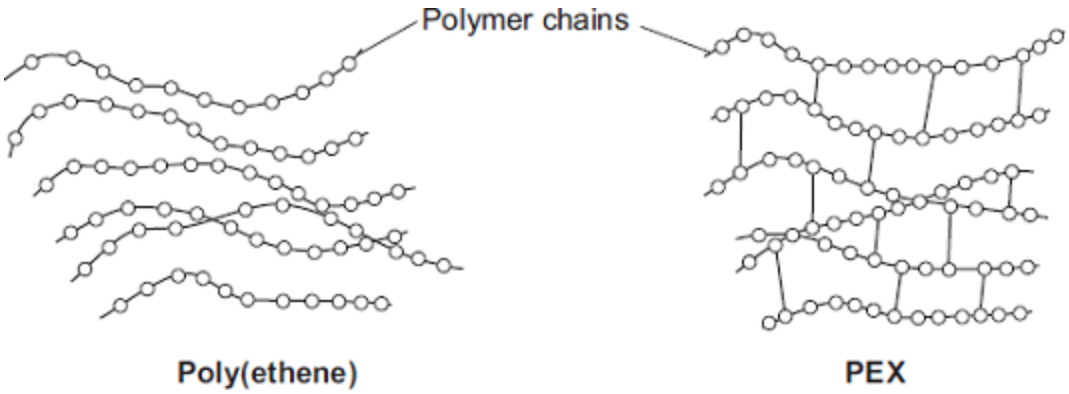
(ii) PEX is a shape memory polymer. What property does a shape memory polymer have?

_____

_____

(1)

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



Poly(ethene) is a thermoplastic that softens easily when heated.
Suggest and explain how the structure of PEX changes this property.

_____

_____

_____

_____

_____

_____

(3)

(b) Copper is a suitable material to use for hot water pipes.
PEX is now used as an alternative material for hot water pipes.

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

1 The low-grade copper ore is powdered and concentrated.

2 The concentrated powdered copper ore is blown into a furnace with air to produce impure, molten copper. (This furnace is heated to 1100 °C using a hydrocarbon fuel.)

3 Oxygen is blown into the impure, molten copper to remove any sulfur. The molten copper is cast into rectangular slabs.

4 The final purification of copper is done by electrolysis.

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

- fractional distillation of crude oil
- cracking of naphtha fraction
- polymerisation of ethene
- conversion of poly(ethene) into PEX.

Use the information above and your knowledge and understanding to suggest possible environmental advantages of using PEX instead of copper for hot water pipes.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

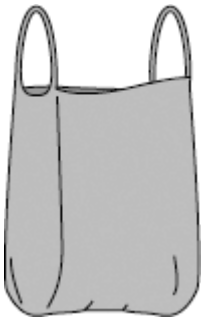
_____

_____

(4)

(Total 10 marks)

16 The plastic used for shopping bags is made from crude oil.



(a) Complete each sentence.

(i) The compounds of hydrogen and carbon

in crude oil are called _____

(1)

(ii) Crude oil is separated into fractions, such as naphtha, using

fractional _____

(1)

(b) Plastics are made from alkenes.
The alkenes are made from naphtha.

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

(i) First the liquid naphtha is made into a gas. This process is called

distilling.
filtering.
vaporising.

(1)

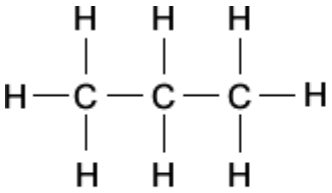
(ii) The naphtha gas is then passed over a hot catalyst.

This process is called

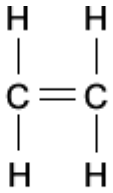
boiling.
bonding.
cracking.

(1)

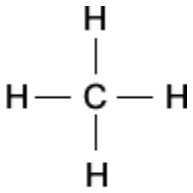
(c) The displayed formulas of three molecules are:



Molecule A



Molecule B



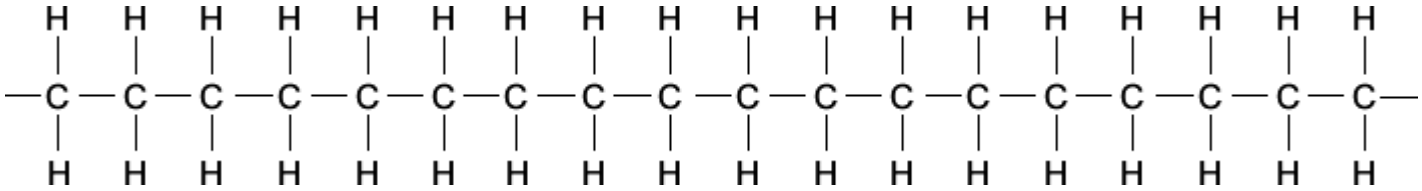
Molecule C

Which molecule, **A**, **B** or **C**, is an alkene? ☐

(1)

(d) The plastic for the bag is made when many alkene molecules are joined together to make the polymer called poly(ethene).

Part of a very large poly(ethene) molecule is shown below.



After plastic bags have been used for shopping, the bags can be reused, recycled, buried in landfill sites or burned.

(i) Reusing and recycling used plastic bags is good for the environment because this conserves crude oil.

Tick (✓) another reason why recycling used plastic bags is good for the environment.

Reason	Tick (✓)
energy is used to transport and melt the used plastic bags	
new plastic products are made from the used plastic bags	
new plastic bags made from crude oil are cheap to produce	

(1)

(ii) Complete the sentence.

One reason why burying used plastic bags in landfill sites is not good for the environment is that poly(ethene) _____

(1)

(iii) Some statements about burning used plastic bags are given below.

Tick (✓) **one** advantage and tick (✓) **one** disadvantage of burning used plastic bags.

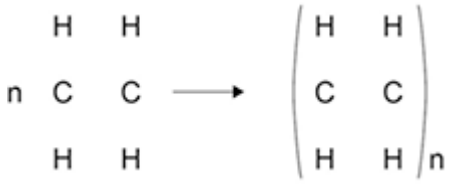
	Advantage Tick (✓)	**Disadvantage Tick (✓)**
new plastic bags can be produced		
carbon dioxide is produced		
water is one of the products		
energy is released		

(2)

(Total 9 marks)

17 Ethene is used to produce poly(ethene).

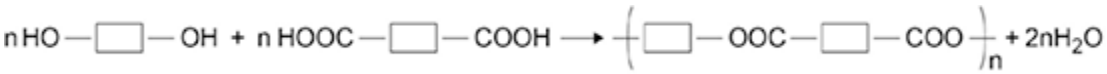
(a) Draw the bonds to complete the displayed formulae of ethene and poly(ethene) in the equation.



(2)

(b) Polyesters are made by a different method of polymerisation.

The equation for the reaction to produce a polyester can be represented as:



Compare the polymerisation reaction used to produce poly(ethene) with the polymerisation reaction used to produce a polyester.

(4)

(Total 6 marks)

18 This question is about polymers.

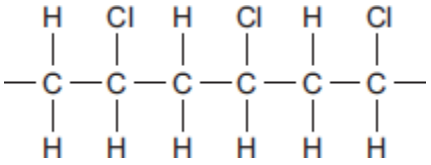
(a) The polymer polyvinyl chloride (PVC) is non-biodegradable.

Give **one** problem caused by non-biodegradable polymers.

(1)

(b) **Figure 1** shows a short section of a PVC molecule.

Figure 1



PVC is produced from a monomer that contains two carbon atoms.

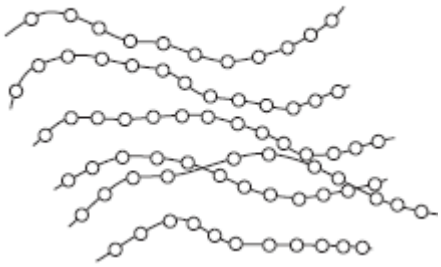
Complete the structure of the monomer.

C C

(2)

(c) **Figure 2** represents a few short chains of PVC molecules.

Figure 2



Explain why PVC softens and melts when heated.

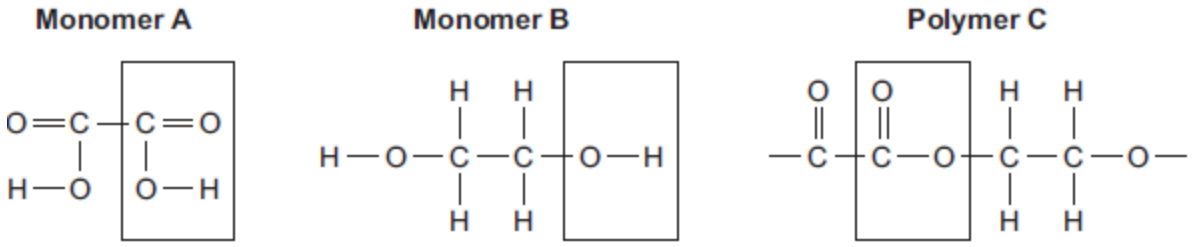
Use **Figure 2** and your knowledge of structure and bonding to help you to answer the question.

(3)

(d) Monomer **A** and monomer **B** react to form polymer **C**.

The displayed structures of monomer **A**, monomer **B** and a short section of polymer **C** are shown in **Figure 3**. The functional group of each structure is shown in a box.

Figure 3



Complete the **Table** below below by writing the names of the functional groups for monomer **A** and polymer **C**.

Table

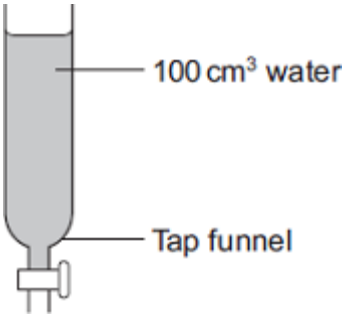
	Name of functional group
Monomer **A**	_____
Monomer **B**	alcohol
Polymer **C**	_____

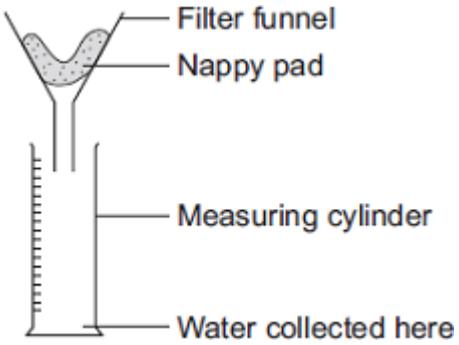
(2)

(Total 8 marks)

19 Disposable nappies for babies need to absorb as much water as possible.
Disposable nappies have a pad containing a special polymer called a hydrogel.
Hydrogels absorb water.

A company called Aqanaps compared the water absorption of its nappy pads with nappy pads made by other companies.





- A scientist from Aqanaps poured 100 cm^3 of water onto the pad of one of their nappies.
- He measured the volume of water that passed through.
- He did the test three times using a new nappy pad for each test.
- The scientist then repeated the procedure using the nappy pads from three other companies, **A**, **B** and **C**.

The results are shown in the table.

Company	Volume of water collected in cm^3		
	Pad 1	**Pad 2**	**Pad 3**
Aqanaps	55	57	55
A	47	46	39
B	65	63	64
C	38	39	38

(a) (i) Choose **one** result in the table that should be tested again.

Result: Company _____ Pad _____

Explain why you chose this result.

_____

_____

_____

(2)

(ii) Suggest **one** variable that should be controlled in this investigation.

_____

_____

(1)

(iii) Suggest **one** possible cause of error in this investigation.

_____

_____

(1)

(b) (i) The Aqanaps company studied the results. The company concluded that it should increase the amount of hydrogel used in its nappy pads.

Give **two** reasons why the company decided to increase the amount of hydrogel used in its nappy pads.

1. _____

_____

2. _____

_____

(2)

(ii) Suggest **one** disadvantage for the company if it increases the amount of hydrogel used in its nappy pads.

_____

_____

(1)

(Total 7 marks)

20 The raw materials used to make the polymer polyvinyl chloride (PVC) are crude oil and sea salt (sodium chloride).

(a) There are three main stages in the production of PVC.

(i) **Stage 1** Cracking of hydrocarbons from crude oil produces ethene, C_2H_4

$$C_{10}H_{22} \longrightarrow C_8H_{18} + C_2H_4$$

How are hydrocarbons cracked?

_____

_____

_____

_____

(2)

(ii) **Stage 2** Electrolysis of sodium chloride solution produces chlorine.
Ethene from **Stage 1** is then reacted with this chlorine.
One of the hydrogen atoms in each ethene molecule is replaced by a chlorine atom to produce vinyl chloride.

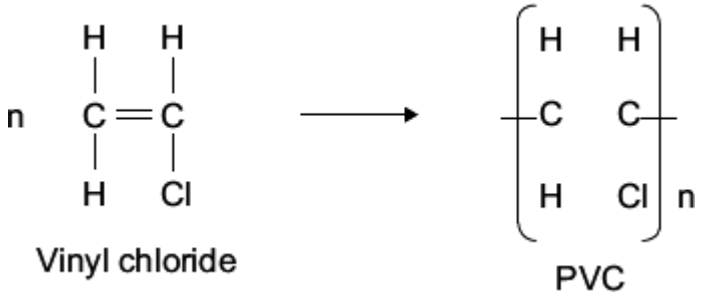
Complete the chemical equation by writing in the formula of the product vinyl chloride.

C_2H_4 + Cl_2 ⟶ _____ + HCl

(1)

(iii) **Stage 3** Polymerisation of vinyl chloride produces polyvinyl chloride (PVC).

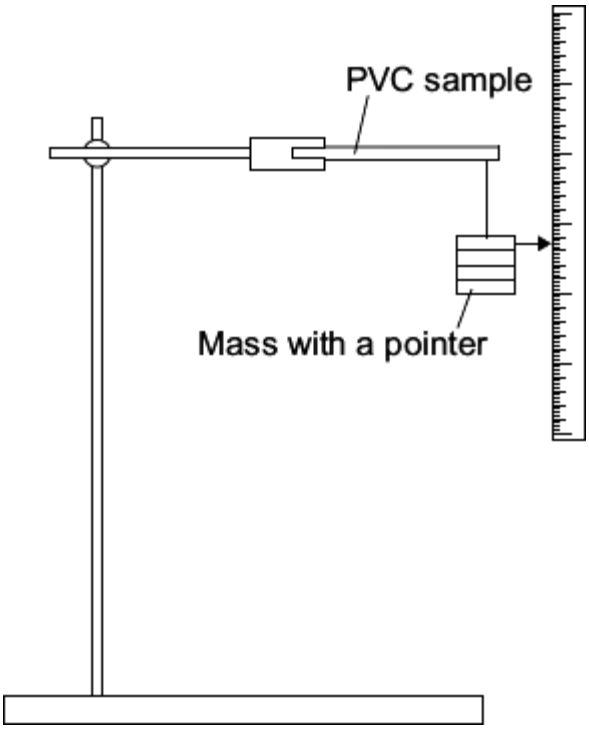
Complete the chemical equation by drawing in the missing bonds of the product, PVC.



(1)

(b) Unplasticised polyvinyl chloride (uPVC) is used to make door and window frames.
PVC with a plasticiser added is used to make cling film for wrapping food.
A plasticiser is a chemical compound.

A student investigated how the percentage of plasticiser added to PVC affected its flexibility.
The student measured the bending of PVC samples when a mass was added.



The student's results are shown in the table.

Sample of PVC	Percentage (%) of plasticiser added	Bending of PVC sample in mm				
		Test 1	Test 2	Test 3	Test 4	Mean
A	**0**	2	3	3	4	3
B	**5**	22	15	23	24	
C	**10**	27	27	29	29	28
D	**15**	34	35	35	36	35

(i) Each PVC sample should be the same size to make it a fair test.
Explain why.

_____

_____

(1)

(ii) The student repeated the test four times for each sample.
Explain why.

_____

_____

(1)

(iii) Calculate the mean value for sample **B**.

_____

_____

_____

_____

(2)

(iv) Each of the samples bent the most in test **4**.
Suggest a possible reason for this.

_____

_____

(1)

(c) Suggest why unplasticised polyvinyl chloride (uPVC) is used to make door and window frames.

_____

_____

(1)

(Total 10 marks)

1

(a) any **one** advantage from:

- conserves resources (of crude oil / metal ores)
  ignore can be made into other items
  allow the materials (in the pen) are non-renewable
  allow less expensive than producing from the raw material
- reduces use of landfill
  ignore less waste
- less use of fuels/energy
- less carbon dioxide produced
  ignore global warming unqualified

1

any **one** disadvantage from:

- made of different polymers / alloys / materials
- difficulty / cost of separating the different materials
  allow not all the materials can be recycled

1

(b) hard / strong / durable

1

resistant to corrosion **or** unreactive
allow do not rust
*do **not** allow corrosive*

1

(c) (i) vapours (of decane)
ignore pressure / hot / heat
allow high temperature (≥150 °C)

1

passed over a catalyst **or** porous pot **or** aluminium oxide
allow catalyst even if incorrectly named

1

or
mixed with steam (1)
at a (very) high temperature (1)
if temperature quoted, must be ≥ 500 °C

(ii) <u>many</u> monomers **or** <u>many</u> ethene molecules

1

join / bond

allow addition polymerisation for second mark

1

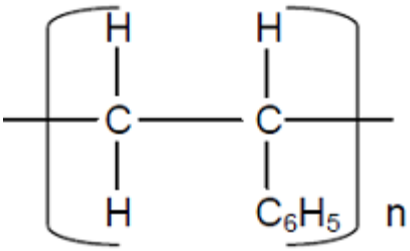
OR

monomers / ethene molecules (1)

form chains **or** very large molecules (1)

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

(d)



allow bonds that do not extend through brackets

7 single bonds are used and are in the correct places with no additional atoms (1)

the brackets and the n are in the correct place (1)

2

[10]

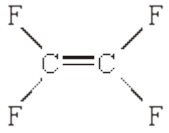
2

(a) poly(tetrafluoroethene) **or** polytetrafluoroethene

accept PTFE or Teflon

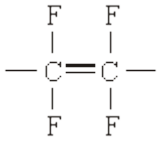
1

(b) double bond

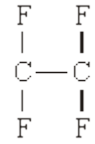


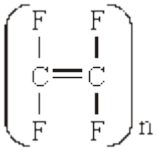
1

all other atoms and bonds correct including F for fluorine



ignore n in front

or  ***= 1*** *mark*

 *= **1** mark*

$CF_2 = CF_2$ *= **1** mark*

*do **not** accept structures with more than 2 C atoms*

1

(c) any **three** from:

- many monomers / (small) molecules / tetrafluoroethene molecules

  allow many tetrafluoroethenes
  many particles alone is insufficient
  *do **not** accept many polymers*

- (monomers, molecules etc.) join / bond / link / combine / attach

  allow many particles join
  allow many atoms join
  *do **not** accept collide / add ignore polymerise*
  *do **not** accept many polymers join*

- to form one molecule **or**
  to form a long-chain **or**
  to form a large molecule

- no other substances are produced /
  one substance formed (definition of addition)

- idea of double bond breaking / opening / opens / bond being
  used to join to another molecule **or** the double bond becomes a single bond

3

[6]

3 (a) (fractional) distillation/fractionation

for 1 mark

1

(b) (i) cracking/decomposition

for 1 mark

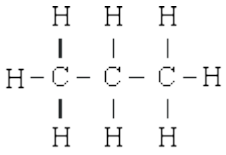
1

(ii) polymerisation/addition reaction

for 1 mark

1

(c)



(Must have H atoms)

for 1 mark

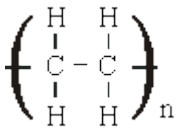
1

(d) contains <u>only/all</u> single bonds
no double bonds
contains maximum number of H atoms
carbon atoms bonded to 4 other atoms (not 4 H atoms)
will not undergo addition reactions

any 1 for 1 mark

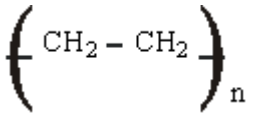
1

(e)



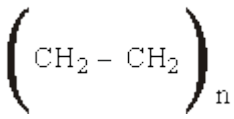
(n must be on (right))

= 2 marks

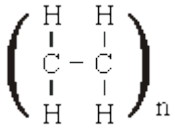


(n on left = 1 mark)

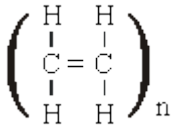
= 2 marks



= 1 mark



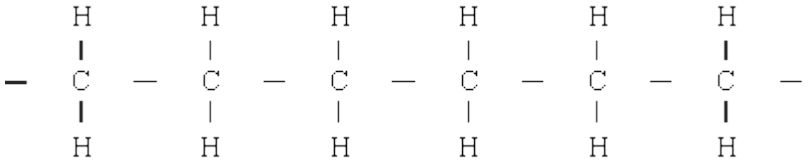
= 1 mark



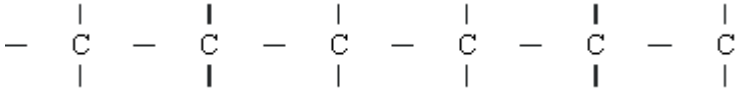
(Double bond loses both marks)

= 0 marks

<u>OR</u>



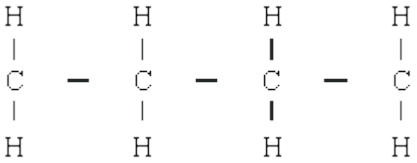
= 2 marks



(for both a minimum of 4 carbon atoms)

= 1 mark

= 2 marks



= 1 mark

= 1 mark

2

[7]

4 (a) (i) heat

accept increase temperature ignore pressure

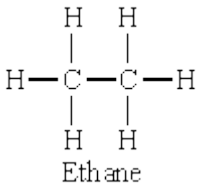
1

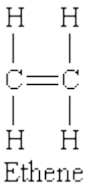
with a catalyst

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

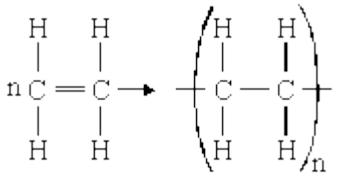
accept many monomers

1

bond together

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

accept



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

1

[10]

5 (a) catalyst

1

(b) (i) made up of **only** carbon and hydrogen

1

(ii) C_8H_{18}

1

(c) (i) ethene

1

(ii) polymerisation

1

[5]

6 (a) not broken down by microorganisms **or** not bio-degradable

accept alternative answers such as:
do not rot / corrode / fade / react with atmosphere etc
any answers which imply the inertness or non-biodegradability of this plastic
accept they don't react, they are 'inert'
ignore rusting
*do **not** accept weathering*

1

(b) (i) (have a) double bond **or** do not have maximum number of (hydrogen) atoms attached

accept can add / react with hydrogen
accept can take part addition reactions

*do **not** accept it is a double bond*
*do **not** accept additional reactions*

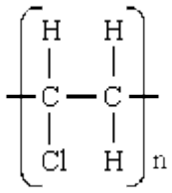
*do **not** accept has 'spare' / 'free' bond*
*do **not** accept alkene alone*

1

(ii) single bond between carbon atoms

1

all atoms correct + 2 'linking' bonds
(linking bonds need not go through bracket)



1

n moved to bottom right of <u>bracket</u> i.e. is below $\frac{1}{2}$ way on the right

first 2 marks are possible for chain structures

accept $[– CHCl–CH_2–]_n$

1

(iii) many molecules **or** many monomers

1

joined / bonded / linked **or** form long chain molecules / large molecules **or** to form a long chain polymer

*accept many alkenes **or** many (ethene) molecules*

*do **not** accept many ethene alone etc.*

to form a long polymer is not enough for 2nd mark

1

(iv) no other substances formed
(A + B → C)

allow because double bond breaks so other atoms can add
allow one product only

*do **not** accept saturation occurs*

1

[8]

7

(a) any **two** from:

- naphtha has a different / low(er) boiling point

  accept different volatility

- condenses at a different temperature / height / place in the column / when it reaches it's boiling point

- different size of molecules

2

(b) (i) $C_{10}H_{22} \rightarrow C_6H_{14} + \mathbf{2}C_2H_4$

allow multiples

1

(ii) (hydrocarbon) heated / vapours

1

(passed over a) catalyst / alumina / porous pot

ignore other catalysts

1

(iii) it / ethene is unsaturated **or** decane and hexane / they are saturated

accept decane and hexane are alkanes / C_nH_{2n+2}

***or** ethene is an alkene / C_nH_{2n}*

***or** different homologous series / general formula*

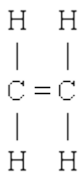
1

ethene has a double (carbon carbon) bond **or** decane and hexane have only single (carbon carbon) bonds

*accept ethene has a reactive double (carbon carbon) bond for **2** marks*

1

(c) <u>all</u> bonds drawn correctly



1

(d) **economic argument** against recycling

any **one** from:

- poly(ethene) / plastic must be collected / transported / sorted / washed

- this uses (fossil) fuels which are expensive

1

environmental argument against recycling

any **one** from:

- uses (fossil) fuels that are non-renewable / form CO_2 / CO / SO_2 / NO_x / particulates
  ignore pollution / harmful gases / etc
- washing uses / pollutes water

1

counter arguments

any **two** from:

- collect / transport alongside other waste
- use biofuels (instead of fossil)
- landfill is running out
- landfill destroys habitats
- incinerators are expensive to build
- saves raw materials / crude oil
- saves energy needed to make new plastic
- incinerators may produce harmful substances
- incinerator ash goes to landfill
- poly(ethene) is non-biodegradable
- poly(ethene) can be made into other useful items
- more jobs / employment for people

2

[12]

8 (a) (i) poly(ethene)
accept polythene

1

(ii) cracking

1

(iii) hydrogen

1

(b) (i) bar labelled 9

1

bar drawn to correct height

1

(ii) (boiling point) increases

1

(iii) heat / evaporate (the crude oil)

accept separate by boiling point

1

cool / condense (hydrocarbons at different temperatures)

accept smaller molecules go to top / larger molecules stay at bottom

*accept fractional distillation for two marks **or** distillation / fractionation for **one** mark*

1

(c) **yes**

any **two** from:

- because plastic does not biodegrade **or** running out of space for landfills **or** land cannot be used for a long time
- it provides heat energy
- which can be used to generate electricity / heat homes or greenhouses
- any other advantage of burning
- any other disadvantage of landfill

or

no

- burning plastic produces carbon dioxide / carbon emissions / toxic gases

accept landfill does not produce carbon dioxide / carbon emissions

- causes global warming / climate change / increase greenhouse effect / global dimming / acid rain
- any other disadvantage of burning
- any other advantage of landfill

2

[10]

9 (a) (i) hydrogen

must be name

1

(ii) a line of four or more ethene molecules joined to the original two with single bonds

*at least two other ethene molecules joined to the original two in a chain gains **1** mark*

2

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

- non-biodegradable

  accept remains a long time
- landfill sites are filling up / limited

  accept land / space used up
- waste of a resource / could be recycled / reused

  ignore references to tablets / animals

2

(ii) any **one** from:

- (two) different polymers / plastics / materials
- need to be separated
- limited collection points / many need to be collected
- tablets may still be present

1

[6]

10 (a) (i) C_2H_4

1

(ii) poly(ethene)

1

(b) (i) is not biodegradable

1

(ii) not enough landfill sites / space

*accept landfill sites are filling up **or** plastics remain for years **or** plastics not broken down*

ignore cost / waste of resources / not biodegradable / wildlife

1

(iii) less (crude) oil / fuels / energy used

accept (crude) oil is a non-renewable resource

1

[5]

11 (a) (i) polyethene / poly(ethene)

accept polythene / polyethylene

1

(ii) needs heat / energy / high temperature / fuel (for cracking)

ignore other processes

1

produces carbon dioxide / CO_2

ignore use of CO_2 ***or*** *'produces carbon'*

1

(b) any **three** from:

- use water from local sources **or** water from close to home
- recycle bottles in the UK / close to home

  accept do not recycle in other countries / Asia
- (reduction in distance travelled) would reduce CO_2 emitted by transport

  accept use of transport with low / no carbon dioxide emissions
- use tap water
- use glass bottles / waxed cartons / metal bottles

  do ***not*** *accept 'do not use plastic bottles' without an alternative material*
- do not put in landfill **or** recycle <u>more</u>
- reuse / refill plastic bottles
- <u>tax</u> imported water / plastic bottles (to offset carbon cost)
- make more / all plastic bottles in UK

  answers must be about the reduction of carbon cost

3

[6]

12 (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]

13 (a) (i) any **one** from:

- bond / join (together)

ignore polymerisation / heat

- double bond opens

1

(ii) any **one** from:

- heat / energy
  ignore many processes / distillation / cracking / polymerisation
- cost of fuels / the crude oil
- construction of the factory / plant
- wages / salaries

1

(iii) any **two** from:

ignore gases released / burning / habitats

- non-biodegradable
  accept remains a long time
- landfill sites are filling up / limited
  accept land / space used up
- waste of a resource / could be recycled / reused
  accept crude oil is running out

2

(b) any **two** from:

- renewable / sustainable
  ignore recycling
  ignore crude oil is running out
- less fuel <u>burned</u>
  accept less energy / heat needed
- biodegradable
- <u>natural</u> resource
- plants absorb carbon dioxide

2

[6]

14 (a) (i) carbon

1

hydrogen

accept in either order
ignore number eg 2 carbons
4 hydrogens

1

(ii) (a carbon carbon) double (bond)

1

(b) poly(ethene)

1

(c) any **two** from:

ignore pollution / cost / global warming / harms environment / recycling

- made from crude oil
- non-renewable resources

  accept resources are running out
- litter

  accept go to landfill
- not biodegradable
- use energy to make
- when burned or biodegraded carbon dioxide is released
- encourage customers to reuse bags / use their own bags

  accept reduces carbon emissions / footprint

2

[6]

15 (a) (i) many ethene / molecules / monomers

accept double bonds open / break

accept addition polymerisation

1

join to form a long hydrocarbon / chain / large molecule

ignore references to ethane

*correct equation gains **2** marks*

1

(ii) (can be deformed but) return to their original shape (when heated or cooled)

ignore 'it remembers its shape'

1

(iii) cross links / extra bonds in PEX

it = PEX throughout

accept inter-molecular bonds

ignore inter-molecular forces

1

molecules / chains in PEX are held in position

accept rigid structure

1

molecules / chains in PEX unable to slide past each other / move

1

(b) any **four** from:

ignore costs / sustainability / non-renewable

- less (hydrocarbon) fuels used
  allow less energy
- less / no electrical energy used
  allow no electrolysis
- reduce carbon / carbon dioxide emissions
  allow less global warming
- reduce / no pollution by sulfur dioxide / acid rain
  allow less / no transportation
- continuous process
- conserve copper which is running out or only low-grade ores available
  allow less waste
- reduce the amount of solid waste rock that needs to be disposed
  allow less mining
- reduce the need to dig large holes (to extract copper ores)

4

[10]

16

(a) (i) hydrocarbons

accept alkanes

1

(ii) distillation

1

(b) (i) vaporising

1

(ii) cracking

1

(c) B

1

(d) (i) new plastic products are made from the used plastic bags

1

(ii) not biodegradable

accept does not decompose

allow does not rot

1

(iii) advantage – energy is released

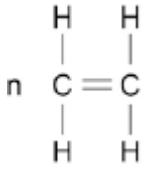
1

disadvantage – carbon dioxide is produced

1

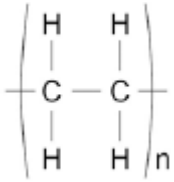
[9]

17 (a) *(ethene)*



1

(polyethene)



1

(b) any **four** from:

- poly(ethene) produced by addition polymerisation whereas polyester by condensation polymerisation
- poly(ethene) produced from one monomer wheareas polyester produced from two different monomers
- poly(ethene) produced from ethene / alkene whereas polyester from a (di)carboxylic acid and a diol / alcohol
- poly(ethene) is the only product formed whereas polyester water also produced
- poly(ethene) repeating unit is a hydrocarbon whereas polyester has an ester linkage

4

[6]

18 (a) any **one** from:

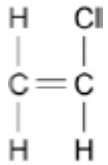
- disposal or does not decompose (in landfill sites) or collection or sorting for recycling

  ignore non-biodegradable alone
- lack of space or more landfill sites
- other specified problems with waste (eg. litter **or** eyesore **or** harm to animals **or** destroys habitats)

  ignore pollution unqualified.

1

(b)



*if 2 marks not awarded, award **1** mark for **one** of the following:*

- *a double bond between the two carbons and no additional trailing bonds*
- *two C atoms bonded together with three single bonds to hydrogen atoms and one single bond to a chlorine atom. no additional Cl or H.*

2

(c) intermolecular forces **or** forces between the chains

allow intermolecular bonds

1

(intermolecular forces are) weak

ignore references to no cross links between chains.

allow 1 mark for weak forces between layers.

1

which are easily overcome (by heat) **or** need little energy to overcome **or** chains / molecules can slide over one another (when heated)

*if weak bonds **or** breaking covalent bonds mentioned only the third marking point is available.*

1

(d) Monomer **A** − carboxylic acid

do not allow carbolic

1

Polymer **C** - ester (linkage)

1

[8]

19 (a) (i) A **and** 3

*accept A **and** 39*

1

anomalous result

independent mark
*accept not close to other two volumes **or** correct comparison using the results*
ignore does not fit the pattern

1

(ii) any **one** from:

- volume of water (used)
  allow amount of water (used)
- time (for water to run through)
  accept rate / speed (at which water runs through)
- temperature
- mass / surface area of pad
  accept amount / size / volume / thickness of pad
- same filter funnel
  ignore other equipment

1

(iii) any **one** from:

ignore human error unqualified

- incorrect / volume / amount of water added
- reading / volume / amount of water collected
- some water does not go through the pad
  allow spillage / poorly placed pad
- not enough time allowed for water to drain through
  accept rate / speed at which water is added
- pads (from one company) not identical / faulty

1

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

- it was not the best (at absorbing the water)
  accept correct descriptions of 'not the best' / third best ***or*** *only better than B*
- (needed) to absorb more (water)
  allow not absorbing enough (water)
- to improve their image / sales
  accept (needs) to absorb more (water) than A and C for ***2*** *marks*

2

(ii) any **one** from:

- cost (more)
- use (more) resources
- use (more) energy

must relate to the company

1

[7]

20 (a) (i) *if (fractional) distillation / hydrogenation mentioned as the method = max 1*

heat / high temperature / hot / vaporise

allow thermal decomposition

ignore evaporation

*do **not** accept 'burns'*

*do **not** accept temperature < 100*

1

catalyst **or** silica / alumina / porous pot

ignore other named catalyst

or steam

*allow heat (the vapour) to a <u>very</u> high temperature / >800°C for **2** marks*

1

(ii) C_2H_3Cl

ignore attempts to balance equation

1

(iii) single bonds between C – H, C – Cl **and** C – C

*do **not** accept symbols outside the bracket*

1

(b) (i) so that the amount of plasticiser / (sample of) PVC is the independent / only variable that affects the bending / flexibility of the samples

allow because different sizes would give different results

accept because size is a control variable

ignore references to reliability / precision etc

1

(ii) to improve the <u>reliability</u> (of the investigation)

accept to calculate a mean

*accept to check for anomalous results **or** to check the range of results*

ignore accuracy / precision etc

1

(iii) 23

*correct answer with or without working = **2** marks*

if answer is incorrect

allow $\frac{22+23+24}{3}$

***or** 21 for **1** mark*

2

(iv) (PVC) sample had been stretched / used / tested in first three tests

accept higher temperature

*allow worn **or** become weaker*

ignore (human) error

ignore more flexible / softer

ignore intermolecular forces

1

(c) does not bend (easily / much)

ignore non-biodegradable / low maintenance

or it is <u>not</u> flexible **or** it is rigid

ignore sturdy / stronger / harder

1

[10]

Examiner reports

1

(a) Most students recognised an advantage of recycling materials by using stock phrases such as, conserves resources, less energy use or less landfill. The disadvantages were more confused, with students not appreciating the context of the question, which was looking for the difficulty and expense of separating all the different items in an object such as a pen. Many students still confuse reuse with recycle. Too many students did not clearly state 'advantage' and 'disadvantage' in their response and as such it was difficult sometimes to judge the correctness of their response. It was clear that some students were not relating their comments to the pen, but to recycling in general.

(b) Most students gained at least one mark, with many getting both marks. Stronger or harder together with the idea of resistance to corrosion were the most common correct reasons for why alloys are used in the ballpoint pen. Less corrosive was a common incorrect response.

(c) (i) A simple description of the conditions for reaction 1 (cracking) was a 'catalyst at high temperature', which was worth two marks. A large proportion of students gained at least one mark, usually for catalyst. However, there was still considerable confusion regarding the process being used, with a very large number of students quoting a nickel catalyst at 60°C. Answers such as 'heat' or 'hot' were not sufficient for the 'high temperature' mark, but there was an acceptable range of actual temperatures.

(ii) This question was poorly answered. Most students could not describe how poly(ethene) is produce from the ethene. The lack of understanding of the process was shown by the large number of blank answers. Also a large number of students provided an explanation of cracking and, as such, gained no credit.

(d) This was also poorly answered with only a small percentage of students gaining two marks. The most common mark gained was for the brackets and 'n' in the displayed structure of poly(styrene). Many students nearly gained two marks, but included a double bond between the two carbon atoms or redrew the poly(ethene) structure. A large number of students did not attempt this question.

2

This question discriminated well between the candidates.

(a) Many candidates were unable to name the polymer. Common errors included candidates omitting the *poly*, the *tetra* or the *fluoro*; some changed the *ethene* to *ethane*. Others suggested 'fluor **ene**' or 'polythene'. Trade names such as PTFE and Teflon received credit.

(b) The popular errors included writing the formula of the monomer in brackets with a subscript 'n' at the lower right of the brackets, omitting the double bond or having a trivalent or pentavalent carbon atom.

(c) Most candidates scored two or three marks. The majority of candidates gained credit for mentioning that molecules (monomers) were joining together and that long chain molecules were formed. However, there were some very vague answers, including references being made to *small* monomers joining (rather than *many* monomers joining) and to monomers joining *hands*. Addition polymerisation does not involve the joining of *polymers* nor the formation of long chains of *monomers*.

3

Candidates' knowledge of organic chemistry was often very limited. A significant number of candidates only managed to score one mark, by correctly drawing the structure of propane in part (c).

Part (a)was better known than part (b), where few could identify both cracking and polymerisation.

Many candidates struggled to give a definition of saturated in part (d). Part (e)was the least well answered part of this question. A common error was to leave a double bond in the product. Although a variety of answers were accepted the simplest answer is that given in the syllabus.

4

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.

5

Double and Single Award

Paper 3 Foundation Tier

The basic ideas about reactions of hydrocarbons were not well known. Although many candidates appreciated that using a catalyst would increase the rate of cracking, ‘pressure’ and ‘oxygen’ were incorrectly suggested. The word ‘only’ must be included when describing a hydrocarbon as being ‘made up of carbon and hydrogen’. Many candidates could determine the correct molecular formula for octane, but some wrote the numbers as superscripts instead of subscripts. In part (c) ethene was usually not known and cracking appeared more frequently than the correct process of polymerisation.

Paper 6 Higher Tier

The basic ideas about reactions of hydrocarbons were not always well known. Although ninny candidates did appreciate that using a catalyst would increase the rate of cracking, ‘pressure’ and ‘oxygen’ were incorrectly suggested. Candidates must include the word ‘only’ when describing a hydrocarbon as being ‘made up of carbon and hydrogen’. Many candidates could determine the correct molecular formula for octane but some wrote the numbers as superscripts instead of subscripts. In part (c) ethene was usually known but cracking was often given instead of polymerisation.

6 **Higher Tier**

This was quite a discriminating question which was generally well answered. Weaker candidates usually scored about half marks.

(a) Most candidates recognised the lack of reactivity of plastics.

(b) (i) Unsaturation was usually known and answered in terms of carbon/carbon double bonds. Popular incorrect responses involved 'spare bonds' or molecules not being 'full up'.

(ii) Almost all the candidates realised that the double bond was broken but fewer candidates were able to give an open-ended structure or were able to correctly place the 'n' in the equation.

(iii) Most candidates gained credit for realising that molecules were joining together or that long chain molecules were formed. However, there were many vague answers, with references being made to small monomers (rather than many monomers) or to the making of polymers without indicating how, or describing what a polymer is.

(iv) This was the least well answered part of the paper. Only a small number of candidates could correctly state the meaning of addition polymerisation. Frequently, candidates suggested that polymers were being added together.

7 In part (a) descriptions of separating naphtha by fractional distillation were often poor because of the common misconception that the fractions are separated as they evaporate, rather than as they condense.

In part (b) most candidates can balance equations, a lot cannot. Cracking is well understood, although a significant number concentrated on what happens to the molecules rather than how the process is carried out. A number of candidates appeared to be describing fractional distillation rather than cracking. Most understood the difference between alkanes and alkenes, although some candidates only mentioned the difference in chain length.

In part (c) most candidates gave the correct structure of ethene. In part (d) few candidates structured their answers in this part. Many did not base their arguments on the 'chosen' recycling option. It was often impossible to tell what the candidates were arguing in favour of and against. A number just gave the benefits of recycling, with no counterarguments. This part was marked as a whole, crediting the marking points wherever they were given in a candidates answer. Although most candidates scored some marks on this question, few scored full marks.

8 Many candidates could not name the polymer made from ethene; the most common incorrect answer was plastic. The rest of part (a) was completed correctly by most candidates.

A surprising number of candidates did not attempt part (b)(i). Those who did often lacked the accuracy required to draw the bar for the hydrocarbon with nine carbon atoms. Some candidates forgot to label the bar.

In part (b)(ii) most candidates appreciated the relationship between the number of carbon atoms and the boiling point. Description of the separation of fractions from crude oil was not well answered. Several candidates thought that the process was cracking, although many candidates did gain one mark for correctly stating that the process was distillation.

In part (c) candidates could usually give part of an explanation for their chosen method for the disposal of plastic bags but struggled to produce a full explanation.

9 A significant number of candidates did not appreciate that hydrocarbons contain carbon and hydrogen for part (a)(i). In part (a)(ii) the candidates gaining both marks understood that a chain forms and connected more than two extra molecules to the two already in the box. Several candidates incorrectly drew pairs of molecules or drew lattice structures.

Most candidates scored at least one mark in part (b)(i), usually by stating that the tablet container was non bio-degradable. Landfill sites filling up was another popular correct suggestion with only a few candidates appreciating that it was a waste of a resource or that it could be recycled or reused.

In part (b)(ii) only a few candidates seemed to realise that it would be difficult to recycle the tablet container because it was made of two different polymers and therefore these polymers first needed to be separated.

10

(a) (i) The majority of candidates recognised the molecular formula of ethene from its structural formula.

(ii) It was surprising how many candidates did not understand or know that when many ethene molecules join together they form poly(ethene).

(b) (i) Most candidates knew that the majority of plastic waste is not biodegradable.

(ii) Many candidates understand that because most plastics do not break down for many years this causes landfill sites to become full and so more land is required for new landfill sites.

(iii) Few gained this mark. This was because most candidates did not answer in terms of the resources saved by recycling. Often candidates just restated recycle or reuse the plastics.

11

Foundation Tier

In part (a)(i) it was surprising how many candidates did not know the name of the polymer made from ethene.

Many candidates in part (a)(ii) thought that carbon dioxide was used in 'the process' and not given off. Those candidates who had not read all of the information stated that 'carbon is very expensive so that is why there is a carbon cost.' A reasonable number of candidates did manage to gain a mark here for stating that heat or energy was needed or that carbon dioxide was given off during the cracking of a hydrocarbon.

Most candidates gained marks in part (b) by suggesting that 'more plastic bottles should be recycled in the UK' or that 'all the water should come from the UK'. There were a few candidates who gained the mark for mentioning that 'less distance travelled would reduce the carbon dioxide emitted by transport'. A few candidates suggested inappropriate solutions, such as: 'sending all the used plastic bottles to Asia', 'drinking less water' and 'putting all the used plastic bottles into landfill'. Very few responses suggested reusing the empty plastic bottles or drinking tap water instead of bottled water.

Higher Tier

It was surprising in part (a)(i) how many candidates did not know the name of the polymer made from ethene.

In part (a)(ii) the idea of 'carbon cost' was understood by nearly all candidates. There were many good answers in terms of the use of fossil fuels to provide the heat energy for cracking. However, many candidates focused on the products, rather than the process, of cracking. Others answered in terms of transport of the reactants or the products. A surprising number of candidates thought that carbon dioxide was used in the process, or that the ethene and pentane were themselves burnt in the process.

There were many candidates in part (b) who found it difficult to understand and then apply the information given in the flow diagram. The mark scheme was broad in scope to reward the varied suggestions that the candidates gave. There were a lot of excellent ideas, either developing one aspect of the problem in depth or looking at covering the breadth of the issues involved. A few candidates suggested inappropriate solutions, such as, 'sending all the used plastic bottles to Asia', 'drinking less water' and 'putting all the used plastic bottles into landfill'. Very few responses suggested reusing the empty plastic bottles or drinking tap water instead of bottled water.

12

(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).

13

(a) (i) This was not answered well. Candidates gained the mark for the idea that alkene molecules join or bond to form a molecule of a plastic. Many wrote that the molecule of plastic is formed because of the heat or by polymerisation, both of which do not explain how alkene molecules form a molecule of a plastic.

(ii) There were many good answers usually related to heating. However, a large number of candidates who quoted that there are lots of processes or that crude oil will run out did not gain any credit.

(iii) Most candidates gained marks bystating that plastic is non-biodegradable or that landfill sites are filling up. References to habitats were not credited because the problems had to be related to the plastics that are put into landfill sites.

(b) The candidates who scored marks here did so by stating that bio-plastic was renewable or that plants or corn could be replanted. However, there were many candidates who just repeated parts of the stem, such as it is environmentally friendly or less fuel used and so gained no credit for these responses.

14

(a) (i) Most candidates answered correctly that a hydrocarbon contains only ‘carbon’ and ‘hydrogen’.

(ii) Most candidates managed to state that ethene is unsaturated because it has a ‘double’ bond. The most common incorrect answers were ‘covalent’, ‘chemical’, ‘ionic’, ‘single’ or ‘strong’.

(b) The majority of candidates knew that when many ethene molecules join together a polymer called ‘poly(ethene)’ is formed.

(c) Most candidates gained a least one mark. There was confusion between the terms ‘recycling’ and ‘reusing’ the plastic bags. Popular but incorrect answers were that ‘plastic bags are not strong or break easily’ or that ‘plastic bags cannot be recycled’. No marks were awarded for vague answers, such as, ‘pollution’, ‘cost’, and ‘harms the environment’. The most common correct answers referred to plastics being ‘non biodegradable’, ‘a litter problem’ or ‘a landfill problem’. There were some excellent responses showing candidates’ knowledge and understanding of the method by which plastics are made and the use of limited resources. Very few candidates presented the idea that supermarkets were advised to stop handing out plastic bags to encourage customers to reuse bags or to use their own bags.

15

(a) (i) Answers were vague and badly organised. Polymerisation was not well known or understood.

(ii) However, many students new that a shape memory polymer would revert to its original shape on heating.

(iii) Knowledge of the cross links in PEX was good, but after that the explanations were weak. Many students just talked about poly(ethene).

(b) This question, asking for environmental advantages of using PEX instead of copper for hot water pipes, was well answered by many students. Students are used to answering this type of question. The major error was concentrating on one or two points and not giving enough detail to score all the marks.

16

(a) (i) Many students realised that the compounds of hydrogen and carbon in crude oil are called hydrocarbons. Several students did not attempt this question.

(ii) The majority of students gained the mark for knowing that crude oil is separated into fractions, such as naphtha, using fractional distillation.

(b) (i) The majority of students knew that the process to turn liquid naphtha into a gas is called vaporising.

(ii) A majority of students knew that the process of passing naphtha gas over a hot catalyst to produce alkenes is called cracking.

(c) Most students gained credit for correctly identifying that B was the displayed structure of an alkene.

(d) (i) The majority of students gained the mark for knowing that recycling used plastic bags is good for the environment because new plastic products are made from the used plastic bags.

(ii) Less than half of the students understood that burying used plastic bags in landfill sites is not good for the environment because poly(ethene) is not biodegradable. Vague incorrect answers included ‘causes pollution’ or ‘gives off gas’.

(iii) Many students did not follow the instructions and ticked more than one box on each side. Several students appeared to have failed to notice the word ‘burning’ in the question. Most of these students answered as if the word was ‘recycling’ and incorrectly ticked ‘new plastic bags can be produced’ as the advantage, and so only a few students gained maximum marks.

18

(a) The majority of students were able to gain a mark here, with most students focusing on the use of landfill sites. A small number of students thought that polymers could not be recycled.

(b) Many completely correct monomer structures were seen, although a significant proportion of students misread the question and drew the repeat unit of the polymer. Other common errors included incorrect valencies (particularly of carbon) and the chlorine atom being replaced by a hydrogen atom.

(c) Many students gave fully correct answers to this question. The correct use of the term “intermolecular” was widespread. The most common error was students writing about the bonds being weak. A surprising number of students seemed to have confused the diagram with the structure of graphite and wrote about layers sliding.

(d) The majority of students gained both marks; there were many interesting and varied spellings of “carboxylic”, but if it was recognisable, and (almost) phonetically correct, then credit was given. A few students had the answers reversed − possibly failing to read the question carefully and just recalling their notes.

19 (a) (i) Most students identified the correct nappy and explained that it was an anomalous result.

(ii) Control variables were well known, although sometimes answers were vague and ambiguous. For example, there were two measurements of the volume of water so volume of water collected was incorrect.

(iii) Errors in this investigation were known, although there was the usual scattering of vague generalised answers such as human error.

(b) (i) Although many students answered that more hydrogel was needed to absorb more water, the second mark was less common. A lot of students confused the volume of water collected with the volume of water absorbed by the nappy and therefore identified the worst nappy as the best one.

(ii) Most students knew one disadvantage, for the company, of increasing the amount of hydrogel used in their nappy pads.

20

(a) (i) This part was poorly answered with very few candidates gaining two marks. There were lots of blank answer spaces here, which was disappointing. Most candidates that gained one mark did so by stating that for cracking the hydrocarbon was heated, and there were a few that then went on to correctly state that it was heated with a catalyst. There was the usual confusion with 'hydrogenation' and 'fractional distillation'. A common error by candidates was to answer the question by describing what happens when a hydrocarbon is cracked.

(ii) There were lots of blank answer spaces here, which was disappointing. The equation was challenging. There were lots of guesses, several giving 'VC', 'PVC', 'VCl' or named elements. A common error was to interpret 'Cl' as two separate elements, 'C' (carbon) and 'l' (iodine), which led to the incorrect formula, C_3H_3I. It was pleasing to see the vast majority of candidates using subscripts for numbers in the formula, even those who got the incorrect answer.

(iii) Lots of blank answer spaces here and very few candidates that attempted the structure of the polymer gained the mark here. Several candidates came close but spoilt an otherwise correct answer by additions outside of the brackets. The most common error was to show a double bond between the carbon atoms.

(b) (i) This question was poorly answered by most candidates. Several candidates correctly realised that changing the size of the PVC sample would affect the results. However, many just stated that it would 'not give accurate/precise results' or it would 'not be a fair test'. It was disappointing that so few candidates made reference to control variables.

(ii) Many candidates again just wrote about 'accurate/precise results' or 'fair test'. Many candidates did link repeating the test to reliable results and gained the mark. There were a few candidates who mentioned 'anomalous results' or 'the need to calculate a mean/average'. The word 'anomalous' presented many candidates with a spelling problem.

(iii) Most candidates did not realise that they needed to ignore the anomalous result and they calculated, for one mark, that the mean was 21. Many candidates who managed to work out that the mean was 23 also explained how they calculated their answer. Many candidates just guessed and gave answers like '22.5', '19.5' or forgot to divide and gave '84'.

(iv) Many candidates managed to realise that the samples 'had been used before' or 'were worn out/weaker'. Several thought that the student had added more plasticiser/mass to the last sample. A few thought that test 4 must be the 'most correct' as the student had perfected their investigative skills by then.

(c) Unfortunately 'strong/sturdy/harder' or 'air/weather/heat proof' were common incorrect responses. Some candidates thought that the uPVC needed to be flexible so that it could be moulded or fitted into the required shape. There were quite a few candidates who did realise from the results of the experiment that the uPVC would not bend or flex very much.