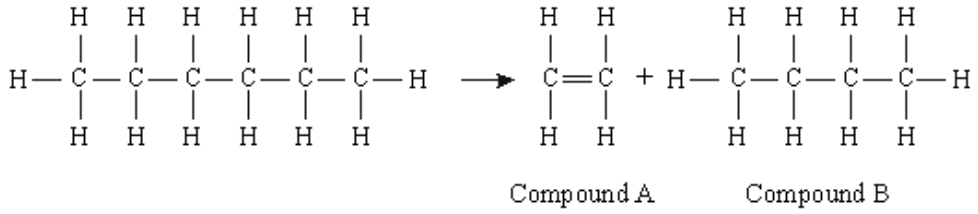
Q1. The equation below shows the cracking of a hydrocarbon compound into two different compounds, A and B.



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

.....

.....

.....

.....

(2)

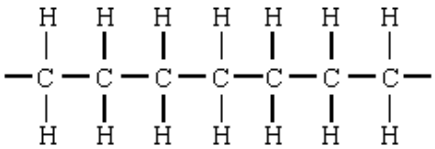
(b) Why is compound A useful in industry?

.....

.....

(1)
(Total 3 marks)

Q2. Poly(ethene) is a long-chain saturated hydrocarbon. The formula for part of the polymer chain is:



(a) Write the structural formula of the small molecule from which poly(ethene) is made.

(2)

(b) Saturated hydrocarbons, such as propane, are fuels.

Write a balanced equation for the complete combustion of propane, C_3H_8.

..... + ... → ..... + ...

(3)

(Total 5 marks)

Q3. Crude oil is a mixture of long-chain hydrocarbons. It is cracked to produce a mixture of smaller alkanes and alkenes. Among the gases formed are ethane and ethene.

(a) Write the structural formula for:

(i) ethane

(1)

(ii) ethene

(1)

(iii) Give an example of **one** chemical reaction which both ethane and ethene undergo.

.....

(1)

(iv) Describe how to distinguish between ethane and ethene. Include a description of the practical method you would use and what you would expect to observe.

.....

.....

.....

.....

.....

.....

(3)

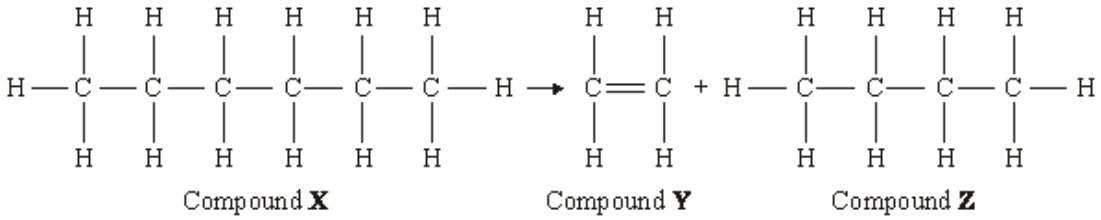
(b) Ethene may be polymerised to form a polymer. Give the name of the polymer and a use for it.

Name ..... Use .....

(1)

(Total 7 marks)

Q4. The diagram shows a reaction which takes place in an oil refinery.



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

.....

(1)

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

.....

(1)

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

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

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

.....

(1)

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

.....

(1)

(Total 4 marks)

Q5. (a) Some hydrocarbons are used as fuels in power stations.

The table gives the boiling points of four hydrocarbons.

Hydrocarbon	**Boiling point in °C**
W	165
X	–160
Y	–40
Z	180

(i) Which of these hydrocarbons are gases at room temperature (20 °C)?

.....

(1)

(ii) Which of these hydrocarbons has the largest molecules?

.....

(1)

(iii) Which of these hydrocarbons ignites most easily?

.....

(1)

(b) Some hydrocarbons are used to produce polymers.

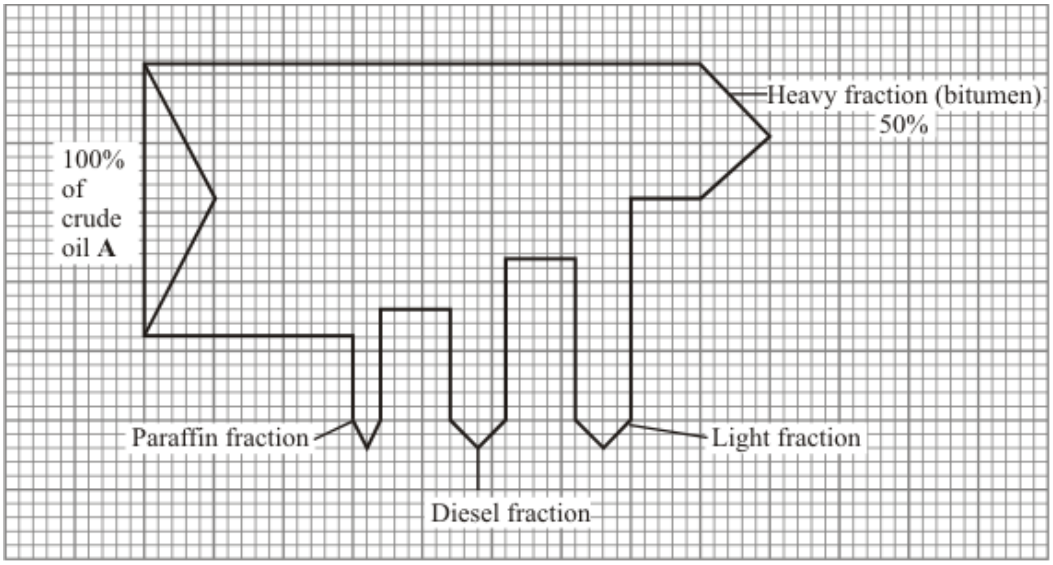
Which type of hydrocarbons can be converted into polymers?

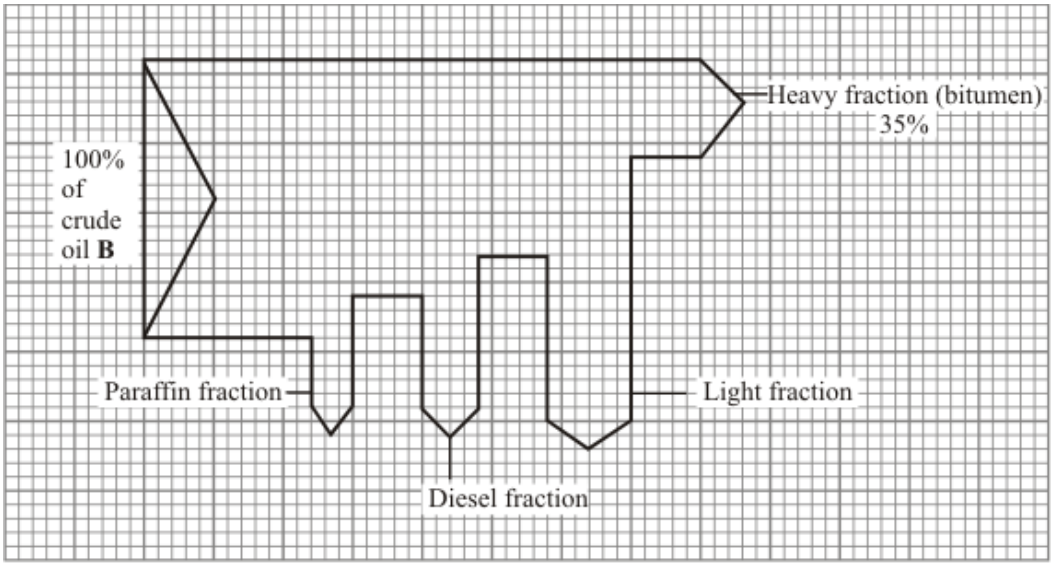
.....

(1)

(Total 4 marks)

Q6. The diagrams show the percentages of the four main fractions produced from two samples of crude oil, **A** and **B**.





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

.....

.....

.....

.....

.....

.....

(2)

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

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

(1)

(ii) Describe how the reaction is carried out.

.....

.....

.....

.....

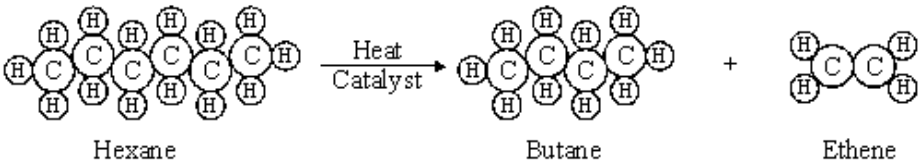
.....

.....

(2)
(Total 5 marks)

Q7. The many hydrocarbons in crude oil are separated into fractions.

(a) Some of the larger hydrocarbon molecules can be broken down to produce smaller, more useful hydrocarbon molecules.



Hexane and butane are alkanes. Describe the structure of alkanes.

.....

.....

.....

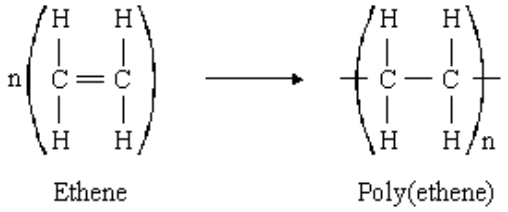
.....

.....

.....

(3)

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



This process is called polymerisation. Explain what is meant by polymerisation.

.....

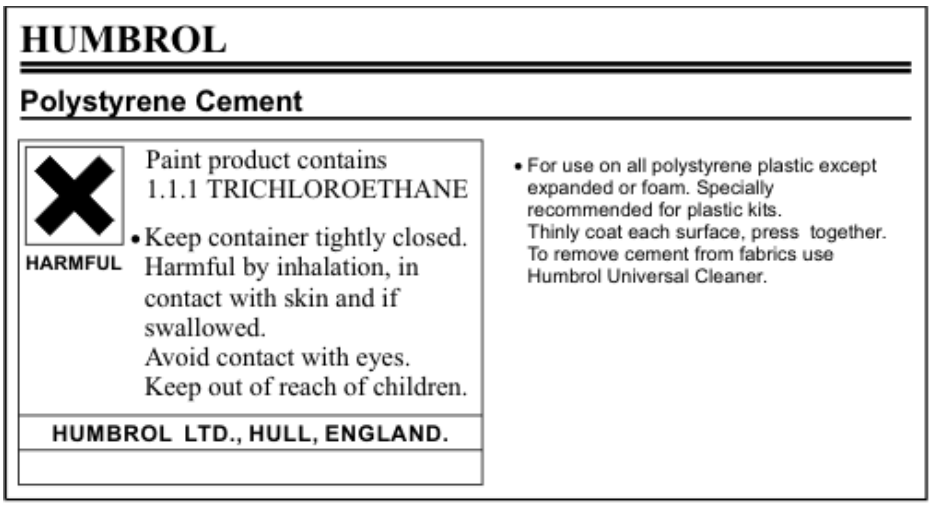
.....

.....

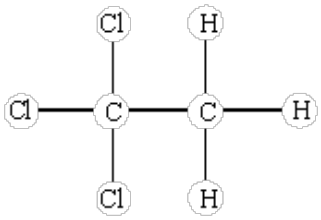
.....

(2)
(Total 5 marks)

Q8. The label has been taken from a tube of *Humbrol Polystyrene Cement*, a glue used in model making.



(a) The solvent used is 1,1,1-trichloroethane. The structural formula of this molecule is:



(i) What do the lines between the atoms represent?

.....

(1)

(ii) State whether 1,1,1-trichloroethane is saturated or unsaturated. Give **one** reason for your answer.

.....

.....

.....

(1)

(iii) 1,1,1-trichloroethane is being replaced in favour of a 'better' solvent. Use information on the label to help you to suggest why.

.....

.....

(1)

(b) Polystyrene is a plastic. Plastics are polymers which are made by the process of polymerisation.

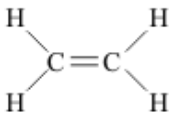
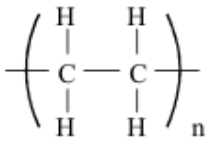
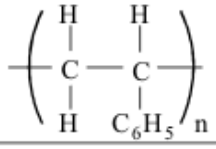
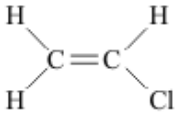
(i) What is meant by polymerisation?

.....

.....

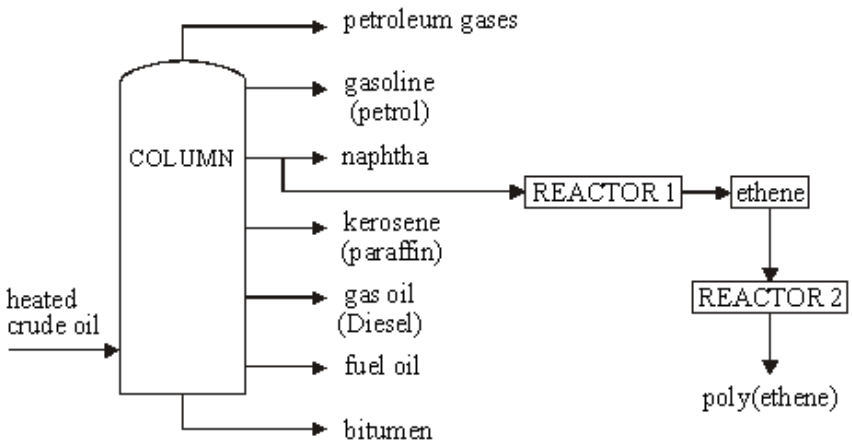
(2)

(ii) The table gives information about monomers and the polymers made from them. Complete the table.

MONOMER		POLYMER	
name	formula	name	formula
ethene			
styrene		polystyrene	
chloroethene		poly(chloroethene)	

(3)
(Total 8 marks)

Q9. 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:

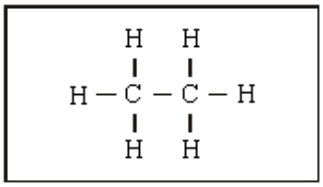
(i) REACTOR 1 .....

(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

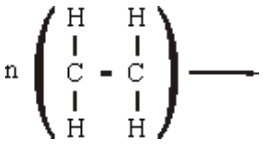
(1)

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

(1)

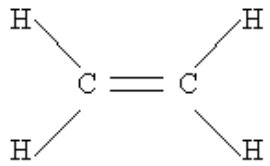
(e) Many molecules of ethene join together to form poly(ethene) in REACTOR 2.

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



(2)
(Total 7 marks)

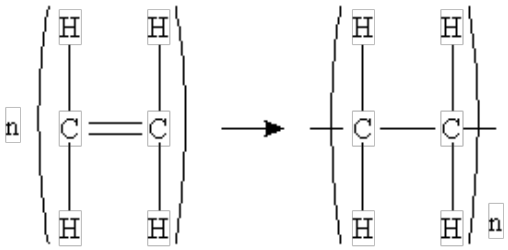
Q10. Propane and ethene are both important hydrocarbons.

	propane	ethene
formula	C_3H_8	
structure		

(a) **Complete the table** by adding the formula of the ethene molecule and the structure of the propane molecule.

(2)

(c) Ethene can be changed into a plastic. The equation shown below represents the reaction in which ethene is polymerised.



(i) What is the name of the plastic formed in this reaction?

.....

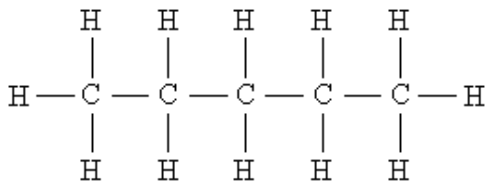
(1)

(ii) What type of polymerisation reaction is shown in the equation?

.....

(1)
(Total 4 marks)

Q11. Crude oil is a mixture of a large number of compounds most of which are hydrocarbons such as the molecule shown below.



(a) What is a hydrocarbon?

.....

.....

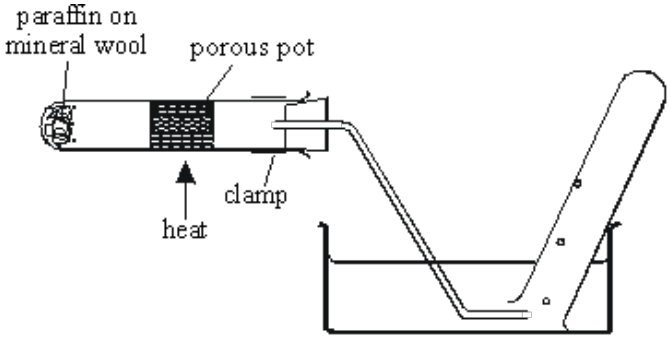
(1)

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

.....

(1)

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



(i) What happens during thermal decomposition?

.....

.....

.....

(2)

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

.....

.....

(1)

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

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

(1)

(Total 6 marks)

Q12. 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)

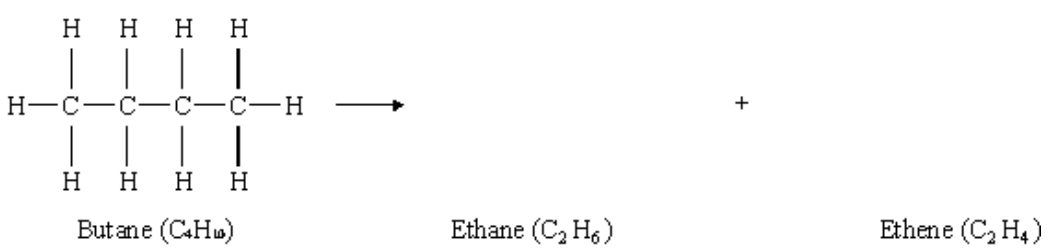
(i) For cracking to happen what needs to be done to the hydrocarbon?

.....

.....

(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)

Q13. The molecular formulae of two hydrocarbons **M** and **N** are given.

M = C_4H_{10}

N = C_4H_8

(a) **M** reacts with chlorine to form C_4H_9Cl.

(i) Write a balanced chemical equation for the reaction of chlorine with **M**.

.....

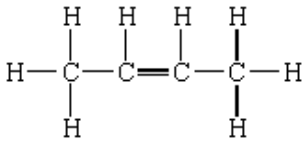
(2)

(ii) Name this type of reaction.

.....

(1)

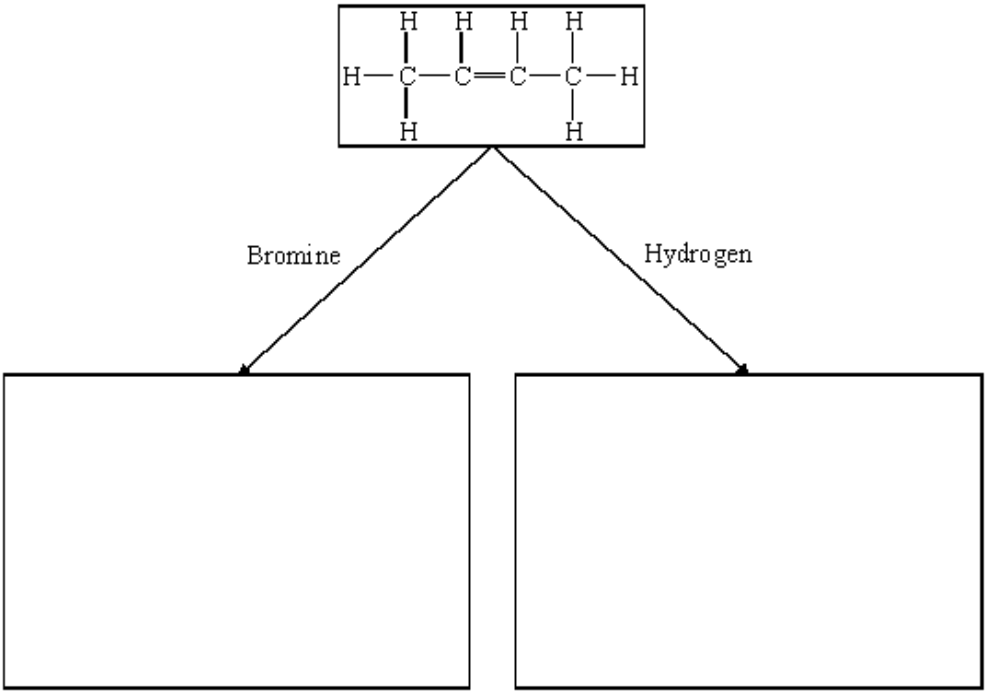
(b) A displayed structural formula for **N** is:



Draw a displayed structural formula of a compound which is an isomer of **N**.

(1)

(c) Complete the boxes to show the displayed structural formula for each of the products formed.



(2)
(Total 6 marks)

Q14. (a) Alkenes can be made by cracking large alkane molecules.

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

.....

.....

.....

.....

(2)

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

Test .....

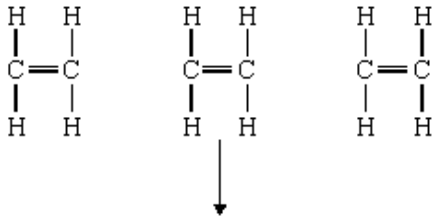
Result of test .....

.....

(2)

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

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



(1)

(ii) Name the polymer formed from ethene.

.....

(1)

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

.....

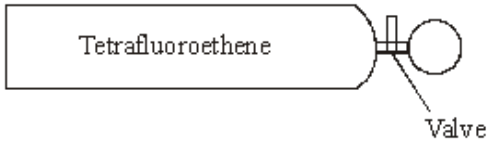
.....

.....

(2)

(Total 8 marks)

Q15. In 1939 Roy Plunkett opened the valve on a new cylinder of tetrafluoroethene gas. No gas came out!



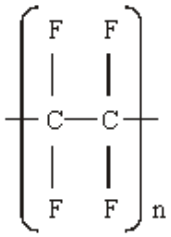
He cut the cylinder open and found that the gas had changed into a white solid. This solid was an addition polymer.

(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)

##

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.

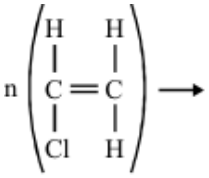
(i) Chloroethene is an unsaturated molecule. Why is this molecule said to be unsaturated?

.....

.....

(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)

Q17. Known crude oil reserves are being used up rapidly. Crude oil is used to produce many useful fuels, such as petrol. One way to conserve crude oil reserves would be to increase the production of bio-fuels.

(a) Ethanol can be produced for use as a bio-fuel. Cars can be powered by ethanol or ethanol–petrol mixtures.

Sugar cane can be fermented to give a mixture of water (boiling point 100 °C) and ethanol (boiling point 78 °C).

(i) How can ethanol be separated from water?

.....

.....

(1)

(ii) Ethanol, C_2H_5OH, burns to release heat energy.

Complete the balanced symbol equation by writing in the formulae of the two products.

C_2H_5OH + $3O_2$ 2..... + 3.....

(2)

(b) The cost of producing a bio-fuel, such as ethanol, by fermentation, is at least three times higher than the production cost of petrol. It costs less to produce ethanol from alkanes. In the production, the vapour of an alkane is passed over a hot catalyst.

$$\underset{\text{hexane}}{C_6H_{14}} \xrightarrow{\text{Hot catalyst}} \underset{\text{ethane}}{C_2H_6} + \underset{\text{ethene}}{2C_2H_4}$$

Ethene is then converted into ethanol.

(i) What has happened to the hexane to produce ethene?

.....

(1)

(ii) Complete the structural formula for ethene, C_2H_4.

C **C**

(1)

(iii) Name the compound that is added to ethene to produce ethanol, C_2H_5OH.

.....

(1)

(c) As explained in parts (a) and (b), ethanol can be made using either sugar or alkanes as the starting material.

Evaluate the advantages and disadvantages of using these two starting materials to produce ethanol.

.....

.....

.....

.....

.....

.....

.....

.....

(4)
(Total 10 marks)

Q18. Scientists study the atmosphere on planets and moons in the Solar System to understand how the Earth's atmosphere has changed.

(a) Millions of years ago the Earth's atmosphere was probably just like that of Mars today.

The table shows data about the atmospheres of Mars and Earth as they are now.

Mars		**Earth**	
nitrogen	3%	nitrogen	78%
oxygen	trace	oxygen	21%
water	trace	water	trace
carbon dioxide	95%	carbon dioxide	trace
Average surface temperature –23 °C		Average surface temperature 15 °C	

Suggest what has caused the main gases in the Earth's atmosphere of millions of years ago to change to the present-day atmosphere.

.....

.....

.....

.....

(2)

(b) Titan is the largest moon of the planet Saturn. It has an atmosphere that, like the Earth's, contains mainly nitrogen. Methane is the other main gas.

Main gases in Titan's atmosphere	Percentage (%)	Boiling point in °C
Nitrogen	95	–196
Methane	5	–164
Average surface temperature –178 °C		

When it rains on Titan, it rains methane! Explain why.

.....

.....

.....

(2)

(c) Ultraviolet radiation from the Sun produces simple alkenes, such as ethene and propene, from methane in Titan's atmosphere.

(i) Draw the structure of propene, C_3H_6, to show the covalent bonds.

(1)

(ii) Explain how propene molecules form a polymer. You should name the polymer formed.

.....

.....

.....

.....

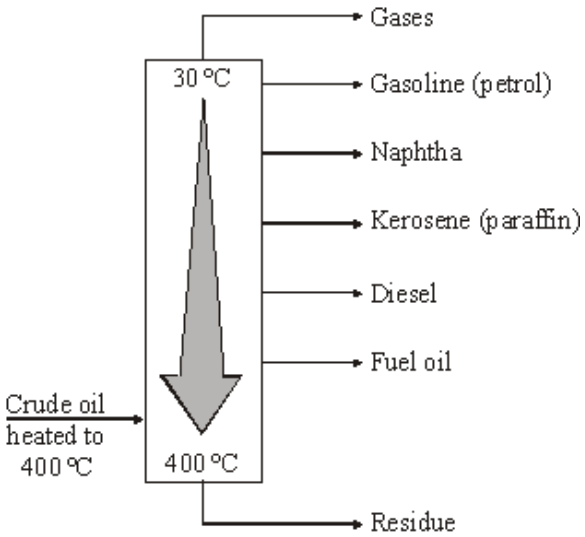
.....

.....

(3)

(Total 8 marks)

Q19. 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
$C_{10}H_{22}$	→	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?

.....

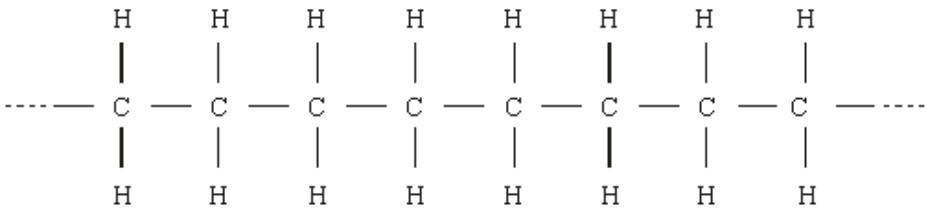
.....

.....

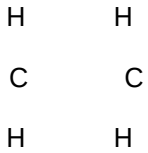
.....

(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.



(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)

Q20. (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)

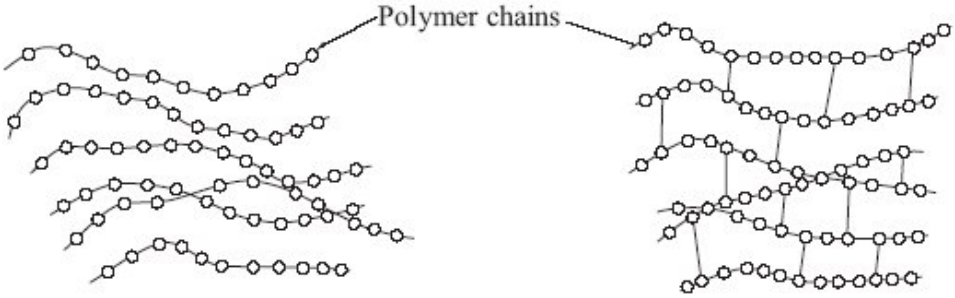
(ii) PEX is a shape memory polymer. What property does a shape memory polymer have?

.....

.....

(1)

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



Poly(ethene) **PEX**

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

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

.....

.....

.....

.....

.....

(3)

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

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

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

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

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

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

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(4)
(Total 10 marks)

Q21. This question is about the use hydrocarbons and the production of compounds from hydrocarbons.

(a) The equation shows a reaction involving hydrocarbons.

C_8H_{18}	→	C_2H_4	+	C_6H_{14}
Hydrocarbon **J**		Hydrocarbon **K**		Hydrocarbon **L**

Choose the correct processes from the box to complete the sentences.

combustion	**hydration**	**thermal decomposition**	**polymerisation**

(i) Hydrocarbons **K** and **L** are produced by ..... .

(1)

(ii) Ethanol can be produced from hydrocarbon **K** by ..... .

(1)

(iii) Describe a test to distinguish between hydrocarbons **K** and **L** and give the result of the test.

.....

.....

.....

.....

(2)

(b) Hydrocarbon **J** burns completely in oxygen to produce carbon dioxide and water vapour.

$$2\ C_8H_{18} + 25\ O_2 \rightarrow 16\ CO_2 + 18\ H_2O$$

(i) When 114g of hydrocarbon **J** burns completely in 400g of oxygen it produces 162g of water vapour.

What mass of carbon dioxide would be produced from burning 114g of hydrocarbon **J**?

Show clearly how you work out your answer

.....

.....

Answer = ... g

(2)

(ii) The mass of carbon dioxide produced is greater than the 114g of hydrocarbon J that was burned.
Explain why.

.....

.....

.....

.....

(2)

(c) Two different processes are used to produce ethanol.

Process 1	Process 2
Fermentation of a sugar solution by yeast in a reaction vessel. The reaction vessel has to be emptied, cleaned and refilled every few days. The process produces a 15% ethanol solution in water.	Reaction of ethene (from crude oil) with steam in a reactor. The reaction is only stopped if there is a fault in the reactor. The process produces 100% ethanol.

(i) Give **one** advantage that **Process 1** has over **Process 2**.

.....

.....

(1)

(ii) What advantages to a manufacturer of ethanol, does **Process 2** have over **Process 1**?

.....

.....

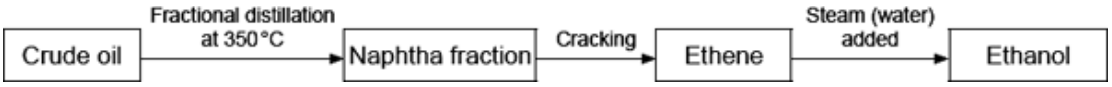
.....

.....

(2)
(Total 11 marks)

Q22. Petrol sold in most countries now contains at least 5% ethanol.
The production of ethanol, for use as a fuel, is being increased.

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



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

.....

.....

(1)

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

$C_{10}H_{22}$	→	C_8H_{18}	+	C_2H_4
decane		octane		ethene

(i) Describe how cracking is done.

.....

.....

.....

.....

(2)

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

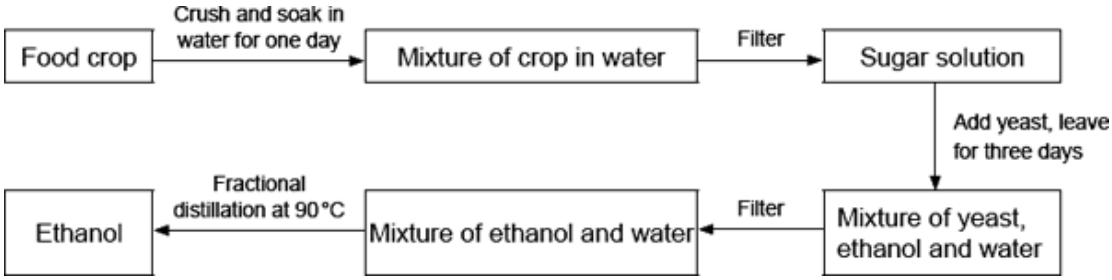
H **H**

C **C**

H **H**

(1)

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



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

Remember to give a conclusion to your evaluation.

.....

.....

.....

.....

.....

.....

.....

.....

.....

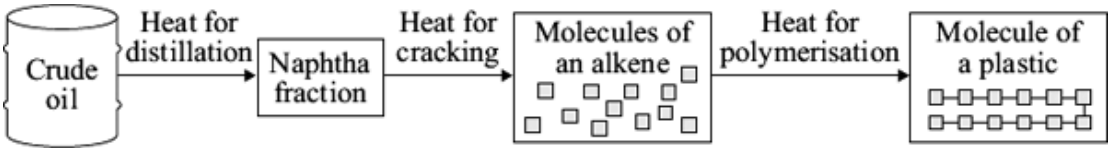
.....

.....

.....

(5)
(Total 9 marks)

Q23. 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.

.....

.....

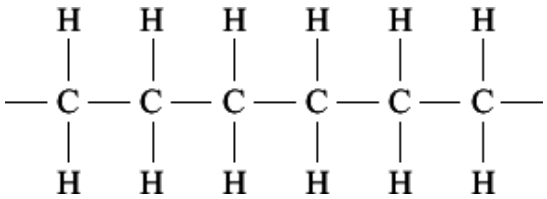
.....

.....

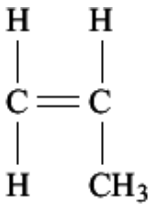
.....

(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)

Q24. Supermarkets in the UK have been advised by the Government to stop giving plastic bags to customers. The Government states that this is because plastic bags use up resources that are not renewable and that the manufacture of plastic bags produces carbon dioxide.
Most of these plastic bags are made from poly(ethene). The table shows methods to deal with large numbers of used plastic bags.

Method	**Description of what happens to the plastic bag**
Reused	used again by the customer
Recycled	collected, transported, washed and melted to make new plastic items
Burned	collected, transported and burnt to release heat energy
Dumped	mixed with other household waste, collected, transported and disposed of at a landfill site

Use the information and your knowledge and understanding to briefly give **one advantage and one disadvantage** for each of these methods.

Reused .....

.....

.....

Recycled .....

.....

.....

Burned .....

.....

.....

Dumped .....

.....

.....

(4)
(Total 4 marks)

Q25. Read the article and then answer the questions.

Supermarkets launch eco-friendly plastic milk bags. Could this be the end of the milk bottle?

Milk bottles are made from glass or from plastic.

Glass milk bottles contain 0.5 litres of milk. When the milk is used up the empty bottles are returned to be re-used. Glass milk bottles are re-used 24 times on average. The glass to make new milk bottles is produced when a mixture of sand, limestone, soda and recycled glass is heated to about 1600 °C in a furnace. There are almost unlimited amounts of the raw materials needed to produce this glass. About 35% of used glass is recycled.

The most common plastic milk bottles contain 2 litres of milk. When the milk is used up the empty bottles are discarded as waste. The plastic used to make these milk bottles is poly(ethene). Poly(ethene) is produced from crude oil by first using fractional distillation, then cracking the naphtha fraction and finally polymerising the ethene. About 5% of used poly(ethene) is recycled.

The new plastic milk bags contain 2 litres of milk. The milk bags are also made from poly(ethene). A milk bag uses 75% less poly(ethene) than is used to make the poly(ethene) milk bottles. When the milk is used up the empty bags are discarded as waste.

(a) Describe what happens in fractional distillation so that fractions, such as naphtha, are separated from crude oil.

.....

.....

.....

.....

.....

.....

(3)

(b) Supermarkets claim that using milk bags instead of milk bottles would have less environmental impact.

Do you agree with this claim?

Use the information in the article and your knowledge and understanding to make appropriate comparisons to justify your answer.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(4)
(Total 7 marks)

Q26. Ethanol (C_2H_5OH) is produced from ethene or from sugar cane.

The two different methods to produce ethanol are summarised in the table.

Ethanol from sugar cane is a batch process	**Ethanol from crude oil is a continuous process**
Sugar cane plants are crushed and soaked in water for one day.	Crude oil is distilled to separate the naphtha fraction.
The sugar solution is separated by filtration.	The naphtha fraction is cracked when the vaporised hydrocarbons are passed over a hot catalyst.
Yeast is added to the sugar solution and fermented for three days.	The ethene produced is separated by distillation.
The solution of water and ethanol produced is separated by filtration.	Ethene is reacted with steam in the presence of a catalyst.
Distillation of this solution produces a 50% solution of ethanol.	This hydration reaction produces 100% ethanol.

(a) Complete and balance an equation for the cracking of the hydrocarbon C_6H_{14} to produce ethene.

C_6H_{14} ⟶ ..... + ...

(2)

(b) What is **seen** when the sugar solution and yeast are fermented?

.....

.....

(1)

(c) Evaluate the issues involved with the production of ethanol from sugar cane compared with the production of ethanol from crude oil.
You should explain why each issue you describe is important.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(5)
(Total 8 marks)

Q27. Ethene is used as a starting material for the production of many other substances, including ethanol.

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

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

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

Complete the sentences.

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

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

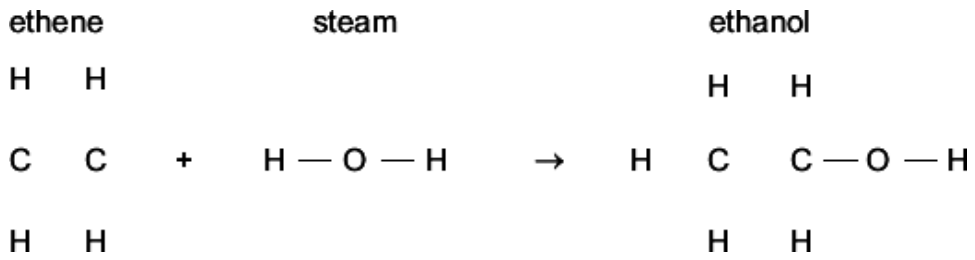
.....

.....

(2)

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

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



(2)

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

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

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

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

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

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

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

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

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(6)
(Total 10 marks)

Q28. (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)

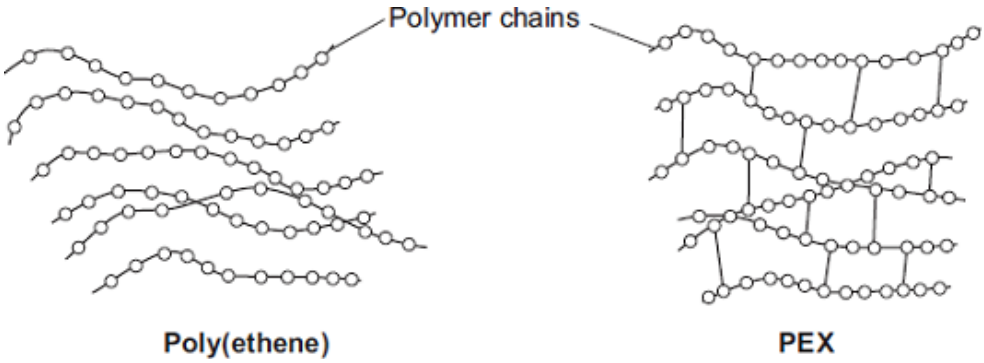
(ii) PEX is a shape memory polymer. What property does a shape memory polymer have?

.....

.....

(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)

Q29. Most petrol used in cars contains about 5% ethanol (C_2H_5OH).

(a) The complete combustion of ethanol produces carbon dioxide and water.

Complete and balance the symbol equation for the complete combustion of ethanol.

C_2H_5OH + ...O_2 → ..... + ...

(2)

(b) Ethanol can be produced from octane (C_8H_{18}).

The two chemical equations represent the production of ethanol from octane.

Equation 1: $C_8H_{18} \rightarrow C_4H_{10} + 2C_2H_4$

Equation 2: $C_2H_4 + H_2O \rightarrow C_2H_5OH$

(i) In **Equation 1** the products are a mixture of two gases.

Describe a chemical test that would indicate the presence of ethene (C_2H_4) in the mixture.

.....

.....

.....

.....

(2)

(ii) Describe, as fully as you can, the conditions used for the two reactions to produce ethanol from octane.

Use **Equation 1** and **Equation 2** to help you with your answer.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(4)
(Total 8 marks)

Q30. There has been research into fuels for car engines.

Fuel	Content	Melting point in °C	Flashpoint in °C	Energy released in MJ per litre
Ethanol	C_2H_5OH	−114	+14	21.2
Diesel	hydrocarbons	About −24	+64	38.6
Petrol	hydrocarbons	About −57	−45	34.8
Rapeseed oil	fats	About +5	+130	32.8

The flashpoint is the lowest temperature a fuel vapour ignites in air.

(a) The melting point of ethanol is precise but the other melting points are approximate.

Suggest why.

.....

.....

.....

(2)

(b) Ethanol is produced by fermentation of sugar cane. Rapeseed oil is produced by pressing rapeseeds. Waste plant material from both processes is used to feed animals.

(i) Describe how the process of fermentation is done.

.....

.....

.....

.....

(2)

(ii) Carbon neutral fuels do **not** increase the amount of carbon dioxide in the atmosphere.

Suggest why using a biofuel, such as ethanol or rapeseed oil, is thought to be carbon neutral.

.....

.....

.....

.....

(2)

(c) When any fuel from the table is used in a car engine, the exhaust gases contain nitrogen oxides.

Explain why.

.....

.....

.....

.....

(2)

(d) Evaluate replacing petrol with ethanol as a fuel for cars.

To gain full marks you should give a justified conclusion.

Use the information from the table and your knowledge to answer this question.

.....

.....

.....

.....

.....

.....

.....

.....

.....

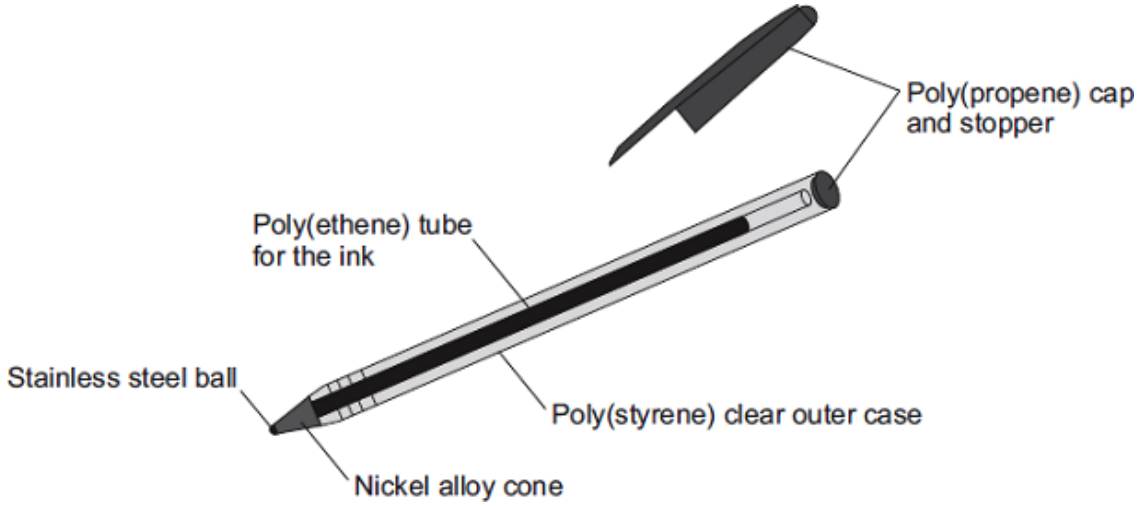
.....

.....

.....

(4)
(Total 12 marks)

Q31. 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.

.....

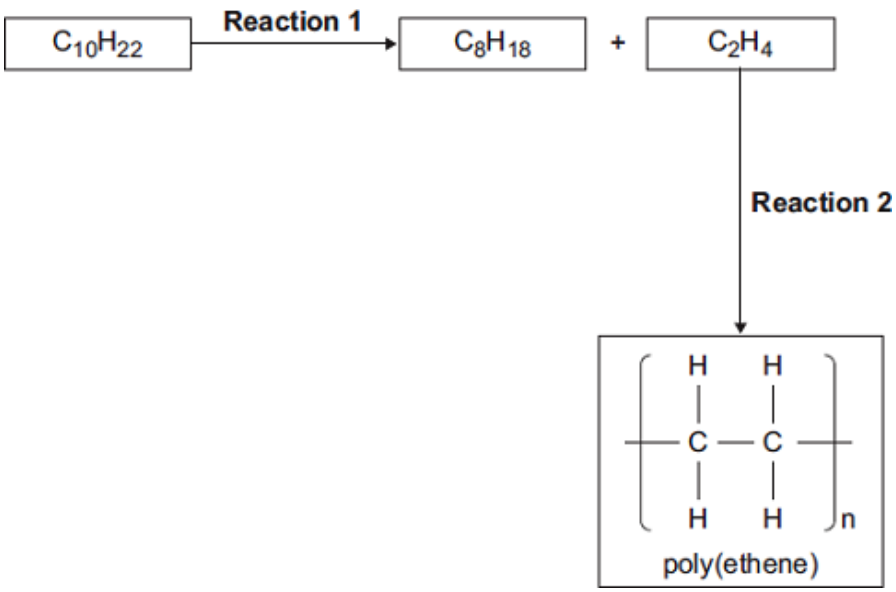
.....

.....

.....

(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**.

.....

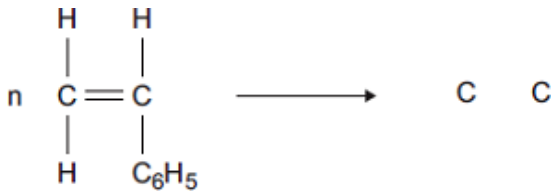
.....

.....

.....

(2)

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



styrene poly(styrene)

(2)
(Total 10 marks)