## Q1.

The table below shows information about the fractions obtained when crude oil is distilled.

| **Fraction** | **Supply** from distillation as percentage (%) of crude oil input | **Demand** by consumers as percentage (%) of crude oil input | **Number of carbon atoms in hydrocarbon chain** |
|---|---|---|---|
| LPG | 2 | 6 | $C_1 – C_4$ |
| Petrol | 14 | 27 | $C_5 – C_{10}$ |
| Kerosene | 13 | 8 | $C_{11} – C_{15}$ |
| Diesel | 21 | 21 | $C_{16} – C_{19}$ |

(a) Some petrol is produced by cracking.

(i) Why is it necessary to produce some petrol by cracking?

_____

_____

**(1)**

(ii) Which fraction is the most suitable to be cracked to produce petrol?

Draw a ring around the correct answer.

**diesel** **kerosene** **LPG**

**(1)**

(iii) Give **two** reasons why the fraction you chose in part (ii) is cracked to produce petrol.

_____

_____

_____

_____

**(2)**

(b) Describe the process used to crack hydrocarbons.

_____

_____

_____

_____

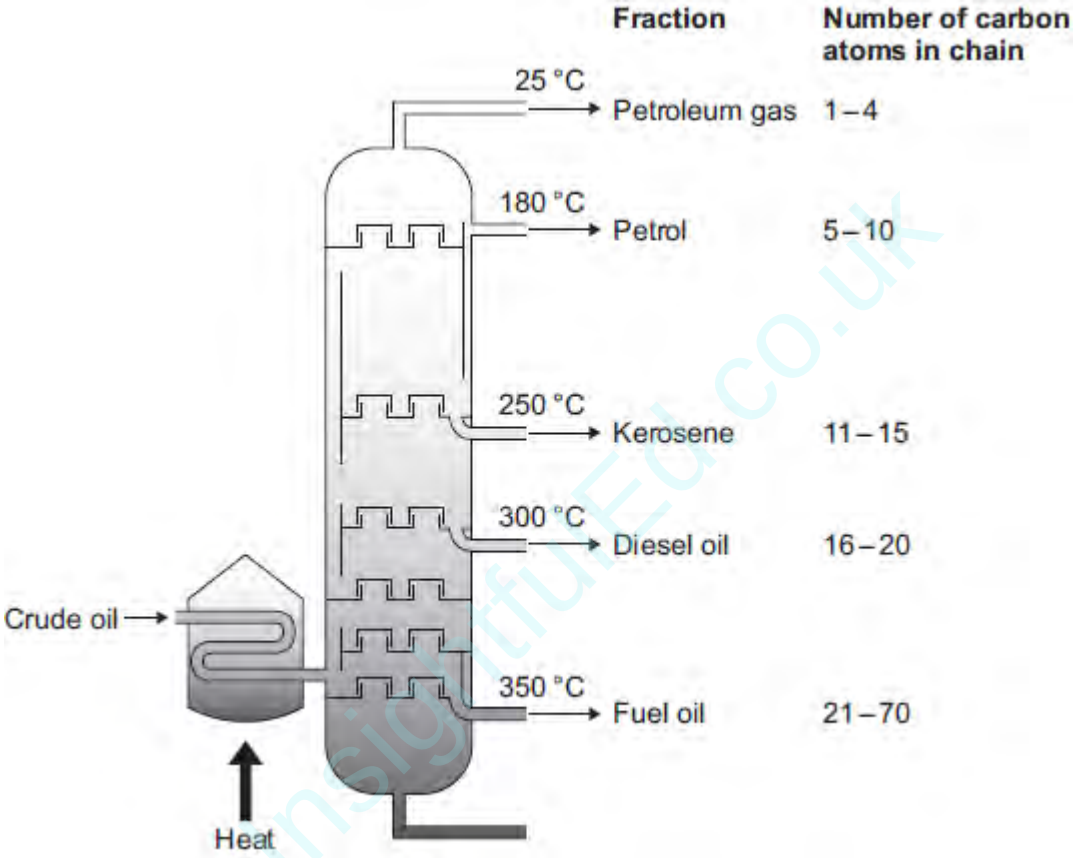
**(2)**
**(Total 6 marks)**

## Q2.

Many fuels are produced from crude oil.

(a) Crude oil is separated into fractions by distillation in a fractionating column.

A fractionating column is shown below.




(i) Describe how crude oil is separated into fractions by fractional distillation.

_____

_____

_____

_____

_____

_____

**(3)**

(ii) Some properties of hydrocarbons change as the size of the molecules increases.

Describe the trends in boiling point and viscosity as the number of carbon atoms in the molecule increases.

Boiling point _____

_____

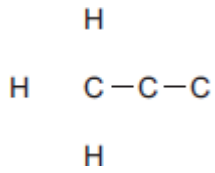
Viscosity _____

_____

**(2)**

(b) LPG (liquefied petroleum gas) is a fuel. LPG contains propane ($C_3H_8$).

(i) Complete the displayed (structural) formula for propane.



**(1)**

(ii) Burning fuels releases energy. Name **two** products formed when LPG is burnt.

_____

_____

**(2)**

(iii) Some cars are now designed to use LPG as a fuel. LPG is about 50p per litre cheaper than petrol.

Suggest **one** reason why most car owners use cars designed to use petrol and not LPG as a fuel.

_____

_____

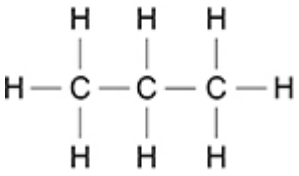
**(1)**

**(Total 9 marks)**

## Q3.

This question is about hydrocarbons.

The diagram below shows a hydrocarbon.



(a) Complete the formula for the hydrocarbon shown in the figuer above.

C_____ H_____

**(1)**

(b) What is the name of the hydrocarbon in the figure above?

_____

**(1)**

(c) Which homologous series does the hydrocarbon in the figure above belong to?

_____

**(1)**

(d) 30 g of another hydrocarbon contains 24 g of carbon.

Which calculation gives the percentage of carbon in the hydrocarbon?

Tick (✓) **one** box.

$\frac{24 \times 30}{100}$ ☐

$\frac{100 \times 30}{24}$ ☐

$\frac{24 \times 100}{30}$ ☐

$\frac{24}{30 \times 100}$ ☐

**(1)**

(e) **Table 1** shows boiling points of some hydrocarbons.

**Table 1**

| **Formula of hydrocarbon** | **Boiling point in °C** |
|---|---|
| $C_2H_6$ | –89 |
| $C_4H_{10}$ | 0 |
| $C_6H_{14}$ | 69 |
| $C_8H_{18}$ | 125 |
| $C_{10}H_{22}$ | 174 |

Describe how the boiling points change as the number of carbon atoms in the hydrocarbon increases.

_____

_____

**(1)**

Hydrocarbons can be cracked.

(f) Give **one** condition used to crack hydrocarbons.

_____

_____

**(1)**

(g) Balance the equation for the cracking of $C_6H_{14}$

$$C_6H_{14} \rightarrow C_2H_6 + \_\_\_\_\_ \; C_2H_4$$

**(1)**

(h) Give **one** reason why hydrocarbons are cracked.

_____

_____

**(1)**

**(Total 8 marks)**

## Q4.

Crude oil is separated into fractions by distillation.

Each fraction contains hydrocarbon molecules of a similar size.

The table shows information about two fractions obtained when crude oil is distilled.

| **Fraction** | **Supply** from distillation as percentage (%) of crude oil input | **Demand** by consumers as percentage (%) of crude oil input | **Number of carbon atoms in hydrocarbon chain** |
|---|---|---|---|
| Petrol | 14 | 27 | $C_5 – C_{10}$ |
| Kerosene | 13 | 8 | $C_{11} – C_{15}$ |

(a) Some of the kerosene fraction is made into petrol.

Use the table to suggest **two** reasons why kerosene is used to make petrol.

_____

_____

_____

_____

**(2)**

(b) Use the correct word from the box to complete each sentence.

| **boiling** | **catalyst** | **cracking** | **filtration** | **polymer** |
|---|---|---|---|---|

Kerosene is made into petrol by a process called _____ .

Kerosene is heated.

The hydrocarbons vaporise.

The gases are passed over a hot _____ .

**(2)**

**(Total 4 marks)**

## Q5.

This question is about the Earth's resources.

When most fuels burn carbon dioxide is produced.

Propane ($C_3H_8$) is a fuel.

(a) Balance the equation for the combustion of propane.

$$C_3H_8 + \_\_\_\_\_ O_2 \rightarrow 3\ CO_2 + 4\ H_2O$$

**(1)**

(b) Describe the test for carbon dioxide.

Give the result of the test.

Test _____

Result _____

_____

**(2)**

(c) Propane can be cracked to produce propene and hydrogen.

Complete the symbol equation for the reaction.

$$\underset{\text{propane}}{C_3H_8} \rightarrow \underset{\text{propene}}{\_\_\_\_\_} + \underset{\text{hydrogen}}{H_2}$$

**(1)**

(d) Describe the test for hydrogen.

Give the result of the test.

Test _____

Result _____

_____

**(2)**

(e) Propene is an alkene.

Describe the test for alkenes.

Give the colour change in the test.

Test _____

Colour change _____ to _____

**(3)**

**(Total 9 marks)**

## Q6.

This question is about crude oil and alkanes.

(a) Describe how crude oil is formed.

_____

_____

_____

_____

_____

_____

**(3)**

(b) Describe how crude oil is separated into fractions by fractional distillation.

_____

_____

_____

_____

_____

_____

_____

_____

**(4)**

The table below shows the boiling points of three alkanes.

| **Alkanes** | **Boiling point in °C** |
|---|---|
| $C_5H_{12}$ | 36 |
| $C_{10}H_{22}$ | 174 |
| $C_{15}H_{32}$ | 271 |

(c) What is the general formula for alkanes?

_____

**(1)**

(d) Explain the trend in the boiling points of the alkanes.

_____

_____

_____

_____

_____

_____

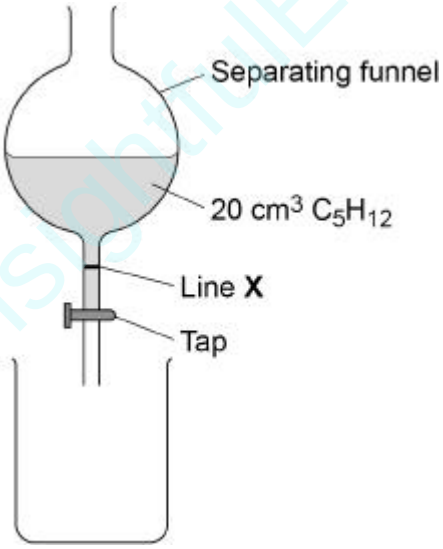
**(3)**

(e) A student investigated one property of the alkanes $C_5H_{12}$, $C_{10}H_{22}$ and $C_{15}H_{32}$

This is the method used.

1. Pour 20 $cm^3$ of $C_5H_{12}$ into a separating funnel.
2. Open the tap of the separating funnel and start a timer.
3. Stop the timer when the level of $C_5H_{12}$ reaches line **X**.
4. Repeat steps 1 to 3 with $C_{10}H_{22}$ and $C_{15}H_{32}$

The diagram below shows the apparatus used.




The level of $C_5H_{12}$ takes 6.4 seconds to reach line **X**.

Predict the trend in times for the other two alkanes.

Give **one** reason for your answer.

Trend _____

_____

Reason _____

_____

**(2)**

**(Total 13 marks)**

## Q7.

Crude oil is a mixture of hydrocarbons.

(a) Complete the sentences.

Choose answers from the box.

| | | | | |
|---|---|---|---|---|
| **air** | **enzymes** | **mud** | **plankton** | **trees** |

Crude oil is the remains of _____.

Millions of years ago biomass was buried under _____.

**(2)**

(b) There are three stages, **A**, **B** and **C**, in separating hydrocarbons from crude oil.

Stage **A** Hydrocarbons evaporate

Stage **B** Crude oil is heated

Stage **C** Vapours condense

Give the correct order for stages **A**, **B** and **C**.

First stage ____

Second stage ____

Third stage ____

**(1)**

(c) What is the name of the process used in separating hydrocarbons from crude oil?

Tick (✓) **one** box.

Chromatography ☐

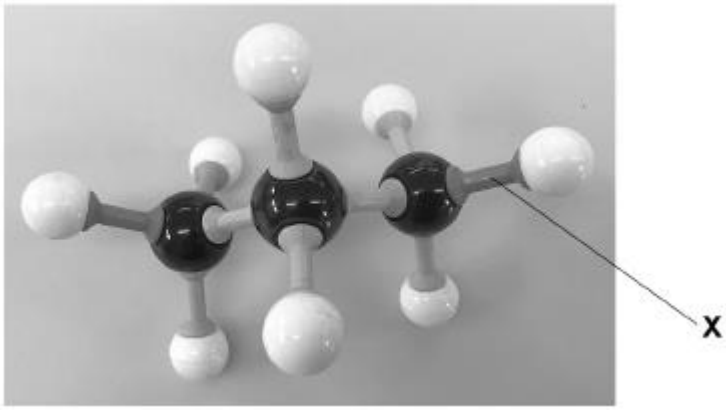
Filtration ☐

Fractional distillation ☐

**(1)**

(d) Alkanes are hydrocarbons.

The image below represents an alkane.




What is the formula of the alkane in the above image?

C___ H___

**(1)**

(e) What does **X** represent in the above image?

Tick (✓) **one** box.

Covalent bond ☐

Ionic bond ☐

Metallic bond ☐

**(1)**

(f) What is the general formula for alkanes?

Tick (✓) **one** box.

$C_nH_{2n-2}$ ☐

$C_nH_{2n}$ ☐

$C_nH_{2n+2}$ ☐

**(1)**

(g) Hydrocarbons are used to make polymers. Polymers are used to make plastic bags.

In one year 8.0 billion plastic bags were used.

The next year there was a charge for plastic bags and only 1.3 billion plastic bags were used.

Calculate the decrease in the number of plastic bags used.

Decrease = _____ billion

**(1)**

**(Total 8 marks)**

## Q8.

Natural gas is mainly a hydrocarbon called methane.

(a) Use **one** word from the box to complete the sentence.

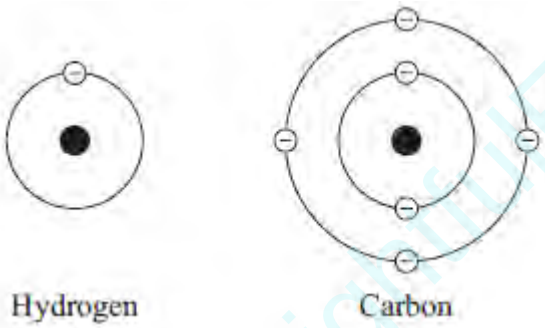
| | | |
|---|---|---|
| **compounds** | **elements** | **molecules** |

Hydrocarbons contain hydrogen and carbon only.

Hydrogen and carbon are _____ .

**(1)**

(b) The diagrams represent atoms of hydrogen and carbon.




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

(i) The centre of each atom is called the

bond.

nucleus.

symbol.

**(1)**

(ii) The hydrogen atom has one electron and the carbon atom has

three

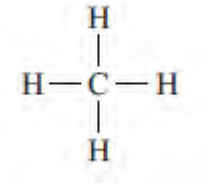
four

six

electrons.

**(1)**

(c) A molecule of methane can be represented as



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

(i) The formula of methane is

| |
|---|
| CH |
| $CH_4$ |
| $C_4H_4$ |

**(1)**

(ii) The line between C—H is called a

| |
|---|
| bond. |
| molecule. |
| nucleus. |

**(1)**

(d) Methane burns to produce carbon dioxide ($CO_2$) and water ($H_2O$).

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

When methane burns it reacts with

| |
|---|
| carbon. |
| nitrogen. |
| oxygen. |

**(1)**

(ii) Hydrogen ($H_2$) can be used as a fuel.

Suggest why burning hydrogen would be less harmful to the environment than burning methane.

_____

_____

**(1)**

**(Total 7 marks)**

## Q9.

Fire dancers use firesticks to make flame patterns.

One end of the firestick is soaked in kerosene.
The kerosene is lit and burns with a yellow flame.

(a) Kerosene is a mixture of hydrocarbons.

Which elements are present in a hydrocarbon?

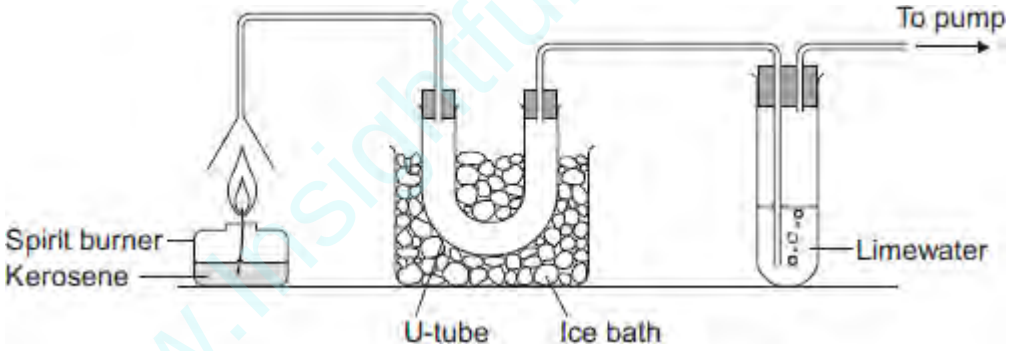
_____

_____

**(1)**

(b) A student investigated the products formed when kerosene burned.

The diagram shows the apparatus the student used.




Describe and explain the observations you would expect the student to make.

_____

_____

_____

_____

_____

_____

_____

_____

**(4)**

**(Total 5 marks)**

## Q10.

(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)**

## Q11.

Crude oil contains many different hydrocarbons.

(i) Which formula in the list represents a hydrocarbon?
Draw a **ring** around the correct formula.

**$CO_2$** **$C_6H_{12}O_6$** **$C_8H_{18}$** **$H_2O$**

**(1)**

(ii) Which word from the list below best describes crude oil?
Draw a **ring** around the correct word.

**alloy** **compound** **element** **mixture**

**(1)**

(iii) Choose, from the list below, words to complete the passage about the separation of the hydrocarbons in crude oil by fractional distillation.

**atoms** **burned** **condensed** **evaporated** **filtered**

**fractions** **ions** **molecules** **neutralised**

During fractional distillation the many hydrocarbons in crude oil are separated into _____ each of which contains _____ with a similar number of carbon _____ .

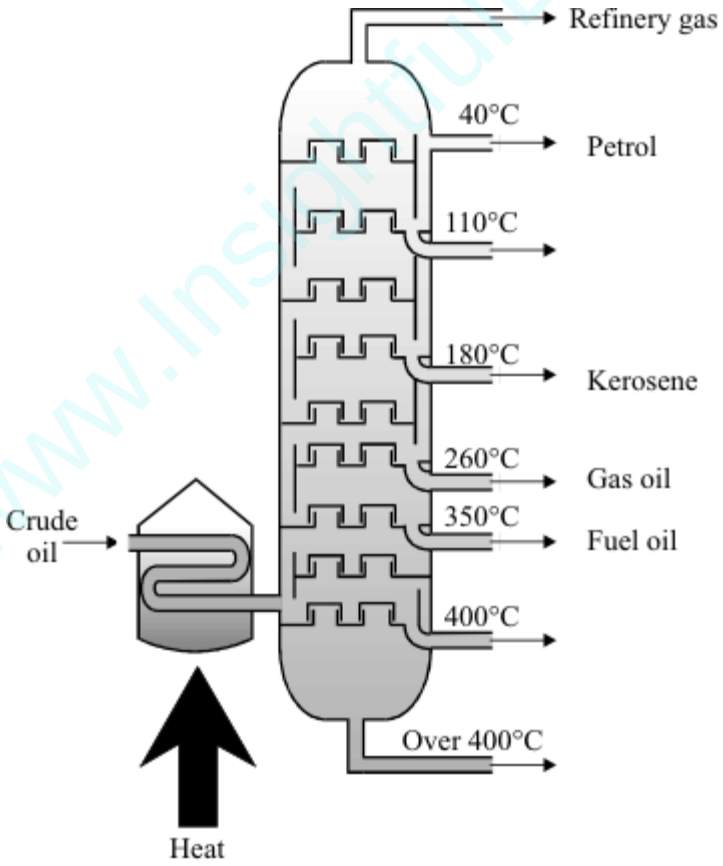
To do this the oil is first _____ and then _____ at a number of different temperatures.

**(5)**

**(Total 7 marks)**

## Q12.

To make crude oil more useful it is separated into different fractions.




(a) Complete the gaps in the following sentences.

Crude oil is separated into different fractions by a process called _____

_____ . Each fraction has a different _____ .

**(2)**

(b) Each fraction is a mixture of compounds. Most of these compounds are hydrocarbons, made up of the elements hydrogen and carbon.

(i) Explain the difference between a mixture and a compound.

_____

_____

_____

**(2)**

(ii) Explain the difference between a compound and an element.

_____

_____

_____

**(2)**

**(Total 6 marks)**

## Q13.

The table shows some information about alkanes.

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

(a) Give the formula of propane.

_____

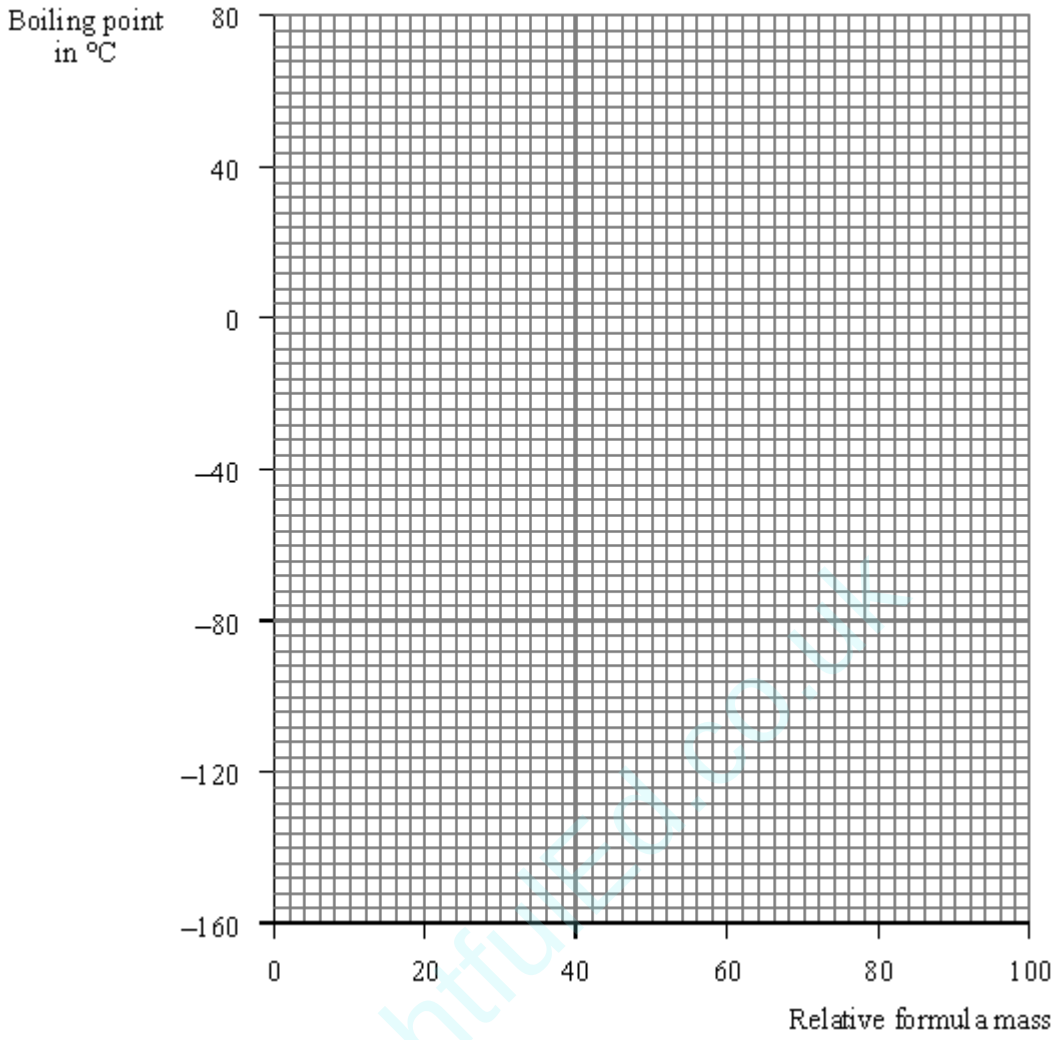
**(1)**

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

_____

**(1)**

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




**(3)**

(iii) What is the boiling point of butane?

_____

**(1)**

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

**(1)**

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

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

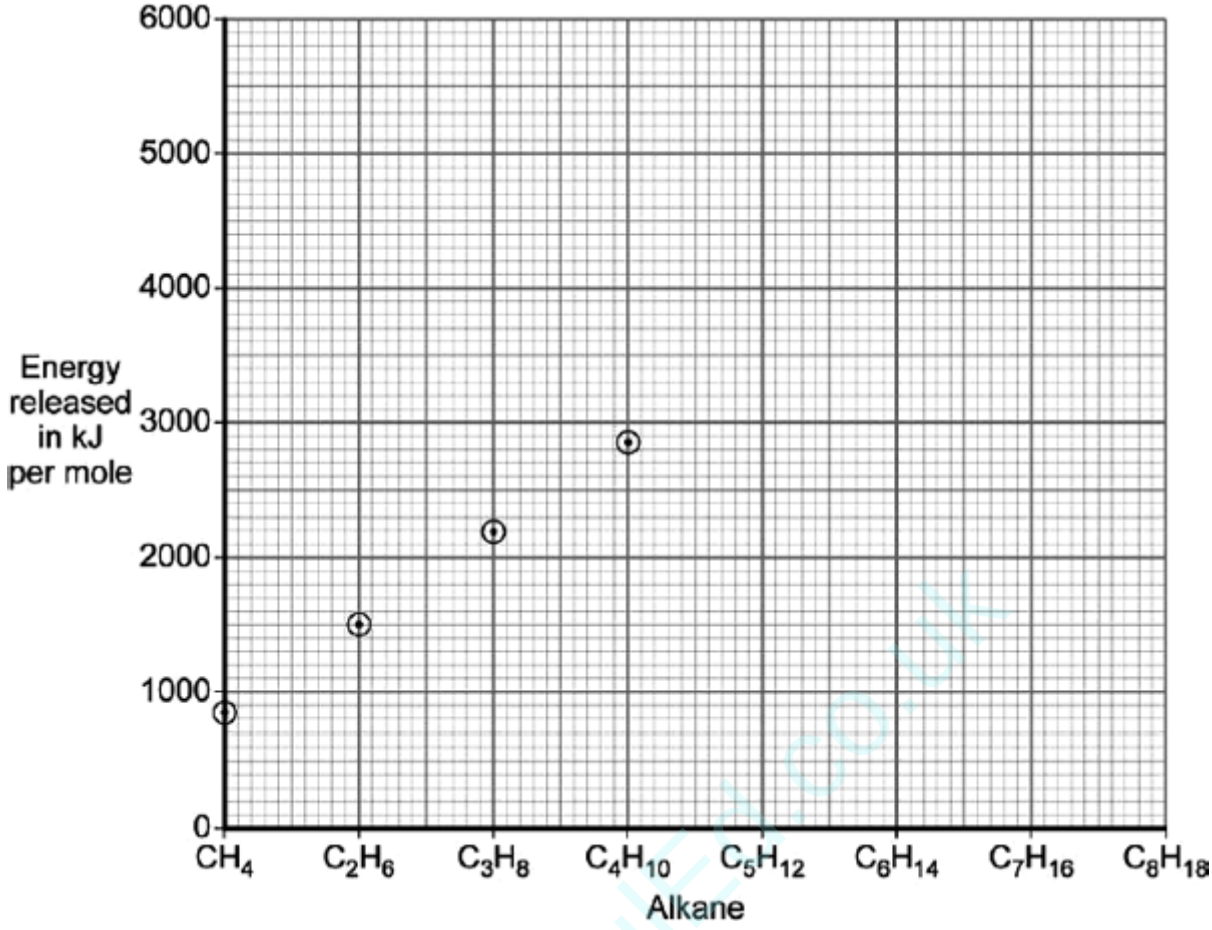
**(1)**

**(Total 8 marks)**

## Q14.

(a) Alkanes are important hydrocarbon fuels. They have the general formula $C_nH_{2n+2}$

The points on the graph show the amount of energy released when 1 mole of methane ($CH_4$), ethane ($C_2H_6$), propane ($C_3H_8$) and butane ($C_4H_{10}$) are burned separately.




(i) Draw a line through the points and extend your line to the right-hand edge of the graph.

**(1)**

(ii) Use the graph to estimate the amount of energy released when 1 mole of octane ($C_8H_{18}$) is burned.

Energy released = _____ kJ

**(1)**

(iii) Suggest why we can make a good estimate for the energy released by 1 mole of pentane ($C_5H_{12}$).

_____

_____

**(1)**

(iv) A student noticed that octane ($C_8H_{18}$) has twice as many carbon atoms as butane ($C_4H_{10}$), and made the following prediction:

"When burned, 1 mole of octane releases twice as much energy as 1 mole of butane."

Use the graph to decide if the student's prediction is correct. You **must** show your working to gain credit.

_____

**(2)**

(b) Some information about four fuels is given in the table.

| Fuel | Type | Heat released in kJ per g | Combustion products | | | Type of flame |
|---|---|---|---|---|---|---|
| | | | $CO_2$ | $SO_2$ | $H_2O$ | |
| **Bio-ethanol** | Renewable | 29 | ✓ | | ✓ | Not smoky |
| **Coal** | Non-renewable | 31 | ✓ | ✓ | ✓ | Smoky |
| **Hydrogen** | Renewable | 142 | | | ✓ | Not smoky |
| **Natural gas** | Non-renewable | 56 | ✓ | | ✓ | Not smoky |

From this information a student made two conclusions.

For each conclusion, state if it is correct **and** explain your answer.

(i) "Renewable fuels release more heat per gram than non-renewable fuels."

**(2)**

(ii) "Non-renewable fuels are better for the environment than renewable fuels."

**(2)**

**(Total 9 marks)**

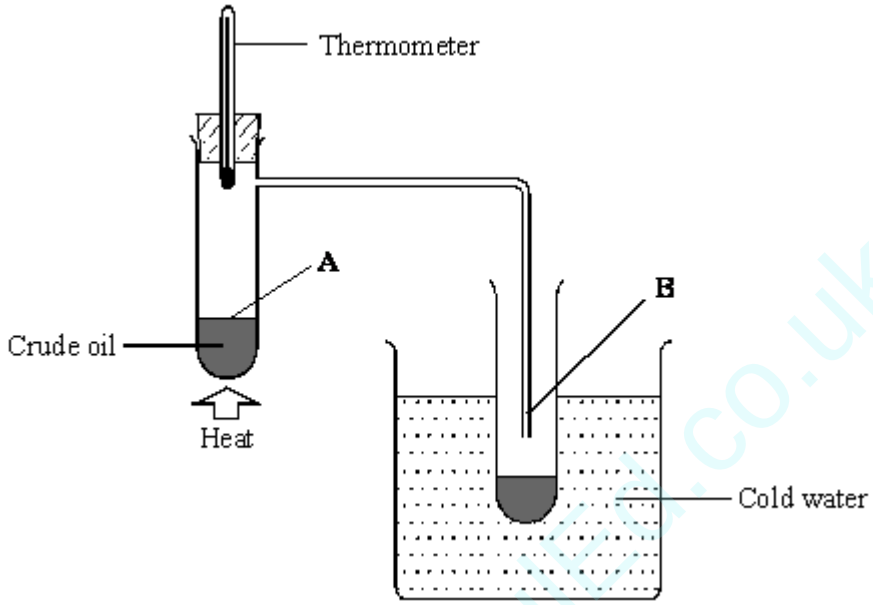
## Q15.

(a) Complete this sentence about crude oil.

Crude oil is mainly a mixture of compounds called _____ which contain carbon and hydrogen only.

**(1)**

(b) The diagram shows a laboratory experiment used to separate crude oil.




Complete each sentence by choosing the correct words from the box.

| | | |
|---|---|---|
| **condensation** | **distillation** | **evaporation** |
| **melting** | **sublimation** | |

The main process taking place at **A** is _____

The main process taking place at **B** is _____

This method of separating crude oil is called _____

**(3)**

(c) Complete this sentence by crossing out the word in each box that is wrong. The first one has been done for you.

This method of separating crude oil works because the [smaller / ~~larger~~] the molecules are,

the [higher / lower] their boiling point and the [more / less] volatile they are.

**(1)**

**(Total 5 marks)**

## Q16.

This question is about hydrocarbons.

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

(i) Large alkane molecules can be cracked to produce more useful molecules.

The equation shows the cracking of dodecane.

$$\underset{\text{dodecane}}{C_{12}H_{26}} \longrightarrow \underset{\text{butane}}{C_4H_{10}} + \underset{\text{hexene}}{C_6H_{12}} + \underset{\text{ethene}}{C_2H_4}$$

Give **two** conditions used to crack large alkane molecules.

1. _____

2. _____

**(2)**

(ii) The products hexene and ethene are alkenes.

Complete the sentence.

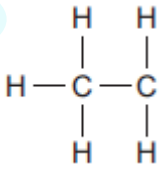
When alkenes react with bromine water the colour changes

from orange to _____ .

**(1)**

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

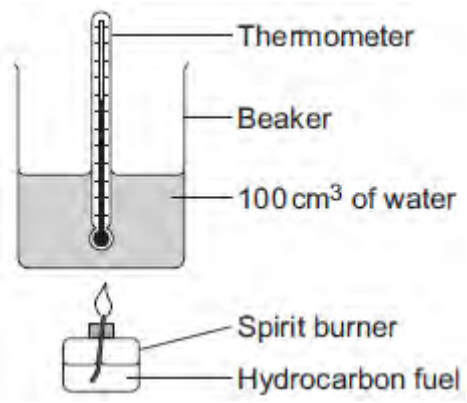
Complete the displayed structure of butane.



**(1)**

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

The diagram below shows the apparatus used.



Each hydrocarbon fuel was burned for two minutes.

**Table 1** shows the students' results.

**Table 1**

| | After two minutes | | | | |
|---|---|---|---|---|---|
| **Name and formula of hydrocarbon fuel** | **Mass of fuel used in g** | **Temperature increase of water in °C** | **Energy released by fuel in kJ** | **Energy released by 1.0 g of fuel in kJ** | **Relative amount of smoke in the flame** |
| Hexane, $C_6H_{14}$ | 0.81 | 40 | 16.80 | 20.74 | very little smoke |
| Octane, $C_8H_{18}$ | 1.10 | 54 | 22.68 | 20.62 | some smoke |
| Decane, $C_{10}H_{22}$ | 1.20 | 58 | 24.36 | | smoky |
| Dodecane, $C_{12}H_{26}$ | 1.41 | 67 | 28.14 | 19.96 | very smoky |

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

_____

_____

Energy released = _____ kJ

**(2)**

(ii) Suggest **one** improvement to the apparatus, or the use of the apparatus, that would make the temperature increase of the water for each fuel more accurate.

Give a reason why this is an improvement.

_____

_____

_____

**(2)**

(iii) The students noticed that the bottom of the beaker became covered in a black substance when burning these fuels.

Name this black substance.

Suggest why it is produced.

_____

_____

_____

_____

**(2)**

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

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

1. _____

_____

2. _____

_____

**(2)**

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

Most car engines use petrol as a fuel.

- Petrol is produced from the fractional distillation of crude oil.
- Crude oil is a mixture of hydrocarbons.
- Sulfur is an impurity in crude oil.

Car engines could be developed to burn hydrogen as a fuel.

- Hydrogen is produced from natural gas.
- Natural gas is mainly methane.

**Table 2** shows information about petrol and hydrogen.

**Table 2**

| | **Petrol** | **Hydrogen** |
|---|---|---|
| State of fuel at room temperature | Liquid | Gas |
| Word equation for combustion of the fuel | petrol + oxygen ⟶ carbon dioxide + water | hydrogen + oxygen ⟶ water |
| Energy released from combustion of 1 g of the fuel | 47 kJ | 142 kJ |

Describe the **advantages** and **disadvantages** of using hydrogen instead of petrol in car engines.

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

**(6)**

**(Total 18 marks)**

## Q17.

Crude oil is a resource found in rocks.

Most of the compounds in crude oil are hydrocarbons.

(a) Complete the sentence.

Crude oil is formed by the decomposition of _____.

**(1)**

(b) Alkanes are hydrocarbons.

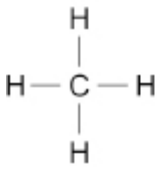
Give the name of the alkane molecule that has three carbon atoms.

_____

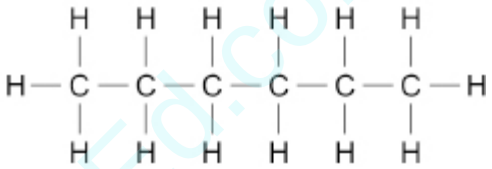
**(1)**

(c) The figure below shows two alkane molecules.

**Methane**



**Hexane**



The table below shows the melting points and boiling points of methane and hexane.

| | **Melting point in °C** | **Boiling point in °C** |
|---|---|---|
| **Methane** | −183 | −162 |
| **Hexane** | −95 | 69 |

Compare the structure and properties of methane and hexane.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

**(6)**

Hydrocarbons are cracked to produce more useful alkanes and alkenes.

(d) Decane ($C_{10}H_{22}$) is cracked to produce **two** products.

Complete the equation for the reaction.

$$C_{10}H_{22} \rightarrow \_\_\_\_\_ + C_2H_4$$

**(1)**

(e) $C_2H_4$ is an alkene.

What is the test for alkenes?

Give the result of the test if an alkene is present.

Test _____

_____

Result _____

_____

**(2)**

**(Total 11 marks)**

## Q18.

(a) The hydrocarbon $C_{16}H_{34}$ can be cracked.

Balance the equation for cracking $C_{16}H_{34}$

$C_{16}H_{34}$ → _____ $C_2H_4$ + $C_8H_{18}$

**(1)**

(b) Describe the differences between cracking and distillation.

_____

_____

_____

_____

**(2)**

(c) What type of reaction is cracking?

Tick **one** box.

Combustion ☐

Decomposition ☐

Neutralisation ☐

Precipitation ☐

**(1)**

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

Poly(ethene) is used to make plastic bags.

the table below shows data from a Life Cycle Assessment (LCA) for a plastic bag and a paper bag.

| | **Plastic bag** | **Paper bag** |
|---|---|---|
| Raw materials | Crude oil or natural gas | Wood |
| Energy used in MJ | 1.5 | 1.7 |
| Mass of solid waste in g | 14 | 50 |
| Mass of $CO_2$ produced in kg | 0.23 | 0.53 |
| Volume of fresh water used in $dm^3$ | 255 | 4 520 |

A company stated: 'A Life Cycle Assessment shows that using plastic bags has less environmental impact than using paper bags'.

Evaluate this statement. Use your knowledge and the information from above the table above.

_____

**(6)**

**(Total 10 marks)**

## Q19.

Crude oil and natural gas are natural resources in many countries.

The table shows percentages of hydrocarbons in natural gas from three different countries.

| **Hydrocarbon** | **Percentage (%) of hydrocarbon in natural gas** | | |
|---|---|---|---|
| | **Country X** | **Country Y** | **Country Z** |
| Methane | 78.03 | 88.10 | 94.36 |
| Ethane | 9.70 | 5.30 | 2.37 |
| Propane | 4.82 | 2.16 | 0.15 |
| Butane | 1.33 | 0.72 | 0.02 |
| Pentane | 0.30 | 0.18 | 0.00 |

(a) Calculate the mean percentage of propane from countries **X**, **Y** and **Z**.

Give your answer to 2 decimal places.

_____

_____

_____

Mean percentage of propane = _____ %

**(2)**

(b) Suggest why natural gas from different countries has different percentages of hydrocarbons.

_____

_____

**(1)**

(c) Complete the sentence.

Choose the answer from the box.

| **an atom** | **an electron** | **an ion** | **a molecule** |
|---|---|---|---|

The formula $CH_4$ represents _____ of methane.

**(1)**

(d) Complete the sentence.

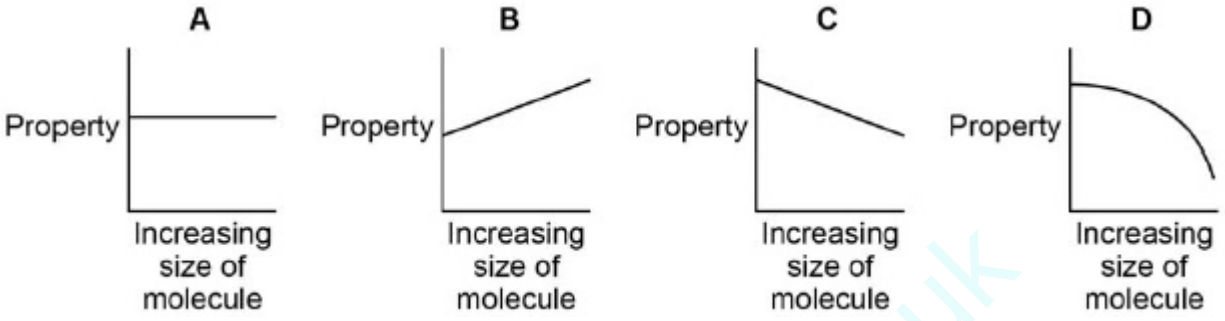
The hydrocarbons in the table belong to the homologous series of

_____ .

**(1)**

**Figure 1** shows how properties vary with the increasing size of molecule in this homologous series.

**Figure 1**




(e) Which graph shows how boiling points vary?

Tick **one** box.

**A** ☐ **B** ☐ **C** ☐ **D** ☐

**(1)**

(f) Which graph shows how viscosity varies?

Tick **one** box.

**A** ☐ **B** ☐ **C** ☐ **D** ☐

**(1)**

(g) Crude oil is fractionally distilled.

Fractions with larger molecules are cracked.

Describe **two** differences between fractional distillation and cracking.

1. _____

_____

2. _____

_____

**(2)**

(h) Ethene is a product of crude oil.

Complete the sentence.

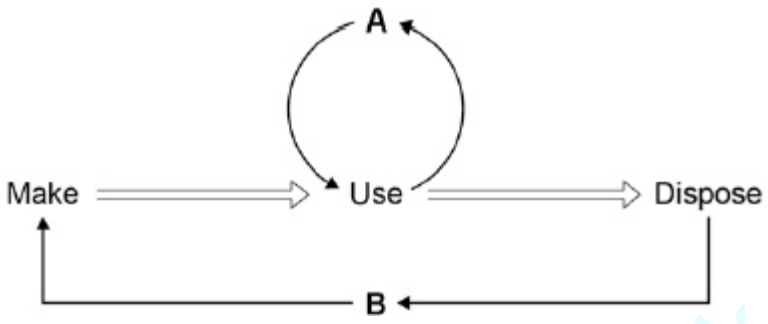
Ethene polymerises to produce _____ .

**(1)**

(i) The production of plastic bags uses limited resources.

**Figure 2** shows two ways (**A** and **B**) of saving limited resources.

**Figure 2**




Name **A** and **B**.

Choose the answers from the box.

| | | | | |
|---|---|---|---|---|
| **recycle** | **reduce** | **release** | **reuse** | **reverse** |

**A** _____

**B** _____

**(2)**

**(Total 12 marks)**

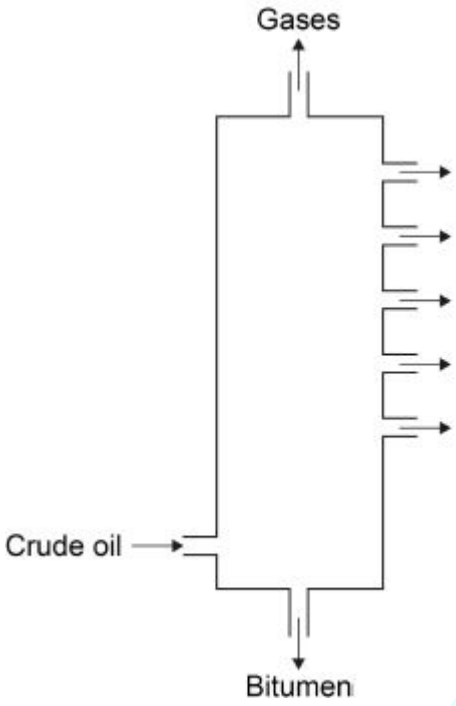
## Q20.

Crude oil is a mixture of hydrocarbons.

(a) The hydrocarbons in crude oil are separated into fractions by fractional distillation.

**Figure 1** shows a fractional distillation column.

**Figure 1**




Crude oil vapour passes up the column.

Complete the sentence.

Choose the answer from the box.

| | | | |
|---|---|---|---|
| **condenses** | **dissolves** | **freezes** | **melts** |

Each fraction _____ at a different level.

**(1)**

(b) Why do the fractions separate?

Tick **one** box.

The fractions have different boiling points. ☐

The fractions have different flammability. ☐

The fractions have different melting points. ☐

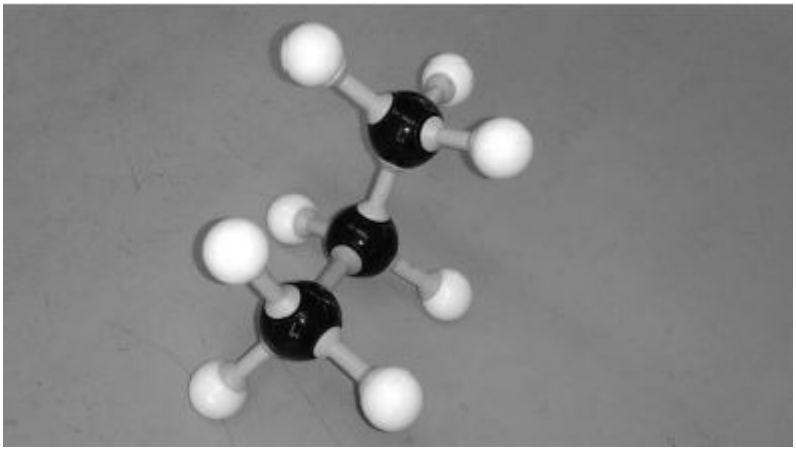
The fractions have different viscosity. ☐

**(1)**

Most of the hydrocarbons in crude oil are alkanes.

(c) **Figure 2** represents an alkane molecule.

**Figure 2**



Name the alkane.

_____

**(1)**

(d) Methane ($CH_4$) is an alkane.

What is the general formula for alkanes?

Tick **one** box.

$C_nH_n$ ☐

$C_nH_{2n}$ ☐

$C_nH_{2n-2}$ ☐

$C_nH_{2n+2}$ ☐

**(1)**

(e) Alkanes burn in oxygen.

Balance the equation for methane burning.

_____$CH_4$ + _____$O_2$ → _____$CO_2$ + _____$H_2O$

**(1)**

(f) Ethene is an alkene.

Which reagent is used to test for alkenes?

Tick **one** box.

Anhydrous copper sulfate ☐

Bromine water ☐

Damp litmus paper ☐

Limewater ☐

**(1)**

The table below shows data from a life cycle assessment (LCA) for the disposal of 10 000 biodegradable plastic bags.

| | **Burning and using the energy to generate electricity** | **Landfill** |
|---|---|---|
| **Mass of carbon dioxide produced in kg** | 25 | 15 |
| **Mass of solid residue in kg** | 0.050 | 0.070 |
| **Mass of sulfur dioxide produced in kg** | 0.20 | 0.30 |

(g) Why are life cycle assessments (LCA) done?

_____

_____

**(1)**

(h) Compare the **two** methods for the disposal of biodegradable plastic bags.

Use information from the table above.

_____

_____

_____

_____

_____

_____

_____

_____

_____

**(4)**

**(Total 11 marks)**

## Q21.

This question is about hydrocarbons and crude oil.

(a) Hydrocarbon fuels are produced from crude oil.

Describe how crude oil is separated into fractions.

**(4)**

Butane is a hydrocarbon.

(b) Two equations for the combustion of butane are:

- $2\ C_4H_{10} + 13\ O_2 \rightarrow 8\ CO_2 + 10\ H_2O$
- $2\ C_4H_{10} + 5\ O_2 \rightarrow 8\ C + 10\ H_2O$

Why are different products formed?

**(1)**

(c) One other product of the combustion of butane is carbon monoxide.

Balance the equation.

_____ $C_4H_{10}$ + _____ $O_2$ → _____ $CO$ + _____ $H_2O$

**(1)**

(d) Carbon dioxide is a greenhouse gas.

Describe the greenhouse effect in terms of the interaction of short and long

wavelength radiation with matter.

**(4)**

**(Total 10 marks)**

## Q22.

Large hydrocarbon molecules can be cracked to produce smaller, more useful molecules.

Alkanes and alkenes are produced when hydrocarbons are cracked.

(a) Give **two** conditions used for cracking.

1 _____

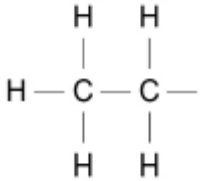
2 _____

**(2)**

(b) Butane ($C_4H_{10}$) is an alkane.

The figure below shows part of the displayed structural formula of butane.

Complete the displayed structural formula of butane in the figure.



**(1)**

(c) Butane burns in oxygen.

Complete the word equation for the complete combustion of butane.

butane + oxygen ⟶ _____ + _____

**(2)**

(d) Ethene is an alkene.

Give a test for alkenes.

Give the result of the test if an alkene is present.

Test _____

Result _____

_____

**(2)**

(e) Each year many tonnes of crude oil are extracted from the Earth.

It took millions of years for the crude oil to be formed.

What do we call development that meets the needs of current generations without compromising the resources for future generations?

Tick (✓) **one** box.

Finite development ☐

Global development ☐

Natural development ☐

Sustainable development ☐

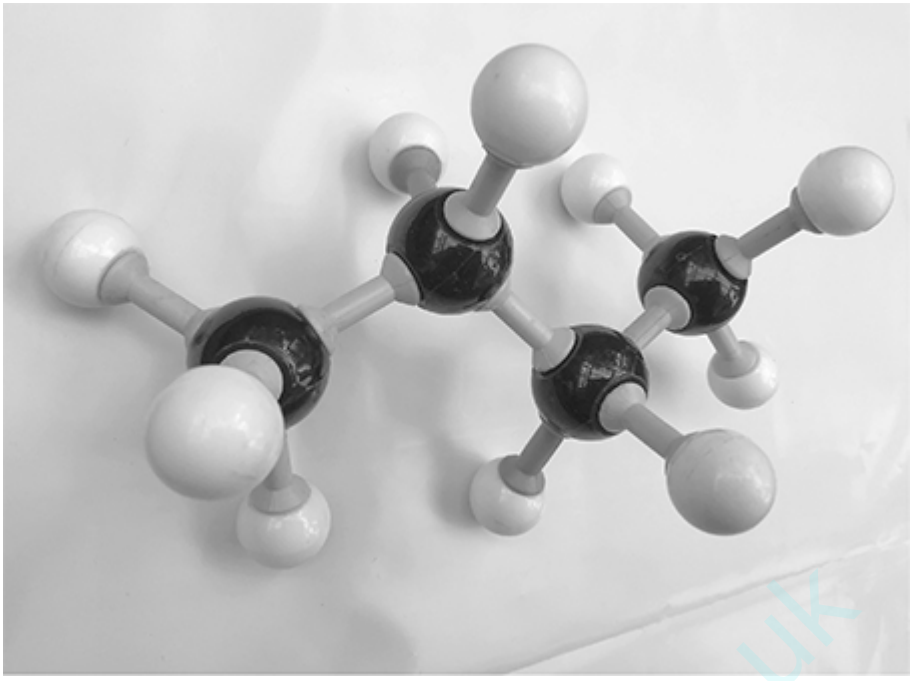
**(1)**

**(Total 8 marks)**

## Q23.

This question is about hydrocarbons and the uses of hydrocarbons.

(a) The figure below shows a model of an alkane.



What is the name of the alkane in the figure above?

_____

**(1)**

(b) What is a hydrocarbon?

_____

_____

**(1)**

Large hydrocarbon molecules are cracked.

(c) When $C_{11}H_{24}$ is cracked, three products are formed.

Complete the equation for the reaction.

$$C_{11}H_{24} \rightarrow C_5H_{10} + 2 \text{ \_\_\_\_\_} + \text{\_\_\_\_\_}$$

**(2)**

(d) Explain why **one** of the products of cracking is in high demand.

_____

_____

_____

_____

**(2)**

(e) Window frames can be manufactured from wood or from plastic.

The table below shows data from a life cycle assessment (LCA) for a wooden window frame and a plastic window frame.

Both window frames are the same size.

| | Wood | Plastic |
|---|---|---|
| Sources of hydrocarbons used for production in kg | 5.37 | 18.23 |
| Greenhouse gases released during production, use and disposal in kg equivalent of $CO_2$ | 457 | 487 |
| Oxides of nitrogen and sulfur dioxide produced in arbitrary units | 29.6 | 37.7 |
| Waste materials in kg | 16.5 | 28.8 |
| Total energy consumption in production, use and disposal in MJ | 9150 | 9713 |
| Lifetime cost to customer to buy and maintain in £ | 147 | 102 |

Evaluate the sustainability of wooden and plastic window frames.

You should include environmental and economic factors.

**(6)**

**(Total 12 marks)**

## Q1.

(a) (i) demand (for petrol) is greater than supply

*ignore reference to figures unless qualified*

**1**

(ii) kerosene

**1**

(iii) supply (of kerosene) is greater than demand

**1**

contains larger molecules (which can be split into smaller molecules)

**1**

(b) heat to vaporise (hydrocarbons)

**1**

(then pass the vapours over a) hot catalyst

*allow zeolites / aluminium oxide for catalyst*

*accept as an alternative approach:*

*mix (the vapours) with steam (1 mark)*

*(then) heat to a (very) high temperature. (1 mark)*

**1**

**[6]**

## Q2.

(a) (i) any **three** from:

- (crude) oil is heated
- (crude) oil evaporates
- vapour condenses

*allow fractions condense*

- at different temperatures.

*allow the fractions have different boiling points*

**3**

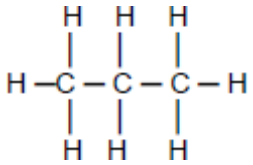
(ii) (as number of carbon atoms increases)
(Boiling point) increases

**1**

(Viscosity) increases

**1**

(b) (i)



**1**

(ii) any **two** from:

- carbon dioxide

*allow $CO_2$*

- water

  *allow $H_2O$*

  *allow water vapour*
- carbon monoxide

  *allow CO*
- carbon.

  *allow soot*

**2**

(iii) any **one** from:

- lack of availability of LPG
- cars need to be modified.

  *allow LPG cars are more expensive*

**1**

**[9]**

## Q3.

(a) $C_3H_8$

**1**

(b) propane

**1**

(c) alkane(s)

**1**

(d) $\frac{24 \times 100}{30}$

**1**

(e) (as the number of carbon atoms increases the) boiling point increases

**1**

(f) any **one** from:

- high temperature

  *allow a temperature between 400 °C and 900 °C*

  *ignore heat / hot*
- steam
- high pressure
- low / no oxygen (atmosphere)
- catalyst

  *allow aluminium oxide*

  *allow alumina*

  *allow zeolites*

  *allow porous pot*

**1**

(g) $C_6H_{14} \rightarrow C_2H_6 + \mathbf{2}\ C_2H_4$

*allow multiples or halves*

**1**

(h) any **one** from:

- to make smaller molecules

- to make more useful molecules
- to produce fuels
- more demand for smaller molecules
- to make (starting materials for) polymers

*allow to make (starting materials for) other chemicals*

*allow to make alkenes*

**1**

**[8]**

## Q4.

(a) any **two** from:

- high demand for petrol (compared to petrol supply)
- insufficient supply of petrol
- surplus kerosene

*allow less demand for kerosene (compared to supply)*

- greater demand for petrol than kerosene

*allow petrol is used more (than kerosene)*

- (hydrocarbon) molecules in kerosene are bigger (so can be cracked / made smaller).

*allow for **2** marks: more demand for petrol than supply*
***or***
*kerosene more supply than demand*

**2**

(b) cracking

*answers must be in this order*

**1**

catalyst

**1**

**[4]**

## Q5.

(a) $C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O$

*allow multiples*

**1**

(b) *MP2 is dependent upon correct response in MP1*

(bubble gas through) lime water

*allow (bubble gas through) calcium hydroxide (solution)*

**1**

turns milky / cloudy / white
**or**
white precipitate forms

**1**

(c) $C_3H_6$

**1**

(d) *MP2 is dependent upon correct response in MP1*

burning / lit splint

*allow flame*
*do **not** accept glowing splint*

**1**

burns with a (squeaky) pop sound

*allow pops*

**1**

(e) bromine (water)

*do **not** accept bromide*

**1**

(colour change) orange*

**1**

(to) colourless*

**1*** *allow 1 mark for colourless (to) orange*
*ignore clear*

**[9]**

## Q6.

(a) plankton

*allow biomass*
*allow (marine) animals / organisms*
*ignore plants*

**1**

buried in mud

*allow compressed under mud*
*allow compressed in sedimentary rock*
*ignore fossilised*

**1**

over a long period of time
**or**
over millions of years

**1**

(b) crude oil heated

**1**

(hydrocarbons / liquids) evaporate

*allow (hydrocarbons / liquids) vaporise / boil*

**1**

vapours / gases condense

**1**

fractions have different boiling points
**or**
fractions collect at different levels depending upon boiling point

**1**

(c) $C_nH_{2n+2}$

1

(d) *max **2** marks for incorrect reference to particles **/** bonds*

*allow converse*

the boiling point increases as the number of (carbon) atoms increases

1

(because the weak) intermolecular forces increase
**or**
(because the weak) forces between the molecules increase

1

(and these intermolecular forces increase) as the size of the molecules increases

1

(e) *MP2 dependent on correct response in MP1*

(as number of carbon atoms increase) the time increases

1

(because) the viscosity increases

1

**[13]**

## Q7.

(a) plankton

*must be in this order*

1

mud

1

(b) **B or** crude oil is heated

**A or** hydrocarbons evaporate

**C or** vapours condense

*must be in this order*
*all correct for **1** mark*

1

(c) fractional distillation

1

(d) $C_3H_8$

1

(e) covalent bond

1

(f) $C_nH_{2n+2}$

1

(g) 6.7 (billion)

*allow 6 700 000 000*

1

**[8]**

## Q8.

(a) elements

**1**

(b) (i) nucleus

**1**

(ii) six

**1**

(c) (i) $CH_4$

**1**

(ii) bond

**1**

(d) (i) oxygen

**1**

(ii) any **one** from:

- (water) does not pollute
  *accept no harmful gas(es)*
  *allow less pollution*
- (only) water is produced
- no carbon dioxide / monoxide (is produced)
  *accept no greenhouse gas(es) / effect **or** no global warming*

**1**

**[7]**

## Q9.

(a) hydrogen **and** carbon

*both elements in either order needed for mark*
*any additional elements negates the mark*

**1**

(b) colourless liquid / condensation in U tube

*ignore ice melts*

**1**

(because) water produced

**1**

lime water goes cloudy

**1**

(because) carbon dioxide produced

**1**

**[5]**

## Q10.

(a) (i) **X** and **Y**

*both needed*

**1**

(ii) **Z**

**1**

(iii) **X**

**1**

(b) unsaturated / alkenes / those with double (C = C) bonds

**1**

**[4]**

## Q11.

(i) $C_8H_{18}$

*for one mark*

**1**

(ii) mixture

*for one mark*

**1**

(iii) fractions molecules
atoms
evaporated condensed

*in this order for 1 mark each*

**5**

**[7]**

## Q12.

(a) fractional distillation

**1**

boiling point or use

**1**

(b) (i) mixture: compounds **or** elements **or** substances together but not chemically combined

*ignore references to separation*

**1**

compound: (different) elements **or** different atoms together and chemically combined

*ignore references to separation*

**1**

(ii) element: contains only one type of atom

*accept made of atoms which contain the same number of protons*

**1**

compound: contains different types of atom chemically combined

*'chemically combined' not needed here if already stated in (b)(i)*

1

**[6]**

## Q13.

(a) $C_3H_8$

1

(b) (i) increases / gets larger

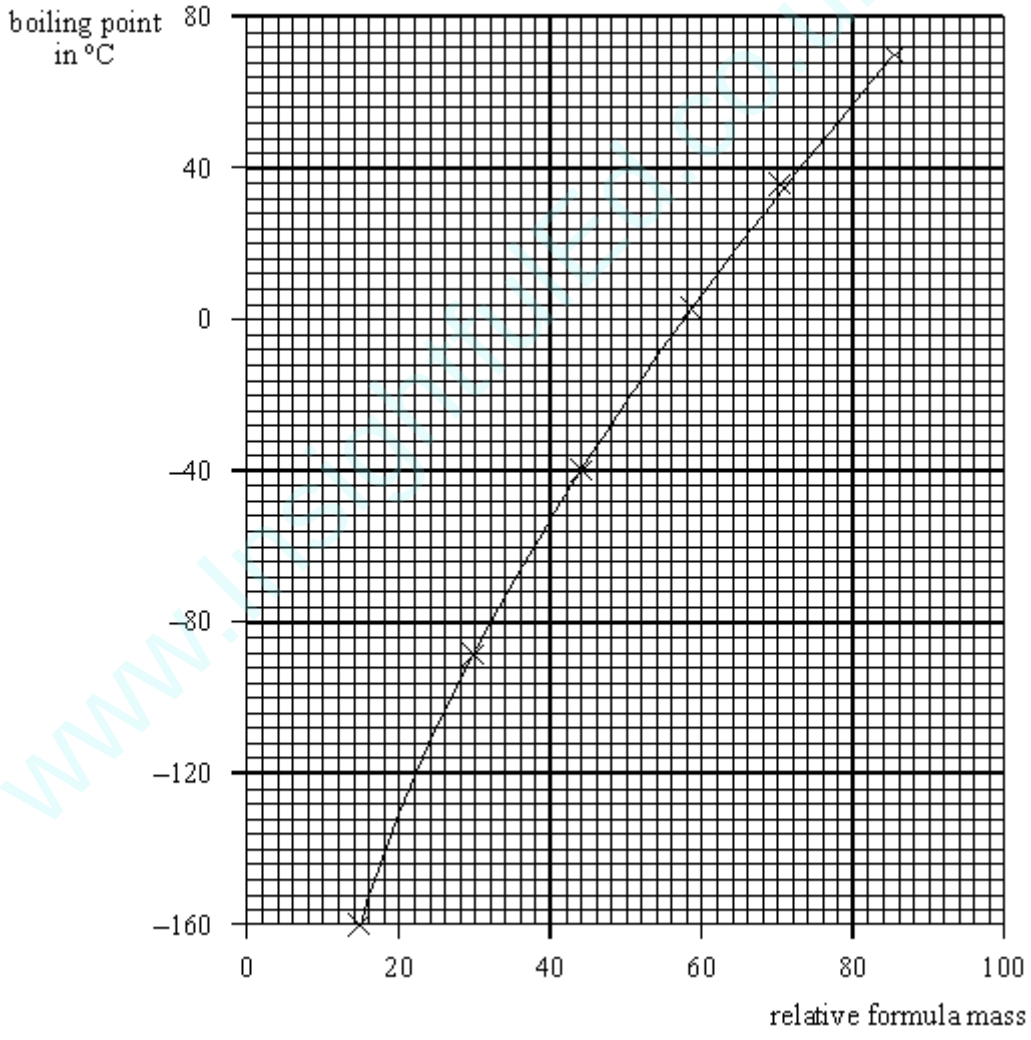
1

(ii) all 5 points plotted correctly

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

2

smooth line graph




1

(iii) boiling point estimate from their graph

*allow ± 2 °C*

1

(iv) shown clearly on graph

*allow just one construction line drawn*

1

(c) $C_9H_{18}$

1

**[8]**

## Q14.

(a) (i) straight line through the 'points' and extended to $C_8H_{18}$

*do **not** accept multiple lines*

1

(ii) 5500

*range 5400 to 5600*

*accept ecf from their graph*

1

(iii) it is a straight line graph

*allow directly proportional*

*accept constant difference between (energy) values*

*accept $C_5H_{12}$ close to values on the graph*

***or** $C_5H_{12}$ comes in middle of the graph*

*ignore 'fits the pattern' unqualified*

*ignore 'line of best fit'*

*ignore 'positive correlation'*

1

(iv) expected ranges for working are:

*accept correct numerical answer as evidence of working*

(5400 to 5600) – (2800 to 2900) = (2500 to 2800)

**or**

their value from (a)(ii) – a value from 2800 to 2900

**or**

(5400 to 5600) / their (a)(ii) divided by 2

**or**

a value from 2800 to 2900 - 2

1

no / not quite / almost / yes

*this mark is only awarded on evidence from their correct working*

1

(b) (i) incorrect / no **or** partially correct

*ignore references to hydrogen*

1

bio-ethanol produces least energy

*mark independently*

**or**

bio-ethanol produces 29 kJ

**1**

(ii) *ignore incorrect / correct*

any **two** from:

- hydrogen produces only $H_2O$
  *accept hydrogen does not produce harmful gases / $CO_2$ / $SO_2$*
- coal produces $SO_2$
  *allow coal causes acid rain / respiratory problems*
- coal produces smoke
  *allow coal causes global dimming*
- both renewable and non-renewable fuels produce $CO_2$
  *accept bio-ethanol and natural gas / coal produce $CO_2$ / global warming*
- (both) the non-renewable fuels produce $CO_2$
  *accept coal and natural gas produce $CO_2$ / global warming*
- (both) renewable fuels produce no smoke
  *accept hydrogen and bio-ethanol do not produce smoke / global dimming*
- (both) renewable fuels produce no $SO_2$
  *accept hydrogen and bio-ethanol*
  *do not produce $SO_2$ / acid rain*

**2**

**[9]**

## Q15.

(a) hydrocarbons

**1**

(b) evaporation

**1**

condensation

**1**

distillation

*allow fractional distillation*

**1**

(c) lower **and** more

**1**

**[5]**

## Q16.

(a) (i) high temperature

*allow heating / hot / 250-900 °C*

**1**

catalyst or steam

*allow named catalyst eg zeolite, $Al_2O_3$, silica, ceramic*

*allow in the absence of air / oxygen*

**1**

*ignore any references to pressure*

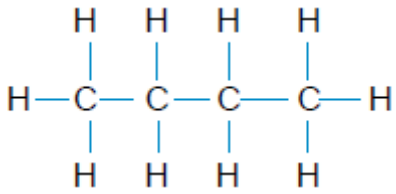
(ii) colourless

*allow decolourised*

*ignore clear / discoloured*

**1**

(iii)



**1**

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

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

**2**

(ii) use a lid

*allow insulate beaker or use draught shield*

**1**

reduce energy / heat loss

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

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

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

**1**

(iii) carbon/soot

*ignore tar, smoke*

**1**

(produced by) incomplete combustion

*allow from a limited supply of oxygen/air*

**1**

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

*ignore more energy*

**1**

hexane produces the least smoke / carbon / soot

*allow has the cleanest flame*

*ignore less smoke / carbon / soot*

**1**

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

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

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

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

**0 marks:**
No relevant content

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

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

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

**6**

**[18]**

## Q17.

(a) plankton

**or**

(ancient) biomass

*allow microscopic plants / animals*

**1**

(b) propane

*allow* $C_3H_8$

**1**

(c) **Level 2:** Scientifically relevant features are identified; the way(s) in which they are similar / different is made clear and (where appropriate) the magnitude of the similarity / difference is noted.

**4–6**

**Level 1:** Relevant features are identified and differences noted. 1–3 AO1 AO2

**1–3**

**No relevant content**

**0**

**Indicative content**

- methane has 1 carbon atom, hexane has 6
- methane has 4 hydrogen atoms, hexane has 14
- both contain C – H bonds
- only hexane contains C – C bonds
- both are hydrocarbons

- hexane has a higher melting point than methane (or converse)
- hexane has a higher boiling point than methane (or converse)
- methane is a gas at room temperature
- hexane is a liquid at room temperature

- both are small molecules
- hexane has larger molecules than methane
- weak forces between molecules
- forces between hexane molecules stronger than between methane molecules

- hexane is more viscous than methane
- both are flammable
- methane is more flammable than hexane (or converse)
- possible products of combustion from both are: carbon, carbon monoxide, carbon dioxide, water
- neither conduct electricity

(d) $C_8H_{18}$

**1**

(e) bromine (water)

**1**

turns (from orange / brown) to colourless

*MP2 is dependent on MP1 allow decolourises*
*ignore clear*

**1**

**[11]**

## Q18.

(a) 4 ($C_2H_4$)

**1**

(b) cracking involves a catalyst

**1**

distillation does not

**or**

distillation does not involve a chemical change

but cracking does

**1**

(c) Decomposition

**1**

(d) **Level 3 (5–6 marks):**
A logically structured evaluation with links involving several comparisons. Nearly all points made are relevant and correct.

**Level 2 (3–4 marks):**
Some valid comparisons made between the two types of bag. There may be some incorrect or irrelevant points.

**Level 1 (1–2 marks):**
A vague response with few correct and relevant points and with no direct comparisons.

**0 marks:**
No relevant content

**Indicative content**

Accept converse in terms of plastic bags for all statements

- Paper bags are made from a renewable resource
- Plastic bags are made from a finite resource
- Paper bags require more energy to manufacture
- Paper bags produce more waste
- Paper bags are biodegradable
- Paper bags create more $CO_2$
- $CO_2$ created by paper bags offset by photosynthesis in growing wood
- Paper bag requires much more fresh water
- Paper bags cannot be recycled
- Agree because non-renewability less important than other factors **or** disagree because of converse **or** can't say because data inconclusive / incomplete

**6**

**[10]**

## Q19.

(a) 2.38

*if answer incorrect, allow **1** mark for 2.37 to full calculator display*

***or***

*for (4.82 + 2.16 + 0.15) / 3*

**2**

(b) different types of biomass / plankton

*allow they are mixtures*

**1**

(c) a molecule

**1**

(d) alkanes

**1**

(e) **B**

**1**

(f) **B**

**1**

(g) any **two** from:
- cracking uses a catalyst, fractional distillation doesn't
- cracking breaks up molecules, fractional distillation separates them
- cracking is a chemical process, fractional distillation is a physical process

**2**

(h) poly(ethene)

**1**

(i) (**A**=) reuse

**1**

(**B**=) recycle

**1**

**[12]**

## Q20.

(a) condenses

**1**

(b) the fractions have different boiling points

**1**

(c) propane

*do **not** accept propene*

**1**

(d) $C_nH_{2n+2}$

**1**

(e) $CH_4 + \mathbf{2}\ O_2 \longrightarrow CO_2 + \mathbf{2}\ H_2O$

*allow multiples*

**1**

(f) bromine water

**1**

(g) to assess the environmental impact (of the stages in the life of a product)

*allow to see the effect / harm / damage on the Earth / environment / planet*

*ignore references to energy, pollution, carbon footprint, carbon dioxide, sustainability*

**1**

(h) **Level 2:** Scientifically relevant features are identified; the ways in which they are similar / different is made clear and the magnitude of the similarity / difference noted.

**3–4**

**Level 1:** Relevant features are identified and differences noted.

**1–2**

**No relevant content**

**0**

**Indicative content**

- burning 10 000 bags produces 10 kg more of carbon dioxide than landfill
- putting 10 000 bags in landfill produces 0.02 kg more of solid residue than burning
- putting 10 000 bags in landfill produces 50% more sulfur dioxide than burning
- burning 10 000 bags produces 25 kg of carbon dioxide, but landfill only produces 15 kg
- putting 10 000 bags in landfill produces 0.07 kg of solid residue but burning only produces 0.05 kg
- landfill produces less carbon dioxide than burning
- landfill produces more solid residue than burning
- burning produces less sulfur dioxide than landfill

**[11]**

## Q21.

(a)

*maximum of **3** marks if incorrect reference made to cracking*
*ignore fractional distillation*
*ignore fracking*

heat or vaporise (oil)

**1**

temperature gradient in column

*allow column is cooler at the top*
*or*
*allow column is hotter at the bottom*

**1**

(vapour) condenses (into fractions)

**1**

depending on boiling point of fraction

*allow at different levels*

**1**

(b) different amounts of oxygen available

*allow complete combustion **and** incomplete / partial combustion*

**1**

(c) $2\ C_4H_{10} + 9\ O_2 \longrightarrow 8\ CO + 10\ H_2O$

*allow correct multiples / halves*

**1**

(d) short wavelength radiation which enters the atmosphere

*because uv / ultra violet radiation which enters the atmosphere*

**1**

is absorbed by materials **and** re-emitted

**1**

as a longer wavelength radiation

*as ir / infrared radiation*

**1**

(the longer wavelength radiation is trapped by) a greenhouse gas / carbon dioxide / methane which stops radiation escaping (from the atmosphere)

*allow so temperature increases*

**1**

**[10]**

## Q22.

(a) any **two** from:

- high temperature

  *ignore heat / hot*

  *allow a temperature between 400 °C and 900 °C*

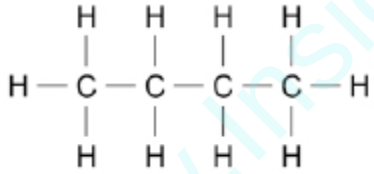
- catalyst

  *allow aluminium oxide, alumina, porous pot, zeolites*

- steam
- high pressure
- low oxygen atmosphere

**2**

(b)



*all bonds and atoms must be present*

**1**

(c) carbon dioxide

*allow $CO_2$*

**1**

water

*allow $H_2O$*

**1**

(d) bromine (water)

*do **not** accept bromide*

**1**

turns (from orange / brown / yellow to) colourless

*MP2 is dependent on MP1*

*allow decolourises*

*ignore clear*

**1**

(e) sustainable development

**1**

**[8]**

## Q23.

(a) butane

**1**

(b) (molecule) made up of carbon and hydrogen (atoms) only

**1**

(c) $C_{11}H_{24} \longrightarrow C_5H_{10} + 2\ C_2H_4 + C_2H_6$

*allow **1** mark for 2 $C_2H_4$*

*allow **1** mark for $C_2H_6$*

**OR**

$C_{11}H_{24} \longrightarrow C_5H_{10} + 2\ C_3H_6 + H_2$ (2)

*allow **1** mark for 2 $C_3H_6$*

*allow **1** mark for $H_2$*

**OR**

$C_{11}H_{24} \longrightarrow C_5H_{10} + 2\ C_2H_6 + C_2H_2$ (2)

*allow **1** mark for 2 $C_2H_6$*

*allow **1** mark for $C_2H_2$*

**2**

(d) $C_2H_6$ is useful as a fuel

*allow smaller molecule so useful as a fuel*

**1**

(because more) flammable (than larger molecules)

**1**

**OR**

$C_2H_4$ / $C_3H_6$ / $C_5H_{10}$ is used to make polymers (1)

*allow $C_2H_4$ / $C_3H_6$ / $C_5H_{10}$ is used to make plastics*

*allow $C_2H_4$ / $C_3H_6$ / $C_5H_{10}$ is used to make other chemicals*

(because more) reactive (than alkanes) (1)

*if a named product is given, allow **1** mark for a correct use and **1** mark for a correct linked reason*

(e) **Level 3:** A judgement, strongly linked and logically supported by a sufficient range of correct reasons is given.

**5–6**

**Level 2:** Some logically linked reasons are given. There may also be a simple judgement.

**3–4**

**Level 1:** Relevant points are made. They are not logically linked.

**1–2**

No relevant content

**0**

**Indicative content**

- production of plastic uses more hydrocarbons which are from non-renewable crude oil

- production of plastic produces more greenhouse gases in the atmosphere which contributes to global warming
- production of plastic produces more sulfur dioxide which causes acid rain
- production of plastic produces more oxides of nitrogen which cause acid rain and respiratory problems
- disposal of plastic produces more waste which increases landfill
- burning plastic produces fumes which are toxic so cause respiratory problems

- lifetime cost of plastic frames is less
- plastic frames have lower costs for maintaining

- the total energy consumption for plastic frames is greater than for wooden frames

- judgement

**[12]**