Combined Science Higher Past Paper Practice

5.7 Organic Chemistry

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Q1. 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 ☐

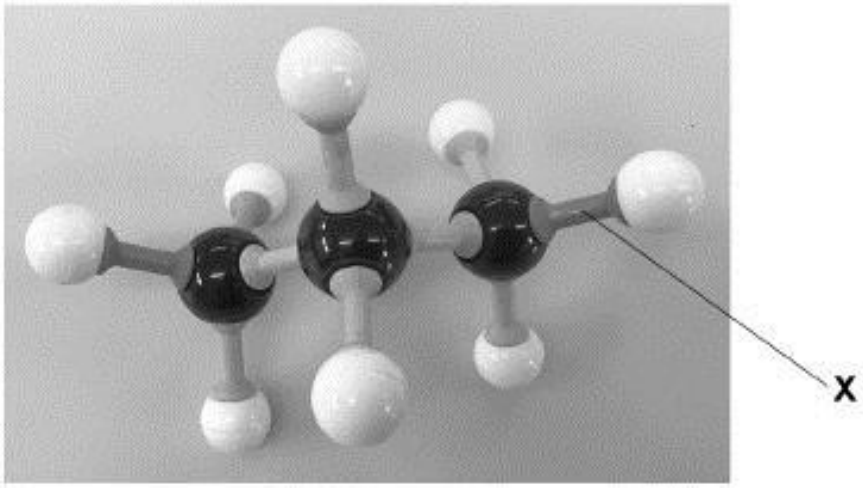
Filtration ☐

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.

CnH_{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

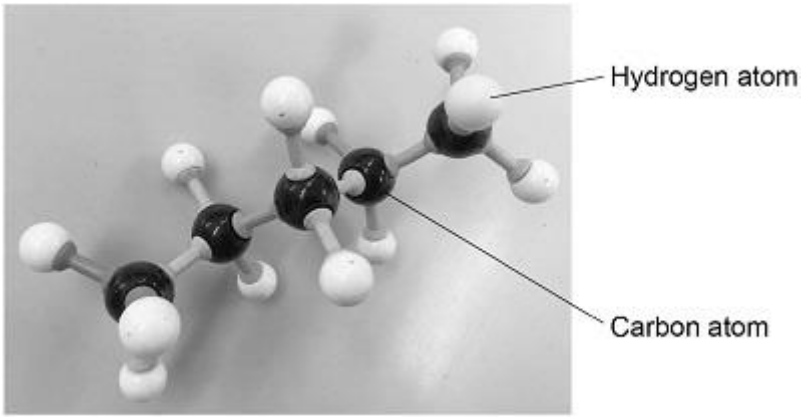
(1)

(Total 8 marks)

Q2. This question is about hydrocarbons.

Figure 1 represents hydrocarbon **A**.

Figure 1



(a) Complete the chemical formula of hydrocarbon **A**.

C_5

(1)

(b) What do the links between the atoms in **Figure 1** represent?

_____

_____

(1)

(c) Hydrocarbon **A** is a fuel. Hydrocarbon **A** is completely combusted in air.

Which **two** substances are produced?

Tick (✓) **two** boxes.

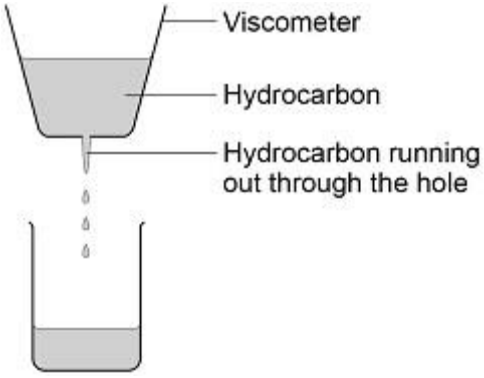
Carbon dioxide	☐
Ethene	☐
Nitrogen	☐
Oxygen	☐
Water	☐

(2)

Some students investigated how changing the temperature of a hydrocarbon affects the viscosity of the hydrocarbon.

Figure 2 shows the apparatus used.

Figure 2



The students recorded the time it took for 25 cm^3 of the hydrocarbon to flow through the hole in the viscometer.

(d) **Table 1** shows a student's results at 60 °C

Table 1

Temperature in °C	**Time to flow through the viscometer in s**				
	Trial 1	**Trial 2**	**Trial 3**	**Trial 4**	**Mean**
60	21	20	24	23	**X**

Calculate the mean value **X**.

_____

_____

Mean value **X** = _____ s

(1)

Another student investigated a different hydrocarbon.

Table 2 shows the results.

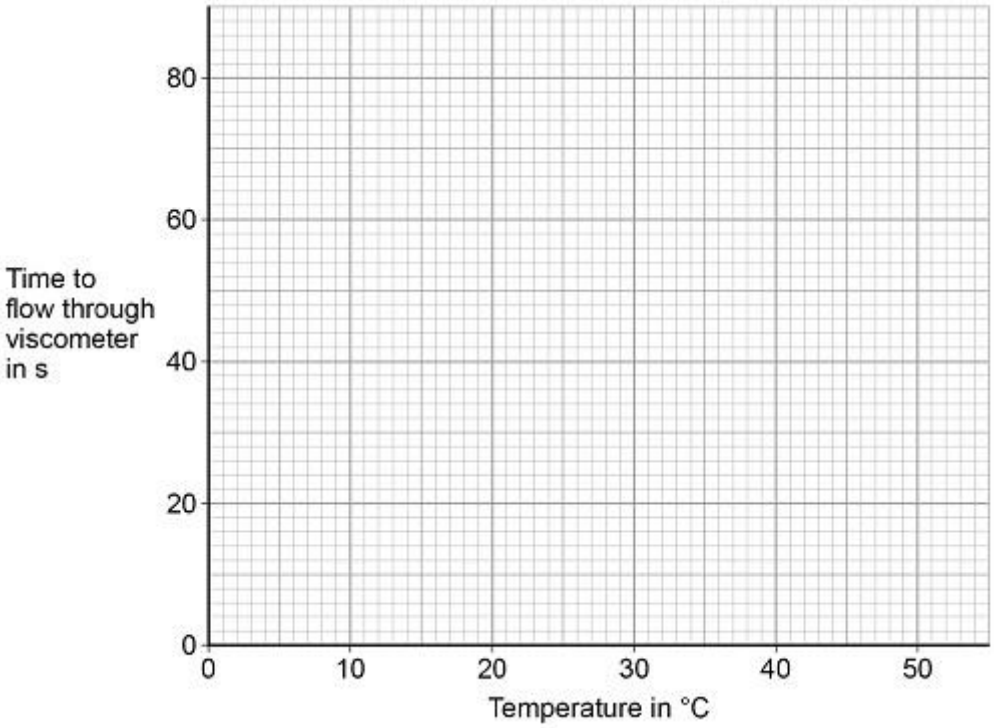
Temperature in °C	**Time to flow through the viscometer in s**
20	66
25	50
30	40
40	30
50	25

(e) Complete **Figure 3**.

You should:

- plot the data from **Table 2**.
- draw a line of best fit.

Figure 3



(3)

(f) Describe the pattern shown on **Figure 3**.

_____

_____

(1)

(g) The viscosity of a substance is linked to how fast the substance flows.

The lower the viscosity, the faster the substance flows.

Complete the sentence.

Choose the answer from the box.

decreases	**increases**	**stays the same**

As the temperature increases, the viscosity of

the hydrocarbon _____.

(1)

(Total 10 marks)

Q3. Crude oil is a mixture of hydrocarbons.

(a) Name the **two** elements in a hydrocarbon.

1. _____

2. _____

(2)

(b) What was crude oil formed from?

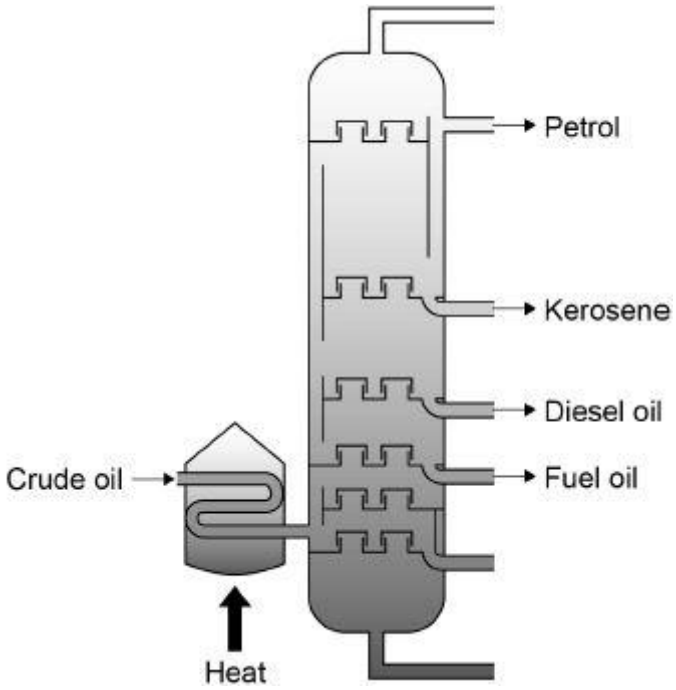
Tick **one** box.

Acids	☐
Enzymes	☐
Metals	☐
Plankton	☐

(1)

Figure 1 shows how crude oil is separated to produce different fuels.

Figure 1



(c) What is the name of this process?

Tick **one** box.

- Combustion ☐
- Fractional distillation ☐
- Phytomining ☐
- Steam cracking ☐

(1)

(d) Why is the crude oil heated?

_____

_____

(1)

The table below shows some properties of the fuels produced by the process.

Fuel	**Number of carbon atoms in chain**	**Lowest boiling point in °C**	**Highest boiling point in °C**
Petrol	5−10	20	200
Kerosene	10−16	180	260
Diesel oil	14−20	260	340
Fuel oil	20−70	370	600

(e) Which of the fuels has the largest boiling point range?

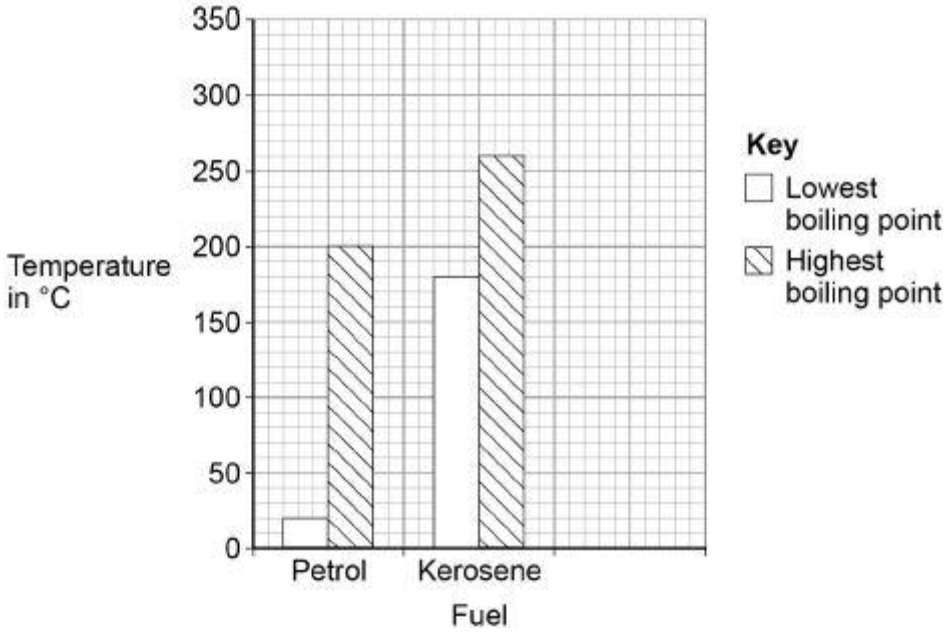
Tick **one** box.

- Petrol ☐
- Kerosene ☐
- Diesel oil ☐
- Fuel oil ☐

(1)

(f) Plot the data for diesel oil from the table on **Figure 2**.

Figure 2



(3)

(Total 9 marks)

Q4. 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.

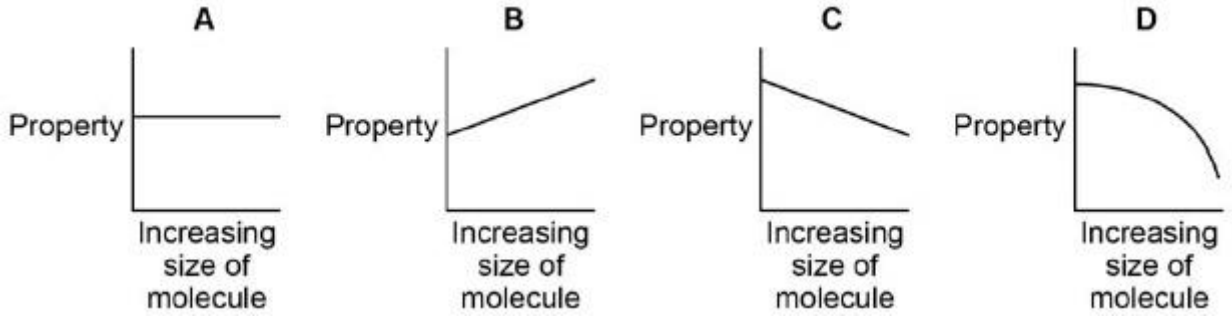
The hydrocarbons in the table belong to the homologous series of

_____ .

(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.

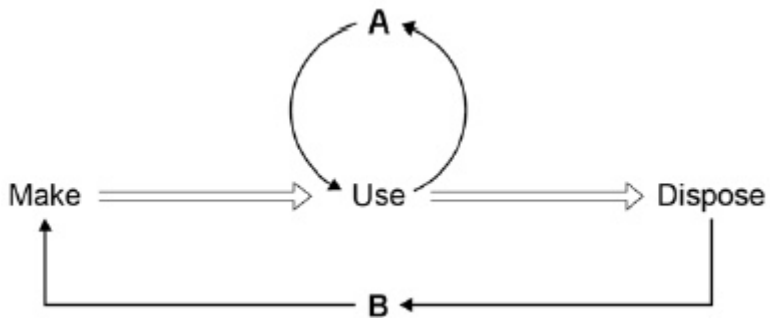
Ethene polymerises to produce _____ .

(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 _____

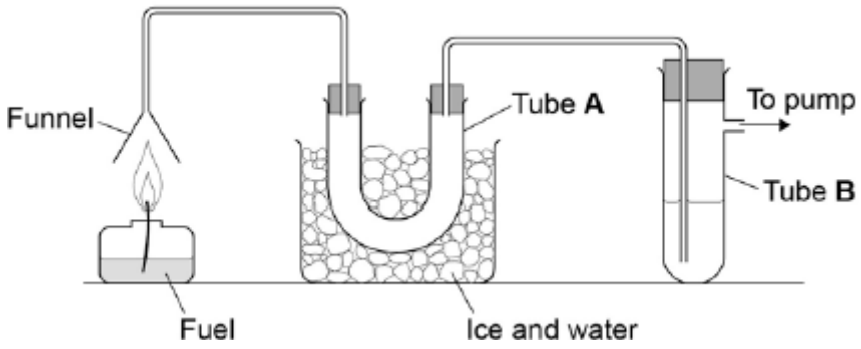
B _____

(2)

(Total 12 marks)

Q5. A student investigated the substances produced when fuels burn.

The figure below shows the apparatus the student used.



(a) The complete combustion of a hydrocarbon produces carbon dioxide and one other substance.

Look at the figure above. What would the student see in tube **A**?

_____

_____

(1)

(b) When the student burned the fuel she saw soot in the funnel.

Explain why soot forms.

_____

_____

_____

(2)

(c) The student burned another fuel which contained impurities.

The substance in tube **B** is water containing universal indicator.

The indicator turned red.

Which gas made the indicator turn red?

Tick **one** box.

Ammonia ☐

Carbon monoxide ☐

Nitrogen ☐

Sulfur dioxide ☐

(1)

(Total 4 marks)

Q6. 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 _____

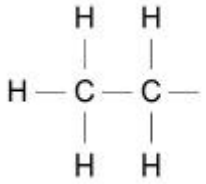
2 _____

(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?

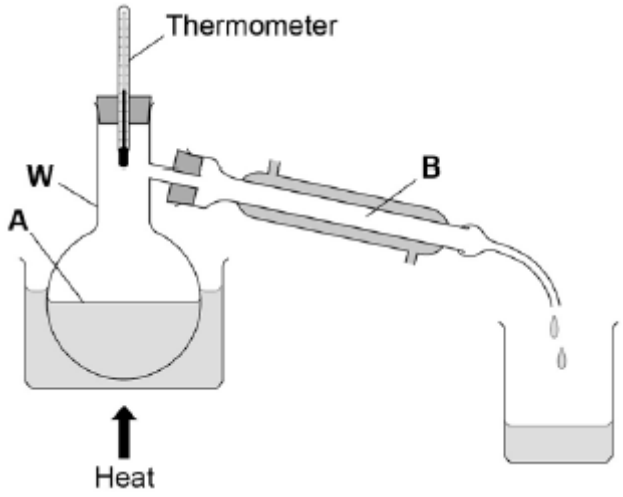
Tick (✓) **one** box.

- Finite development ☐
- Global development ☐
- Natural development ☐
- Sustainable development ☐

(1)

(Total 8 marks)

Q7. The apparatus in the figure below is used to separate a mixture of liquids in a fuel.



(a) What is apparatus **W** on above the figure above?

Tick **one** box.

Beaker ☐

Boiling Tube ☐

Flask ☐

Jug ☐

(1)

(b) What is the name of this method of separation?

Tick **one** box.

Crystallisation ☐

Electrolysis ☐

Filtration ☐

Distillation ☐

(1)

(c) Name the changes of state taking place at **A** and **B** in the figure above.

Use words from the box.

boiling	**condensing**	**freezing**	**melting**

Change of state at **A**: _____

Change of state at **B**: _____

(2)

(d) **Table 1** shows the boiling points of the hydrocarbons in the fuel.

Table 1

Hydrocarbon	Boiling point in °C
Pentane	36
Hexane	69
Heptane	98
Octane	125

Which hydrocarbon will be the last to collect in the beaker?

Tick **one** box.

Pentane ☐

Hexane ☐

Heptane ☐

Octane ☐

(1)

(e) The fuel is a mixture of liquids that has been designed as a useful product.

What name is given to this type of mixture?

Tick **one** box.

Catalyst ☐

Formulation ☐

Polymer ☐

Solvent ☐

(1)

(f) Describe how this fuel is different from crude oil.

_____

_____

_____

_____

(2)

(g) A student measured the melting point of a solid hydrocarbon four times.

The student's results are in **Table 2**.

Table 2

	Trial 1	**Trial 2**	**Trial 3**	**Trial 4**
Melting point in °C	35	48	37	37

Calculate the mean melting point of the hydrocarbon, leaving out any anomalous result.

Give your answer to two significant figures.

_____

_____

Mean melting point = _____ °C

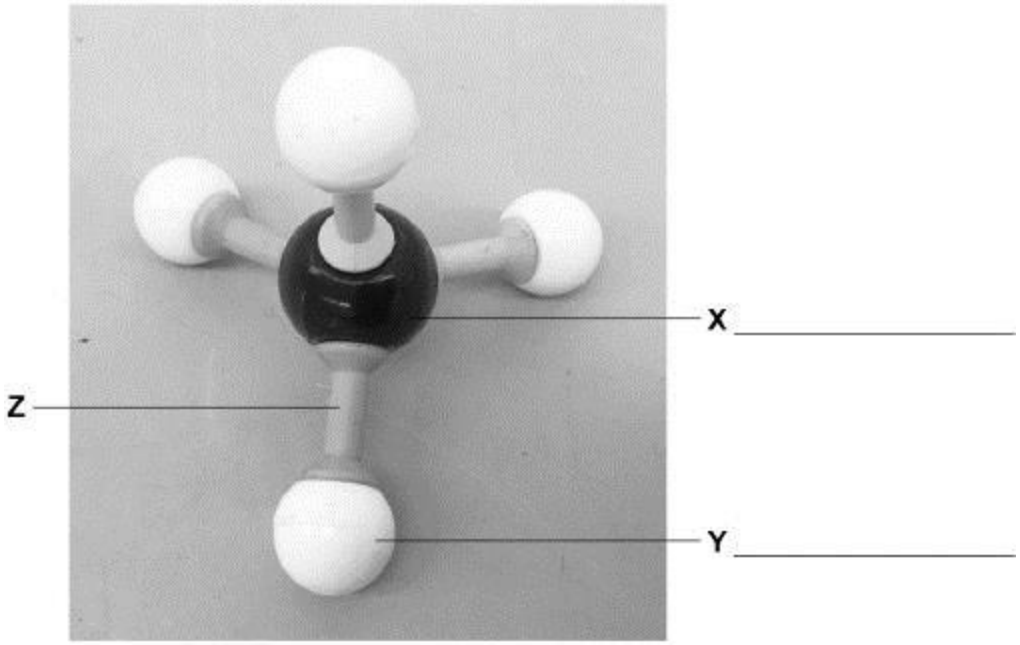
(2)

(Total 10 marks)

Q8. Crude oil is a mixture containing hydrocarbons.

Alkanes are hydrocarbons.

The image below represents an alkane.



(a) **X** and **Y** represent atoms of different elements in an alkane.

Label element **X** and element **Y** on the image above.

(2)

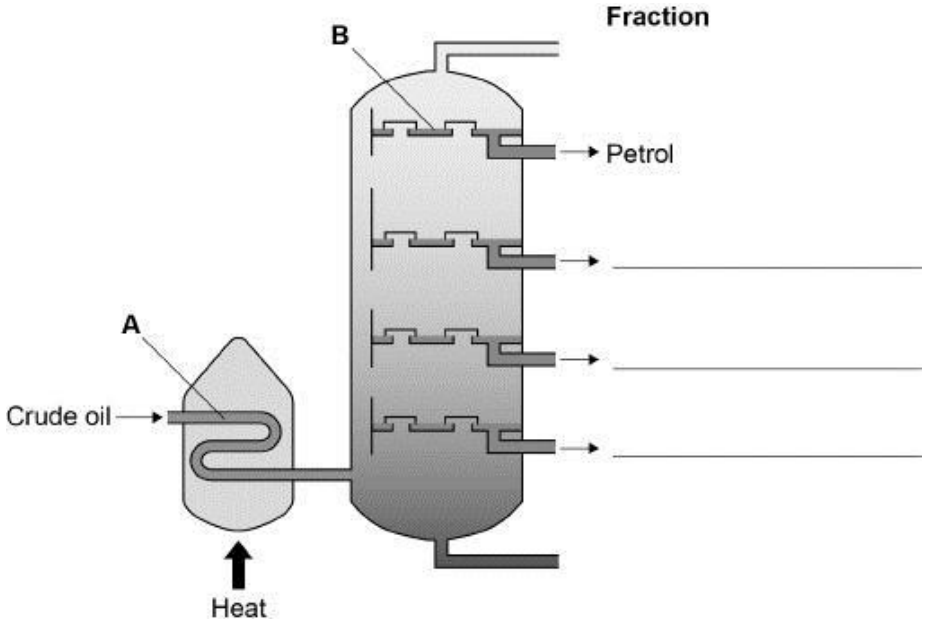
(b) What is represented by **Z** on the image above?

_____

(1)

Crude oil is separated into fractions in a fractionating column.

The diagram below shows a fractionating column.



The table below gives some properties of different fractions separated from crude oil.

Fraction	**Range of number of carbon atoms in one molecule**	**Boiling point range in °C**
Heavy fuel oil	C_{20}–C_{25}	300–400
Diesel	C_{15}–C_{20}	250–300
Kerosene	C_{10}–C_{15}	180–250
Petrol	C_5–C_{10}	40–180

(c) Label the diagram above to show where diesel, heavy fuel oil and kerosene fractions are collected.

Use the table above.

(1)

(d) Complete the sentences.

Choose answers from the box.

condensation	**cracking**	**distillation**
evaporation	**oxidation**	**polymerisation**

Crude oil is separated by fractional _____.

The process happening at **A** in the diagram above is _____.

The process happening at **B** in the diagram above is _____.

(3)

(e) Which statement about the flammability of petrol and diesel is correct?

Use the table above.

Tick (✓) **one** box.

Petrol and diesel have the same flammability. ☐

Petrol is less flammable than diesel. ☐

Petrol is more flammable than diesel. ☐

(1)

The table above is repeated here.

Fraction	**Range of number of carbon atoms in one molecule**	**Boiling point range in °C**
Heavy fuel oil	C_{20}–C_{25}	300–400
Diesel	C_{15}–C_{20}	250–300
Kerosene	C_{10}–C_{15}	180–250
Petrol	C_5–C_{10}	40–180

Octane is a hydrocarbon obtained from crude oil.

Octane has 8 carbon atoms.

(f) Which fraction in the table above contains octane?

Tick (✓) **one** box.

Diesel ☐

Heavy fuel oil ☐

Kerosene ☐

Petrol ☐

(1)

(g) Name the **two** substances produced from the complete combustion of octane.

1. _____

2. _____

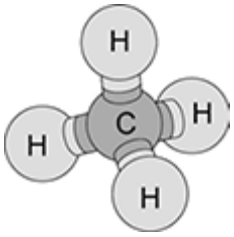
(2)

(Total 11 marks)

Q9. There are several different forms of carbon and many different carbon compounds.

(a) **Figure 1** shows a 3D model of a molecule of methane (CH_4).

Figure 1

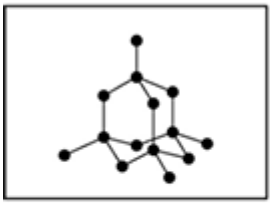
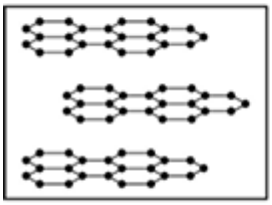
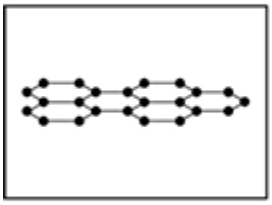


Draw the 2D structure of a methane molecule.

(1)

(b) Different forms of carbon have different bonding and structure.

Draw **one** line from the form of carbon to the bonding and structure.

Form of carbon	**Bonding and structure**
	Each carbon atom is bonded to three other carbon atoms in a single layer
	Each carbon atom is bonded to four other carbon atoms
	Layers of carbon atoms with no covalent bonds between the layers
	Carbon ions held together by strong electrostatic forces
	Pairs of carbon atoms with no covalent bonds between the molecules

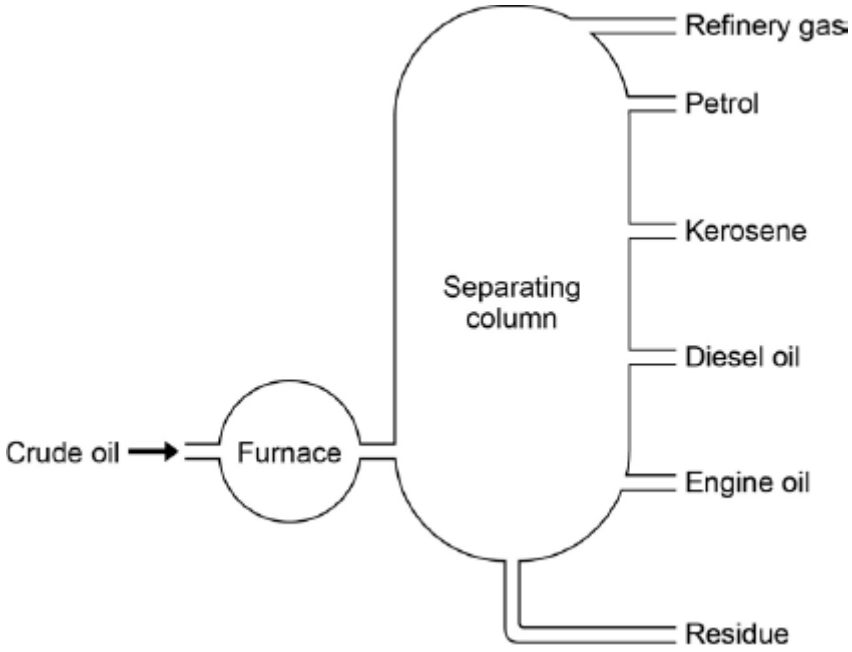
(3)

(c) Crude oil is a mixture of many different carbon compounds.

Crude oil can be separated into useful fractions by fractional distillation.

Figure 2 shows a column used to separate crude oil.

Figure 2



Complete the sentences.

Use words from the box.

condense	**evaporate**	**freeze**

Crude oil is heated so that most of the compounds _____

At different temperatures the compounds cool and _____

(2)

(d) Which fraction is the most **viscous**?

Tick **one** box.

Engine oil ☐

Diesel oil ☐

Kerosene ☐

Petrol ☐

(1)

(e) Which fraction is the most **flammable**?

Tick **one** box.

- Diesel oil ☐
- Kerosene ☐
- Petrol ☐
- Refinery gas ☐

(1)

(f) Why does kerosene separate out of the mixture before diesel oil?

_____

_____

(1)

(Total 9 marks)

Q10. 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 _____

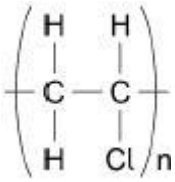
Colour change _____ to _____

(3)

(Total 9 marks)

Q11. This question is about polymers and plastics.

The diagram below shows the displayed formula for poly(chloroethene).



(a) What does 'n' represent in the displayed formula for poly(chloroethene)?

_____

_____

(1)

(b) The representation of poly(chloroethene) in the diagram above does **not** show the actual structure of the molecule.

Give **one** reason why.

_____

_____

(1)

Poly(chloroethene) is commonly known as PVC.

PVC does not decompose in the ground.

Many polymer plastics like PVC become pollutant waste in the oceans.

In the oceans, PVC can break into smaller pieces.

The smaller pieces are called PVC nanoplastic.

(c) A piece of PVC nanoplastic has a thickness of 50 nm

Calculate the thickness of the PVC nanoplastic in metres.

Give your answer in standard form.

1 nm = 0.000 000 001 m

_____

_____

_____

Thickness (in standard form) = _____ m

(2)

(d) Suggest **two** reasons why PVC nanoplastic can be harmful to marine life.

1. _____

_____

2. _____

_____

(2)

(e) Suggest **two** ways to reduce plastic waste.

1. _____

_____

2. _____

_____

(2)

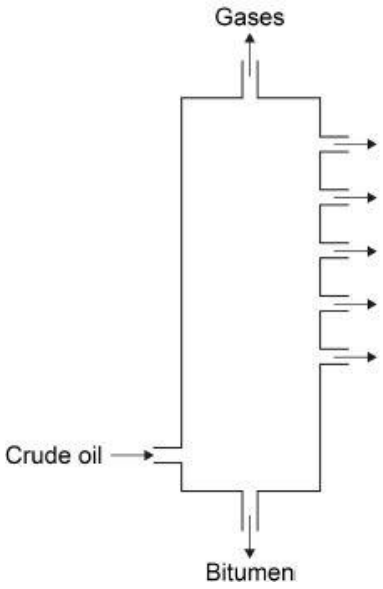
(Total 8 marks)

Q12. 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. ☐

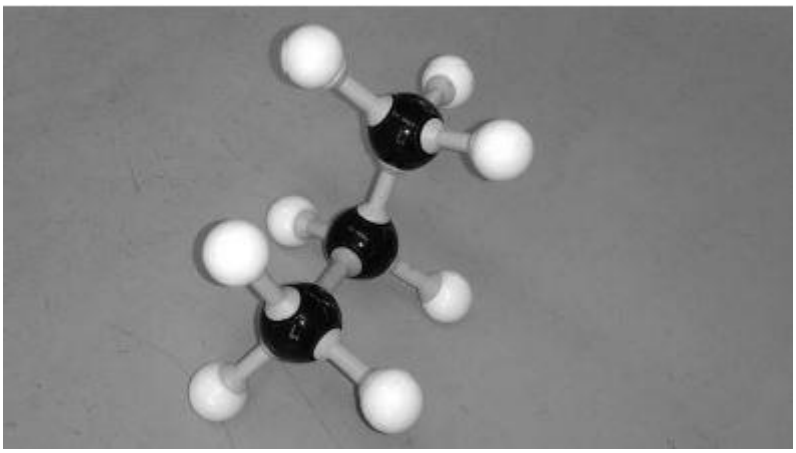
The fractions have different viscosity. ☐

(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)

Q13. (a) Methane is burned in a plentiful supply of oxygen.

Which is the correct balanced chemical equation?

Tick **one** box.

$CH_4 + O_2 \rightarrow CO_2 + H_2O$ ☐

$CH_4 + 2O_2 \rightarrow CO_2 + H_2O$ ☐

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ ☐

$CH_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$ ☐

(1)

(b) Burning fuels causes atmospheric pollution.

Write **one** effect for each pollutant in **Table 1**.

Table 1

Pollutant	Effect
Carbon monoxide	
Sulfur dioxide	
Particulates	

(3)

(c) Methane, petrol and coal are fuels.

Table 2 shows information about these fuels.

Table 2

Fuel	State	Energy content in kJ per g	Mass in mg of CO_2 produced for one kJ of energy released
Methane	Gas	52	53
Petrol	Liquid	43	71
Coal	Solid	24	93

Evaluate the use of the fuels.

Use in the information in **Table 2** and your knowledge.

(6)

(Total 10 marks)

Q14. Crude oil is a mixture of many different chemical compounds.

The table shows information about four compounds that can be obtained from crude oil.

Compound	**Chemical formula**	**Melting point in °C**	**Boiling point in °C**
Decane	$C_{10}H_{22}$	–30	+174
Ethene	C_2H_4	–169	–104
Icosane	$C_{20}H_{42}$	+37	+343
Methane	CH_4	–183	–164

(a) Which compound in the table is a liquid at room temperature (20 °C)?

Tick **one** box.

Decane ☐

Ethene ☐

Icosane ☐

Methane ☐

(1)

(b) Which compound in the table has the highest viscosity?

Tick **one** box.

Decane ☐

Ethene ☐

Icosane ☐

Methane ☐

(1)

(c) Which compound can be used to produce a polymer?

Tick **one** box.

Decane ☐

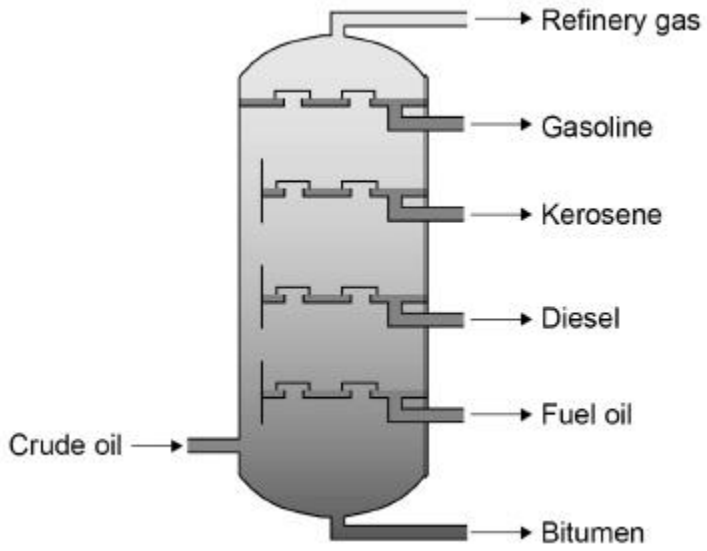
Ethene ☐

Icosane ☐

Methane ☐

(1)

(d) The diagram shows the separation of crude oil in a fractionating column.



Explain how crude oil is separated into different fractions by fractional distillation.

_____

_____

_____

(6)

(Total 9 marks)

Q15. (a) The hydrocarbon $C_{16}H_{34}$ can be cracked.

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

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

(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)

Q16. 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.

_____

_____

_____

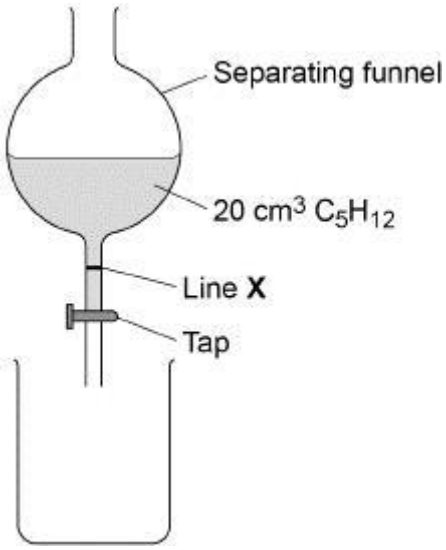
(3)

(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)

Q17. This question is about the hydrocarbons obtained from crude oil.

Octane is a hydrocarbon.

The formula of octane is C_8H_{18}

(a) How does the formula of octane show that octane is an alkane?

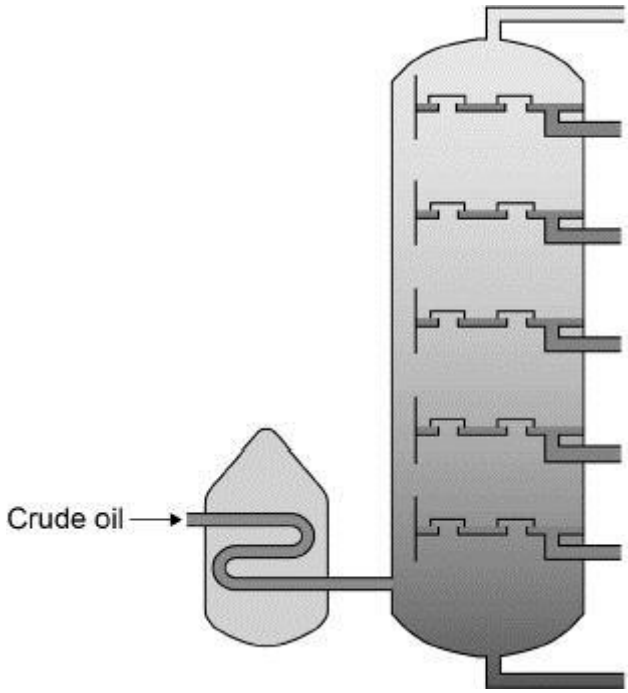
_____

_____

(1)

The fractions in crude oil are separated by fractional distillation.

The diagram below shows a fractionating column.



The table below gives some properties of different fractions separated from crude oil.

Fraction	**Range of number of carbon atoms per molecule**	**Boiling point range in °C**
Diesel	C_{15}–C_{20}	250–300
Heavy fuel oil	C_{20}–C_{25}	300–400
Kerosene	C_{10}–C_{15}	180–250
Petrol	C_5–C_{10}	40–180

(b) Which fraction in the table above is the most viscous?

Give **one** reason for your answer.

Tick (✓) **one** box.

Diesel	☐
Heavy fuel oil	☐
Kerosene	☐
Petrol	☐

Reason _____

_____

(2)

(c) Describe how the fraction containing octane is separated from crude oil.

Use data from the table above in your answer.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 7 marks)

Q18. 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:

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

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)

Q19. This question is about hydrocarbons.

(a) When a hydrocarbon $C_{10}H_{22}$ is cracked, two substances are produced.

Complete the equation for the reaction.

$$C_{10}H_{22} \rightarrow C_7H_{16} + \_\_\_\_\_$$

(1)

(b) Explain why the hydrocarbon C_7H_{16} has a lower boiling point than $C_{10}H_{22}$

_____

_____

_____

_____

(2)

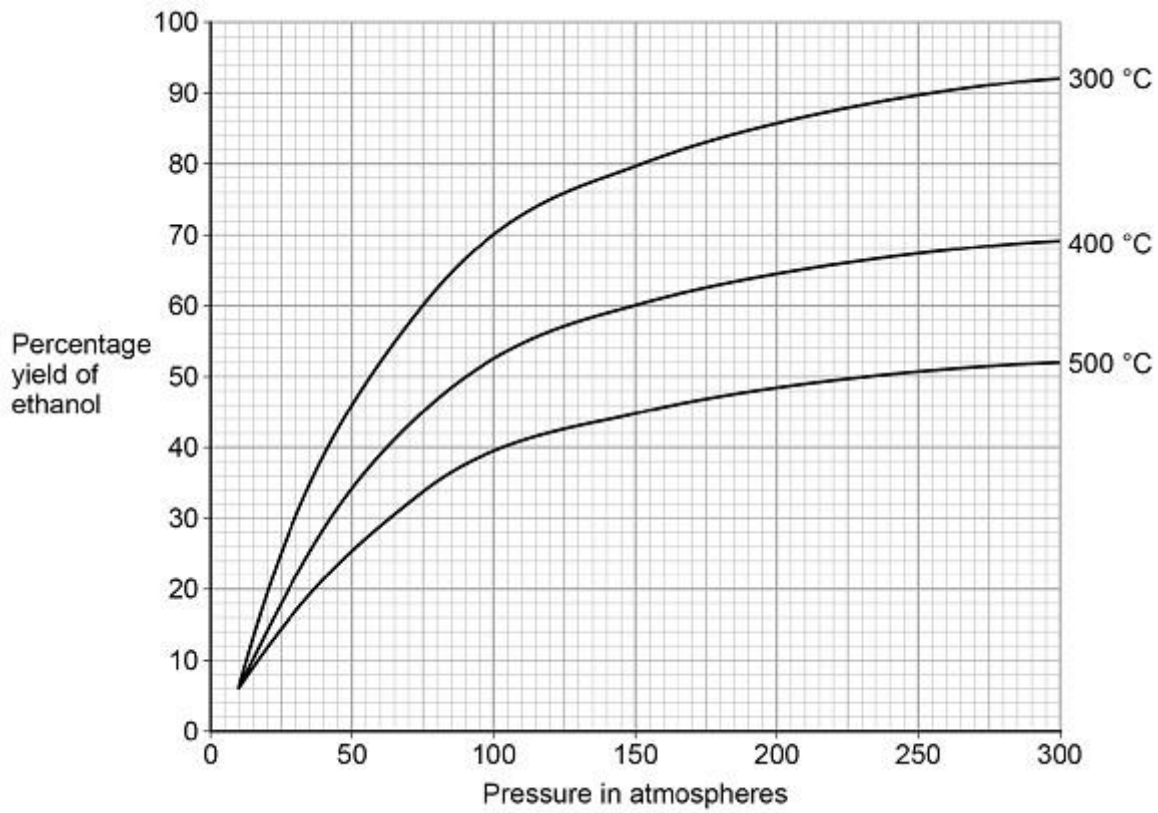
Ethanol is produced by reacting ethene with steam.

The equation for the reaction is:

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g)$$

Figure 1 shows the percentage yield of ethanol using different reaction conditions.

Figure 1



(c) Explain why changing the pressure affects the percentage yield of ethanol.

_____

_____

_____

_____

_____

_____

(3)

The forward reaction is exothermic.

(d) How does **Figure 1** provide evidence for this?

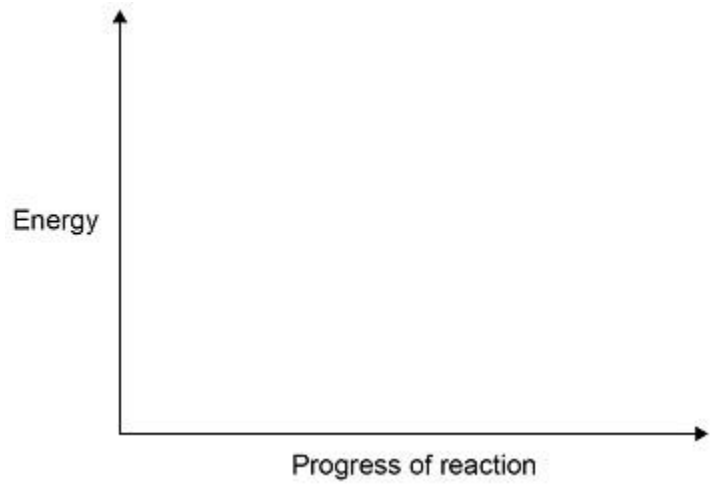
_____

_____

(1)

(e) **Figure 2** shows part of a reaction profile diagram.

Figure 2



A catalyst is used in the reaction to produce ethanol.

Complete **Figure 2** to show how the catalyst increases the rate of this reaction.

You should label the reaction profile diagram.

(4)

(f) Suggest why the catalyst does not affect the yield of ethanol at equilibrium.

_____

_____

_____

_____

(2)

(Total 13 marks)

Q20. Crude oil is a mixture of hydrocarbons.

Hydrocarbons can be used as fuels.

(a) One alkane hydrocarbon contains 34 hydrogen atoms.

What is the formula of the hydrocarbon?

Tick **one** box.

$C_{15}H_{34}$ ☐

$C_{16}H_{34}$ ☐

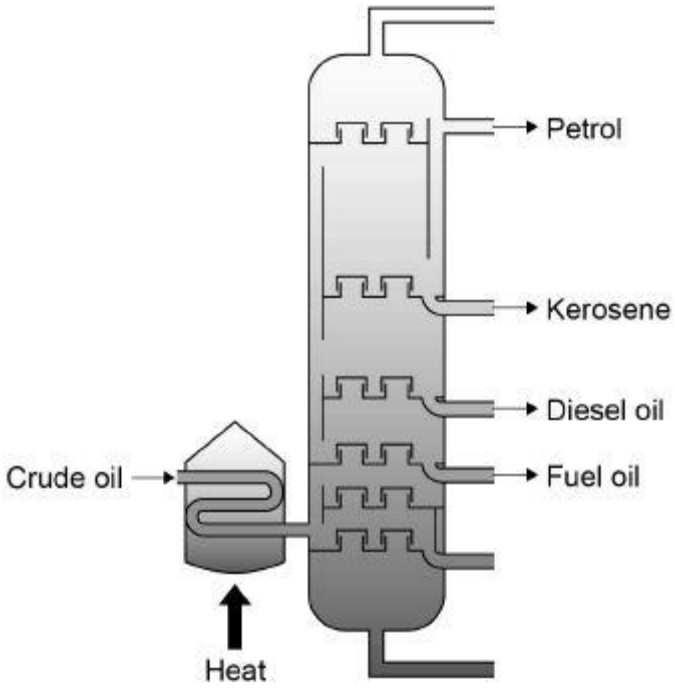
$C_{17}H_{34}$ ☐

$C_{18}H_{34}$ ☐

(1)

(b) **Figure 1** represents a fractionating column used to separate crude oil.

Figure 1



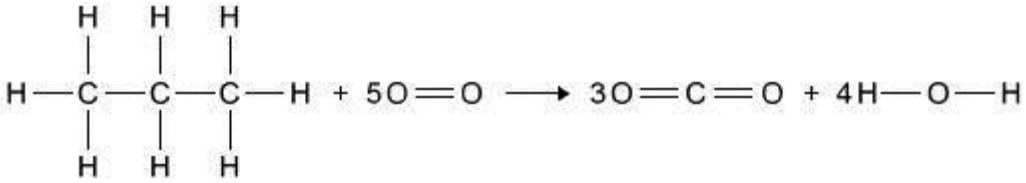
Describe how crude oil is separated using fractional distillation.

(4)

(c) Propane is a hydrocarbon fuel obtained from crude oil.

Figure 2 shows the displayed equation for the complete combustion of propane.

Figure 2



The table below shows bond energies.

Bond	**Bond energy in kJ/mol**
C−C	347
C−H	413
O=O	495
C=O	799
O−H	467

Calculate the overall energy change in kJ/mol for the reaction.

Use the diagram and the table above.

Overall energy change = _____ kJ/mol **(3)**

(d) Some fuels are obtained from plants.

Evaluate the environmental impact of fuels obtained from plants and from crude oil.

(4)

(e) Butane is another hydrocarbon fuel obtained from crude oil.

The equation for the complete combustion of butane is:

$2\ C_4H_{10} + 13\ O_2 \longrightarrow 8\ CO_2 + 10\ H_2O$

14.5 g of butane was burned in 72.0 g of oxygen. Determine the limiting reactant.

You must include calculations in your answer.

Relative atomic masses (A_r): C = 12 H = 1 O = 16

(4)

(Total 16 marks)

Q21. This question is about crude oil.

(a) The table shows information about crude oil fractions.

Crude oil fraction	Number of carbon atoms	Approximate percentage (%) in crude oil	Approximate percentage (%) demand
Gas	1–4	3	4
Petrol	5–10	9	23
Naphtha	8–12	10	5
Kerosene	9–16	14	8
Diesel	15–25	16	22
Residue	20–30+	48	38

Explain the advantage of cracking hydrocarbons.

Give **one** example from the table.

(3)

(b) Ethene is a product of cracking.

Relative formula mass (M_r) of ethene = 28

Calculate the number of moles of ethene (C_2H_4) in 50.4 kg

Give your answer in standard form.

Numbers of moles = _____

(3)

(c) $C_{21}H_{44}$ can be cracked to produce ethene.

$$C_{21}H_{44} \rightarrow 3C_2H_4 + C_{15}H_{32}$$

Relative formula mass (M_r) of $C_{21}H_{44}$ = 296

Calculate the mass of $C_{21}H_{44}$ needed to produce 50.4 kg of ethene.

_____

_____

_____

_____

_____

Mass = _____ kg

(3)

(Total 9 marks)

Q1.

(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]

Q2.

(a) C_5H_{12}

must be upper case, with subscript

1

(b) (covalent) bonds

allow strong bonds

1

(c) carbon dioxide

1

water

1

(d) 22 (s)

1

(e) all points correct

allow tolerance of ± ½ a small square

*allow **1** mark for at least three points plotted correctly*

2

line of best fit

allow line of best fit consistent with plotted points

1

(f) as the temperature increases, the time (to flow through the viscometer) decreases

allow as the temperature increases, the hydrocarbon flows (through the viscometer) more quickly

allow negative correlation

allow credit if their answer is consistent with the graph drawn on Figure 8

1

(g) decreases

1

[10]

Q3.

(a) hydrogen

ignore H

1

carbon

ignore C

1

in either order

(b) plankton

1

(c) fractional distillation

1

(d) to vaporise the hydrocarbons / (crude) oil

allow to evaporate the hydrocarbons / (crude) oil
ignore to boil the hydrocarbons / (crude) oil

1

(e) fuel oil

1

(f) lowest boiling point bar correctly plotted (260 °C)

1

highest boiling point bar correctly plotted (340 °C)

1

correct label added to axis: diesel (oil)

1

allow ± ½ a square

[9]

Q4.

(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]

Q5.

(a) Colourless liquid / condensation / water

1

(b) incomplete combustion of the fuel

1

because not enough oxygen

1

(c) Sulfur dioxide

1

[4]

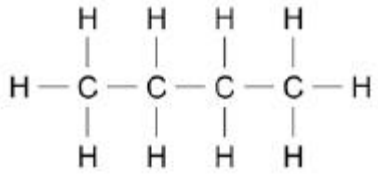
Q6.

(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]

Q7.

(a) Flask

1

(b) Fractional distillation

1

(c) **A** – boiling

in this order

1

B – condensing

1

(d) Octane

1

(e) Formulation

1

(f) the fuel is a pure compound

1

and crude oil is a mixture

or

the fuel is made up of four hydrocarbons

allow crude oil contains a large number of compounds and the fuel contains four

and crude oil could have many more

1

(g) (35 + 37 + 37 / 3) = 36.33

1

36

1

*allow (35 + 48 + 37 + 37 / 4 =) 39(.25) for **1** mark*

[10]

Q8.

(a) (**X**) carbon

allow C

1

(**Y**) hydrogen

allow H
ignore H_2
ignore atoms

1

(b) (single / covalent) bond

1

(c) order from top

(petrol) kerosene

diesel

heavy fuel oil

1

(d) distillation

1

evaporation

1

condensation

must be in this order

1

(e) petrol is more flammable than diesel

1

(f) petrol

1

(g) carbon dioxide

allow CO_2

1

water

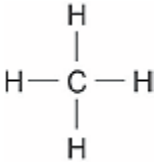
allow H_2O
either order

1

[11]

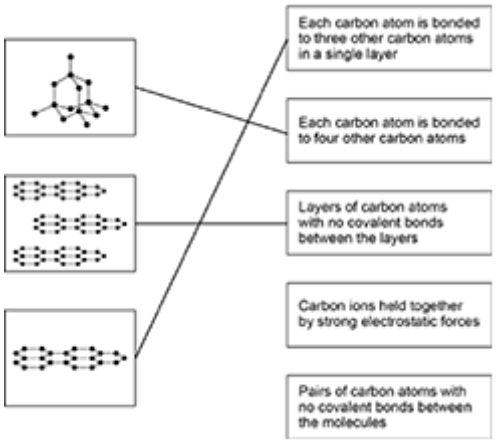
Q9.

(a)



1

(b) **Form of carbon** **Bonding and structure**



extra lines from the left negate the mark

3

(c) evaporate

1

condense

1

(d) Engine oil

1

(e) Refinery gas

1

(f) because its boiling point is lower

1

[9]

Q10.

(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*

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

1

[9]

Q11.

(a) number of repeating units
or
a large number

allow number of monomers (joined together)

1

(b) any **one** from:
- only shows in 2D
- doesn't show the shape of the molecule
- only shows a very small proportion of all atoms bonded together.

1

(c) 50 nm = 0.000 000 05 m

allow 50 × 10^{-9} (m)

1

= 5 × 10^{-8} (m)

allow correct value in standard form obtained from an incorrect conversion

1

(d) marine animals eat them

1

build up in food chain

allow too small to be seen

1

(e) any **two** from:
- stop using plastic items

  allow specific examples eg, stop using plastic drinking straws, or plastic bags
- recycle plastic items
- reuse plastic items
- charge for plastic bags
- refill own water bottle instead of buying new bottle
- deposit schemes for plastic bottles.

2

[8]

Q12.

(a) condenses

1

(b) the fractions have different boiling points

1

(c) propane

*do **not** accept prop<u>e</u>ne*

1

(d) C_nH_{2n+2}

1

(e) CH_4 + **2** O_2 ⟶ CO_2 + **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]

Q13.

(a) $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

1

(b) toxic

accept causes death

1

acid rain
or
respiratory problems

accept respiratory problems / asthma

1

global dimming

1

(c)

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 • methane is the best fuel because it gives more energy per gram than coal, and gives less carbon dioxide per kJ of energy produced • petrol is best because it being a liquid is easier to handle than gas or coal - although the energy content is lower than the others, it gives out less carbon dioxide than coal • methane has more energy per gram than coal • coal produces most carbon dioxide • coal can produce sulfur dioxide	

6

[10]

Q14.

(a) decane

1

(b) icosane

1

(c) ethene

1

(d)

Level 3: Relevant points (reasons/causes) are identified, given in detail and logically linked to form a clear account.	5-6
Level 2: Relevant points (reasons/causes) are identified, and there are attempts at logically linking. The resulting account is not fully clear.	3-4
Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.	1-2
No relevant content	0
Indicative content • crude oil is heated • hydrocarbons/compounds vaporise • vapours enter the fractionating column near the bottom • there is a temperature gradient in the column **or** the column is hotter at the bottom and cooler at the top • vapours / hydrocarbons / fractions condense • to become liquid • at their boiling points • different substances have different boiling points • so the different fractions collect at different levels • hydrocarbons / fractions with smallest molecules have lowest boiling points • collect as gases at top of the column where temperature is lower • hydrocarbons / fractions with larger molecules have higher boiling points • so collect nearer the bottom • where temperature is higher	

6

[9]

Q15.

(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]

Q16.

(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

Q17.

(a) (alkane) has the (general) formula C_nH_{2n+2}

1

(b) heavy fuel oil

*do **not** award any marks if incorrect fraction given*

1

contains largest molecules (which have greatest viscosity)

allow has most carbon atoms (per molecule)

ignore reference to highest boiling point

1

(c) crude oil is heated to vaporise hydrocarbons

1

there is a temperature gradient in the column

allow the column gets cooler going up

1

as gases rise up the column the gases condense

1

fraction (containing octane / petrol) condenses between 40 °C and 180 °C

1

[7]

Q18.

(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]

Q19.

(a) C_3H_6

1

(b) smaller molecule

allow shorter (hydrocarbon) chain

allow smaller hydrocarbon if MP2 obtained

1

(so) fewer intermolecular forces

*do **not** accept fewer covalent bonds*

1

(c)

allow converse argument

yield increases as pressure increases

1

(because) fewer (gas) molecules as products

1

(so) equilibrium moves to right / products

1

(d) the yield increases when temperature is decreased

allow converse statements

1

(e) reaction profile showing exothermic reaction

1

labelling of activation energy

allow correct labelling of activation energy if endothermic reaction shown

1

second profile drawn with different activation energy

in each profile reactants level and products level must be the same

1

correct distinction between catalyst and no catalyst

1

(f) increases the rate of the forward and reverse reaction

allow changes the rate of the forward and reverse reaction

1

by the same amount

1

[13]

Q20.

(a) $C_{16}H_{34}$

1

(b) heat to vaporise the hydrocarbons / (crude) oil

allow heat to evaporate the hydrocarbons / (crude) oil
allow alkanes for hydrocarbons
ignore boil

1

temperature (of column) decreases from bottom to top

1

as gases / vapours rise up the column, they condense

1

at different points according to their boiling point

1

(c) (energy required to break bonds = (2 × 347) + (8 × 413) + (5 × 495) =)
6473 (kJ/mol)

1

(energy released when bonds formed = (6 × 799) + (8 × 467) =)
8530 (kJ/mol)

1

(overall energy change = 6473 − 8530 =)
−2057 (kJ/mol)

allow calculation of difference between their values from step 1 and step 2
ignore order / sign

1

*an answer of 2057 (kJ/mol) or −2057 (kJ/mol) scores **3** marks*

(d) **Level 2:** A judgement, strongly linked and logically supported by a sufficient range of correct reasons, is given.

3–4

Level 1: Some logically linked reasons are given. There may also be a simple judgement.

1–2

No relevant content

0

Indicative content

- carbon dioxide is released by both (during combustion)
- carbon dioxide emissions contribute to global warming
- fuels from plants are carbon-neutral when taking into account the CO_2 taken in by the plants as they grow
- combustion of crude oil-derived fuels causes sulfur dioxide emissions
- sulfur dioxide emissions cause acid rain
- transport of crude oil can lead to oil spills
- transport of both releases carbon dioxide
- fuel from plants require a large area of land to grow plants

- fuel from plants may displace food crops
- clearing land to grow plants for fuel may contribute to deforestation
- growing plants for fuel can destroy habitats **or** reduce biodiversity
- fuel from plants can be produced from recycled cooking oil so reduces waste

(e) $\left(\text{moles } C_4H_{10} = \frac{14.5}{58} = \right) 0.25$

1

$\left(\text{moles } O_2 = \frac{72}{32} = \right) 2.25$

1

0.25 moles butane requires

$\left(0.25 \times \frac{13}{2} = \right) 1.625$

moles of oxygen

1

1.625 is less than 2.25 moles (so oxygen is in excess) therefore butane is limiting

1

or

2.25 moles oxygen requires

$\left(0.25 \times \frac{13}{2} = \right)$

0.346 moles of butane(1)

0.346 is greater than 0.25 moles therefore butane is limiting (1)

or

(0.25 : 2.25 =)
1 : 9
or 2 : 18 (1)

9 is greater than 6.5
or 18 is greater than 13

(therefore oxygen is in excess) so butane is limiting (1)

alternative approach:

116 (g butane reacts with) 416 (g oxygen) (1)

(14.5 g butane requires)

$\frac{416}{116} \times 14.5$ *(1)*

= 52 g oxygen (1)

52 is less than 72 so (oxygen is in excess)
therefore butane is limiting (1)

or

116 (g butane reacts with) 416 (g oxygen) (1)

(72 g oxygen requires)

$\frac{116}{416} \times 72$ *(1)*

= 20.1g butane (1)

20.1 is greater than 14.5 so butane is limiting (1)

*an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps*

[16]

Q21.

(a) break large molecules into small molecules

1

to satisfy demand

1

example

1

(b) 50.4 kg = 50 400 g

1

50 400/28

1

1.8×10^3

1

(c) 1.8/3 = 0.6

1

0.6 × 296

1

= 177.6 kg

1

[9]