Questions are for both separate science and combined science students unless indicated in the question

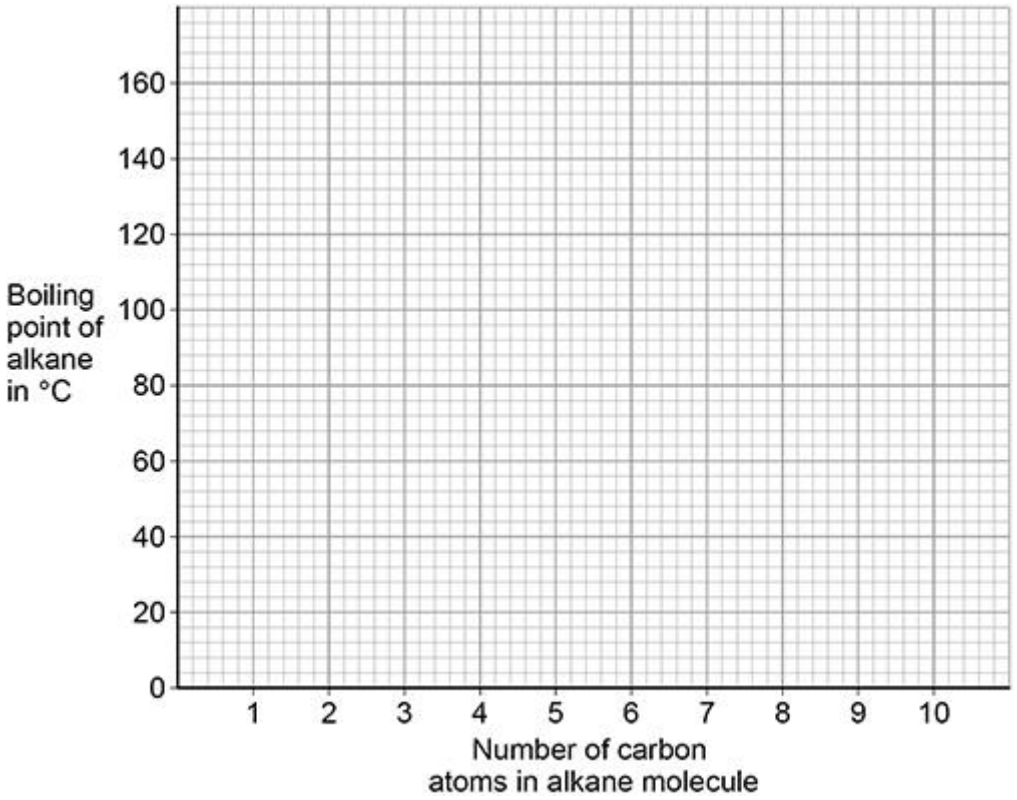
Q1.

This question is about alkanes.

The table below shows information about some alkanes.

Number of carbon atoms in alkane molecule	Boiling point of alkane in °C
4	0
5	36
6	69
7	**X**
8	126
9	151

(a) Plot the data from the table above on the graph below.



(2)

(b) Predict the boiling point **X** of the alkane with seven carbon atoms in a molecule.

Use the table and the graph.

X = _____ °C

(1)

(c) The graph above is **not** suitable to show the boiling point of the alkane with three carbon atoms in a molecule.

Suggest **one** reason why.

_____

_____

(1)

(d) What is the state at 20 °C of the alkane with four carbon atoms in a molecule?

Use the table above.

_____

(1)

The table in part (a) is repeated below.

Number of carbon atoms in alkane molecule	**Boiling point of alkane in °C**
4	0
5	36
6	69
7	**X**
8	126
9	151

The alkane with nine carbon atoms in a molecule is called nonane.

(e) Complete the formula of nonane.

$C_9H\_\_\_$

(1)

(f) Nonane will condense lower in a fractionating column during fractional distillation than the other alkanes in the table above.

Explain why.

You should refer to the temperature gradient in the fractionating column.

_____

_____

_____

_____

(2)

(Total 8 marks)

Q2.

This question is about hydrocarbons.

Hexane and hexene are hydrocarbons containing six carbon atoms in each molecule.

Hexane is an alkane and hexene is an alkene.

(a) Draw **one** line from each hydrocarbon to the formula of that hydrocarbon.

Hydrocarbon	**Formula**
	C_6H_8
Hexane	C_6H_{10}
	C_6H_{12}
Hexene	C_6H_{14}
	C_6H_{16}

(2)

(b) Bromine water is added to hexane and to hexene.

What would be observed when bromine water is added to hexane and to hexene?

Hexane _____

_____

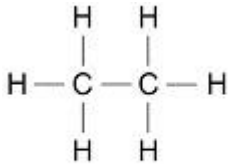
Hexene _____

_____

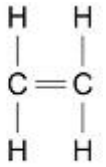
(2)

(c) Ethane is an alkane and ethene is an alkene.

The diagram below shows the displayed structural formulae of ethane and of ethene.



Ethane



Ethene

Compare ethane with ethene.

You should refer to:

- their structure and bonding
- their reactions. **(separate only)**

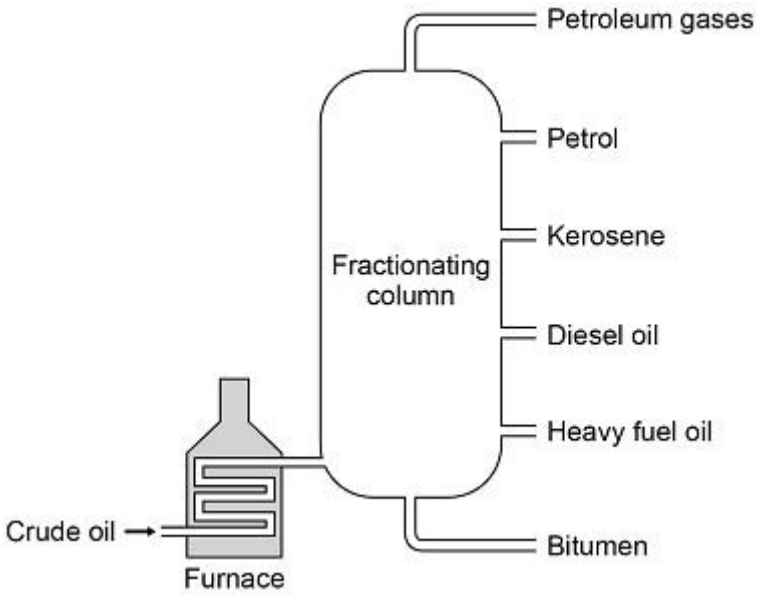
(6)

(Total 10 marks)

Q3.

This question is about crude oil and hydrocarbons.

The figure below shows a fractionating column used to separate crude oil into fractions.



The following table gives information about some of the fractions.

Fraction	Boiling point range in °C
Petroleum gases	Below 30
Petrol	40-110
Kerosene	180-260
Diesel oil	260-320
Heavy fuel oil	320-400
Bitumen	400-450

(a) Suggest a suitable temperature for the furnace in the figure.

_____ °C

(1)

(b) Explain why diesel oil collects above heavy fuel oil but below kerosene in the fractionating column.

Use the table above.

_____

_____

_____

_____

(2)

(c) Suggest **two** reasons why bitumen is **not** used as a fuel.

1 _____

_____

2 _____

_____

(2)

(d) Petrol contains mainly alkanes.

Which of the following compounds is an alkane?

Tick (✓) **one** box.

C_2H_4 ☐

C_4H_8 ☐

C_6H_{14} ☐

C_8H_{16} ☐

(1)

Large hydrocarbon molecules in the diesel oil fraction are cracked to produce smaller hydrocarbon molecules.

(e) Describe the conditions needed to crack hydrocarbon molecules from the diesel oil fraction.

_____

_____

_____

_____

(2)

(f) Explain why large hydrocarbon molecules in the diesel oil fraction are cracked to produce smaller hydrocarbon molecules.

_____

_____

_____

_____

(2)

(g) Complete the equation for the cracking of $C_{15}H_{32}$

$$C_{15}H_{32} \rightarrow C_{12}H_{26} + \_\_\_\_\_$$

(1)

(Total 11 marks)

Q4.

This question is about combustion of fuels.

(a) Some central heating boilers use wood as a fuel.

Suggest **two** reasons why wood is more sustainable than natural gas as a fuel for central heating boilers.

1 _____

_____

2 _____

_____

(2)

Natural gas is mainly methane.

When methane burns it can produce both carbon monoxide and carbon dioxide.

(b) Explain the process by which carbon monoxide can be produced when methane is burned.

_____

_____

_____

_____

(2)

(c) Balance the equation for the combustion of methane to produce carbon monoxide.

$$\_\_\_\_ CH_4(g) + \_\_\_\_ O_2(g) \rightarrow \_\_\_\_ CO(g) + \_\_\_\_ H_2O(l)$$

(1)

(d) Propane burns to form carbon dioxide and water.

The equation for the reaction is:

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

3.60 dm^3 carbon dioxide is produced when a sample of propane is burned in 7.25 dm^3 oxygen.

Calculate the volume of unreacted oxygen.

Give your answer in cm^3 **(separate only)**

Volume of unreacted oxygen = _____ cm^3

(4)

(Total 9 marks)

Q5.

This question is about fuels.

Octane (C_8H_{18}) is a hydrocarbon in petrol.

(a) Cracking breaks down large hydrocarbon molecules into smaller hydrocarbon molecules.

Which hydrocarbon molecule can be cracked to produce octane, C_8H_{18}?

Tick **one** box.

C_4H_8 ☐

C_4H_{10} ☐

C_8H_{16} ☐

$C_{12}H_{26}$ ☐

(1)

(b) What type of carbon compound is octane, C_8H_{18}?

Tick **one** box.

Alcohol ☐

Alkane ☐

Carboxylic acid ☐

Ester ☐

(1)

(c) Oxygen is needed to burn fuels.

Name the source of the oxygen needed to burn fuels.

_____

_____

(1)

(d) Particulates and sulfur dioxide are pollutants produced when some fuels burn.

Draw **one** line from each pollutant to the polluting effect.

Pollutant	**Polluting effect**
	Acid rain
Particulates	Global dimming
	Global warming
Sulfur dioxide	Landfill
	Sewage sludge

(2)

(e) Which **two** gases are produced when fuels burn in car engines?

Tick **two** boxes.

Ammonia ☐

Carbon dioxide ☐

Carbon monoxide ☐

Nitrogen ☐

Oxygen ☐

(2)

(f) Vehicles produce most of the atmospheric pollution in cities.

How could the atmospheric pollution in cities be reduced?

Tick **two** boxes.

Build more roads in cities ☐

Build new car factories ☐

Develop fuel efficient engines ☐

Make car tax cheaper ☐

Use electric cars ☐

(2)

(Total 9 marks)

Q6.

This question is about hydrocarbons.

The table gives information about four hydrocarbons.

The hydrocarbons are four successive members of a homologous series.

Hydrocarbon	Formula	Boiling point in °C
A	C_4H_{10}	0
B		36
C	C_6H_{14}	69

D	C_7H_{16}	98

(a) What is the formula of hydrocarbon **B**?

Tick (✓) **one** box.

C_4H_{12} ☐

C_5H_{12} ☐

C_5H_{12} ☐

C_6H_{12} ☐

(1)

(b) What is the simplest ratio of carbon : hydrogen atoms in a molecule of hydrocarbon **A**?

Ratio = 2 : _____

(1)

(c) Which hydrocarbon is a gas at room temperature (25 °C)?

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

(1)

(d) Which hydrocarbon is most flammable?

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

(1)

(e) Which **two** substances are produced when a hydrocarbon **completely** combusts in air?

Tick (✓) **two** boxes.

Carbon ☐

Carbon dioxide ☐

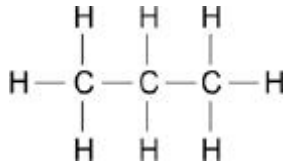
Hydrogen ☐

Sulfur dioxide ☐

Water ☐

(2)

The diagram shows the displayed structure of a hydrocarbon molecule.



(f) What is the name of the hydrocarbon in the diagram above?

Tick (✓) **one** box.

Butane ☐

Ethane ☐

Methane ☐

Propane ☐

(1)

(g) Calculate the relative formula mass (M_r) of the hydrocarbon in the diagram above.

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

_____

_____

Relative formula mass (M_r) = _____

(2)

(Total 9 marks)

Q7.

This question is about alkenes and crude oil.

(a) Pentene is an alkene molecule containing five carbon atoms.

Complete the formula for pentene.

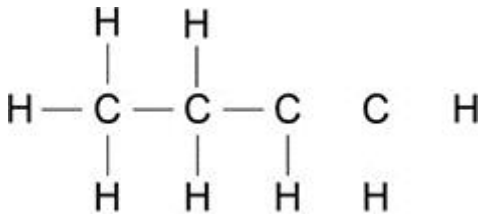
C _____ H _____

(1)

(b) Butene is an alkene molecule containing four carbon atoms.

The diagram shows all of the atoms and some of the bonds in the displayed formula for butene.

Complete the displayed formula by adding the remaining bonds.



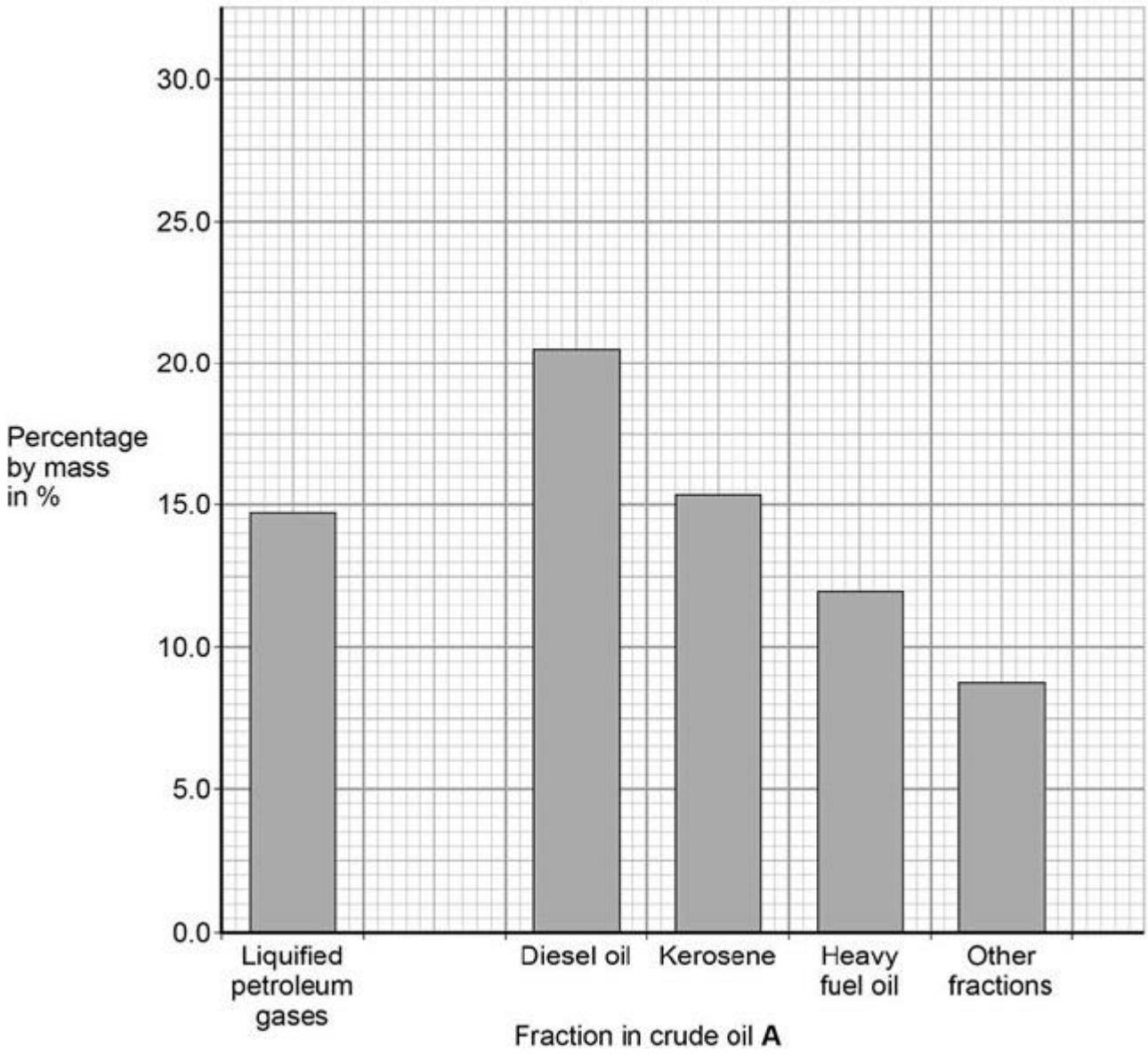
(1)

Pentene and butene are produced from crude oil.

The table shows the percentages of different fractions in two samples of crude oil.

Fraction	**Percentages by mass in %**	
	Crude oil A	**Crude oil B**
Liquefied petroleum gases	14.7	7.1
Petrol	28.6	11.1
Diesel oil	20.5	17.2
Kerosene	15.4	38.5
Heavy fuel oil	12.0	16.0
Other fractions	8.8	10.1

The graph shows the percentages of different fractions in crude oil **A**.



(c) Plot the data for petrol in the table above on the graph.

(1)

(d) What mass of crude oil **A** is needed to obtain 12 tonnes of heavy fuel oil?.

Use the table above.

10 tonnes ☐

100 tonnes ☐

1000 tonnes ☐

10 000 tonnes ☐

(1)

(e) What mass of crude oil **A** is needed to obtain 12 tonnes of heavy fuel oil?.

Calculate the total mass of car fuel that can be produced from 2000 kg of crude oil **B**.

Use the table above.

_____

_____

_____

_____

Mass of car fuel = _____ kg

(3)

(f) Crude oil **B** is a better source of hydrocarbons for cracking than crude oil **A**.

Suggest why.

Use the table above.

_____

_____

(1)

(g) Alkenes are obtained from crude oil using fractional distillation followed by cracking.

Explain how alkenes are produced using fractional distillation followed by cracking.

(6)

(Total 14 marks)

Q8.

This question is about hydrocarbons.

(a) The names and formulae of three hydrocarbons in the same homologous series are:

Ethane	C_2H_6
Propane	C_3H_8
Butane	C_4H_{10}

The next member in the series is pentane.

What is the formula of pentane?

_____

(1)

(b) Which homologous series contains ethane, propane and butane?

Tick **one** box.

Alcohols ☐

Alkanes ☐

Alkenes ☐

Carboxylic acids ☐

(1)

(c) Propane (C_3H_8) is used as a fuel.

Complete the equation for the complete combustion of propane.

C_3H_8 + $5O_2$ → 3 _____ + 4 _____

(2)

(d) Octane (C_8H_{18}) is a hydrocarbon found in petrol.

Explain why octane is a hydrocarbon.

_____

_____

(2)

(e) The table below gives information about the pollutants produced by cars using diesel or petrol as a fuel.

Fuel	**Relative amounts of pollutants**		
	Oxides of Nitrogen	**Particulate matter**	**Carbon dioxide**
Diesel	31	100	85
Petrol	23	0	100

Compare the pollutants from cars using diesel with those from cars using petrol.

_____

_____

_____

_____

_____

_____

(3)

(f) Pollutants cause environmental impacts.

Draw **one** line from each pollutant to the environmental impact caused by the pollutant.

Pollutant	**Environmental impact caused by the pollutant**
	Acid rain
Oxides of nitrogen	Flooding
	Global dimming
Particulate matter	Global warming
	Photosynthesis

(2)

(Total 11 marks)

Q9.

This question is about organic compounds.

Hydrocarbons can be cracked to produce smaller molecules.

The equation shows the reaction for a hydrocarbon, $C_{18}H_{38}$

$C_{18}H_{38} \rightarrow C_6H_{14} + C_4H_8 + 2\,C_3H_6 + C_2H_4$

(a) Which product of the reaction shown is an alkane?

Tick **one** box.

C_2H_4 ☐

C_3H_6 ☐

C_4H_8 ☐

C_6H_{14} ☐

(1)

(b) The table below shows the boiling point, flammability and viscosity of $C_{18}H_{38}$ compared with the other hydrocarbons shown in the equation.

	Boiling point	**Flammability**	**Viscosity**
A	highest	lowest	highest
B	highest	lowest	lowest
C	lowest	highest	highest
D	lowest	highest	lowest

Which letter, **A**, **B**, **C** or **D**, shows how the properties of $C_{18}H_{38}$ compare with the properties of C_2H_4, C_3H_6, C_4H_8 and C_6H_{14}?

Tick **one** box.

A ☐

B ☐

C ☐

D ☐

(1)

(c) The hydrocarbon C_4H_8 was burnt in air.

Incomplete combustion occurred.

Which equation, **A**, **B**, **C** or **D**, correctly represents the incomplete combustion reaction?

A $C_4H_8 + 4O \rightarrow 4CO + 4H_2$

B $C_4H_8 + 4O_2 \rightarrow 4CO + 4H_2O$

C $C_4H_8 + 6O_2 \rightarrow 4CO_2 + 4H_2O$

D $C_4H_8 + 8O \rightarrow 4CO_2 + 4H_2$

Tick **one** box.

A ☐

B ☐

C ☐

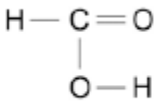
D ☐

(1)

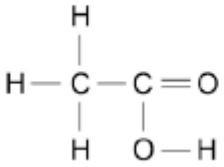
(d) Propanoic acid is a carboxylic acid.

Which structure, **A**, **B**, **C** or **D**, shows propanoic acid?

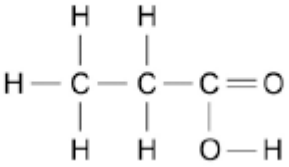
A



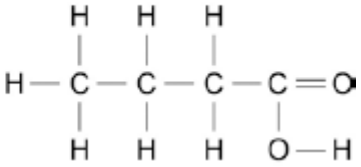
B



C



D



Tick **one** box. **(separate only)**

A ☐

B ☐

C ☐

D ☐

(1)

(e) Propanoic acid is formed by the oxidation of which organic compound?

Tick **one** box. **(separate only)**

Propane ☐

Propene ☐

Propanol ☐

Polyester ☐

(1)

(Total 5 marks)

Q10.

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.

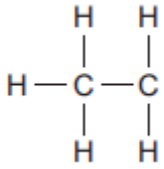
When alkenes react with bromine water the colour changes

from orange to _____ .

(1)

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

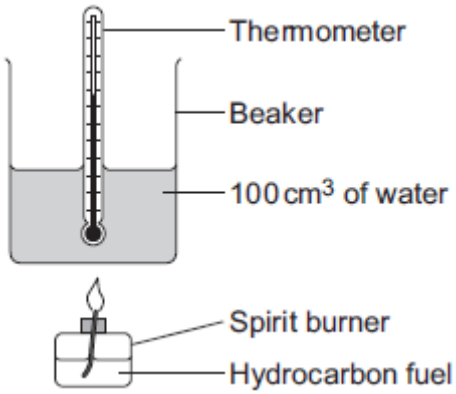
Complete the displayed structure of butane.



(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)