

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

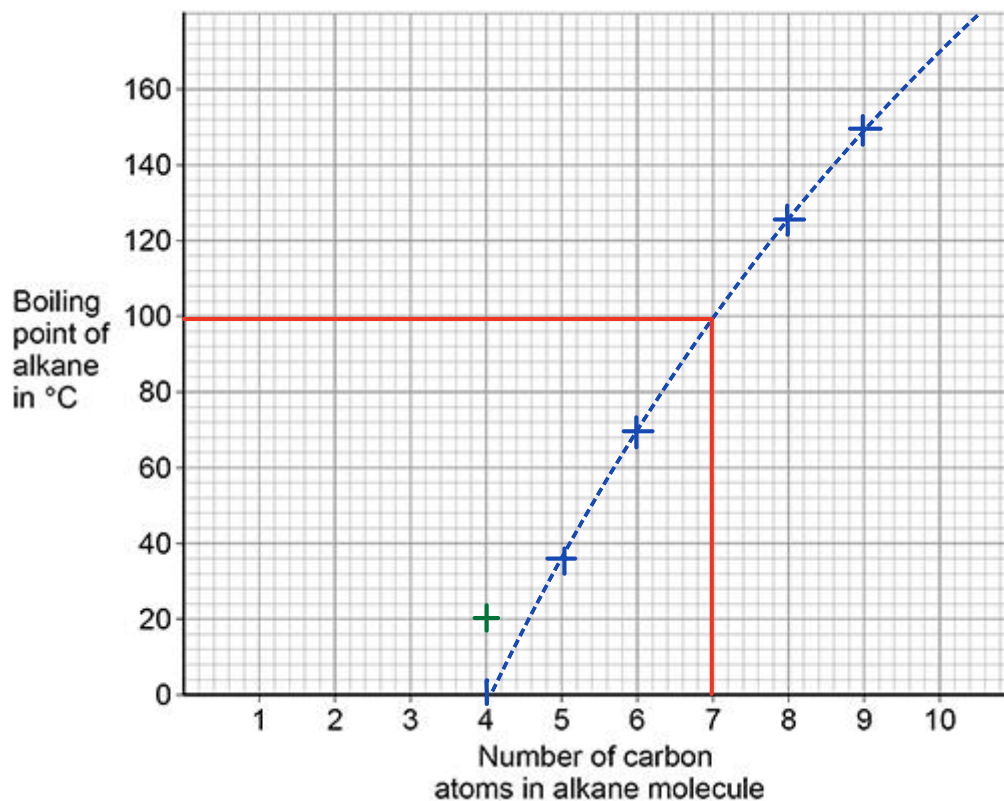
Q1.

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.

$$X = \underline{100} \text{ } ^\circ\text{C}$$

(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.

The boiling point is lower than 0 °C

(1)

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

Use the table above.

(b.p. of 4C = 0 °C) ∴ @ 20° will be a gas

(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.

alkane C_nH_{2n+2}



(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.

Nonane has a higher boiling point, so condenses where the column has a higher temperature

which is towards the bottom of 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?

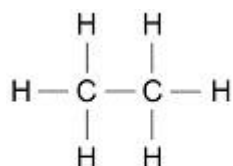
Hexane Remains orange

Hexene Becomes colourless

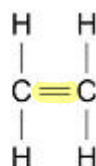
(2)

(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)

Structure and Bonding:

Both are hydrocarbons with 2 C per molecule. (small)
 Both have covalent bonds, ethane has C-C, both have C-H
 ethene contains a double bond C=C.

Reactions:

Both react with O_2 in complete oxidation reactions to produce $\text{CO}_2 + \text{H}_2\text{O}$. Incomplete $\text{O}_2 \Rightarrow \text{CO} + \text{C} + \text{H}_2\text{O}$

Ethene decolorises bromine water (ethane does not)

Ethene is more reactive than ethane.

Ethene can react with $\text{H}_2 \Rightarrow$ ethane C_2H_6

$\text{H}_2\text{O} \Rightarrow$ ethanol $\text{C}_2\text{H}_5\text{OH}$

halogens \Rightarrow halogenoalkanes

can undergo addition reactions

can polymerise \Rightarrow poly(ethene)

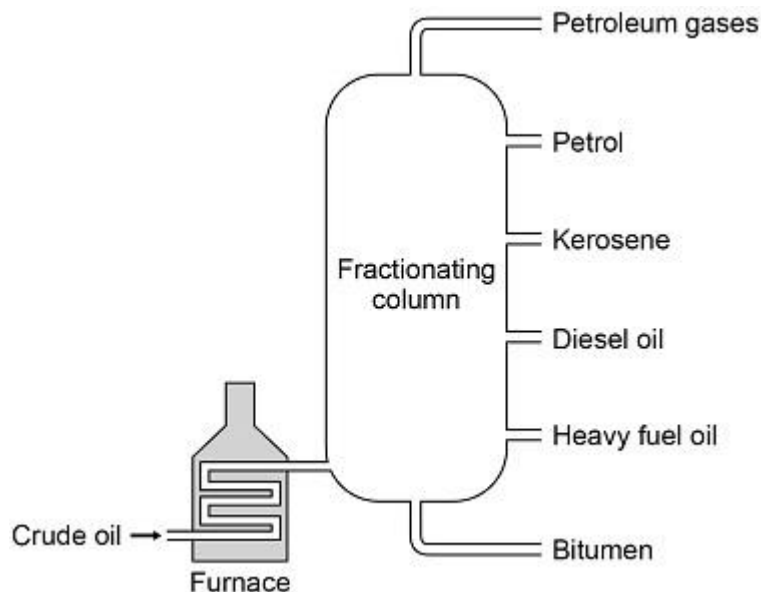
(6)

(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.

Between 400 - 500 °C

(1)

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

Use the table above.

Diesel oil has a lower b.p. range than heavy fuel
But diesel oil has a higher b.p. range than kerosene

(2)

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

1 Too viscous (to flow through engine)

2 Not very flammable.

(2)

(d) Petrol contains mainly alkanes.

Which of the following compounds is an alkane?

Tick (✓) **one** box.

C₂H₄

C₄H₈

C₆H₁₄

C₈H₁₆



(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.

High temperature > 320°C
Steam and catalyst

(2)

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

There is a greater demand for smaller molecules
as they make better fuels, used to make
polymers etc.

(2)

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



(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 Wood is renewable (natural gas is finite)2 Burning wood produces the same amount of CO_2 as the trees absorbed.

(2)

Natural gas is mainly methane.

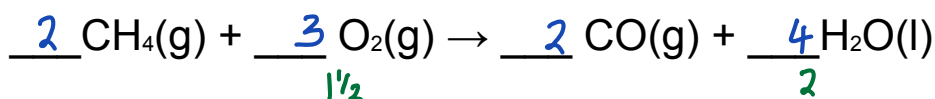
When methane burns it can produce both carbon monoxide and carbon dioxide.

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

Process is incomplete combustion, when there is not enough oxygen.

(2)

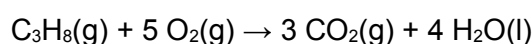
- (c) Balance the equation for the combustion of methane to produce carbon monoxide.



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

(1)

The equation for the reaction is:



3.60 dm³ carbon dioxide is produced when a sample of propane is burned in 7.25 dm³ oxygen.

Calculate the volume of unreacted oxygen.

Give your answer in cm³ (separate only)

$$\begin{array}{l} \text{Ratio of } O_2 : CO_2 \\ \hline 5 : 3 \end{array}$$

$$\begin{array}{l} O_2 \text{ needed} = 3.60 \text{ dm}^3 \times \frac{5}{3} \\ \hline = 6 \text{ dm}^3 \end{array}$$

$$\text{Vol } O_2 \text{ unreacted} = 7.25 \text{ dm}^3 - 6 \text{ dm}^3 = 1.25 \text{ dm}^3$$

$$\begin{array}{l} \text{" " in cm}^3 = 1.25 \text{ dm}^3 \times 1000 \\ \hline = 1250 \text{ cm}^3 \end{array}$$

Volume of unreacted oxygen = 1250 cm³

(4)

(Total 9 marks)

Q5.

This question is about fuels.

Octane (C₈H₁₈) 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, C₈H₁₈?

Tick **one** box.

C₄H₈

C₄H₁₀

C₈H₁₆

C₁₂H₂₆

↓
C must be > 8

(1)

- (b) What type of carbon compound is octane, C₈H₁₈?

Tick **one** box.

- | | | |
|-----------------|-------------------------------------|---------------|
| Alcohol | <input type="checkbox"/> | |
| Alkane | <input checked="" type="checkbox"/> | C_nH_{2n+2} |
| Carboxylic acid | <input type="checkbox"/> | |
| Ester | <input type="checkbox"/> | |

(1)

- (c) Oxygen is needed to burn fuels.

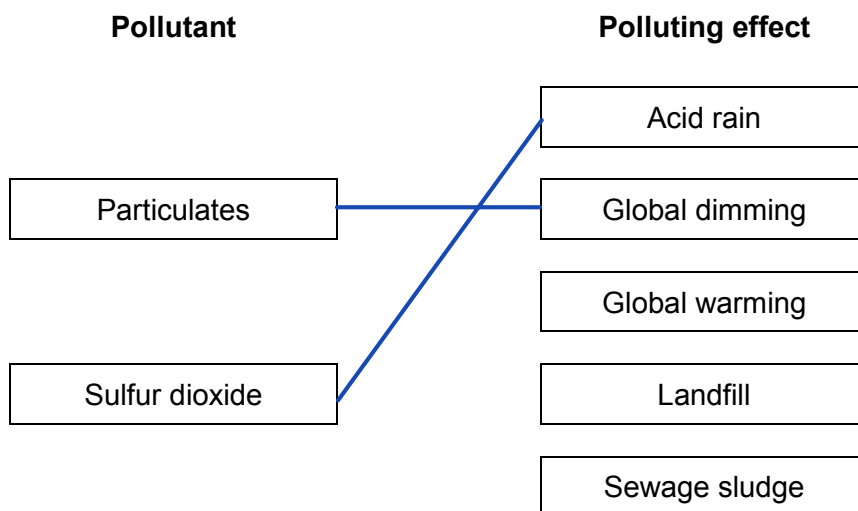
Name the source of the oxygen needed to burn fuels.

Air

(1)

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

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



(2)

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

Tick **two** boxes.

- | | |
|---------|--------------------------|
| Ammonia | <input type="checkbox"/> |
|---------|--------------------------|

- Carbon dioxide
- Carbon monoxide (Incomplete combustion)
- 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 ₄ H ₁₀	0
B	C ₅ H ₁₂	36
C	C ₆ H ₁₄	69

D	C_7H_{16}	98
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(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 : 5

$\begin{array}{l} C \\ 4 \\ 2 \end{array} \quad \begin{array}{l} H \\ 10 \\ 5 \end{array}$

(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?

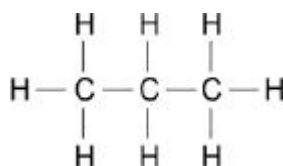
Tick (✓) **two** boxes.

Carbon

Carbon dioxide	<input checked="" type="checkbox"/>
Hydrogen	<input type="checkbox"/>
Sulfur dioxide	<input type="checkbox"/>
Water	<input checked="" type="checkbox"/>

(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	<input type="checkbox"/>
Ethane	<input type="checkbox"/>
Methane	<input type="checkbox"/>
Propane	<input checked="" type="checkbox"/>

(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

$$\text{Propane} = \text{C}_3\text{H}_8 \quad M_r = (12 \times 3) + (1 \times 8) \\
 = 44$$

Relative formula mass (M_r) = 44

(2)

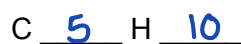
(Total 9 marks)

Q7.

This question is about alkenes and crude oil.

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

Complete the formula for pentene.

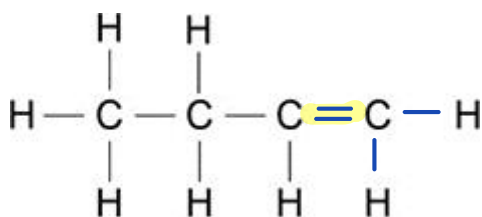


(1)

- (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)

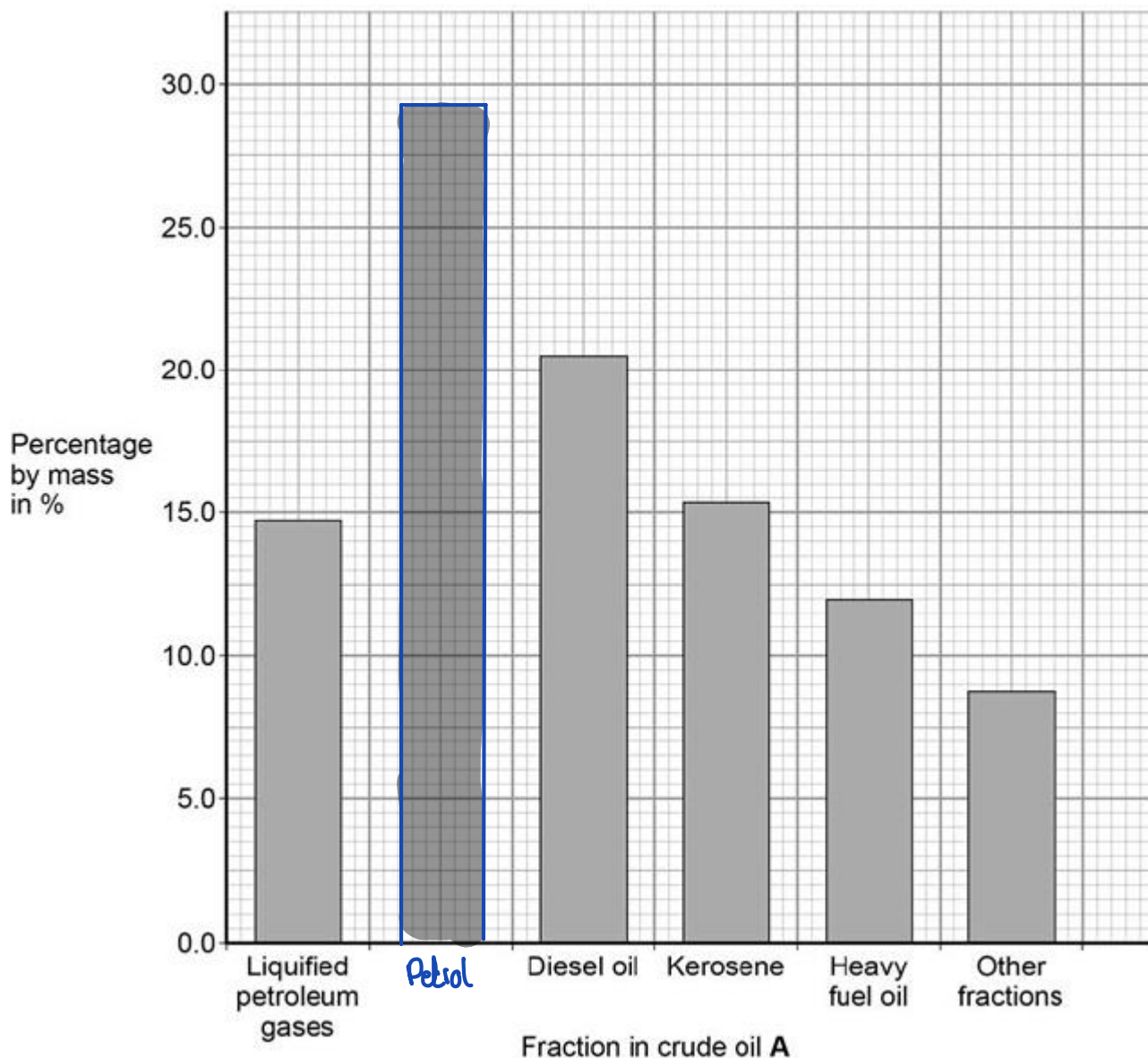
Pentene and butene are produced from crude oil.

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

Car
fuels

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.

A = 12% heavy fuel oil

10 tonnes

100 tonnes

1000 tonnes

$$\frac{12}{100} \times M = 12$$

$$M = 12 \times \frac{100}{12}$$

$$M = 100 \text{ tonnes}$$

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.

Crude oil B contains $\left. \begin{array}{l} 7.1\% \text{ LPG} \\ 11.1\% \text{ Petrol} \\ 17.2\% \text{ Diesel} \end{array} \right\} = 35.4\%$ (car fuel)

Mass of car fuel = $\frac{35.4}{100} \times 2000 \text{ kg} = 708 \text{ kg}$

Mass of car fuel = 708 kg

(3)

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

Suggest why.

Use the table above.

Higher percentage by mass of heavier fractions (larger molecules)

(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.

79)

Fractional Distillation

Oct heated

Fractionating column used

Fractions have different boiling point ranges

Column has a temperature gradient:

(Hotter at bottom, cooler at top).

Cracking

High temperature

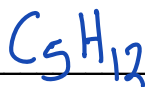
Catalyst / steam

Large molecules split into small molecules

Mixture of alkanes and alkenes produced.



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.



(2)

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

Explain why octane is a hydrocarbon.

Octane contains hydrogen and carbon only

(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.

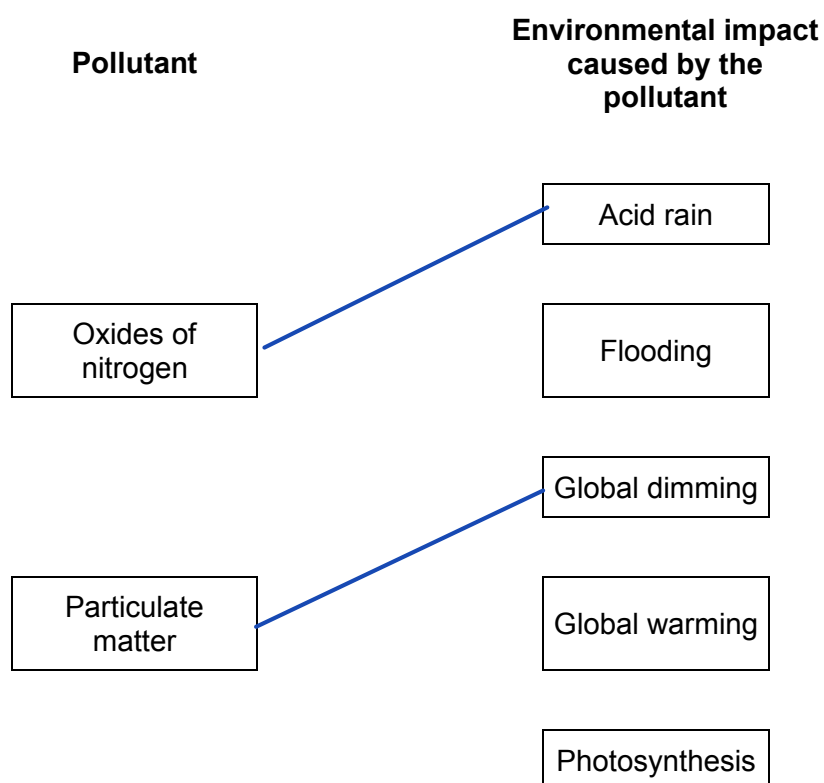
Diesel cars produce more oxides of nitrogen
 more particulate matter
 less carbon dioxide

than petrol cars.

(3)

(f) Pollutants cause environmental impacts.

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



(2)

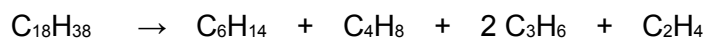
(Total 11 marks)

Q9.

This question is about organic compounds.

Hydrocarbons can be cracked to produce smaller molecules.

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



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

C_nH_{2n+2}

Tick **one** box.

C₂H₄

C₃H₆

C₄H₈

C₆H₁₄

C_nH_{2n+2}

(1)

- (b) The table below shows the boiling point, flammability and viscosity of C₁₈H₃₈ compared with the other hydrocarbons shown in the equation.

	Boiling point	Flammability	Viscosity
<input checked="" type="checkbox"/> A	highest <input checked="" type="checkbox"/>	lowest <input checked="" type="checkbox"/>	highest <input checked="" type="checkbox"/>
B	highest <input checked="" type="checkbox"/>	lowest <input checked="" type="checkbox"/>	lowest
C	lowest	highest	highest <input checked="" type="checkbox"/>
D	lowest	highest	lowest

↑ C atoms

Which letter, **A**, **B**, **C** or **D**, shows how the properties of C₁₈H₃₈ compare with the properties of C₂H₄, C₃H₆, C₄H₈ and C₆H₁₄?

Tick **one** box.

A

B

C

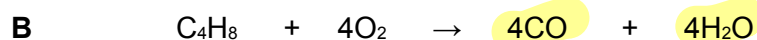
D

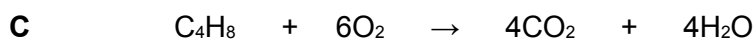
(1)

- (c) The hydrocarbon C₄H₈ was burnt in air.

Incomplete combustion occurred.

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





Tick **one** box.

A

B

C

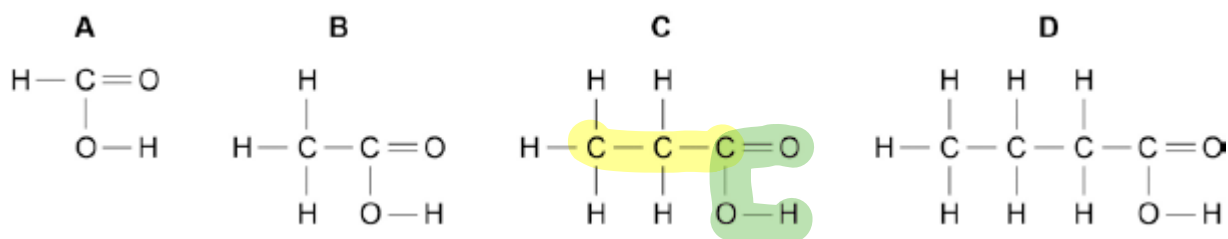
D

(1)

(d) Propanoic acid is a carboxylic acid.

3c

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



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	<input checked="" type="checkbox"/>
Polyester	<input type="checkbox"/>

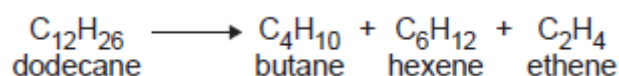
(1)
(Total 5 marks)

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.



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

- High temperature
- Steam or catalyst

(2)

- (ii) The products hexene and ethene are alkenes.

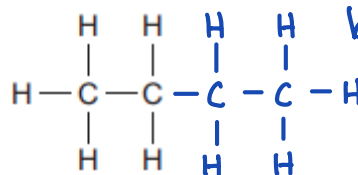
Complete the sentence.

When alkenes react with bromine water the colour changes from orange to colourless.

(1)

- (iii) Butane (C₄H₁₀) is an alkane.

Complete the displayed structure of butane.

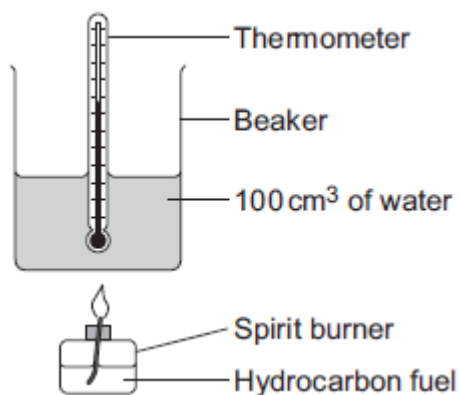


meth - 1
eth - 2
pro - 3
but - 4

(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

Name and formula of hydrocarbon fuel	After two minutes			Energy released by 1.0 g of fuel in kJ	Relative amount of smoke in the flame
	Mass of fuel used in g	Temperature increase of water in °C	Energy released by fuel in kJ		
Hexane, C ₆ H ₁₄	0.81	40	16.80	20.74	very little smoke
Octane, C ₈ H 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.

$$\frac{24.36 \text{ kJ}}{1.20 \text{ g}} = 20.3 \text{ kJ per g}$$

Energy released = 20.3 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.

Use a lid to reduce heat loss.

(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.

Carbon (soot)

produced by incomplete combustion

(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. Hexane gives out the greatest energy per 1.0g

2. Hexane produces the least smoke

(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 \rightarrow carbon dioxide + water	hydrogen + oxygen \rightarrow 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)

Advantages of using hydrogen:

Combustion only produces water - so no pollution

Combustion does not produce CO_2 so does not contribute to global warming or climate change.

Combustion does not produce SO_2 so does not contribute to acid rain

Incomplete combustion of petrol produces particulates that contribute to global warming

Petrol comes from a non-renewable source but there are renewable methods of generating hydrogen.

Hydrogen releases more energy, so less fuel is needed

Disadvantages of using hydrogen:

H₂ is a gas, so difficult to store or transfer to vehicles

H₂ gas is very flammable, leaks cause risk of explosion

Most H₂ produced from fossil fuels - which are running out

Cannot be used in existing car engines so modification, development or replacement needed.

Lack of filling stations - so difficult to re-fuel vehicle.