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EDEXCEL GCSE CHEMISTRY: QUESTIONS BY TOPIC

Fuels and Earth Science (8)

GCSE Chemistry (Higher) Topic 8

17 questions · 170 marks · Mark schemes included

Pearson Edexcel GCSE (9-1) Chemistry 1CH0, Higher Tier, June 2018 - June 2025

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HOW TO USE THIS BOOKLET

Questions run from the lowest mark tariff to the highest, so similar questions sit together.

Click any row below to jump straight to that question.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme.

Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

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QUESTIONS

17 questions · 170 marks · lowest tariff first



7-MARK QUESTIONS

3 questions in this booklet



- 1 The Earth’s atmosphere contains several gases.
- (a) Figure 1 shows the relative amounts of gases thought to be in the Earth’s early atmosphere.

gas	relative amount in Earth’s early atmosphere
oxygen	small
carbon dioxide	large
nitrogen	small
water vapour	large

Figure 1

The amount of water vapour in today’s atmosphere is much less than the amount in the Earth’s early atmosphere.

Explain why the amount of water vapour in the atmosphere has decreased.

(2)

(b) The apparatus shown in Figure 2 is used to find the percentage of oxygen in dry air.

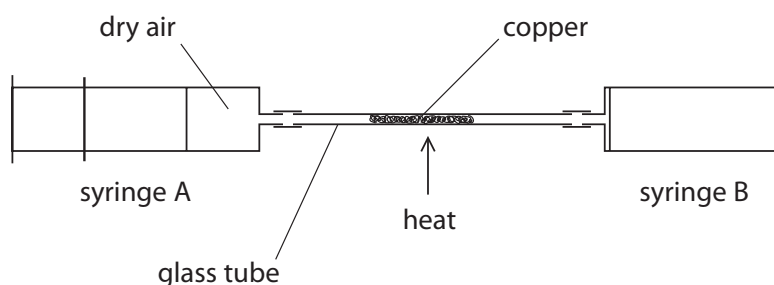


Figure 2

Syringe A contains 50 cm^3 of dry air and syringe B contains no air.

The copper in the glass tube is heated strongly.

The air in the apparatus is passed backwards and forwards over the copper until all the oxygen has been removed.

(i) The following results were obtained

initial volume of air in apparatus = 50 cm^3

final volume of gas in apparatus = 40 cm^3

Calculate the percentage of oxygen in this sample of dry air.

(2)

.....

.....

.....

percentage oxygen in the air = ...

(ii) At the end of the experiment, the apparatus and its contents are allowed to cool before the final volume of gas is measured.

(1)

The apparatus and its contents must be allowed to cool because

- ☒ **A** reading the volume while the apparatus is hot is dangerous
- ☒ **B** the glass tube may crack when it is hot and allow air into the apparatus
- ☒ **C** the gas has expanded when it is hot
- ☒ **D** the copper reacts with other gases in the air when it is hot

- (c) The Earth's earliest rocks contained iron sulfide and no iron oxide. Later the rocks contained iron oxide as well as iron sulfide.

Explain what happened to allow this change to occur.

(2)

(Total for Question 1 = 7 marks)



3 Diesel oil is a mixture of hydrocarbons that can be obtained from crude oil.

(a) State the name of the process used to separate diesel oil from crude oil.

(1)

(b) Diesel oil contains alkanes.

These alkanes are part of an homologous series.

Which statement about compounds in this homologous series is true?

(1)

- ☐ **A** they have the same chemical formula
- ☐ **B** they have the same empirical formula
- ☐ **C** they have the same general formula
- ☐ **D** they have the same molecular formula

(c) When fuels such as diesel oil are burned, the high temperatures produced can cause nitrogen and oxygen in the air to form the pollutant nitrogen dioxide.

Complete the balanced equation for the reaction.

(2)



(d) Explain how the greenhouse effect is caused by the gases produced by the complete combustion of diesel oil.

(3)

(Total for Question 3 = 7 marks)



3 Crude oil is a mixture of hydrocarbons.

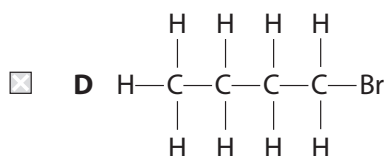
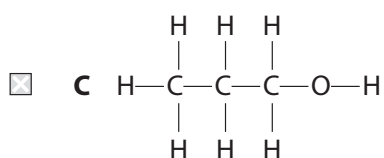
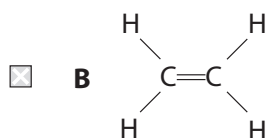
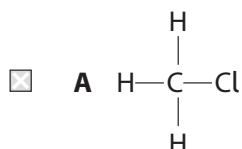
(a) (i) The majority of hydrocarbons in crude oil belong to one homologous series.

Give the name of this series.

(1)

(ii) Which structure represents a molecule of a hydrocarbon?

(1)



(b) When hydrocarbons undergo combustion, water is produced.

Draw a dot and cross diagram of a molecule of water.

(2)

(c) One compound in crude oil contains 0.96 g of carbon atoms combined with 0.32 g of hydrogen atoms.

Calculate the empirical formula of this compound.

(relative atomic masses: C = 12, H = 1.0)

(3)

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empirical formula of this compound = ...

(Total for Question 3 = 7 marks)



9-MARK QUESTIONS

5 questions in this booklet



- 5 (a) Figure 8 shows some information about the composition of pollutant exhaust gases from the engines of two different vehicles.

pollutant	mass of pollutant given out in g per kilometre driven	
	petrol engine	diesel engine
carbon dioxide	210	180
carbon monoxide	1.5	0.10
unburnt hydrocarbons	0.13	0.020
nitrogen oxides	0.36	2.0
particulates	0.0060	0.046
sulfur dioxide	0.0089	0.0037

Figure 8

- (i) Give **two** ways in which the data in Figure 8 shows that the diesel engine is **more** damaging to the environment than the petrol engine.

(2)

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- (ii) Explain, using information from Figure 8, **one** way in which the diesel engine is **less** damaging to the environment than the petrol engine.

(2)

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(b) (i) Which statement about the members of the alkane homologous series is correct?

(1)

- ☐ A they show a trend in chemical properties
- ☐ B their boiling point decreases as the molecules get larger
- ☐ C the molecular formula of neighbouring compounds differs by CH_3
- ☐ D their viscosity increases as the molecules get larger

(ii) Which one of the following hydrocarbons belongs to the same homologous series as octane, C_8H_{18} ?

(1)

- ☐ A C_4H_6
- ☐ B C_4H_8
- ☐ C C_4H_{10}
- ☐ D C_4H_{12}

(iii) Write the balanced equation for the complete combustion of octane, C_8H_{18} .

(3)

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(Total for Question 5 = 9 marks)



- 5 (a) Figure 9 shows the percentage of three gases, **X**, **Y** and **Z**, in the Earth's early atmosphere.

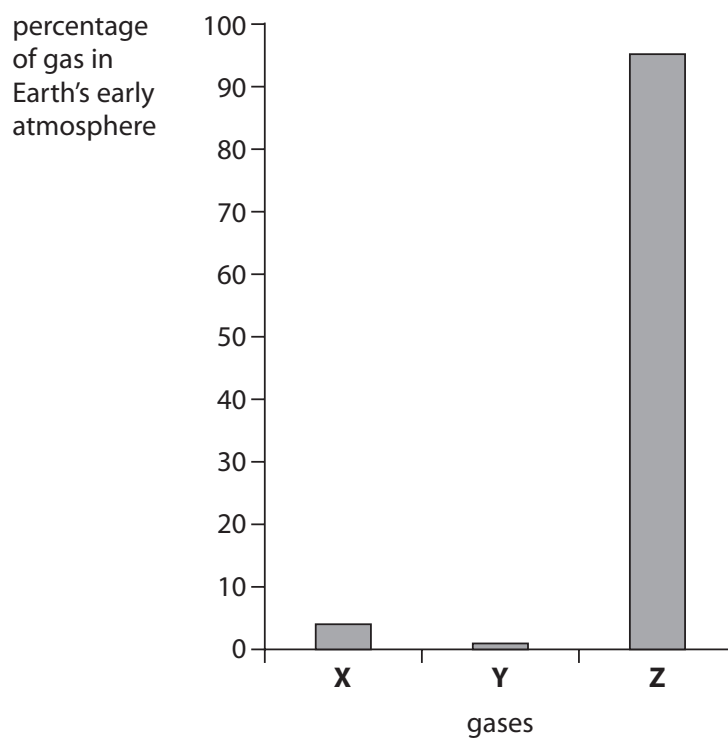


Figure 9

What is the name of gas **Z**?

- ☐ **A** argon
- ☐ **B** carbon dioxide
- ☐ **C** nitrogen
- ☐ **D** oxygen

(1)

- (b) It is thought that small quantities of hydrogen sulfide, H_2S , were also in the Earth's early atmosphere.

Draw the dot and cross diagram for a molecule of hydrogen sulfide.

Show outer electrons only.

(2)

- (c) Acid rain is caused by some pollutant gases present in the atmosphere.

Explain how impurities in fossil fuels can result in acid rain.

(3)

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(d) A student investigates the effect of acid rain on cress plants.

The student uses this method.

step 1 grow 20 cress plants in each of two dishes, **A** and **B**

step 2 water the cress plants in dish **A** with 10 cm^3 of dilute hydrochloric acid with a pH of 2

step 3 water the cress plants in dish **B** with 10 cm^3 of pure water with a pH of 7

step 4 repeat steps 2 and 3 every day for one week

step 5 count how many plants are still alive after one week.

(i) State what piece of equipment the student could use to measure the pH of each liquid.

(1)

(ii) Explain **one** improvement that the student could make to the method to make the results more valid.

(2)

(Total for Question 5 = 9 marks)



3 This question is about the atmosphere.

(a) Describe the test to show that a gas is oxygen.

(2)

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(b) Copper reacts with oxygen to form copper oxide.

2.100 g of copper will react completely with 0.529 g of oxygen.

In an experiment, 4.200 g of copper is heated with 50.000 g of oxygen until the reaction is complete.

Calculate the mass of oxygen remaining at the end of the experiment.

(2)

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mass of oxygen = ... g

(c) Helium, neon and argon are all inert.

(i) Explain, in terms of electrons, why these gases are inert.

(2)

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(ii) Two pieces of steel can be joined by heating the metal pieces with a very hot flame.

This process is often carried out in an argon atmosphere rather than in air.

Which property makes argon gas suitable for this use?

(1)

- ☐ **A** argon has a low density
- ☐ **B** argon has a low melting point
- ☐ **C** argon is colourless
- ☐ **D** argon is unreactive

- (d) Carbon dioxide is removed from the atmosphere by plants and stored in plants and soil as carbon compounds.

Figure 5 shows the relative amounts of carbon stored in plants and soils in different environments.

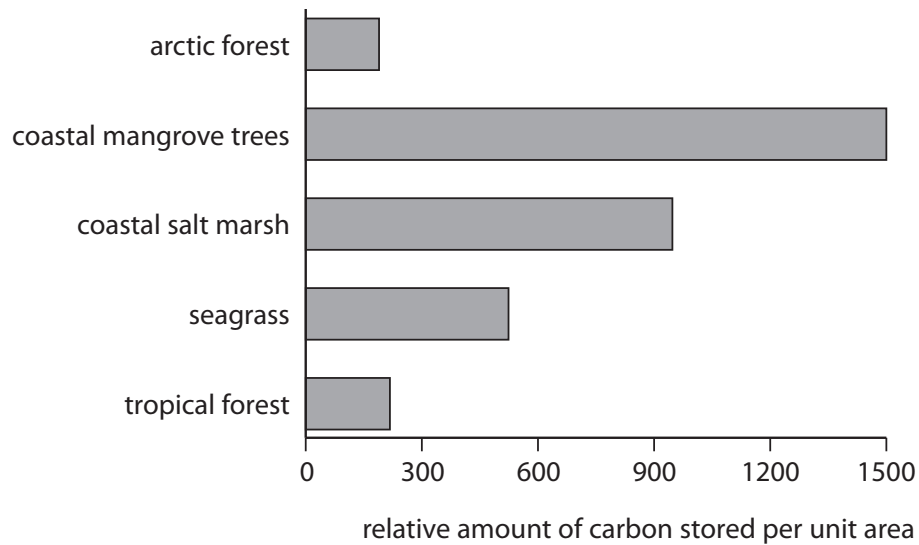


Figure 5

It has been suggested that preserving coastal ecosystems is more effective than reforestation in the mitigation of climate change.

Describe how the data in Figure 5 supports this suggestion.

(2)

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(Total for Question 3 = 9 marks)

- 5 (a) (i) Most hydrocarbons found in fossil fuels are members of the alkane homologous series.

State **two** features of an homologous series.

(2)

1

2

- (ii) Which molecule is in the same homologous series as CH_4 ?

(1)

- ☐ A C_5H_{20}
- ☐ B C_6H_{12}
- ☐ C C_8H_{18}
- ☐ D C_9H_{16}

- (b) A fossil fuel contains carbon and sulfur.

Explain how the products of the complete combustion of this fossil fuel would affect the environment.

(4)

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(c) Incomplete combustion of fuels may produce carbon monoxide.

Write the balanced equation for the incomplete combustion of heptane, C_7H_{16} , where all of the carbon atoms form carbon monoxide.

(2)

(Total for Question 5 = 9 marks)



- 6 (a) Damp iron wool reacts with oxygen in the air.
A student uses the apparatus in Figure 7 to investigate the percentage of oxygen in the atmosphere.

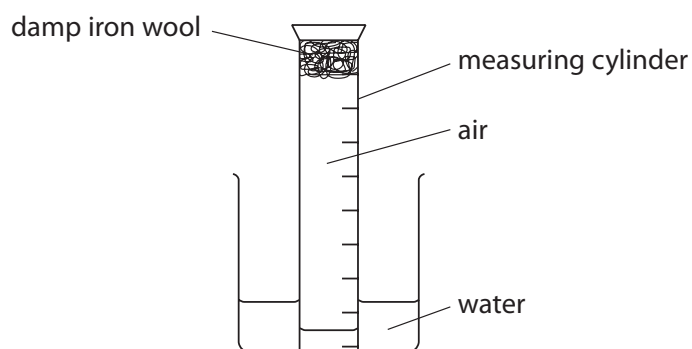


Figure 7

- (i) The initial volume of air in the measuring cylinder was 18.0 cm^3 .

The student left the apparatus overnight.

The volume of gas in the measuring cylinder the next day was 14.5 cm^3 .

To the nearest whole number, what percentage of the air has reacted with the iron wool?

(1)

- ☐ A 19%
- ☐ B 21%
- ☐ C 24%
- ☐ D 81%

- (ii) Describe **one** improvement the student could make to this method to ensure that all of the oxygen in the measuring cylinder has reacted.

(2)

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- (b) (i) When hydrocarbon fuels are burned, the products are water and carbon dioxide.

Describe what needs to be done to the apparatus in Figure 8 to collect the water and show that carbon dioxide has been produced.

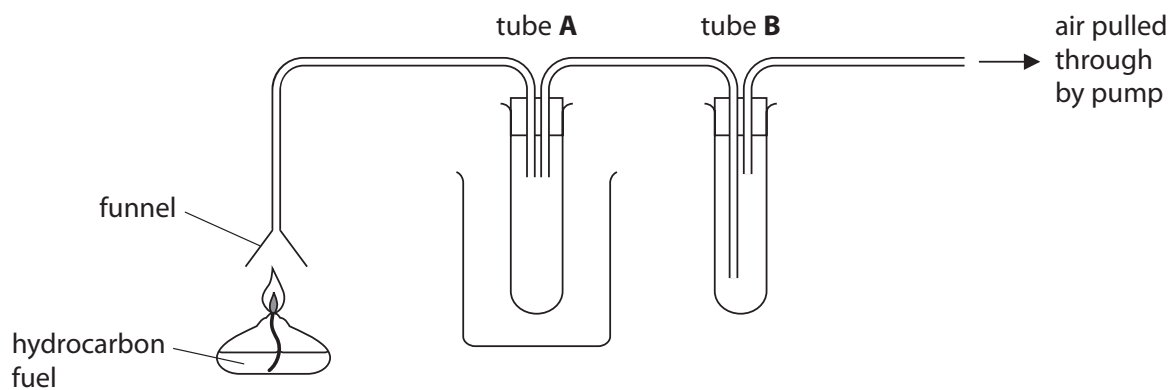


Figure 8

(2)

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- (ii) A hydrocarbon, C_xH_y , is burned in excess oxygen, forming 26.4 g of carbon dioxide and 5.4 g of water.

The relative formula mass of C_xH_y is 78.

Calculate the molecular formula of the hydrocarbon C_xH_y .

(relative atomic masses: $H = 1.0$, $C = 12$;
relative formula masses: $H_2O = 18$, $CO_2 = 44$)

(4)

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molecular formula = ...

(Total for Question 6 = 9 marks)

11-MARK QUESTIONS

6 questions in this booklet



6 Crude oil is a complex mixture of substances.

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

Figure 7 shows a fractional distillation column and the fractions produced when a sample of crude oil is distilled.

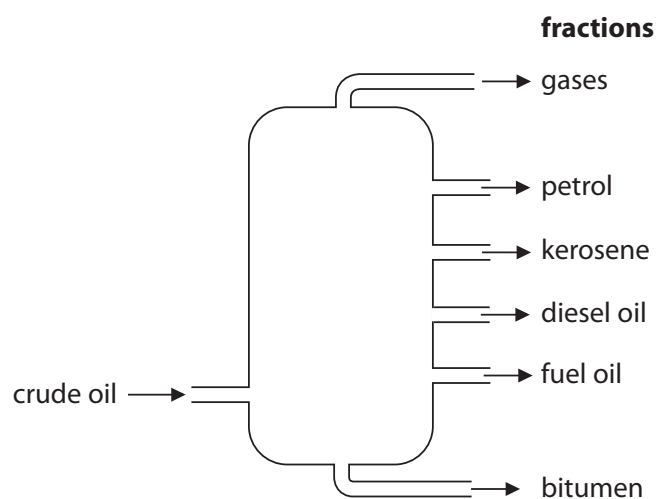


Figure 7

The properties of these fractions vary from the top of the column to the bottom of the column.

Which of the following is a trend in a property of the fractions obtained from the top of the column to those obtained from the bottom?

(1)

- ☐ A the average number of carbon atoms in molecules present decreases
- ☐ B the ease of ignition increases
- ☐ C the boiling points decrease
- ☐ D the viscosities increase

(b) Most of the substances in crude oil are alkanes.

(i) Which of the following is the general formula of an alkane?

(1)

- ☐ A C_nH_{2n}
- ☐ B C_nH_{2n+1}
- ☐ C C_nH_{2n-1}
- ☐ D C_nH_{2n+2}

(ii) Explain why alkanes are described as hydrocarbons.

(2)

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(c) Figure 8 shows a graph of the boiling points of some alkanes against the number of carbon atoms in one molecule of each alkane.

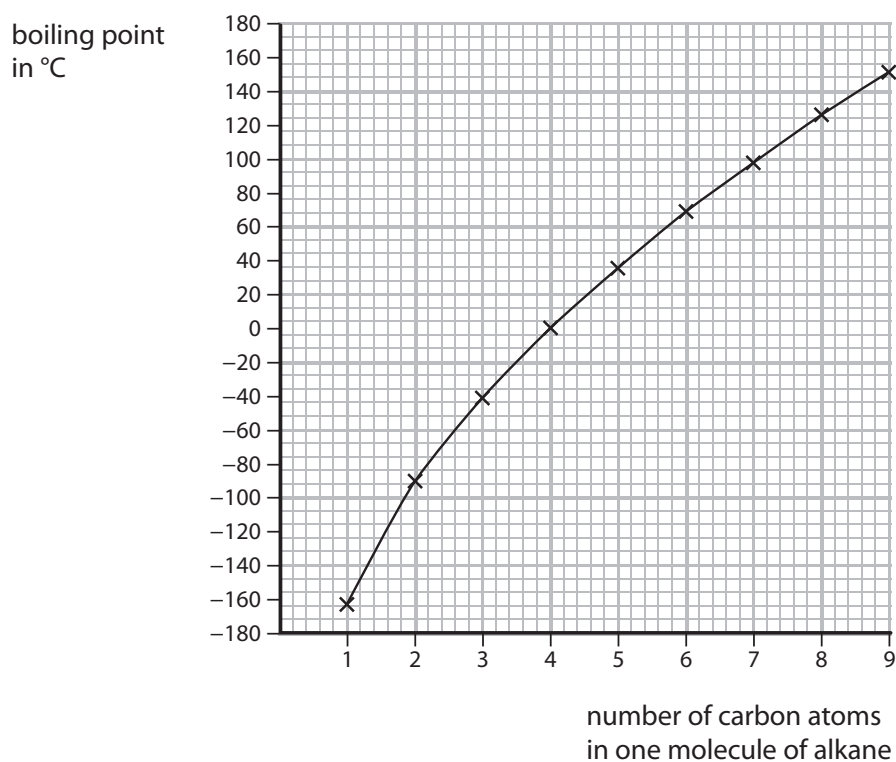


Figure 8

Explain the pattern shown by this graph.

(2)

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- (d) When crude oil is separated into fractions, the amount of each fraction obtained rarely matches the demand for that fraction.

Figure 9 shows the relative amounts of six of the fractions present in a crude oil and the relative demand for each of these fractions.

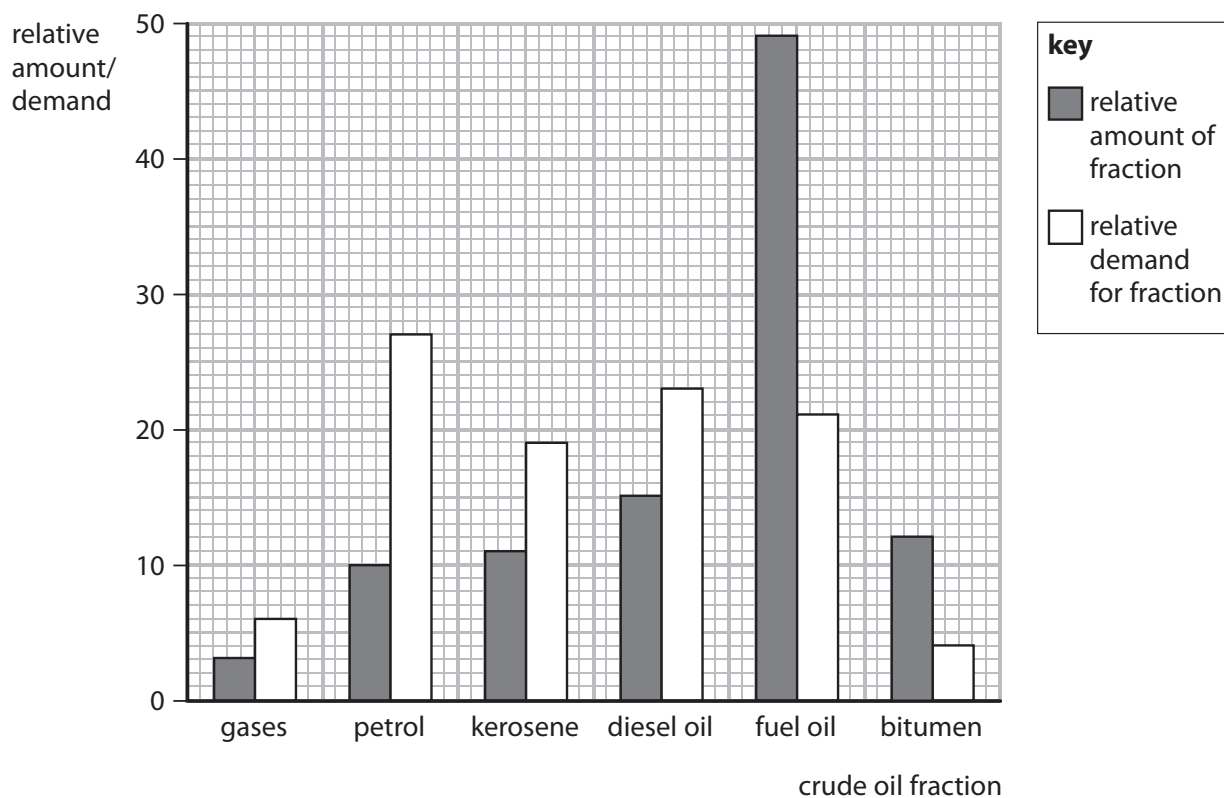


Figure 9

Cracking is used to match the relative amount of a fraction of crude oil to the demand for that fraction.

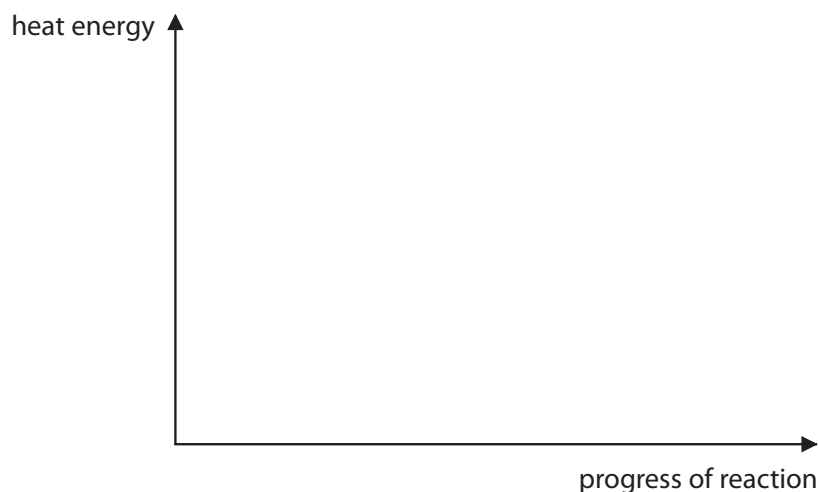
- (i) Use the information in Figure 9 to give the name of the fraction that is most likely to need to be cracked.

(1)

- (ii) In a cracking reaction, reactants are heated to form products.
This reaction is endothermic.

On the axes provided, draw the reaction profile of this reaction.
Label the energy of the reactants, the energy of the products and the activation energy of the reaction.

(3)



- (iii) Dodecane, $C_{12}H_{26}$, can be cracked to form useful products.

Complete the equation for the cracking of dodecane by filling in the formula of the single molecule needed to balance the equation.

(1)



(Total for Question 6 = 11 marks)

7 (a) Air contains several gaseous elements.

Which of these shows the three most common gaseous elements in air, listed in order from the most common to the least common?

(1)

- ☐ A oxygen, chlorine, nitrogen
- ☐ B nitrogen, oxygen, hydrogen
- ☐ C oxygen, nitrogen, helium
- ☐ D nitrogen, oxygen, argon

(b) The density of a gas can be found using the equation

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

A student carried out an experiment to find the density of argon.

The mass of a stopper and flask, containing no gas, was known.
The flask was completely filled with argon and its mass measured.

Figure 4 shows the results the student wrote down.

mass of stopper and flask in g	78.639
mass of stopper and flask full of argon in g	79.120
volume of flask in cm ³	250.0

Figure 4

(i) Use the results to calculate the density of argon in g cm⁻³.

(2)

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density of argon = ... g cm⁻³

- (ii) The flask used for the experiment is shown in Figure 5.
The flask holds 250.0 cm^3 when filled up to the line.

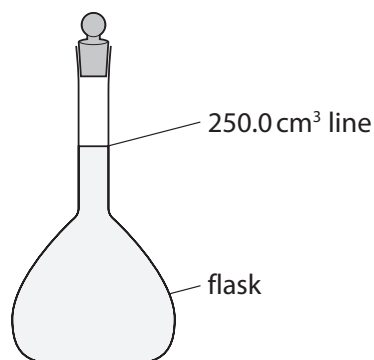


Figure 5

There is an error in the volume the student has used in the calculation.
This would give an incorrect value for the density of argon.

Identify this error and state what should be done to correct it.

(2)

error

what should be done to correct it

- (c) Four of the noble gases are argon, helium, krypton and neon.

Give these gases in order of increasing density.

(2)

- (d) Much of the carbon dioxide present in the Earth's early atmosphere dissolved into the oceans.

This led to the formation of compounds including calcium carbonate, CaCO_3 .

Some of the calcium carbonate reacted with magnesium ions to form dolomite, $\text{CaMg}(\text{CO}_3)_2$.

Complete the **ionic** equation for the reaction of calcium carbonate with magnesium ions.

(2)



- (e) **P** and **Q** are both mixtures of gases.

One has the same composition as the early atmosphere and the other has the same composition as the current atmosphere.

Tests are carried out on gas mixtures **P** and **Q**.

The test for carbon dioxide is to bubble the gas into limewater; if carbon dioxide is present calcium carbonate is formed.

The results of the tests are shown in Figure 6.

test	result with gas mixture P	result with gas mixture Q
bubble gas into limewater	white precipitate forms after 4 minutes	white precipitate forms after 10 seconds
place burning splint into gas mixture	splint continues to burn	splint immediately goes out

Figure 6

Explain, using the data in Figure 6, which gas mixture represents the early atmosphere.

(2)

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.....

(Total for Question 7 = 11 marks)

9 Pentadecane, $C_{15}H_{32}$, is a hydrocarbon and is used as a fuel.

(a) The incomplete combustion of pentadecane produces carbon monoxide. Carbon monoxide is a toxic gas.

(i) Explain why the incomplete combustion of pentadecane can produce carbon monoxide as one of the products.

(2)

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(ii) Explain how carbon monoxide behaves as a toxic gas.

(2)

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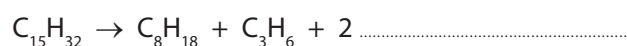
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(b) 1 mole of pentadecane can be cracked to form 1 mole of octane, C_8H_{18} , and 1 mole of propene, C_3H_6 , and 2 moles of another product.

Complete the balanced equation for this reaction by adding the formula of the missing product.

(1)



(c) Figure 11 shows the reaction of propene, C_3H_6 , with water.

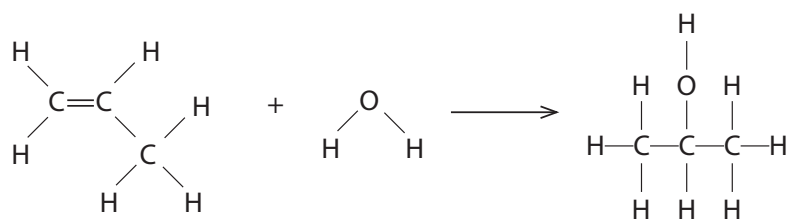


Figure 11

Figure 12 shows some bond energies.

bond	bond energy in kJ mol^{-1}
C—C	347
C—O	358
C—H	413
O—H	464
C=C	612

Figure 12

Use the bond energies in Figure 12 to calculate the energy change of the reaction in Figure 11.

(4)

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energy change of reaction = ... kJ mol^{-1}

(d) Methane gas, CH_4 , was burned using the apparatus shown in Figure 13.

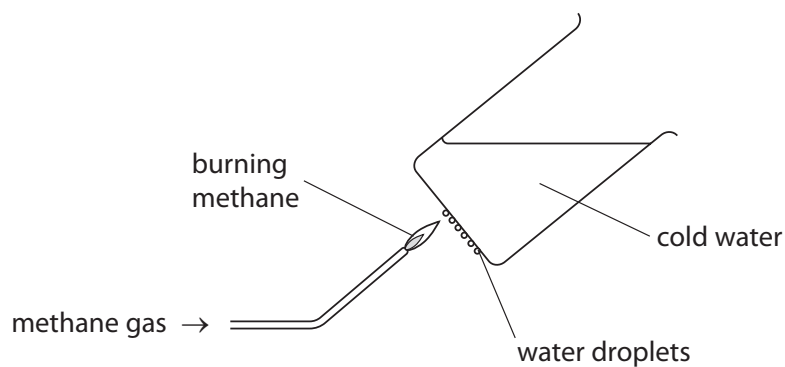


Figure 13

Explain why water droplets form on the bottom of the beaker of cold water.

(2)

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(Total for Question 9 = 11 marks)

- 10 (a) Propanol, $\text{C}_3\text{H}_7\text{OH}$, can undergo reactions to form compounds **Y** and **Z** shown in Figure 14.

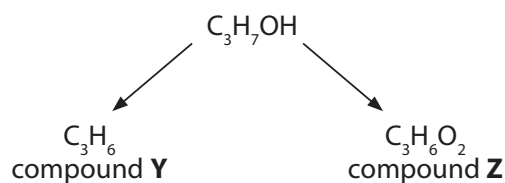


Figure 14

- (i) What happens to propanol when it forms compound **Y**?

(1)

- ☐ **A** propanol undergoes an addition reaction
☐ **B** propanol is dehydrated
☐ **C** propanol is hydrated
☐ **D** propanol is oxidised

- (ii) Compound **Y** can also be formed in the following reaction



Explain how bromine water can be used to distinguish between compound **X** and compound **Y**.

(3)

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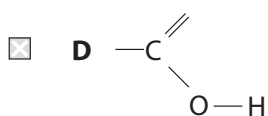
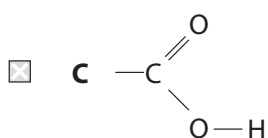
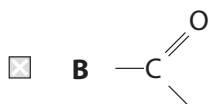
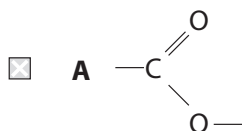
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(iii) Compound **Z** is a carboxylic acid.

Which of the following shows the functional group of a carboxylic acid?

(1)



(iv) Compound **Z** is an acid and turns litmus and universal indicator papers red.
Compound **Z** also shows other acidic properties.

Devise an experiment that would show another acidic property of compound **Z**.

(2)

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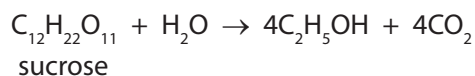
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- (b) The balanced equation for the production of ethanol from the carbohydrate sucrose is



Calculate the minimum mass of sucrose needed to produce 26.9 g of ethanol.

(relative formula masses: $\text{C}_2\text{H}_5\text{OH} = 46$, $\text{C}_{12}\text{H}_{22}\text{O}_{11} = 342$)

(2)

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.....

minimum mass of sucrose = ... g

- (c) Calculate the total number of atoms in 10.0 g of sucrose, $\text{C}_{12}\text{H}_{22}\text{O}_{11}$.

(relative formula mass: $\text{C}_{12}\text{H}_{22}\text{O}_{11} = 342$; Avogadro constant = 6.02×10^{23})

(2)

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number of atoms = ...

(Total for Question 10 = 11 marks)



10 (a) Figure 14 shows the structure of a molecule of hydrocarbon **Z**, C_4H_8 .

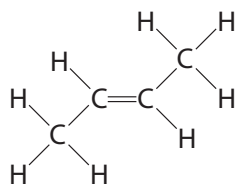


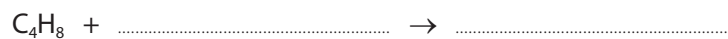
Figure 14

(i) Give the name of hydrocarbon **Z** shown in Figure 14.

(1)

(ii) Complete the balanced equation for the reaction of hydrocarbon **Z**, C_4H_8 , with bromine.

(2)



(iii) Draw the repeating unit of the addition polymer formed when hydrocarbon **Z** undergoes polymerisation.

(2)

(b) Figure 15 shows the arrangement of atoms in a molecule of an alcohol.

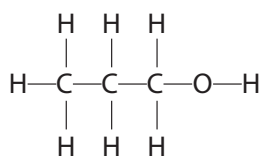


Figure 15

- (i) Give the name of the carbon-containing product formed when the alcohol in Figure 15 undergoes dehydration.

(1)

- (ii) Give the formula of the functional group of the product formed when the alcohol in Figure 15 undergoes oxidation.

(1)

- (iii) A student wants to investigate the amount of energy released when 1.00 g of the alcohol is burned.

They set up the apparatus shown in Figure 16 to measure the temperature rise of the water.

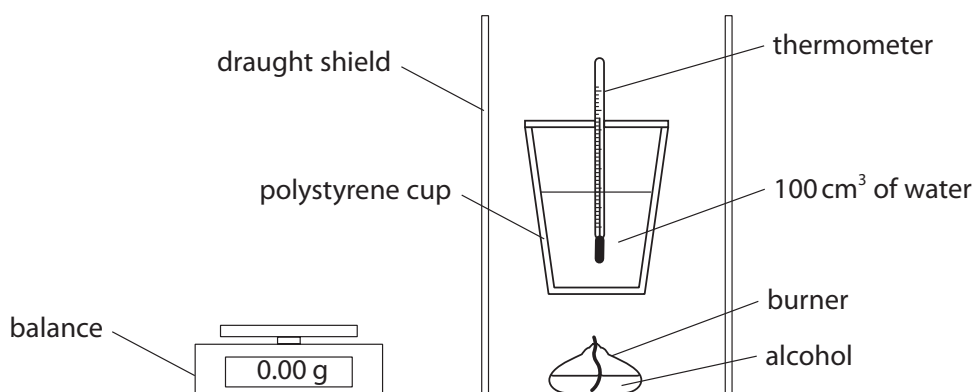


Figure 16

State why this apparatus is not suitable for use in this experiment.

(1)

- (c) Some alcohols can react with some carboxylic acids to form polyesters, which are condensation polymers.

Figure 17 shows the repeating unit of the polyester molecule formed in a reaction between a carboxylic acid and an alcohol.

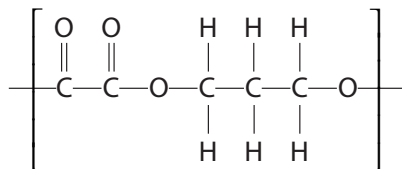


Figure 17

- (i) Give the formula of the other product formed in this reaction.

(1)

- (ii) Draw the structure of one molecule of the alcohol used to produce the polyester shown in Figure 17, showing all covalent bonds.

(2)

(Total for Question 10 = 11 marks)



7 Figure 12 shows the structure of the molecules of three organic compounds.

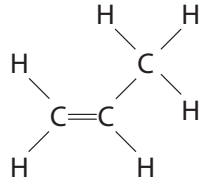
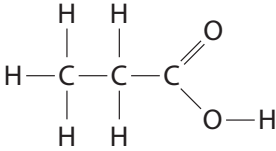
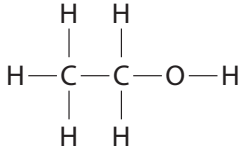
propene	propanoic acid	ethanol
		

Figure 12

(a) (i) Each molecule in Figure 12 contains a different functional group.

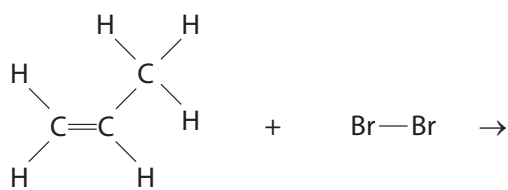
Circle the alkene functional group in **propene**.

(1)

(ii) Propene reacts with bromine water.

Complete the equation for the reaction of propene with bromine by drawing the structure of a molecule of the product.

(2)



propene

bromine

product

(iii) Propanoic acid reacts with calcium carbonate, CaCO_3 , to form calcium propanoate, $\text{Ca}(\text{C}_2\text{H}_5\text{COO})_2$, and two other products.

Name the **two** other products.

(2)

product 1

product 2

*(b) Glucose, $C_6H_{12}O_6$, is a carbohydrate.

A dilute solution of ethanol can be produced from glucose by fermentation.

The dilute solution of ethanol can then be processed to form a concentrated solution of ethanol.

Describe how the fermentation of glucose is carried out and how the dilute solution of ethanol produced can then be processed to form a concentrated solution of ethanol.

You may include diagrams in your answer.

(6)



(Total for Question 7 = 11 marks)



12-MARK QUESTIONS

1 question in this booklet



7 This question is about oxygen.

- (a) The percentage of oxygen in today's atmosphere is greater than the percentage of oxygen in the Earth's early atmosphere.

Explain what caused this change to happen.

(2)

- (b) Magnesium reacts with oxygen from the air to form magnesium oxide.

A student carries out an investigation to determine the mass of magnesium oxide formed when a known mass of magnesium reacts completely with oxygen.

This is the method the student used.

- step 1** find the mass of a crucible and lid
- step 2** put a known mass of magnesium into the crucible and put the lid on
- step 3** heat for five minutes using a roaring Bunsen burner flame
- step 4** let the crucible, lid and contents cool down
- step 5** find the final mass of the crucible, lid and contents

Explain how the student could check that the magnesium had reacted completely with oxygen.

(2)



- (c) In another experiment, it was found that 1.24 g of phosphorus reacted completely with 1.60 g of oxygen to form phosphorus oxide.

The relative formula mass of this phosphorus oxide is 284.

Deduce the molecular formula of this phosphorus oxide.

You must show your working.

(relative atomic masses: O = 16, P = 31)

(4)

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molecular formula = ...



- (d) A student uses the apparatus shown in Figure 10 to investigate the percentage of oxygen in the atmosphere.

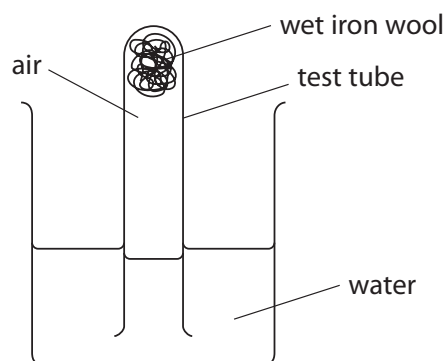


Figure 10

The apparatus was left for a few days.

- (i) Explain one change the student would see after a few days.

(2)

.....

.....

- (ii) Explain one change that can be made to the apparatus in Figure 10 to allow the student to calculate the percentage of oxygen in the atmosphere.

(2)

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(Total for Question 7 = 12 marks)

13-MARK QUESTIONS

2 questions in this booklet



9 (a) An impure hydrocarbon fuel is burned in the apparatus in Figure 7.

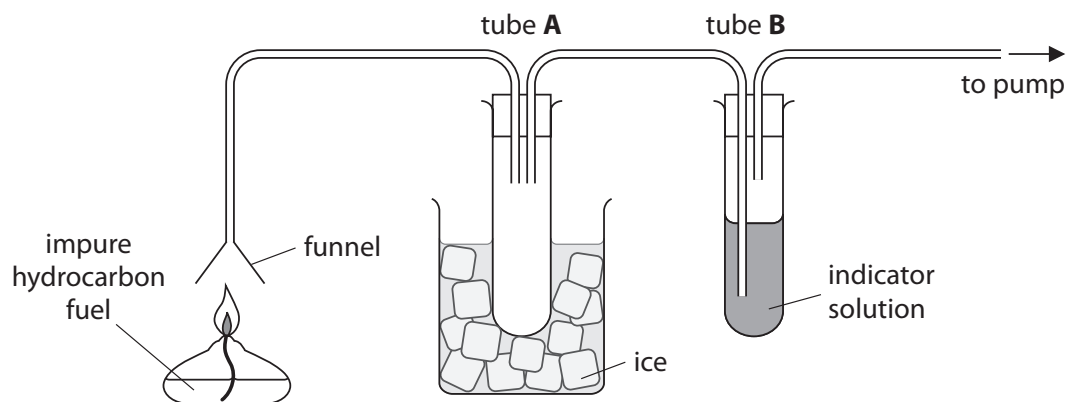


Figure 7

When the fuel is burned

- the funnel becomes hot
- a colourless liquid forms in tube **A**
- the indicator in tube **B** changes colour to show an acidic gas.

Explain these observations.

(3)

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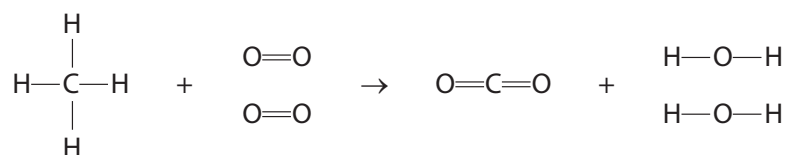
(b) The energies of some bonds are shown in Figure 8.

bond	bond energy in kJ mol^{-1}
C—H	435
O=O	496
C=O	805
H—O	463

Figure 8

Methane burns in oxygen to form carbon dioxide and water.

The equation shows the structures of the molecules.



Calculate the energy change, in kJ mol^{-1} , for this reaction.

(4)

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energy change = ... kJ mol^{-1}



(Total for Question 9 = 13 marks)

9 Crude oil is a mixture of hydrocarbons.

Crude oil can be separated into useful fractions by the process of fractional distillation in a fractionating column.

- (a) Figure 15 shows a fractionating column, the fractions obtained and the trend in viscosity of the fractions.

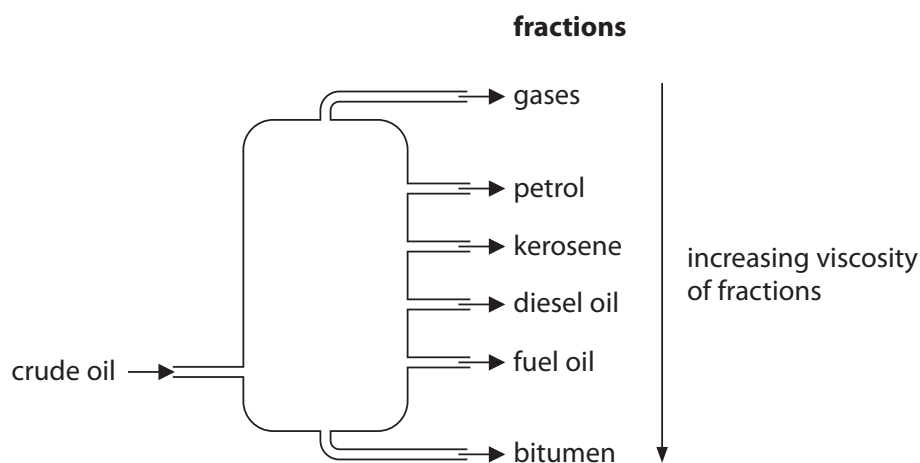


Figure 15

- (i) Which row shows the correct uses for bitumen, diesel oil and fuel oil?

(1)

	bitumen	diesel oil	fuel oil
☐ A	fuel for large ships	surfacing roads	fuel for trains
☐ B	fuel for large ships	fuel for trains	surfacing roads
☐ C	surfacing roads	fuel for trains	fuel for large ships
☐ D	surfacing roads	fuel for large ships	fuel for trains

- (ii) Explain the trend in the viscosity of the fractions.

(2)

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- (b) Hydrocarbon **X** was cracked to form one molecule of hexane, C_6H_{14} , and one molecule of alkene **Y**.



The relative formula mass of **Y** is 56.

The empirical formula of **Y** is CH_2 .

Deduce the molecular formula of hydrocarbon **X**.

Show your working.

(relative atomic masses: $\text{H} = 1.0$, $\text{C} = 12$)

(4)

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molecular formula of **X** = ...



(Total for Question 9 = 13 marks)



MARK SCHEMES

official Pearson Edexcel mark schemes



Question Number	Answer	Additional guidance	Mark
1(a)	An explanation linking (Earth) cooled / temperature decreased (1) (water vapour / steam) condensed / oceans formed (1)	allow temperature of atmosphere/ Earth decreased allow it rained (and formed oceans) allow lakes/seas	(2) AO 1 1

Question Number	Answer	Additional guidance	Mark
1(b)(i)	final answer of 20 (%) with or without working (2) volume gas used = 50-40 (1) (= 10 (cm³)) percentage = (50-40)/50 x 100 (1) = 20 (%)	allow ecf throughout allow 40-50 (1) (= -10cm³) allow 40/50 x 100 = 80% (1) then 100 – 80 = 20% (1) if no other marks awarded allow 10/50 = 0.2 (1)	(2) AO 2 2

Question Number	Answer	Mark
1(b)(ii)	C the gas has expanded when it is hot The only correct answer is C <i>A is not correct because this is not true</i> <i>B is not correct because this is not relevant</i> <i>D is not correct because this is not true</i>	(2) AO 2 2



Question Number	Answer	Additional guidance	Mark
1(c)	An explanation linking - oxygen increased (in atmosphere) (1) (oxygen) { reacts / combines } with iron (sulphide) / iron is oxidised (1)	allow oxygen appears (1) photosynthesis produces oxygen (1) ignore oxygen reacts with <u>rocks</u> / sulfur <u>in rocks</u> replaced by oxygen / oxygen enters <u>rocks</u> / iron ore	(2) AO 2 1

(Total for Question 1 = 7 marks)



Question number	Answer	Mark
3(a)	fractional distillation / fractionation (1)	(1) AO1

Question number	Answer	Mark
3(b)	C they have the same general formula A, B and D not correct as compounds in homologous series have different chemical, empirical and molecular formulae.	(1) AO1

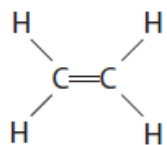
Question number	Answer	Additional guidance	Mark
3(c)	$\text{N}_2 + 2\text{O}_2 \rightarrow 2\text{NO}_2$ (2) or NO_2 (1)	other incorrect balancing max 1	(2) AO2

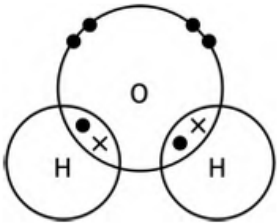
Question number	Answer	Additional guidance	Mark
3(d)	An explanation linking {carbon dioxide / water} produced (1) (the gases) absorb heat radiated from earth (1) - re-radiate heat back into the atmosphere (1)	allow formula allow traps the heat	(3)

Total for Question 3 = 7 marks



Question number	Answer	Additional guidance	Mark
3(a)(i)	alkane(s)	ignore saturated hydrocarbons reject alkenes	(1) A01-1

Question number	Answer	Mark
3(a)(ii)	B  is the only correct answer A, C and D are not correct because they are not hydrocarbons	(1) A02-1

Question number	Answer	Additional guidance	Mark
3(b)	 a shared pair of electrons (1) rest of molecule correct including correct atomic symbols, if given (1)	allow all dots / all crosses allow unlabelled atoms ignore inner electrons even if incorrect if no circles present, atomic symbols must be present ignore double / triple bonds MP2 depends on MP1	(2) A01-1

Question number	Answer	Additional guidance	Mark
3(c)	CH₄ without working (0) carbon $\frac{0.96}{12}$ (= 0.08) and hydrogen $\frac{0.32}{1}$ (= 0.32) (1) simplest whole number ratio 1 : 4 (1) empirical formula CH₄ (1)	marks awarded for working using the masses from the question MP1 for mass/A_r calculated MP2 for MP1 converted to simplest whole number ratio MP3 for whole number ratio from MP2 correctly converted to formula allow C₁H₄ / CH₄ (3 with working) allow C₄H / C₄H₁ (2 – with working, scores MP2 and 3 only)	(3) A02-1

Total for Question 3 = 7 marks



Question number	Answer	Additional guidance	Mark
5(a)(i)	diesel releases more (nitrogen oxides / NO _x) (per km driven) / ORA (1) diesel releases more particulates (per km driven) / ORA (1)	ignore just quoting numbers from the table answer does need to make comparison – can be shown by statements about diesel and petrol ignore any effect of pollutants ignore anything about rights and wrongs of either NO _x or particulates	(2) A03 1

Question number	Answer	Additional guidance	Mark
5(a)(ii)	an explanation linking - diesel releases less carbon dioxide (1) - which is a greenhouse gas/contributes to global warming (1) OR - diesel releases less sulfur dioxide (1) - which causes acid rain (1)	vague references to pollution / harms environment do need to be qualified for any MP2 allow climate change ignore effects of climate change ignore carbon monoxide / unburnt hydrocarbons ignore ozone / ozone layer / effects of acid rain reject particulates MP2 depends on MP1	(2) A03 2

Question number	Answer	Mark
5(b)(i)	D their viscosity increases as the molecules get larger is the only correct answer A, B, C are incorrect statements	(1) A01 1

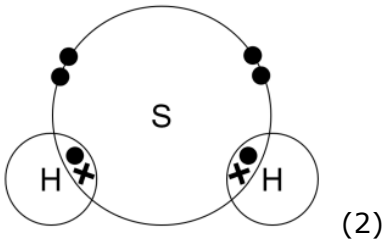


Question number	Answer	Mark
5(b)(ii)	C C ₄ H ₁₀ is the only correct answer A , B and D are not alkanes	(1) AO2 1

Question number	Answer	Additional guidance	Mark
5(b)(iii)	2 C ₈ H ₁₈ + 25 O ₂ → 16 CO ₂ + 18 H ₂ O LHS formulae → (1) → RHS formulae (1) balancing correct formulae (1)	allow multiples including halves ignore any state symbols	(3) AO2 1

(Total for question 5 = 9 marks)

Question number	Answer	Mark
5(a)	B carbon dioxide is the only correct answer A, C and D are incorrect because the gas thought to be the highest percentage in the Earth's early atmosphere is carbon dioxide	(1) A03-2b

Question number	Answer	Additional guidance	Mark
5(b)	 OR one shared pair of electrons between S atom and each of two H atoms (1) rest of molecule correct (1)	for any marks must be molecule with two H and one S atom, but ignore shape/ bond angles unlabelled atoms can be assumed to be H and S max 1 mark if charge on molecule allow dots or crosses or a mixture of both allow with no circles ignore inner shells even if incorrect MP2 dependent on MP1	(2) A02-1

Question number	Answer	Additional guidance	Mark
5(c)	An explanation linking any 3 from: • sulfur/ S (is present as an impurity) (1) • (when fuel burns) {impurity/sulfur} is {burned/ combusted/ oxidised/ reacts with oxygen} (1) • sulfur dioxide/ SO₂ (formed) (1) • sulfur dioxide dissolves in {rain/ water/ clouds} (1) • sulfuric acid is formed (1)	ignore any references to nitrogen oxides/ nitric acid S + O₂ → SO₂ scores MP1, MP2 and MP3 allow sulfur dioxide <u>reacts</u> with {rain/ water/ clouds} ignore sulfur dioxide mixes with {rain/ water/ clouds} allow forms sulfurous acid. suitable equation forming H₂SO₃ or H₂SO₄ scores MP3, MP4 and MP5	(3) AO1-1
Question number	Answer	Additional guidance	Mark
5(d)(i)	pH meter	allow pH probe allow universal indicator/ UI reject any other indicators ignore pH paper/ pH strips/ pH scale/ pH indicator	(1) AO3-3a



Question number	Answer	Additional guidance	Mark
3(a)	A description to include - add glowing splint (1) - it relights (1)	reject lit splint/ flame ignore description of forming glowing splint e.g. light splint and blow it out MP2 depends on MP1	(2) AO1 2

Question number	Answer	Additional guidance	Mark
3(b)	48.942 with or without working scores (2) $0.529 \times \frac{4.200}{2.100} = 1.058$ (1) $50.000 - 1.058 = 48.942$ (1)	48.94 or 48.9 (with or without working) scores 2 49 rounded from 48.942 scores 2 49 rounded from 49.471 scores 1 49 with no or other working scores 0 allow $0.529 \times 2 = 1.058$ allow ecf for 50 – calculated mass of oxygen 49.471 scores 1	(2) AO2 1

Question number	Answer	Additional guidance	Mark
3(c)(i)	An explanation linking: (the gas atoms) have full <u>outer</u> shell(s) (1)	mark independently ignore mention of numbers of electrons allow outer orbital / outer energy level allow do not form ions	(2) AO1 1



Question number	Answer	Mark
3(c)(ii)	D argon is unreactive is the only correct answer A, B and C are incorrect as they are irrelevant	(1) AO2 1

Question number	Answer		Mark
3(d)	A description including (coastal ecosystems) store more (carbon/ carbon dioxide) (than forests) (1) - storing 2450 per unit area (for coastal) AND compared to 900 for non-coastal storage (1)	allow coastal mangrove trees and/or coastal salt marsh OR just "they" ignore seagrass in MP1 ORA allow 2400-2500 allow 850-950 allow 350-450 for forests allow any reasonable relative values (2.5-3 x as much as non-coastal, 6-6.5 x as much as forests)	(2) AO3 1

Total for question 3 = 9 marks



Question number	Answer	Additional guidance	Mark
5(a)(i)	a description including any two from • same general formula (1) • same functional group (1) • (neighbouring molecules) differ by CH_2 (1) • <u>similar</u> {chemical properties/ reactions} (1) • trend in physical properties (1)	allow $\text{C}_n\text{H}_{2n+2}$ ignore any other specific general formula ignore same (formula/ name ending} reject same {empirical / molecular} formula ignore they are all hydrocarbons ignore similar properties ignore same {chemical properties/ reactions} ignore similar properties/ similar physical properties allow specific examples e.g. increasing melting points	(2) AO1 1

Question number	Answer	Mark
5(a)(ii)	C C_8H_{18} is the only correct answer A, B and D are not alkanes	(1) AO2 1

Question number	Answer		Mark
5(b)	an explanation linking CARBON – max 2 • carbon dioxide / CO₂ (1) • (carbon dioxide is a) greenhouse gas/ contributes to global warming (1) SULFUR – max 2 • sulfur dioxide / SO₂ (1) • (sulfur dioxide causes) acid rain (1)	MP2 depends on MP1 for both gases ignore formation of water/ carbon monoxide/ carbon allow causes climate change allow specific effects of global warming allow sulfur trioxide ignore sulfur oxide(s) but allow ECF for MP3 allow forms sulfuric acid allow specific environmental effects – kills fish/ kills trees / breathing problems	(4) AO1 1

Question number	Answer	Additional guidance	Mark
5(c)	$2\text{C}_7\text{H}_{16} + 15\text{O}_2 \rightarrow 14\text{CO} + 16\text{H}_2\text{O}$ (2) all formulae correct only (1) balancing correct formulae only (1)	allow multiples inc. 7.5, 7, 8 ignore any state symbols allow incorrect cases or subscripts allow = for →	(2) AO2 1

Total for question 5 = 9 marks



Question number	Answer	Mark
6(a)(i)	A 19% is the only correct answer B, C and D are incorrect because $3.5/18.0 \times 100 = 19$ to nearest whole number	(1) AO3 1

Question number	Answer	Additional guidance	Mark
6(a)(ii)	a description linking • leave (for more time) (1) • until volume of gas stops changing (1) OR • take repeated readings at different times (1) • which must be the same (1) OR • use more (iron) wool (1) • so iron in excess (1)	ignore references to testing oxygen ignore so oxygen fully reacts ignore repeat the experiment alone add excess (iron) wool scores 2	(2) AO3 3b

Question number	Answer	Additional guidance	Mark
6(b)(i)	a description including • add {ice/ cold water} <u>to beaker</u>(1)	allow add ice/cold water around tube A reject add condenser / cool delivery tube ignore cobalt chloride paper/ anhydrous copper	(2) AO3 3a

Question number	Answer		Mark
6(b)(ii)	- moles of carbon = $\frac{26.4}{44} = 0.6$ (1) - moles of hydrogen = $\frac{(2 \times 5.4)}{18} = 0.6$ (1) - ratio = 1 : 1 / empirical formula = CH / x = y (1) C₆H₆ (1)	allow moles of carbon dioxide = 0.6 moles of water/ hydrogen = 0.3 scores 0 for MP2 allow ECF for MP3 only depending on calculated moles 0.6: 0.3 (from MP2) = 2: 1 / C₂H / x = 2y scores MP1 and MP3 allow ratio of moles CO₂ : H₂O = 2:1 for MP3 no ECF for MP4 C₆H₆ or H₆C₆ is a stand alone mark for MP4 only the other 3 marks must be shown to be scored	(4) AO2 1

Total for question 6 = 9 marks



Question Number	Answer	Mark
6(a)	D the viscosities increase The only correct answer is D <i>A is not correct because average number of carbon atoms increases</i> <i>B is not correct because ease of ignition decreases</i> <i>C is not correct because boiling points increase</i>	(1) AO 1 1

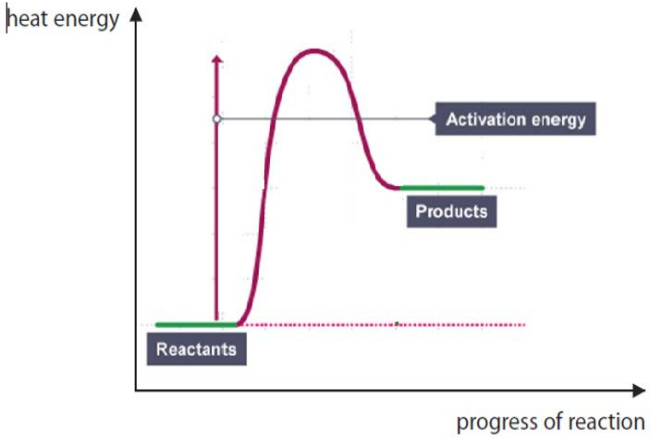
Question Number	Answer	Mark
6(b)(i)	D C_nH_{2n+2} The only correct answer is D <i>A is not correct because this is the general formula of an alkene</i> <i>B is not correct because this is not the general formula of an alkane</i> <i>C is not correct because this is not the general formula of an alkane</i>	(1) AO 1 1

Question Number	Answer	Additional guidance	Mark
6(b)(ii)	An explanation linking (compounds) containing hydrogen and carbon (atoms) (1) - only (1) MP2 is dependent on MP1	reject carbon molecules and hydrogen molecules /mixtures of carbon and hydrogen ignore symbols C and H	(2) AO 1 1

Question Number	Answer	Additional guidance	Mark
6(c)	An explanation including - boiling points increase as the number of carbon atoms (per molecule) increases (1) - because {stronger forces between molecules / (increased / more) intermolecular forces (1)	ignore {positive correlation alone / proportional} allow 'longer chain' for more C atoms reject any reference to 'bonds' for MP2 allow van der Waals' forces/London forces	(2) AO 3 1a AO 3 1b

Question Number	Answer	Mark
6(d)(i)	fuel oil	(1) AO 3 2a



Question Number	Answer	Additional guidance	Mark
6(d)(ii)	- reactant(s) and product(s) labelled in their correct positions (1) - activation energy labelled (1) - energy of reactants lower than energy of products (1)	example of diagram  ignore arrow heads allow unlabelled diagram of an endothermic reaction showing the basic outline shape if exothermic reaction profile shown, allow (1) for reactants and products in correct position and (1) for correct labelling of activation energy	(3) AO 1 1
Question Number	Answer	Additional guidance	Mark
6(d)(iii)	C ₆ H ₁₄		(1) AO 2 1

Question number	Answer	Mark
7(a)	D nitrogen, oxygen, argon is the only correct answer A is not correct because nitrogen is the most common gas B is not correct because hydrogen is not the third most common gas C is not correct because nitrogen is the most common gas	(1)

Question number	Answer	Additional guidance	Mark
7(b)(i)	mass argon = $79.120 - 78.639 (= 0.481 \text{ (g)})$ (1) density = $0.481/250 = 0.001924 \text{ (gcm}^{-3}\text{)}$ (1)	allow ECF allow 0.002, 0.0019, 0.00192, 0.001924..... for (2)	(2)

Question number	Answer	Additional guidance	Mark
7(b)(ii)	An explanation including - the volume of the flask is more than 250 cm^3 / more argon is in the flask than up to the line (1) - measure the whole volume of the flask (e.g. fill with water and measure volume of water) (1)	allow use a flask/ container of known volume	(2)

Question number	Answer	Additional guidance	Mark
7(c)	helium, neon, argon, krypton (2)	krypton, argon, neon, helium (1) if order correct except that two adjacent elements transposed allow 1 allow formulae	(2)



Question number	Indicative content	Mark
7(d)	$2 \text{CaCO}_3 + \text{Mg}^{2+} \rightarrow \text{CaMg}(\text{CO}_3)_2 + \text{Ca}^{2+}$ 2 (1) Mg²⁺ (1)	(2)

Question number	Indicative content	Additional guidance	Mark
7(e)	An explanation to include Q is early atmosphere (0) because - limewater ppt faster so contains { more/ large amount of } carbon dioxide (1) - splint goes out so { little/no oxygen } (1)	If P given then (0) If neither P nor Q stated they must be clearly referring to Q to score.	(2)

Question number	Answer	Mark
9(a)(i)	An explanation linking - insufficient oxygen (1) - to oxidise all carbon to carbon dioxide (1)	(2) AO1

Question number	Answer	Mark
9(a)(ii)	An explanation linking - carbon monoxide reacts with {haemoglobin (in blood) / blood / red blood cells} (1) - stops oxygen being carried by {haemoglobin / blood / red blood cells} / so less oxygen reaches brain (1)	(2) AO1

Question number	Answer	Additional guidance	Mark
9(b)	C ₂ H ₄	Allow H ₄ C ₂	(1) AO2

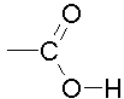
Question number	Answer	Additional guidance	Mark
9(c)	bonds broken = C=C + O-H = 612 + 464 (1) (= 1076 (kJ mol ⁻¹)) bonds formed = C-C + C-O + C-H = 347 + 358 + 413 (1) (= 1118 (kJ mol ⁻¹)) energy change of reaction = 1076 – 1118 (1) = - (1) (42 (kJ mol ⁻¹))	answer of - 42 (kJ mol ⁻¹) scores 4 marks answer of (+) 42 (kJ mol ⁻¹) scores 3 marks bonds broken = C=C + C-C + 6 C-H + 2 O-H = 612 + 347 + 6x413 + 2x464 (1) (= 4365 (kJ mol ⁻¹)) bonds formed = 2C-C + 7C-H + C-O + O-H = 2x347 + 7x413 + 358 + 464 (1) (= 4407 (kJ mol ⁻¹)) Energy change = 4365 – 4407 (1) = - (1) (42 (kJ mol ⁻¹))	(4) AO2



Question number	Answer	Mark
9(d)	An explanation to include • water vapour forms during combustion (1) • (water vapour) condenses on cold surface (1)	(2) AO2

Total for Question 9 = 11 marks



Question number	Answer	Mark
10(a)(i)	B propanol is dehydrated is the only answer Reaction B involves loss of water, A, C and D do not involve loss of water	(1) AO1
10(a)(ii)	An explanation linking • bromine water is yellow (1) • with compound X, yellow colour remains / no change of colour (1) • with compound Y, bromine water turns colourless (1) or • bromine water and compound X – no change in colour of bromine water (1) • bromine water and compound Y – bromine water changes from yellow (1) to colourless (1)	(3) AO2
10(a)(iii)	C  is the only answer. A, B and D are not correct	(1) AO1

Question number	Answer	Additional guidance	Mark
10(a)(iv)	Any suitable reaction and result such as • add a piece of magnesium ribbon (1) • bubbles of gas form (1) • add a (metal) carbonate (1) • bubbles of gas form (1) • add a metal oxide and warm (1) • metal oxide reacts to form a solution (1) • measure pH (1) • pH less than 7 (1) • add an alkali (1) • a neutral solution produced (1)	ignore add any metal but allow MP2 ignore using other indicators	(2) AO3

Question number	Answer	Mark
10(b)	moles of sucrose = $\frac{\text{moles of ethanol}}{4}$ (1) (= $\frac{26.9}{4 \times 46} = 0.146$) mass of sucrose = $\frac{\text{moles of ethanol}}{4} \times 342$ (1) (= $\frac{26.9 \times 342}{4 \times 46} = 49.999$ g) allow 50 g for 2 marks	(2) AO2

Question number	Answer	Mark
10(c)	moles sucrose = $\frac{10.0}{342}$ (1) (=0.029) number of atoms = $10.0 \times 45 \times 6.02 \times 10^{23}$ (1)	(2) AO2



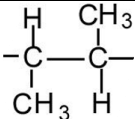
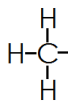
	$\frac{342}{(= 7.92 \times 10^{23})}$	
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Total for Question 10 = 11 marks



Question number	Answer	Additional guidance	Mark
10(a)(i)	but-2-ene	allow 2-butene	(1) AO1 1

Question number	Answer	Additional guidance	Mark
10(a)(ii)	$C_4H_8 + Br_2 \rightarrow C_4H_8Br_2$ fully correct equation (2) if equation not fully correct, then correct formula of product $C_4H_8Br_2$ (1)	reject charges on formulae reject superscript numbers allow incorrect lower and upper case letters	(2) AO2 2

Question number	Answer	Additional guidance	Mark
10(a)(iii)	 2 neighbouring carbon atoms with single bond and continuation bonds shown (1) rest of repeating unit correct (1)	allow CH_3 or  ignore brackets and n MP2 depends on MP1	(2) AO2 1

Question number	Answer	Additional guidance	Mark
10(b)(i)	propene	accept prop-1-ene / 1-propene	(1) AO2 1

Question number	Answer	Additional guidance	Mark
10(b)(ii)	-COOH / COOH /	allow CO ₂ H allow displayed formula	(1) AO2 1

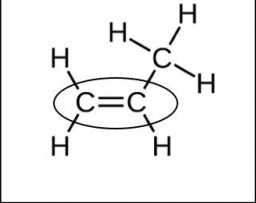
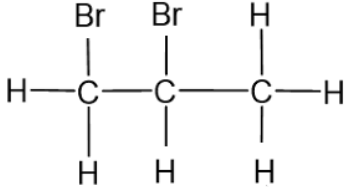
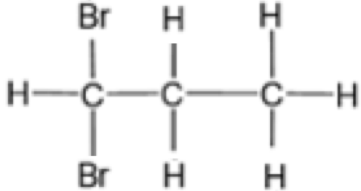
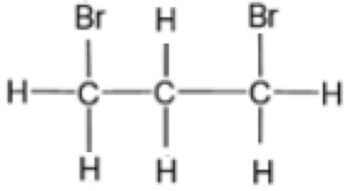
Question number	Answer	Additional guidance	Mark
10(b)(iii)	the polystyrene cup {is a poor conductor of heat / will melt / will burn}	ignore reference to any equipment other than the polystyrene cup (e.g. clamp stand)	(1) AO1 2

Question number	Answer	Mark
10(c)(i)	H ₂ O	(1) AO1 1

Question number	Answer	Additional guidance	Mark
10(c)(ii)	$ \begin{array}{ccccccc} & \text{H} & \text{H} & \text{H} & & & \\ & & & & & & \\ \text{H} & -\text{O}-\text{C} & -\text{C} & -\text{C}-\text{O}-\text{H} \\ & & & & & & \\ & \text{H} & \text{H} & \text{H} & & & \end{array} $ fully correct diagram scores (2) if not scores (1) for 3 single bonded carbon atoms / 2 OH groups	allow OH or O-H reject any double bonds	(2) AO2 1

(Total for question 10 = 11 marks)



Question number	Answer	Additional guidance	Mark
7(a)(i)	propene 	ignore any circles drawn on other molecules must not include hydrogen	(1) AO1-1
7(a)(ii)	 Br on neighbouring carbon atoms (1) rest of molecule correct with no double bond, two bromines and no extra products (1)	allow CH₂BrCHBrCH₃ (1) OR  (1) OR  (1) ignore the molecular formula	(2) AO2-1

Question number	Answer	Additional guidance	Mark
7(a)(iii)	water (1) carbon dioxide (1)	allow H ₂ O allow CO ₂ allow answers in either order allow lowercase/non subscripts	(2) AO2-1

Question number	Indicative content	Mark
*7(b)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material that is indicated as relevant. Additional content included in the response must be scientific and relevant. AO1 6 marks FERMENTATION • dissolve glucose in water to form a solution • place glucose solution in a suitable flask • add yeast to glucose solution • place fermentation mixture in warm room/water bath / 25-40°C • fit air lock or equivalent in neck of flask • reaction stops when bubbles stop • decant ethanol solution from yeast/ethanol mixture or filter out yeast CONCENTRATION • fractional distillation • place the dilute ethanol in round bottom flask /suitable vessel • add a fractionating column onto the round bottom flask /suitable vessel • and a thermometer on top of the of fractionating column • add condenser to top of fractionating column • run water into bottom of condenser • heat round bottom flask/vessel • to above boiling point of ethanol / below the boiling point of water • collect concentrated ethanol from end of condenser Allow labelled diagrams	(6)



Level	Mark	Descriptor
	0	No rewardable material.
Level 1 a basic description of either process or a very basic description of both	1–2	add yeast to glucose (1) concentrate the ethanol using fractional distillation (1) add yeast to glucose then use fractional distillation (2) use fractional distillation, heat the ethanol solution to above boiling point of ethanol (2)
Level 2 A detailed description of one of the processes or a basic description of both processes	3–4	add yeast to glucose solution and keep in at 25-35°C then use fractional distillation to concentrate (3) mix glucose in water to form a solution and add yeast and keep warm, cotton wool in neck of flask, decant yeast when bubbles stop (4) Use fractional distillation, place the dilute ethanol in round bottom flask, add a fractionating column with a thermometer add condenser to top of fractionating column. Heat the round bottom flask to above boiling point of ethanol (4)
Level 3 both processes described with one described in detail	5–6	put glucose and yeast into conical flask and warm to 35°C, use an airlock to prevent oxygen, decant ethanol solution from mixture then use fractional distillation (5) put glucose solution and yeast into conical flask and warm to around 30°C, use an airlock to prevent oxygen entering flask, decant ethanol solution from mixture then use fractional distillation, place the dilute ethanol in round bottom flask, add a fractionating column onto the round bottom flask and heat, collect concentrated ethanol from top of fractionating column (6)

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1–2	- Demonstrates elements of chemical understanding, some of which is inaccurate. Understanding of scientific, enquiry, techniques and procedures lacks detail. (AO1) - Presents a description which is not logically ordered and with significant gaps. (AO1)
Level 2	3–4	- Demonstrates chemical understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas, enquiry, techniques and procedures is not fully detailed and/or developed. (AO1) - Presents a description of the procedure that has a structure which is mostly clear, coherent and logical with minor steps missing. (AO1)
Level 3	5–6	- Demonstrates accurate and relevant chemical understanding throughout. Understanding of the scientific ideas, enquiry, techniques and procedures is detailed and fully developed. (AO1) - Presents a description that has a well-developed structure which is clear, coherent and logical. (AO1)



Question number	Answer	Additional guidance	Mark
7(a)	an explanation linking - plants (1) (produces oxygen by) photosynthesis (1)	allow cyanobacteria / stromatolites allow 'photosynthetic organisms' = 2 marks	(2) AO1 1

Question number	Answer	Additional guidance	Mark
7(b)	an explanation linking - reheat (and record the mass) (1) - until mass remains constant (1)	allow burn ignore continue heating the magnesium until it no longer glows / all turned white 'heat to constant mass' = 2 marks	(2) AO1 2

Question number	Answer	Additional guidance	Mark
7(c)	$\frac{1.24}{31}$ P (= 0.04) and $\frac{1.6}{16}$ O (= 0.1) (1) ratio = 2:5 OR empirical formula = P_2O_5 (1) relative formula mass P_2O_5 = 142 (1) molecular formula = P_4O_{10} (1)	full marks can only be obtained with working shown allow elements in either order in any formula allow ECF from moles of elements calculated allow 1:2.5 allow 4 : 10 (1) allow $\frac{31}{1.24}$ P = 25 and $\frac{16}{1.6}$ O = 10 (0) ratio = 2.5:1 or 5:2 or empirical formula = P_5O_2 (1) relative formula mass P_5O_2 = 187 (1)	(4) AO2 1



Question number	Answer	Additional guidance	Mark
7(d)(i)	iron wool {turns orange-brown / rusts} (1) (because) it has {oxidised/ reacted with oxygen} (1) OR water level in test tube rises (1) (because) oxygen (in the air) has reacted (with the iron) / volume of oxygen (in test tube) has decreased (1)	allow any suitable colour to describe rust ignore changes colour ignore air allow volume of air decreases the iron turns orange-brown because it has rusted = 2 marks allow 1 mark for volume of water (in beaker) decreases due to evaporation	(2) A02 2

Question number	Answer	Additional guidance	Mark
7(d)(ii)	replace test tube with a measuring cylinder (1) to measure the {volume / amount} of oxygen used up / to measure the change in {volume / amount} of gas in the tube (1)	graduated test tube allow (upturned) burette ignore gas syringe allow air in place of gas allow gas syringe (0) to measure volume of oxygen used (1) allow use of ruler (1) to measure water heights (1)	(2) A03 3

(Total for question 7 = 12 marks)



Question number	Answer	Additional guidance	Mark
9(a)	• (funnel) heat (energy) released in reaction/ exothermic reaction (1) • (liquid) water (1) • (gas) sulfur dioxide / carbon dioxide (1)	ignore NO _x	(3)

Question number	Answer	Additional guidance	Mark
9(b)	-730 as final answer with or without working scores 4 +730 as final answer with or without working scores 3 bonds broken = $(4 \times 435) + (2 \times 496) = 2732$ (1) bonds made = $(2 \times 805) + (4 \times 463) = 3462$ (1) energy change = broken – made (1) [2732 – 3462] = -730 (kJ mol⁻¹) (1)	allow ECF	(4)



Question number	Indicative content	Mark
* 9(c)	Answers will be credited according to candidates' deployment of knowledge and understanding of the material in relation to the qualities and skills outlines in the generic markscheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Pollutants • carbon monoxide combines with haemoglobin so is toxic • nitrogen oxides are acidic / toxic • nitrogen oxides lead to acid rain • references to effects of acid rain – e.g. damages buildings/kills plants etc • carbon dioxide is a greenhouse gas • greenhouse gases cause global warming • references to effects of global warming – e.g sea levels rising etc • particulates cause breathing difficulties/ make buildings dirty Petrol / diesel comparison • compared to diesel, petrol: -releases less nitrogen oxides -releases less particulates • compared to petrol, diesel: -releases more carbon monoxide -releases more carbon dioxide Catalytic converter • reduces carbon monoxide • reduces nitrogen oxides Overall comparison • Petrol car improved with catalytic converter as two pollutants reduced • Diesel better than petrol for carbon oxides • Diesel is worse for particulates and nitrogen oxides	(6) EXP AO3 (6)



All incorrect/ irrelevant/ vague information to be ignored, unless contradictory. Ignore references to ozone layer.

Level	Mark	Descriptor	Example responses
	0	No rewardable material.	
Level 1	1–2	Demonstrates elements of chemical knowledge some of which is inaccurate. Presents a discussion with some structure and coherence. States differences between engines using information from the table or explains the problem of one of the pollutants.	e.g. The diesel engine gives off the least carbon dioxide (1) carbon dioxide causes the greenhouse effect (1) the diesel engine only gives off particulates which cause breathing problems (2)
Level 2	3–4	Demonstrates elements of chemical knowledge and understanding some of which is mostly relevant but which may contain some inaccuracies. Presents a discussion that has structure and is mostly coherent. Describes two or three differences between engines using information from the table and explains the problems of some of the pollutants.	e.g. the petrol engines give off carbon dioxide but the one with a catalytic converter gives off less nitrogen oxides. The carbon dioxide is a greenhouse gas which causes global warming and the nitrogen oxide cause acid rain (4)
Level 3	5–6	Demonstrates accurate and relevant chemical knowledge and understanding. Presents a discussion and comparison with some structure and coherence. Describes three or four differences between engines using information from the table and explains the problem of some of the pollutants. Explains why one of the engines causes the least/ most damage to the environment.	e.g. the petrol engines give off carbon dioxide but the one with a catalytic converter gives off less nitrogen oxides. The diesel engine gives off less carbon dioxide but more nitrogen oxides. The carbon dioxide is a greenhouse gas which causes global warming and the nitrogen oxide cause acid rain. The diesel engine gives off the least carbon monoxide which is toxic. Overall the petrol car with no catalytic converter because it gives off the a lot of carbon dioxide and more carbon monoxide so it would cause the most global warming and breathing problems from the CO (6)



Question number	Answer	Mark
9(a)(i)	C surfacing roads fuel for trains fuel for large ships is the only correct answer A and B are incorrect as bitumen is not used as a fuel for large ships D is not correct as diesel oil is not used for fuel for large ships	(1) AO1-1

Question number	Answer	Additional guidance	Mark
9(a)(ii)	An explanation linking (viscosity increases down the column) as molecules are {larger/ longer/ more carbons} (1) - because there are stronger {intermolecular forces / forces between molecules} (1)	allow ORA allow stronger intermolecular bonds/ forces of attraction/ (surface area of) contact allow more intermolecular forces	(2) AO1-1



Question number	Answer	Additional guidance	Mark
9(b)	$M_r \text{ of } \text{CH}_2 = 12 + (2 \times 1) = 14 \text{ (1)}$ $\frac{56}{14} = 4 \text{ (1)}$ formula of Y = $4 \times \text{CH}_2 = \text{C}_4\text{H}_8 \text{ (1)}$ formula of X = $(\text{C}_6\text{H}_{14} + \text{C}_4\text{H}_8 =) \text{C}_{10}\text{H}_{22} \text{ (1)}$	allow ecf throughout MP1 must be for CH_2 allow $14 \times 4 = 56$ allow Y has 4C and 8H C_4H_8 without working scores MP3 only. $\text{C}_4\text{H}_8 = (4 \times 12) + (8 \times 1) = 56$ scores MP1, 2 and 3 for MP4 must be written as formula $\text{C}_{10}\text{H}_{22}$ without working scores MP4 only ecf can be awarded for MP4 as long as working for alkene to be added is seen ignore formula of X = $(\text{C}_6\text{H}_{14} + \text{CH}_2 =) \text{C}_7\text{H}_{16}$	(4) AO3-1

Question number	Indicative content	Mark
9(c)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material that is indicated as relevant. Additional content included in the response must be scientific and relevant. AO1 (3 marks) and AO2 (3 marks) Ignore any issues with methane itself e.g. it is a greenhouse gas. Ignore different colours of flame with open/ closed air hole. OPEN AIR-HOLE • air-hole open, allows lots of oxygen to mix with methane • therefore complete combustion takes place • $\text{CH}_4 + 2\text{O}_2 \rightarrow 2\text{H}_2\text{O} + \text{CO}_2$ • carbon dioxide and water are produced. CLOSED AIR-HOLE • air-hole closed, less oxygen can enter to mix with methane • therefore incomplete combustion takes place • e.g. $2\text{CH}_4 + 3\text{O}_2 \rightarrow 2\text{CO} + 4\text{H}_2\text{O}$ (allow other correct examples) • carbon monoxide can be produce HARMFUL EFFECTS • CO is odourless and colourless • carbon monoxide combines with haemoglobin in place of oxygen/ reduces capacity of blood for oxygen • therefore toxic • carbon/ soot can also be produced • can aggravate asthma / respiratory problems • soot makes buildings dirty • carbon dioxide and water are greenhouse gases • absorb heat energy radiated from Earth which is re-radiated back into the atmosphere • increases greenhouse effect • causes global warming/ climate change • melt polar ice caps / sea levels rise	(6)



Level	Mark	Descriptor
	0	No rewardable material.
Level 1 A description of open or closed air -hole or description of one harmful effect	1–2	closed air-hole gives less oxygen (1) closed air-hole gives less oxygen, open air-hole gives more oxygen (1) closed air-hole gives incomplete combustion (1) closed air-hole has less oxygen so incomplete combustion (2) complete combustion gives carbon dioxide (1) when the air-hole is open, oxygen allows complete combustion gives carbon dioxide and water (2)
Level 2 Description of two of: open air-hole/ closed air hole/ harmful effect	3–4	A closed air-hole gives less oxygen which produces soot and carbon monoxide which is toxic because it bonds to haemoglobin. (3) More oxygen gives carbon dioxide and water and incomplete combustion gives carbon monoxide and water. (4) Complete combustion produces carbon dioxide and water which are both greenhouse gases. Greenhouse gases absorb heat energy radiated from the earth and re-radiates it, this causes global temperatures to rise and leads to an increase in polar ice caps melting. (4)
Level 3 All three aspects must be covered Description of all three of: open air-hole/ closed air-hole/ harmful effect(s)	5–6	Incomplete combustion makes carbon monoxide but complete combustion produces carbon dioxide and water which are both greenhouse gases. Greenhouse gases absorb heat energy radiated from the earth and re-radiates it, this causes global temperatures to rise and leads to an increase in polar ice caps melting. (5) A closed air-hole gives incomplete combustion which produces carbon monoxide which is an odourless and colourless toxic gas. Complete combustion produces carbon dioxide and water which are both greenhouse gases. Greenhouse gases absorb heat energy radiated from the earth and re-radiates it, increases the greenhouse effect and temperature of the Earth's atmosphere. (6)



Level	Mark	Descriptor
	0	No awardable content
Level 1	1-2	- Demonstrates elements of chemical understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) - The explanation attempts to link and apply knowledge and understanding of scientific ideas, flawed or simplistic connections made between elements in the context of the question. (AO2)
Level 2	3-4	- Demonstrates chemical understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) - The explanation is mostly supported through linkage and application of knowledge and understanding of scientific ideas, some logical connections made between elements in the context of the question. (AO2)
Level 3	5-6	- Demonstrates accurate and relevant chemical understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) - The explanation is supported throughout by linkage and application of knowledge and understanding of scientific ideas, logical connections made between elements in the context of the question. (AO2)

