

**OXFORD CAMBRIDGE AND RSA EXAMINATIONS  
AS GCE**

**F331/01**

**CHEMISTRY B (SALTERS)**

**Chemistry for Life**

**FRIDAY 27 MAY 2016: Morning**

**DURATION: 1 hour 15 minutes  
plus your additional time allowance**

**MODIFIED ENLARGED**

<b>Candidate forename</b>		<b>Candidate surname</b>	
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<b>Centre number</b>						<b>Candidate number</b>				
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**Candidates answer on the Question Paper.**

**OCR SUPPLIED MATERIALS:**

**Data Sheet for Chemistry B (Salters) (inserted)**

**OTHER MATERIALS REQUIRED:**

**Scientific calculator**

**READ INSTRUCTIONS OVERLEAF**



## **INSTRUCTIONS TO CANDIDATES**

**The Insert will be found inside this document.**

**Write your name, centre number and candidate number in the boxes on the first page. Please write clearly and in capital letters.**

**Use black ink. HB pencil may be used for graphs and diagrams only.**

**Answer ALL the questions.**

**Read each question carefully. Make sure you know what you have to do before starting your answer.**

**Write your answer to each question in the space provided. If additional space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.**

## **INFORMATION FOR CANDIDATES**

**The number of marks is given in brackets [ ] at the end of each question or part question.**



**Where you see this icon you will be awarded marks for the quality of written communication in your answer.**

**This means for example you should:**

**ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;**

**organise information clearly and coherently, using specialist vocabulary when appropriate.**

**You may use a scientific calculator.**

**A copy of the Data Sheet for Chemistry B (Salters) is provided as an insert with this question paper.**

**You are advised to show all the steps in any calculations.**

**The total number of marks for this paper is 60.**

**Any blank pages are indicated.**

Answer ALL the questions.

- 1 The alcohol n-butanol,  $C_4H_{10}O$ , is used as an artificial flavouring in food products. It is also a potentially important biofuel.

(a) There are several structural isomers with the molecular formula  $C_4H_{10}O$ .

(i) Explain the term 'structural isomers'.

\_\_\_\_\_  
\_\_\_\_\_ [1]

(ii) Two alcohols of formula  $C_4H_{10}O$  have unbranched carbon chains.

Give the SKELETAL formula and name of each alcohol.

SKELETAL FORMULA		
NAME		

[2]

(iii) Some structural isomers of  $C_4H_{10}O$  are not alcohols.

State the homologous series of these isomers.

\_\_\_\_\_ [1]

- (b) Petrol can be mixed with n-butanol, and the mixture used as a fuel in cars. The octane number of n-butanol is roughly the same as petrol.**

**Explain the term ‘octane number’.**

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**[1]**

- (c) A high ratio of air to fuel is required for the efficient performance of a fuel.  
192 g of oxygen is needed to burn 1.0 mol of  $\text{C}_4\text{H}_{10}\text{O}$ .

- (i) Calculate the mass of AIR needed to burn 1.0 mol of  $\text{C}_4\text{H}_{10}\text{O}$ .

Assume air contains 23% by mass of oxygen,  $\text{O}_2$ .

mass of air needed to burn  
1.0 mol of  $\text{C}_4\text{H}_{10}\text{O}$  = \_\_\_\_\_ g [1]

- (ii) Calculate the mass of air needed to burn 1.0 g of  $\text{C}_4\text{H}_{10}\text{O}$ .

mass of air needed to burn  
1.0 g of  $\text{C}_4\text{H}_{10}\text{O}$  = \_\_\_\_\_ g [1]

- (iii) Suggest why a high ratio of air to fuel results in efficient fuel performance.

\_\_\_\_\_ [1]

- (iv) Petrol has a higher energy density than n-butanol. Energy density is defined as the energy produced, in kJ, per KILOGRAM of fuel.

Calculate the energy density of n-butanol given the following information:

standard enthalpy change of combustion,  $\Delta H^{\ominus}_c$ , of n-butanol =  $-2676 \text{ kJ mol}^{-1}$

Give your answer to THREE significant figures.

energy density = \_\_\_\_\_  $\text{kJ kg}^{-1}$  [3]

- (d) Crude oil can be used to make n-butanol.  
Biobutanol is produced from biomass, such as  
sugar and straw.**

**State ONE benefit associated with the use of a  
biofuel such as biobutanol, compared with a fuel  
produced from crude oil.**

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**[1]**

**[TOTAL: 12]**



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**2** **Magnox is an alloy of magnesium with small amounts of aluminium and other metals. Until recently magnox was used in some nuclear reactors to cover uranium metal.**

**(a) (i) The isotope uranium-238 in the fuel rod undergoes nuclear fission by alpha decay.**

**Write a nuclear equation for this decay.**

**[2]**

**(ii) A disadvantage of using magnox to cover the fuel rods is that the magnesium in the alloy slowly reacts with water. This prevents the long-term storage of spent fuel.**

**Write an equation for the reaction of magnesium with water.  
Include state symbols.**

**[2]**

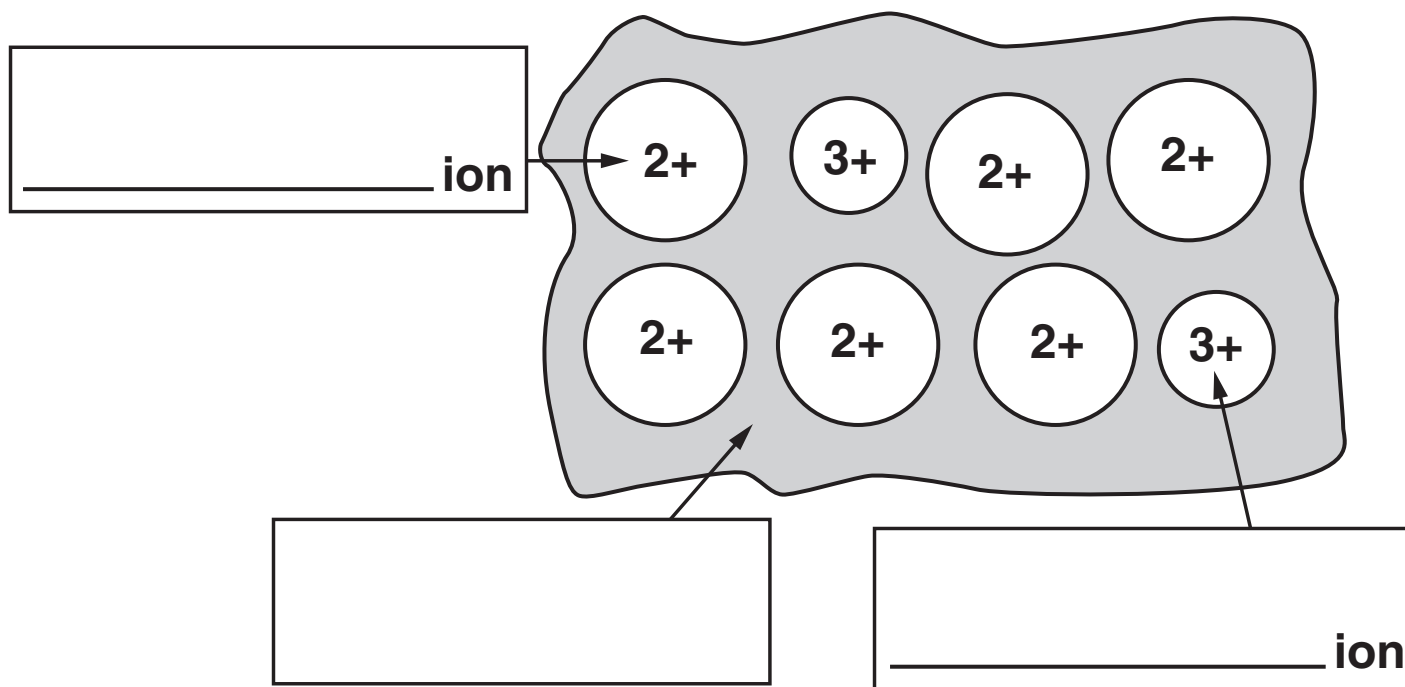
- (iii) The aluminium atoms in magnox form a metallic structure with the magnesium. FIG. 2.1 below represents a simple illustration of the bonding in magnox.

Use your knowledge of atomic structure and metallic bonding to label the boxes.



In your answer, you should use technical terms, spelled correctly.

Fig. 2.1



[2]

**(b) Both magnesium carbonate and magnesium oxide are used in indigestion remedies.**

**(i) Magnesium oxide can be formed by the thermal decomposition of magnesium carbonate.**

**A student investigates the trend in the thermal stability of the Group 2 carbonates.**

**The student heats 0.025 mol of each Group 2 carbonate strongly for 5 minutes.**

**The results are shown in the table below.**

**You may assume that none of the carbonates completely decomposed.**

<b>Carbonate</b>	<b>Mass of 0.025mol /g</b>	<b>Mass after heating/g</b>
<b>BaCO<sub>3</sub></b>	<b>4.9</b>	<b>4.6</b>
<b>CaCO<sub>3</sub></b>	<b>2.5</b>	<b>1.8</b>
<b>MgCO<sub>3</sub></b>	<b>2.1</b>	<b>1.2</b>
<b>SrCO<sub>3</sub></b>	<b>3.7</b>	<b>3.2</b>

**Explain how the results show a trend in thermal stability down the group.**

**Describe how this trend could be confirmed by using limewater.**

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**[4]**

- (ii) A similar experiment can be used to investigate differences in the thermal stability of the Group 2 nitrates.

The general equation for the thermal decomposition of the Group 2 nitrates is:



Suggest and explain a safety precaution that would be needed for this decomposition but not required in (b)(i).

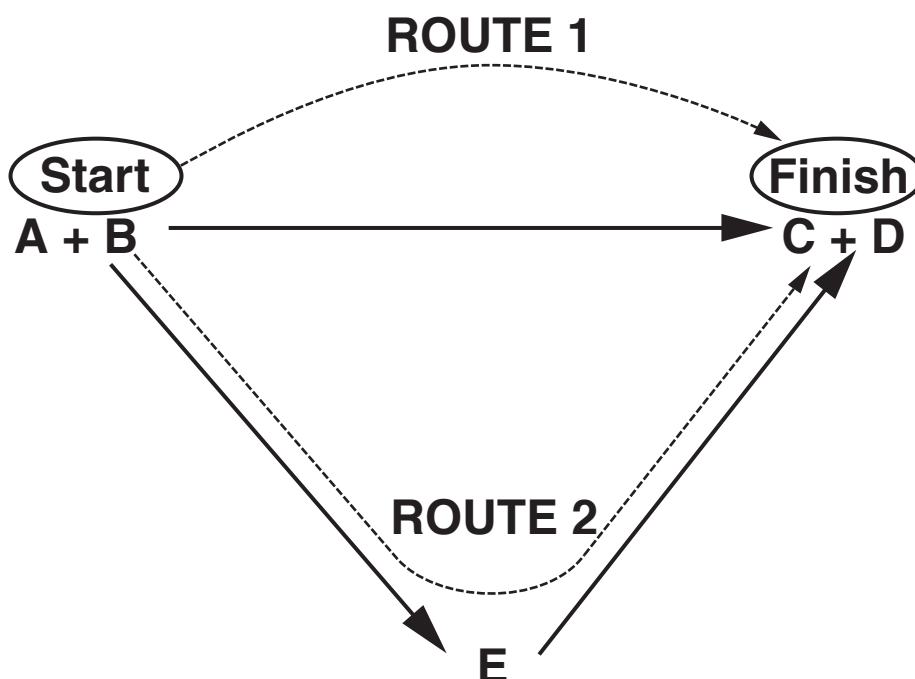
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[1]

(c) It is very difficult to determine the enthalpy change of decomposition of magnesium carbonate directly. The student calculates a value using Hess' law and an enthalpy cycle. This involves two separate experiments.

(i) Use the following general enthalpy cycle to explain Hess' law.



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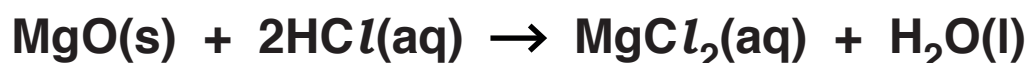
[2]

The student carries out two experiments.

**EXPERIMENT 1: Reaction of magnesium carbonate with hydrochloric acid.**



**EXPERIMENT 2: Reaction of magnesium oxide with hydrochloric acid.**



The student uses an excess of acid and measures the temperature change in each experiment.

The experiments were carried out in a polystyrene cup with a lid.

- (ii) Write the general mathematical formula that would be used to calculate the energy transferred to the solutions in the experiments.

\_\_\_\_\_ [1]

- (iii) Suggest why using a polystyrene cup, rather than a glass beaker, is likely to give a more accurate answer for the enthalpy changes.

\_\_\_\_\_ [1]

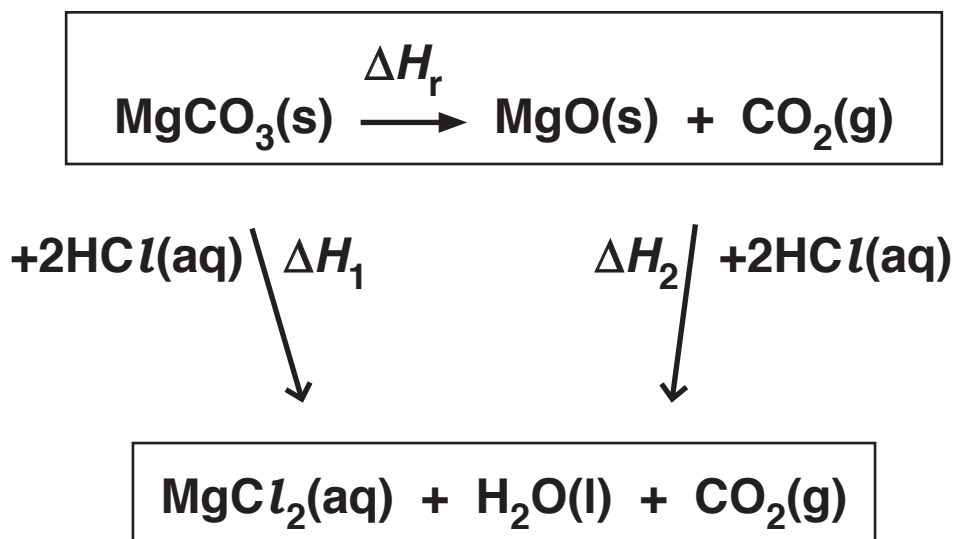


- (iv) After processing the experimental data the student calculated the following results:

enthalpy change of reaction per mole of  $\text{MgCO}_3$  for EXPERIMENT 1,  $(\Delta H_1) = -90 \text{ kJ mol}^{-1}$

enthalpy change of reaction per mole of  $\text{MgO}$  for EXPERIMENT 2,  $(\Delta H_2) = -131 \text{ kJ mol}^{-1}$

Use the following energy cycle to calculate the enthalpy change for the thermal decomposition of magnesium carbonate,  $\Delta H_r$ .



enthalpy change,  $\Delta H_r =$  \_\_\_\_\_  $\text{kJ mol}^{-1}$  [1]

- (v) The value of this experimentally calculated enthalpy change is numerically much smaller than the value from a Data Book.

Suggest a reason for the low value other than heat losses.

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 [1]

[TOTAL: 17]

- 3 The first ‘black powder’, now known as gunpowder, was most likely made in China in about the tenth century. Gunpowder contains potassium nitrate,  $\text{KNO}_3$ , as an oxidising agent, with charcoal (carbon) and sulfur.

- (a) (i) Some properties of the components in gunpowder are shown in the table below.

Complete the table.

PROPERTY	POTASSIUM NITRATE	CHARCOAL (CARBON)	SULFUR
Structure	giant	giant	simple molecular
Bonding	ionic	covalent	covalent
Melting point	high		
Solubility in water		insoluble	
Conduction of electricity when solid		conducts	

[2]

- (ii) Which feature of the atomic structure of carbon and sulfur indicates that they are on the right of the Periodic Table?

\_\_\_\_\_

\_\_\_\_\_ [1]

**(b) Ideas about atoms developed later. Models that were used in the gradual understanding of the structure of atoms include those listed below.**

- A Joseph John Thomson discovers electrons, leading to the ‘plum pudding’ model.**
- B John Dalton suggests everything is made of tiny, indivisible particles called atoms.**
- C Ernest Rutherford and his team use scattering experiments to suggest the ‘nuclear atom’.**
- D Erwin Schrödinger and others suggest that electrons have a wave/particle duality.**
- E Niels Bohr suggests that electrons are arranged in energy levels – the ‘planetary’ model.**

**Place the models used in the correct historical order.**

**EARLIEST MODEL**

**LAST MODEL**

\_\_\_\_\_

**[1]**

- (c) The percentage composition by MASS of some gunpowder is 75%  $\text{KNO}_3$ , 12.5% charcoal (C) and 12.5% sulfur (S).

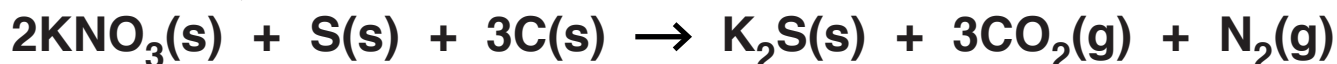
Calculate the percentage of  $\text{KNO}_3$  in the mixture, by MOLES.

% composition of  $\text{KNO}_3$  (by moles) = \_\_\_\_\_ % [2]

- (d) When gunpowder is ignited, the reaction produces a large volume of hot gases very quickly. The gases also expand rapidly, causing the explosion.

The equation is complex, but a simplified version is:

**EQUATION 3.1**



- (i) Draw a '*dot-and-cross*' diagram for  $\text{K}_2\text{S}$ .

Show outer electrons only.

[2]

- (ii) The reaction in EQUATION 3.1 involves a large increase in entropy.

Explain why the entropy increases.

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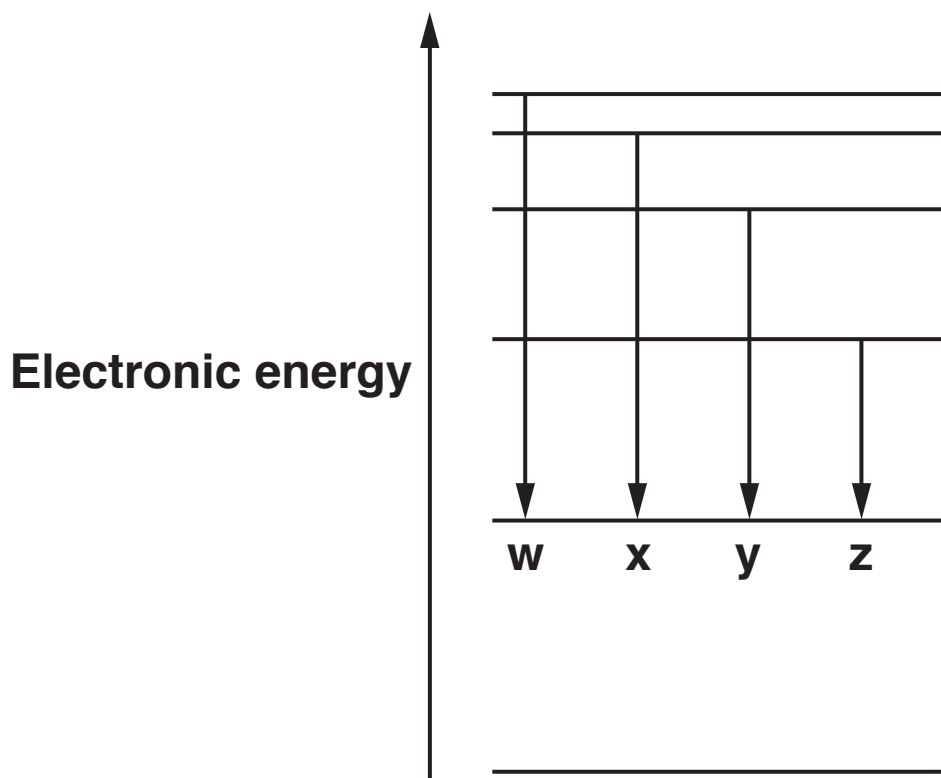
[2]

- (e) Gunpowder is used in fireworks, along with compounds of other elements. These compounds are used either as colourants or for special effects.
- (i) Lithium compounds in burning fireworks create a red colour. This red colour results from a particularly intense line at the red end of the emission spectrum of lithium.

Use the idea of electrons and electronic energy levels to **EXPLAIN** the origin of the red colour, and other lines, in the emission spectrum of lithium.

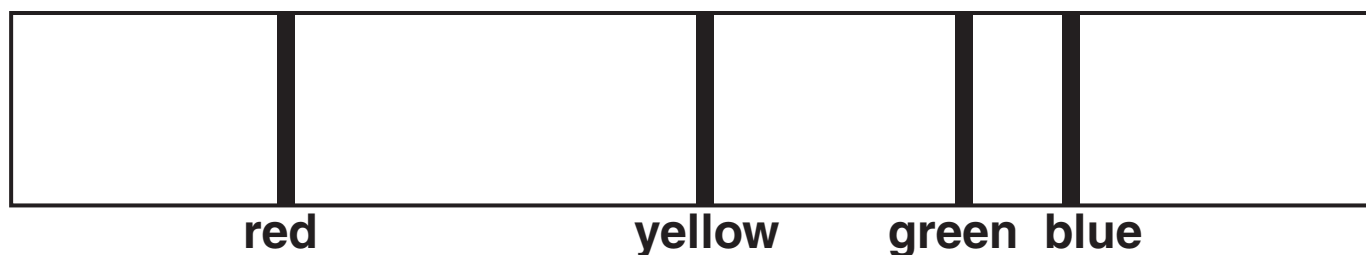
Use FIG. 3.1 below and FIG. 3.2 opposite to help in your explanation.

**FIG. 3.1** Electron movement and some electronic energy levels in a lithium atom.





**FIG. 3.2 Part of the visible emission spectrum of lithium.**



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[4]

- (ii) Which of the following would be an appropriate label for FIG. 3.2?

Put a tick (✓) in the box next to the correct answer.

Frequency → ☐

Wavelength → ☐

← Frequency ☐

[1]

- (iii) Explain why emission spectra can be used to identify the different elements present in a firework.**

\_\_\_\_\_

\_\_\_\_\_ **[1]**

- (iv) An element can also be identified by its absorption spectrum.**

**Describe ONE difference and ONE similarity between an absorption spectrum and an emission spectrum.**

**Difference** \_\_\_\_\_

\_\_\_\_\_

**Similarity** \_\_\_\_\_

\_\_\_\_\_

**[2]**

- (v) Zinc can be added to fireworks to create smoke as a special effect.  
This smoke is a man-made atmospheric pollutant.**

**What name is given to this TYPE of atmospheric pollutant?**

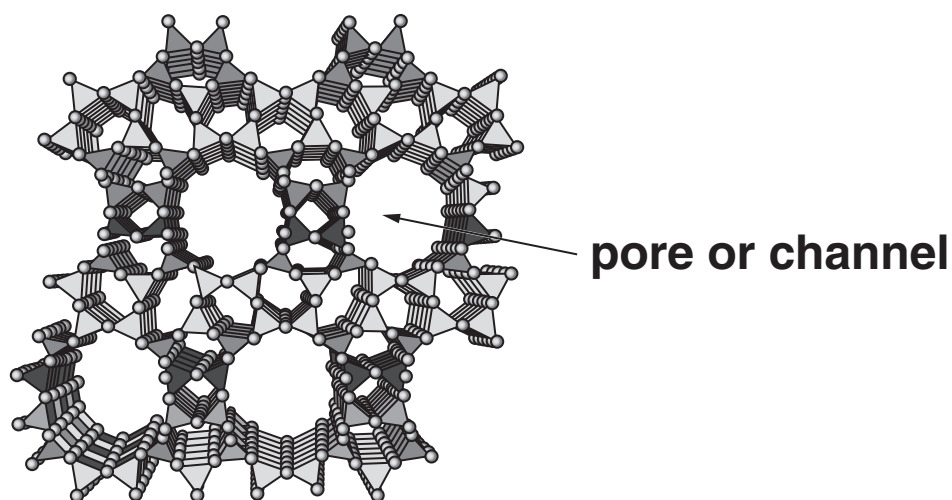
\_\_\_\_\_ **[1]**

**[TOTAL: 19]**

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- 4 Zeolites are microporous, sponge-like materials, developed from naturally occurring minerals. They have an enormous range of applications.

### A typical zeolite structure



- (a) Zeolites are made up of  $\text{SiO}_4$  units linked by sharing the oxygen atom at each corner.
- (i) Use electron pair repulsion theory to suggest the value of the O-Si-O bond angle in the  $\text{SiO}_4$  units.

Explain your reasoning.

O-Si-O bond angle = \_\_\_\_\_

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[3]

- (ii) Draw a diagram, using wedges, lines and dotted lines to represent the 3D shape of an  $\text{SiO}_4$  unit.

[1]

- (b) Zeolites can be used as heterogeneous catalysts in the cracking of crude oil.

- (i) Explain the terms 'heterogeneous' and 'catalyst'.

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[2]

- (ii) Write an equation, using molecular formulae, for the cracking of decane to produce an alkene with three carbon atoms and one other product.

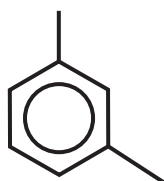
[1]

- (c) Zeolites also can be used to separate or trap molecules.

There are several structural isomers with the formula  $C_8H_{10}$ .

Two of these are shown below, labelled COMPOUND F and COMPOUND G.

COMPOUND F



COMPOUND G



- (i) Underline the name below that correctly describes these molecules.

alkane

arene

cycloalkane

alkene

[1]

- (ii) Using the same type of formula, draw another structural isomer of  $C_8H_{10}$  containing an aromatic ring.

[1]

- (iii) If a mixture of COMPOUNDS F and G is passed through certain zeolites, the isomers can be separated.

Use your knowledge of zeolite structure and the shape of the isomers to suggest how this separation occurs.

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[2]

- (iv) **COMPOUNDS F and G** are produced by reforming reactions in the petrochemical industry.

**Name the other product, apart from ring molecules, formed in a *reforming* reaction.**

\_\_\_\_\_ [1]

**[TOTAL: 12]**

**END OF QUESTION PAPER**



**ADDITIONAL ANSWER SPACE**

**If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).**








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