OCR
Oxford Cambridge and RSA

Friday 26 May 2017 – Morning

AS GCE CHEMISTRY B (SALTERS)

F331/01 Chemistry for Life

Candidates answer on the Question Paper.

OCR supplied materials:
- *Data Sheet for Chemistry B (Salters)* (inserted)

Other materials required:
- Scientific calculator

Duration: 1 hour 15 minutes

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- The Insert will be found inside this document.
- Write your name, centre number and candidate number in the boxes above. 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.
- Do **not** write in the barcodes.

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**.
- This document consists of **16** pages. Any blank pages are indicated.

Answer **all** the questions.

1 It is important to control the emissions from vehicle engines. This reduces atmospheric pollution and maximises engine performance.

(a) Selective catalytic reduction (SCR) is an emissions control method that injects liquid urea, $CO(NH_2)_2$, into the exhaust stream. The urea is then involved in an overall reaction that converts toxic nitrogen oxides to non-toxic products.

(i) Balance the equation below for the reaction of urea with NO.

$$2\ CO(NH_2)_2 + ... NO + O_2 \rightarrow ..... N_2 + ... H_2O + ... CO_2$$ **[1]**

(ii) 10.0 g of urea is sprayed into the exhaust stream of a diesel engine.

Calculate the maximum mass of NO that could be removed from the exhaust emissions.

maximum mass of NO removed = ... g **[3]**

(b) The urea is injected through a heterogeneous catalyst within the exhaust system.

Common catalysts include precious metals, such as platinum, which are used as a very thin layer deposited on a ceramic honeycomb.

(i) The catalysts are expensive.

Explain **one other** reason why only a very thin layer of the metal is used.

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..... **[1]**

(ii) The urea used has to be very pure, otherwise impurities will poison the catalyst.

Explain how a heterogeneous catalyst can be poisoned.

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

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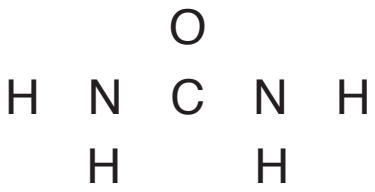
..... **[2]**

(c) **(i)** Draw a *'dot-and-cross'* diagram for urea, using the atoms below.

Show outer shell electrons only.



[2]

(ii) Use the concept of repulsion of electrons to work out and explain the bond angle around the carbon atom in the urea molecule.

Bond angle = ...°

Explanation: .....

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..... **[3]**

(d) Another way to reduce engine emissions is to use alternative fuels such as hydrogen. The only product of burning hydrogen is water. However, levels of NO in the exhaust emissions from a hydrogen fuelled engine are greater than from a petrol engine.

Explain how NO is produced in exhaust emissions.
Use your explanation to suggest a possible reason for the increased level of NO in a hydrogen fuelled engine.

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..... **[3]**

[Total: 15]

2 The Rosetta mission successfully landed the Philae spacecraft on a moving comet. The spacecraft contained several analytical instruments designed to gather information about the comet.

One of the instruments is a time-of-flight mass spectrometer. The mass spectrometer is used to determine the ratio of isotopes of hydrogen. These ratios are different in water found on the comet and water found on Earth.

(a) (i) Complete the following table showing the atomic structure of two isotopes of hydrogen.

Isotope	Number of protons	Number of neutrons	Number of electrons
^{1}H			
^{2}H			

[1]

(ii) Explain how a time-of-flight mass spectrometer is able to separate isotopes of elements.

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..... **[4]**

(b) Another instrument on the spacecraft contains the radioactive curium-244 isotope which undergoes alpha decay.

(i) Complete the nuclear equation for the alpha decay of the isotope curium-244.

$$^{244}_{96}Cm \longrightarrow {}^{4}_{2}He +$$

[2]

(ii) Curium was first isolated in 1944. The isotope curium-242 was produced by a fusion reaction. In this reaction alpha particles collided with plutonium-239 nuclei to produce the isotope curium-242 and one other particle.

Write the nuclear equation for the fusion process described above.

[2]

(iii) In the fusion reaction in part **(b)(ii)** the alpha particles are accelerated to high velocity and collide with the plutonium nuclei.

Explain why fusion only occurs in high velocity collisions.

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..... **[2]**

(c) Further data from the spacecraft detected a range of organic compounds, including propan-2-ol.

(i) In the boxes below draw the **skeletal** formulae of:

- propan-2-ol
- a structural isomer of propan-2-ol belonging to a **different** homologous series.

propan-2-ol	isomer belonging to a different homologous series

[2]

(ii) Name the homologous series which each of the above compounds belongs to.

propan-2-ol .....

isomer ..... **[2]**

[Total: 15]

3 Thermite reactions are highly exothermic reactions involving a metal powder and a metal oxide.

(a) The reaction of powdered iron(III) oxide, Fe_2O_3, and aluminium metal can be used to fill in cracks in railway lines. The reaction produces molten iron and aluminium oxide.

$$Fe_2O_3 + 2Al \longrightarrow 2Fe + Al_2O_3 \qquad \textbf{equation 3.1}$$

(i) It is difficult to measure the standard enthalpy change for the reaction in **equation 3.1** directly. However, a Hess cycle can be used to obtain the value for the enthalpy change of the reaction under standard conditions.

Using the following data, draw a Hess cycle and use it to calculate the standard enthalpy change of the reaction, $\Delta H^{\ominus}$, in **equation 3.1**.

Metal oxide	Standard enthalpy change of formation, $\Delta H^{\ominus}_f$ / kJ mol^{-1}
Al_2O_3	–1601
Fe_2O_3	–821

$\Delta H^{\ominus}$ = ... kJ mol^{-1} **[2]**

(ii) The reactants and products in **equation 3.1** must be in their *standard states* when calculating the standard enthalpy change of the reaction.

Explain the term *standard state.* Say what this state would be (at 298 K) for the reactants and products in **equation 3.1**.

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..... **[2]**

(b) Copper thermite uses copper oxide and aluminium metal. When ignited, this mixture produces a bright green light.
Analysis of the green light shows it to consist of several coloured lines at specific frequencies.

(i) What name is given to this kind of line spectrum?

..... **[1]**

(ii) Explain, in terms of changes between electronic energy levels, how this kind of line spectrum is formed.

You should use a labelled diagram in your answer.

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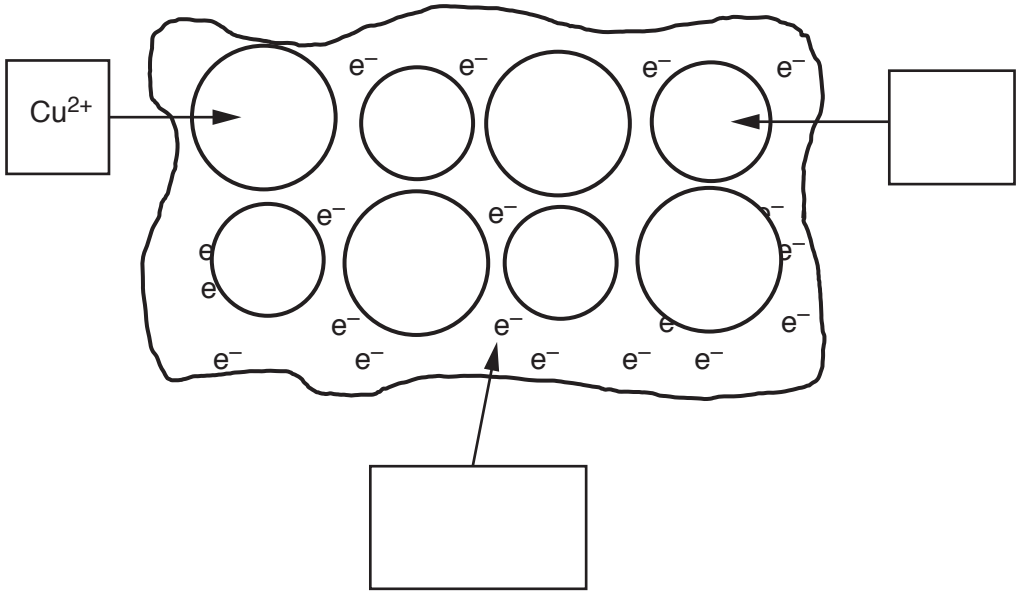
..... **[4]**

(c) The copper thermite mixture produces copper metal. Alloys of copper and aluminium are used in rocket fins.

The diagram below is a simple representation of the metallic structure of an alloy of copper and aluminium.

Write appropriate labels in the two empty boxes.



[2]

(d) In a variation of a thermite reaction it is possible to extract the non-metal silicon from its oxide SiO_2, which is the main component of sand.

The equation for this reaction can be represented as:

$$SiO_2(s) + 2Mg(s) \longrightarrow Si(s) + 2MgO(s)$$

The physical properties of some of the reactants and products of this reaction are shown in the table below.

Complete the table.

Reactant/Product	Melting point	Conduction of electricity	Bonding	Structure
SiO_2	very high	does not conduct in solid or when molten	covalent	
Si		semi-conductor		giant
MgO	very high		ionic	giant

[3]

[Total: 14]

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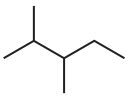
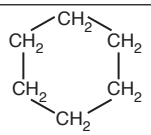
4 Crude oil is a mixture of many organic compounds and is separated into useful components by fractional distillation. In school laboratories a safer alternative mixture is used to show the process of fractional distillation.

(a) This alternative mixture contains some of the compounds in the table below.

(i) Complete the table.

Name	Molecular formula	Empirical formula	Skeletal formula	Structural formula
icosane				$CH_3(CH_2)_{18}CH_3$
2,7-dimethyloctane	$C_{10}H_{22}$	C_5H_{11}		$CH_3CH(CH_3)(CH_2)_4CH(CH_3)_2$
	C_7H_{16}	C_7H_{16}		$CH_3CH(CH_3)CH(CH_3)CH_2CH_3$
cyclohexane				
methoxypropane	$C_4H_{10}O$	$C_4H_{10}O$		$CH_3OCH_2CH_2CH_3$

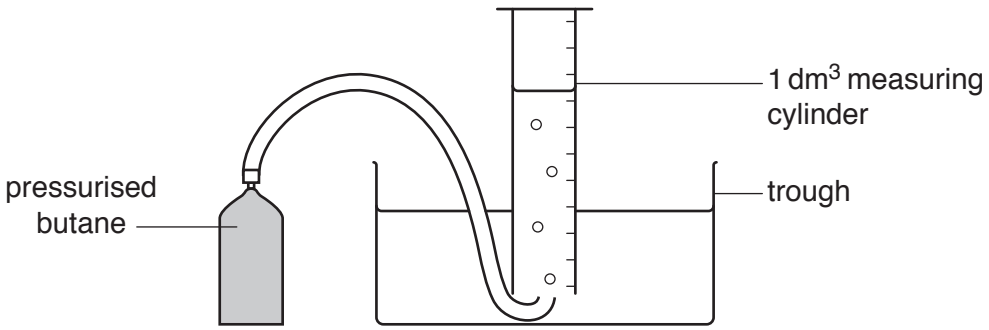
[4]

(ii) Name the physical property of the compounds in crude oil on which fractional distillation depends.

..... **[1]**

(b) Butane is a gas at room temperature and pressure. Butane is used as a fuel for lighters. Refill cans contain pressurised butane.

(i) A student decides to measure the volume occupied by one mole of butane gas at room temperature and pressure using the apparatus below.



The results of the experiment are as follows:

Mass of butane gas cylinder at start / g	255.00
Mass of butane gas cylinder at end / g	253.02
Volume of gas in measuring cylinder at start / cm^3	0
Volume of gas in measuring cylinder at end / cm^3	800
Temperature of room / °C	19

Use the above results to **calculate** the volume (in **dm^3**) that would be occupied by 1.0 mol of butane gas under the conditions of the experiment.

Give your answer to **two** significant figures.

volume occupied = ... dm^3 **[4]**

(ii) The textbook suggests that the volume occupied by one mole of any gas at room temperature and pressure should be 24 dm^3.

Suggest why the student's answer is lower than the textbook value.

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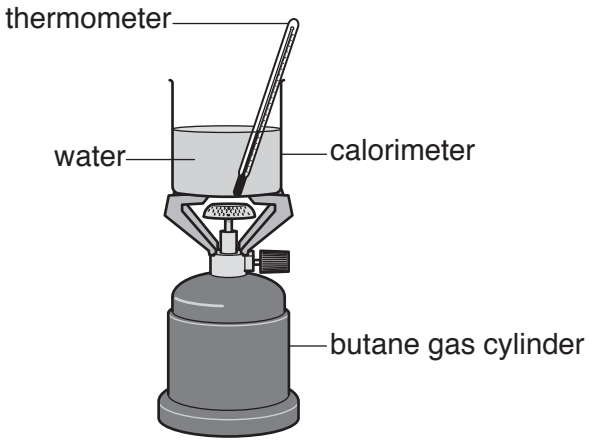
..... **[1]**

(c) The student then went on to find the enthalpy change of combustion of butane using the apparatus shown below.



(i) In order to calculate the enthalpy change of combustion, the student would have to make certain measurements using the apparatus above. The student would also have to look up (or know) some data.

List the measurements and the data below.

Measurements .....

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Data .....

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..... **[4]**

(ii) The student noticed that the gas cylinder was labelled 'contains butane and 2-methylpropane'.

The student reasoned that the presence of 2-methylpropane would make very little difference to the calculated value for the enthalpy change of combustion of butane.

Explain in terms of chemical bonds why the student's reasoning is correct.

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..... **[2]**

[Total: 16]

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).