OCR

RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary GCE

CHEMISTRY (SALTERS) 2850

Chemistry for Life

Wednesday **8 JUNE 2005** Morning 1 hour 15 minutes

Candidates answer on the question paper
Additional materials:
Data Sheet for Chemistry (Salters)
Scientific Calculator

Candidate Name	Centre Number	Candidate Number

TIME 1 hour 15 minutes

INSTRUCTIONS TO CANDIDATES

- Write your name in the space above.
- Write your Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers in the spaces provided on the question paper.
- Read each question carefully and make sure you know what you have to do before starting your answer.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [ ] at the end of each question or part question.
- You may use a scientific calculator.
- You may use the *Data Sheet for Chemistry (Salters).*
- You are advised to show all the steps in calculations.

FOR EXAMINER'S USE		
Qu.	Max.	Mark
1	19	
2	18	
3	22	
4	16	
TOTAL	75	

This question paper consists of 15 printed pages and 1 blank page.

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[Turn over

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Answer **all** the questions.

1 **(a)** One method used by geologists to date igneous rocks relies on the fact that radioactive elements are present in the rock.
These elements decay as part of a radioactive series.
One series starts with the radioactive uranium-238 isotope and ends with a stable lead isotope, lead-206.

(i) Complete the table below for the isotope, lead-206.

	number
protons	
neutrons	
electrons	

[3]

(ii) The first step in the series is the decay of uranium-238 by alpha emission.
Complete the following nuclear equation representing this step.

$$^{238}_{92}\text{U} \longrightarrow \overset{\cdots\cdots}{\underset{\cdots\cdots}{\quad}}\text{Th} + \overset{\cdots\cdots}{\underset{\cdots\cdots}{\quad}}$$

[3]

(iii) The half-life of this first step is very long and this enables the series to be used to date some of the oldest rocks on earth.

Explain the meaning of the term *half-life.*

.....

.....[2]

(iv) In a later step in this series an atom of an isotope of bismuth, Bi, decays to an atom of an isotope of polonium, Po.

Use the Periodic Table on your data sheet to decide what **type** of radioactive decay this is. Write your answer below.

.....[1]

[Turn over

(b) Another stage in this decay series results in the formation and then decay of an isotope of the **gas**, radon.

Suggest why this might result in an **underestimate** of the age of the rock.

.....

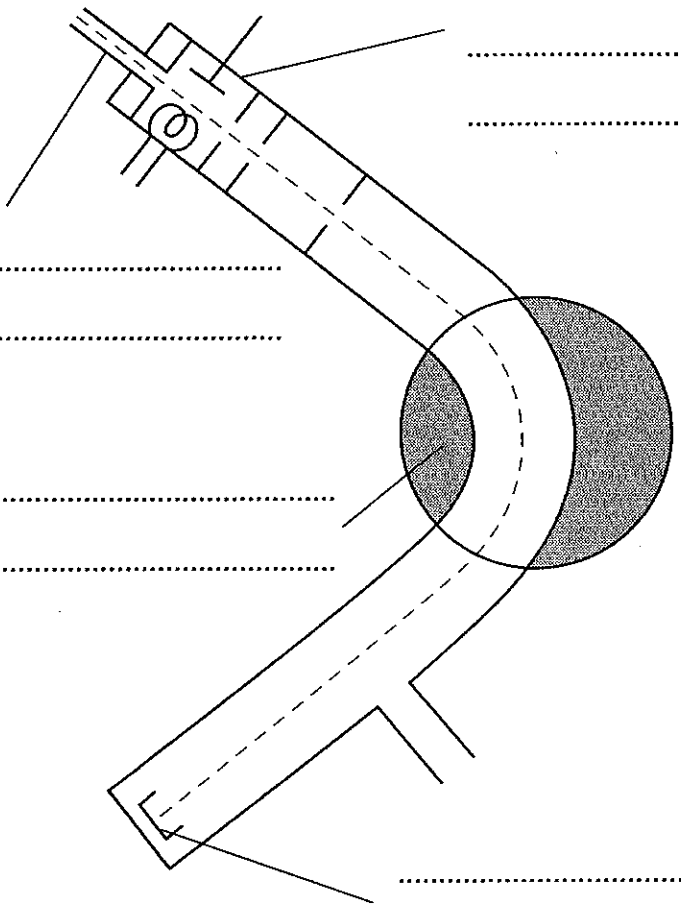
.....

.....[2]

(c) A mass spectrometer is used to find the relative amounts of lead-206 and the remaining uranium-238 in a sample of rock. The ratio gives the geologist an estimate of the age of the rock.

(i) Choose **four** of the following terms to label the simplified diagram of a mass spectrometer below.

ionisation chamber
sample inlet
ion detector
deflecting magnetic field
vacuum pump
accelerating electric field



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[4]

(ii) The dashed line (– – – –) on the diagram represents a $^{238}U^{+}$ ion being focussed onto the detector. How would the deflecting magnetic field need to be varied in order to focus a $^{206}Pb^{+}$ ion onto the detector?

.....[1]

(d) 'Pitchblende' is a uranium ore found in granite rocks. The uranium is present as an oxide.
The purified uranium oxide was analysed and found to contain 88.1% uranium by mass.

Calculate the empirical (simplest) formula of the uranium oxide.
A_r: U, 238; O, 16

empirical formula ..... [3]

[Total: 19]

2 Power stations generate electricity by burning fuels such as natural gas, coal or oil.
The energy given out is used to heat steam to drive turbines.
The more efficient a power station is, the more electricity it produces from a fixed mass of fuel. Heat losses reduce the overall efficiency of the process.

(a) Coal is used as a fuel for generating electricity in some very large power stations.

A student decides to investigate, in the laboratory, the heat transferred when using coal to heat a known mass of water. The student's results are set out below.

Starting mass of coal / g	20.00
Finishing mass of coal / g	18.80
Mass of water / g	200
Starting temperature of water / °C	18
Finishing temperature of water / °C	38

The energy transferred to the water for the mass of coal burned can be calculated using the following relationship.

energy transferred (J)	=	mass of water (g)	×	specific heat capacity of water ($J\,g^{-1}\,K^{-1}$)	×	temperature rise of water (K)

(i) Calculate the energy transferred, in **kJ**, to the water for the mass of coal the student burned.

The specific heat capacity of water = $4.2\,J\,g^{-1}\,K^{-1}$

energy transferred = ... kJ [2]

(ii) Calculate the **maximum** energy that could be released from burning this mass of coal. Assume coal is pure carbon.

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

Enthalpy change of combustion of carbon $\Delta H_c = -394\ kJ\ mol^{-1}$;
A_r: C, 12

energy released = ... kJ [3]

(iii) What percentage of the maximum possible energy was transferred to the water in the student's experiment? This is the efficiency of the process.

efficiency = ...% [1]

(b) Toxic oxides of nitrogen (NO_x) are produced when coal burns at high temperatures. Explain how this NO_x is produced.

.....

.....[2]

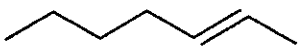
(c) Some power stations use fuel oil.
Fuel oil is a mixture of hydrocarbons with 30 to 40 carbon atoms in their chains.
Another use of these hydrocarbons is as a source of smaller organic molecules, which are produced by the process of cracking.

(i) Below are some possible products from the cracking of a long chain hydrocarbon. Label each of them from the following list.

~~**unbranched** alkane~~
branched alkane
unbranched alkene
branched alkene
cycloalkane.

A $CH_3—(CH_2)_{18}—CH_3$

.....

B 

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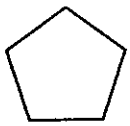
C 

.....

D $CH_3CH_2CH_2CH_2CH(CH_3)CH_2CH_3$

..... [4]

(ii) Name the **type** of structural formulae used to draw **B** and **C** above.

.....[1]

(iii) Many of the shorter chain hydrocarbons produced from cracking are used in petrol. Other processes such as isomerisation and reforming further modify straight chain hydrocarbons, producing products with a higher **octane number** than the original molecules.

Describe the characteristics of a *high octane* fuel.

.....

.....

.....[2]

(d) Hexane can be converted to other substances by the processes described in **(c)(iii).** Three of these substances are given below:

2-methylpentane
cyclohexane
benzene.

(i) Which of these substances is an arene?

.....[1]

(ii) Which is a structural isomer of hexane?

.....[1]

(e) The conversion of hexane to cyclohexane is an example of reforming.
What is the other product formed in this reaction?

.....[1]

[Total: 18]

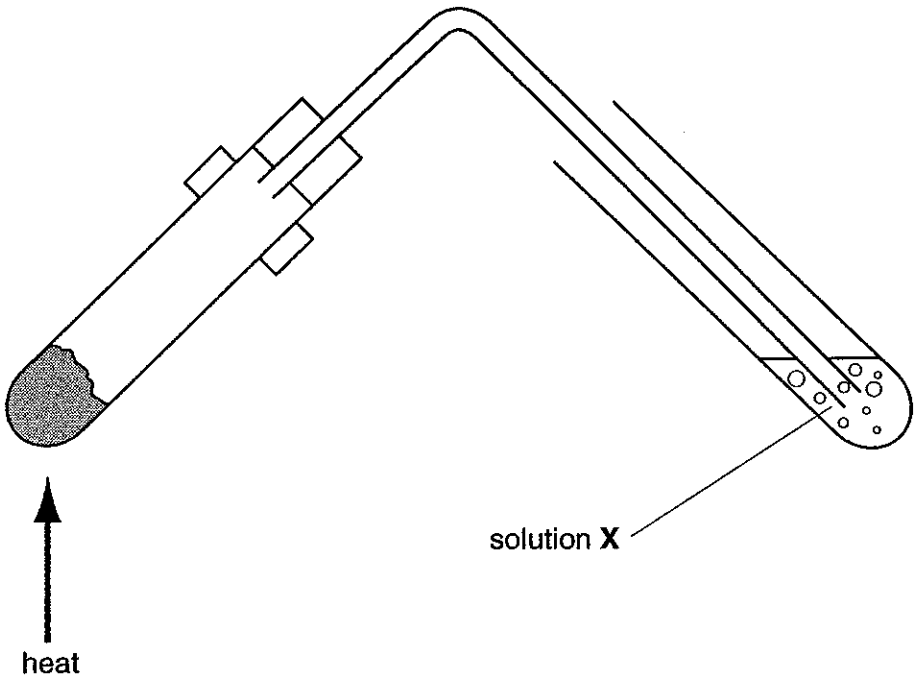
3 Actors in early theatre were literally 'in the limelight'. This was because limestone was heated strongly in front of the stage illuminating the actors.
The limestone (a naturally occurring form of calcium carbonate) decomposed to give calcium oxide and carbon dioxide, emitting a bright light in the process.

(a) Write a balanced equation, including state symbols, for the thermal decomposition of limestone.

[3]

(b) Another form of limestone, 'dolomite', proved less effective as stage lighting.
This was probably because 'dolomite' contains both calcium and magnesium carbonate.
Magnesium carbonate does not emit light when it decomposes.

The following diagram shows an apparatus used by a student in an experiment to try to determine which of the above carbonates decomposes more readily.



(i) Name solution **X**.

..... [1]

(ii) Describe the changes you would see in solution **X**, if the carbonate you are testing decomposes on heating.

.....[1]

(iii) Describe how you could use the experiment to show that magnesium carbonate decomposes more readily than calcium carbonate.
What difference would you observe?

.....

.....

.....

.....

.....[2]

(c) Powdered limestone and 'slaked lime' (calcium hydroxide) have long been used by farmers to help reduce the acidity of some soils.

(i) Suggest a reason why the neutralising effects of limestone on the soil last longer than those of slaked lime.

.....

.....[1]

(ii) What property of slaked lime is important in neutralising acid soils?

.....[1]

(iii) Complete and balance the following equation for the reaction of calcium hydroxide with hydrochloric acid.

$$Ca(OH)_2(s) + \ldots HCl(aq) \longrightarrow \ldots\ldots\ldots(aq) + \ldots\ldots\ldots(l)$$

[3]

(d) Calcium and magnesium are both members of the same group in the Periodic Table.
How many electrons are in the outer shell of elements in this group?

answer ..... [1]

(e) We can use ionisation enthalpies to predict the reactivities of the elements in the group.

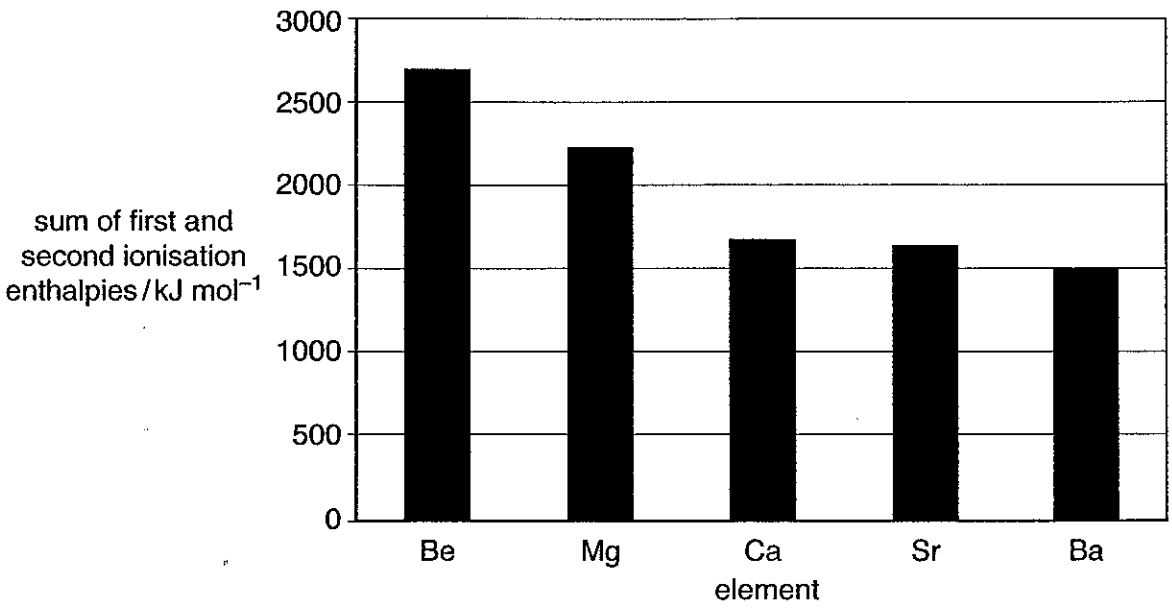
(i) Write equations, with state symbols, to represent the first and second ionisation enthalpies for calcium.

first ionisation enthalpy

second ionisation enthalpy

[3]

(ii) The bar chart below shows the sum of the first and second ionisation enthalpies for elements in this group of the Periodic Table.



Describe and explain the **general** trend in ionisation enthalpies illustrated by the bar chart.

Your answer should include reference to the factors that affect the loss of electrons and the consequent trend in reactivity as the group is descended.

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.....[6]

[Total: 22]

TURN OVER FOR QUESTION 4

4 'Antifreeze' is added to car radiators in the winter to prevent the water from freezing, expanding and cracking the engine.
One common antifreeze is the compound ethane-1,2-diol, $HOCH_2$-CH_2OH.

(a) (i) Draw the **full structural** formula of ethane-1,2-diol. [1]

(ii) An alternative, and less toxic, compound that can also be used as an antifreeze is propane-1,2-diol, $HOCH_2$-$CH(OH)$-CH_3.
What is the **molecular** formula for this compound?

.....[1]

(iii) Water and anti-freeze mix very well.
Describe and explain the entropy change that will occur on mixing.

.....

.....

.....[2]

(b) Ethane-1,2-diol is made in a two stage process. The first stage is the reaction of ethene with oxygen, in the presence of a silver catalyst. A cyclic compound, **epoxyethane** (molecular formula, C_2H_4O) is produced.

The silver catalyst in this reaction is behaving as a heterogeneous catalyst.

(i) Explain what is meant by the terms *heterogeneous* and *catalyst*.

.....

.....[3]

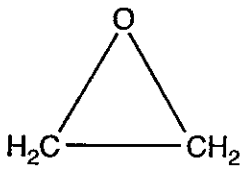
(ii) An unavoidable side-reaction in this first stage is shown below.

$$CH_2{=}CH_2(g) + 3O_2(g) \longrightarrow 2CO_2(g) + 2H_2O(g)$$

What volume of oxygen is needed to react with 1 dm^3 of ethene in this reaction? (Assume all volumes are measured under the same conditions of temperature and pressure.)

volume = ... dm^3 [1]

(iii) The structure of epoxyethane is given below.



Name the functional group in epoxyethane.

.....[1]

(iv) The bond angles in the ring are about 60°.
What is the usual bond angle when carbon forms four bonds?
Explain how you arrived at this value using the principle of electron pair repulsion.

usual bond angle =

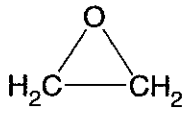
explanation .....

.....

.....

.....[3]

(c) The second stage in the production of ethane-1,2-diol is the reaction of epoxyethane with water.
The equation is shown below.



$+ \quad H_2O \longrightarrow HOCH_2\text{-}CH_2OH$

epoxyethane **ethane-1,2-diol**

The standard enthalpy changes of formation for the above compounds are shown in the table below.

compound	$\Delta H_{f,298}^{\ominus}$ / kJ mol^{-1}
epoxyethane	–78
water	–268
ethane-1,2-diol	–455

(i) What is the standard state at 298 K for water?

.....[1]

(ii) Calculate the enthalpy change for the above reaction using the data in the table.

ΔH = ... kJ mol^{-1} [3]

[Total: 16]

END OF QUESTION PAPER