OXFORD CAMBRIDGE AND RSA EXAMINATIONS

AS GCE

F331/01

CHEMISTRY B (SALTERS)

Chemistry for Life

FRIDAY 22 MAY 2015: Morning

DURATION: 1 hour 15 minutes

plus your additional time allowance

MODIFIED ENLARGED 24pt

Candidate forename		Candidate surname	

Centre number						Candidate number				

Candidates answer on the Question Paper.

OCR SUPPLIED MATERIALS:

Data Sheet for Chemistry B (Salters) (inserted)

OTHER MATERIALS REQUIRED:

Scientific calculator

READ INSTRUCTIONS OVERLEAF

DC (NH/CGW) 6132904847 113946

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 pages 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.

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Answer ALL the questions.

1 The need for rapid data transfer systems has led to the development of fibre optic cables. The Group 4 elements silicon, Si, and germanium, Ge, are important in the manufacture of fibre optic cables.

(a) Complete the following table for the three most abundant isotopes of silicon.

Isotope	Number of protons	Number of neutrons	Number of electrons
^{28}Si			
^{29}Si			
^{30}Si			

[1]

(b) Germanium has five naturally occurring isotopes. A sample of germanium is analysed in a time-of-flight mass spectrometer. The first stage in the spectrometer is vaporisation and the final stage is detection.

(i) Name the other three stages in the order they occur in the mass spectrometer.

Stage 2: _____

Stage 3: _____

Stage 4: _____

[1]

(ii) Explain how the stages from (i) enable particles of different masses to be separated.

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

_____

_____

_____

_____

_____

_____

_____ **[3]**

(iii) The composition of the sample of germanium is shown below.

Isotope	^{70}Ge	^{72}Ge	^{73}Ge	^{74}Ge	^{76}Ge
Percentage abundance	20.55	27.37	7.67	36.74	7.67

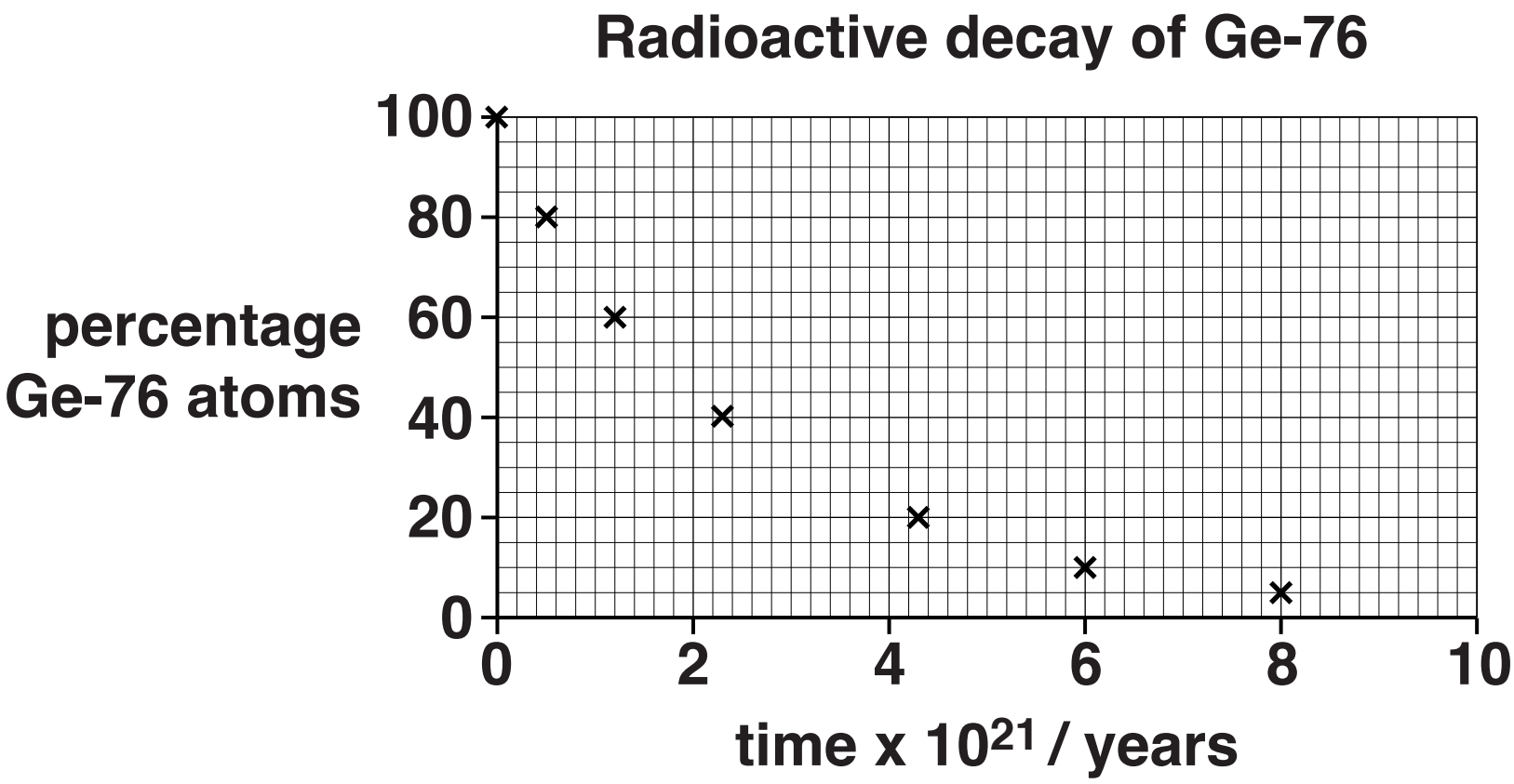
Calculate the relative atomic mass of this sample of germanium, giving your answer to THREE significant figures.

relative atomic mass = _____ **[2]**

(iv) The ^{76}Ge isotope undergoes radioactive decay.

Use the graph below to calculate a value for the half-life of ^{76}Ge.

Show your working on the graph.



half-life = _____ × 10^{21} years [2]

(v) ^{76}Ge undergoes 'double beta' decay. This type of decay produces TWO beta particles per atom decaying.

Write a nuclear equation for the 'double beta' decay of ^{76}Ge.

[2]

(c) The protons and neutrons in the nucleus are responsible for most of the mass of an atom. However, atoms are electrically neutral overall.

(i) Complete the table below.

Particle	Relative mass	Relative charge
proton		
neutron		
electron		

[1]

(ii) The atomic radius of an atom is determined by the number of energy levels containing electrons.

Give the electronic structure of germanium in terms of its occupied main energy levels (shells).

_____ [1]

(d) Germanium had not been discovered when Mendeleev was constructing his Periodic Table. However, he left a gap in his arrangement for an element, yet to be discovered, that he called 'Eka silicon'. This was later confirmed as germanium.

Why did Mendeleev decide an element was yet to be discovered at this position in his arrangement?

_____

_____ [1]

(e) In the modern Periodic Table, electronic structure governs the position of an element in the Table.

Which part of the electronic structure of an element shows:

the period the element is in? _____

the group the element is in? _____

[2]

[TOTAL: 16]

2 Hydrogen peroxide, H_2O_2, was used as a rocket fuel in the UK's first rocket launcher 'Black Knight' and more recently in 'Bloodhound', a supersonic racing car.

(a) Hydrogen peroxide decomposes according to the following equation:

$$2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g) \qquad \textbf{Equation 2.1}$$

(i) Calculate the enthalpy change of reaction, ΔH_r for the decomposition of hydrogen peroxide, as represented by Equation 2.1.

Use the standard enthalpy change of formation, ΔH_f, values in the table below.

	ΔH^{e}_{f} / kJ mol^{-1}
$H_2O_2(l)$	–188
$H_2O(l)$	–286

ΔH_r = _____ kJ mol^{-1} **[2]**

(ii) ΔH_r is NOT the standard enthalpy change of formation of water, ΔH_f.

Write the equation for the reaction that has the enthalpy change ΔH_f for water.

Include state symbols.

[2]

(iii) The reaction in Equation 2.1 is accompanied by an increase in entropy.

Give TWO reasons why an increase in entropy might have been expected.

_____

_____ [2]

(b) Hydrogen peroxide is used as a propellant because the heat evolved during its decomposition raises the temperature to about 600 °C. This causes a rapid expulsion of the oxygen and water (as steam).

Calculate the combined volume, in dm^3, of steam and oxygen produced by the decomposition of 90 g of H_2O_2.

Assume one mole of any gas occupies 70 dm^3 at the temperature reached in the decomposition.

volume = _____ dm^3 [3]

(c) Hydrogen peroxide can also be used with kerosene as a propellant.

Kerosene, obtained from crude oil, is a mixture of both aliphatic and aromatic hydrocarbons with between 10 and 15 carbon atoms.

(i) Describe the difference between an aliphatic and an aromatic hydrocarbon.

_____

_____ [1]

(ii) **The heat from the decomposing hydrogen peroxide ignites the kerosene.**

Write an equation for the complete combustion of the hydrocarbon decane, which is a component of kerosene with 10 carbon atoms.

[1]

(iii) **Apart from its use as a propellant or fuel, kerosene is extensively 'cracked'. One product of cracking is an unsaturated molecule.**

Explain the term 'unsaturated'.

_____

_____ **[1]**

(iv) **Substances called zeolites are used in the cracking process.**

Give the reason for the use of zeolites in cracking.

_____ **[1]**

(d) Give ONE environmental advantage of using hydrogen peroxide as a fuel instead of kerosene.

_____

_____ **[1]**

[TOTAL: 14]

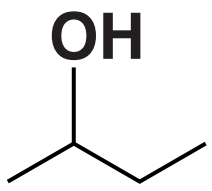
3 Anaesthetics used in the mid-19th century included dinitrogen oxide, N_2O (laughing gas) and ethoxyethane $(C_2H_5)_2O$.

(a) (i) Draw the skeletal formula for ethoxyethane and name the homologous series to which it belongs.

homologous series _____ [2]

(ii) Compound A is a structural isomer of ethoxyethane.

Name compound A and give its molecular formula.



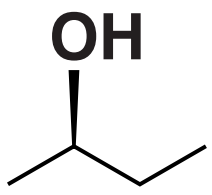
Compound A

name _____

molecular formula _____

[2]

(iii) One form of compound A is represented by the structure below.



Explain the significance of the 'wedge' bond.

_____

_____ [1]

(b) **Dinitrogen oxide is one of several oxides of nitrogen. Some oxides of nitrogen are found in car exhaust emissions.**

Give the formula of an oxide of nitrogen found in exhaust emissions and explain how it is formed.

formula _____

explanation _____

_____

[3]

(c) **The heat from a glowing splint placed in dinitrogen oxide, N_2O, decomposes the gas and the splint relights.**

Write an equation for this decomposition of dinitrogen oxide.

[1]

(d) Dinitrogen oxide is only weakly anaesthetic and ethoxyethane may cause unpleasant side effects. Therefore, new anaesthetics were introduced in the early 20th century. One new anaesthetic, cyclopropane, is effective and has few side effects.

(i) Cyclopropane can be made from propane.

Name the process used in the oil industry to convert chain alkanes to cyclic alkanes.

Name the other product formed in this process.

process _____

other product _____

[1]

(ii) Cyclopropane is not a very stable molecule and forms explosive mixtures with air.

The lack of stability of cyclopropane is related to its 'ring strain'. The ring is strained because the C–C–C bond angle is different from that predicted by electron pair repulsion theory.

State and explain the angle predicted by the electron pair repulsion theory and state how the actual bond angle differs.

_____

_____

_____

_____

_____

_____ [4]

(iii) **The C–C bond enthalpy in cyclopropane is lower than the average C–C bond enthalpy.**

Explain the term 'bond enthalpy' and explain why this is often described as an average value.

_____

_____

_____ **[2]**

[TOTAL: 16]

4 Chemists have been helping archaeologists study a collection of Iron Age glass beads discovered in Scotland. These beads were made by the effect of high temperatures on sand from beaches or deserts.

It is possible to identify whether a glass bead has been produced using beach sand or desert sand by identifying the ratio of strontium to zirconium in the glass.

(a) Beach sand contains crushed shells made of calcium carbonate, $CaCO_3$.

Strontium often replaces some of the calcium in these shells.

(i) Explain why strontium can replace calcium in calcium carbonate.

_____

_____ [1]

(ii) High temperatures are needed in glass manufacture. Under these conditions strontium and calcium carbonates decompose to their oxides.

Draw a 'dot-and-cross' diagram to show the bonding in strontium oxide.

Show outer electron shells only.

[2]

(iii) **Atomic emission spectroscopy can confirm the presence of zirconium in the glass. The atomic emission spectrum of zirconium is unique.**

Describe how an atomic emission spectrum is produced.

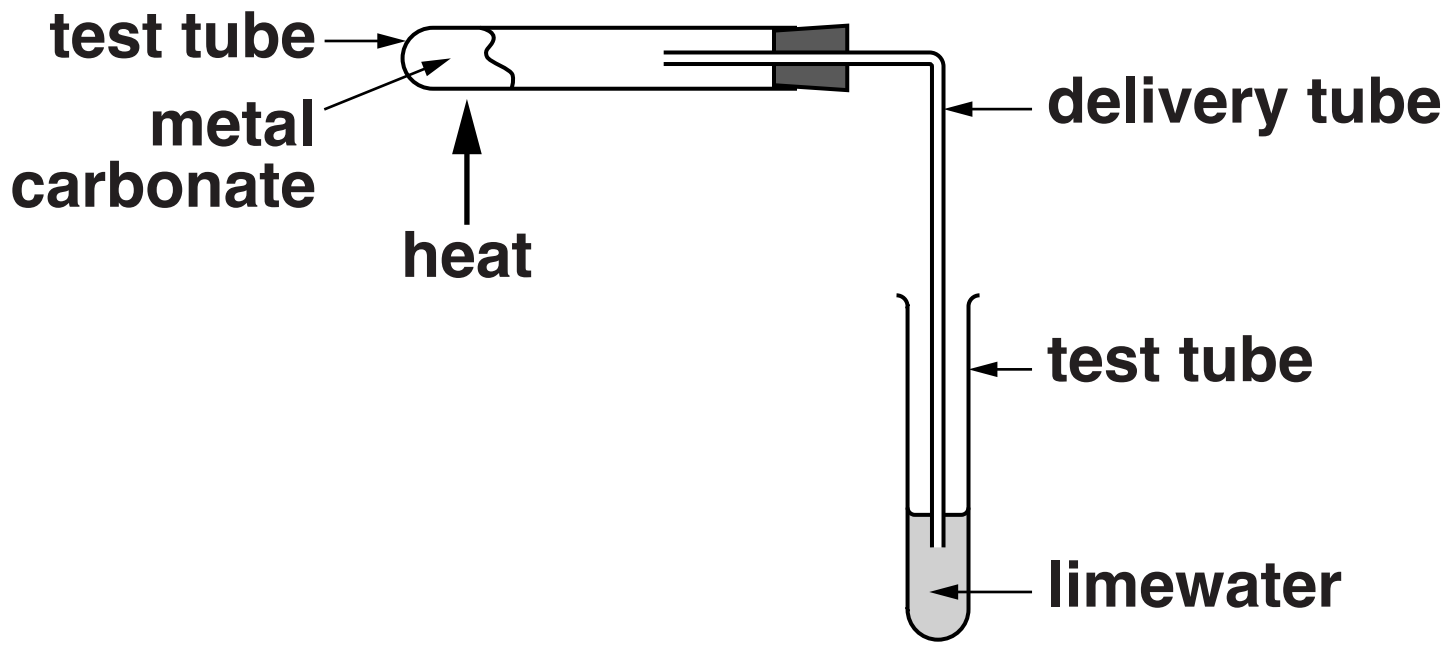
Explain why an atomic emission spectrum is unique to a particular element.

You may use a diagram to help explain your answer.

[5]

(b) **A student decides to investigate whether calcium carbonate or strontium carbonate has the lower thermal stability.**

The student heats separate samples of the carbonates to high temperature using the following apparatus:



(i) **Give TWO variables the student would need to keep constant.**

_____

_____ **[2]**

(ii) **Describe what you would expect the student to SEE when the two carbonates are heated.**

You may assume the temperature gets high enough for both carbonates to decompose.

_____

_____ **[2]**

(c) The strontium in sand is present as strontium carbonate but zirconium is present in sand as zirconium silicate.

Suggest the formula of the silicate ion using knowledge of group properties in the Periodic Table.

_____ **[2]**

[TOTAL: 14]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

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

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