

**Advanced Subsidiary GCE
CHEMISTRY B (SALTERS)**

F331 QP

Unit F331: Chemistry for Life

Specimen Paper

Candidates answer on the question paper.

Time: 1 hour 15 min

Additional Materials:

Data Sheet for Chemistry B (Salters) (Inserted)
Scientific calculator

Candidate
Name

Centre
Number

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Candidate
Number

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INSTRUCTIONS TO CANDIDATES

- Write your name, Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Do **not** write in the bar code.
- Do **not** write outside the box bordering each page.
- WRITE YOUR ANSWER TO EACH QUESTION IN THE SPACE PROVIDED.

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.
- 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**.

FOR EXAMINER'S USE		
Qu.	Max.	Mark
1	13	
2	12	
3	19	
4	16	
TOTAL	60	

This document consists of **13** printed pages, **3** blank pages and a *Data Sheet for Chemistry B (Salters)*.

Answer **all** the questions.

- 1 In April 1986, the nuclear reactor at Chernobyl in the Soviet Union exploded, releasing a mixture of radioactive isotopes into the atmosphere.

One of the main isotopes released was $^{131}_{53}\text{I}$ which can cause cancer, though in controlled amounts it is used as a tracer.

- (a) (i) In the following table, write the numbers of protons, electrons and neutrons in an atom of $^{131}_{53}\text{I}$.

	number of particles
protons	
neutrons	
electrons	

[1]

- (ii) What is meant by the term *isotopes*?

.....

[2]

- (iii) Radioactive isotopes are unstable and many decay by emitting either α - or β -particles.

The table below summarises some of the properties of α - and β -particles. Complete the table by choosing words or numbers from the following list:

small; large; nil; paper; aluminium foil; lead; 0; -1; +2; +1

property	α -particle	β -particle
relative charge		
relative mass	4	negligible
stopped by	paper	
deflection by electric field		large

[2]

- (iv) The relative atomic mass of iodine is given in the Periodic Table as 126.9.

Explain why this value is not a whole number.

.....

[1]

(b) (i) Radioactive isotopes such as $^{131}_{53}\text{I}$ can cause cancers.

However, $^{131}_{53}\text{I}$ can be used as a radioactive tracer for investigating patients suffering from a possible deficiency of iodine.

Suggest how it can be explained to a patient that it is relatively safe to use a dangerous radioactive substance as a tracer in their bodies.

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

(ii) The half-life of $^{131}_{53}\text{I}$ is 8 days. A sample manufactured for use in hospitals has an original count rate of 16 000 counts per minute. It can be used as a tracer as long as its count rate is at or above 500 counts per minute.

For how long after manufacture can $^{131}_{53}\text{I}$ be used as a tracer?

answer =days [2]

(c) In 1911, Geiger and Marsden fired α -particles at gold foil and found that most passed through unchanged, while just a few were deflected by large amounts. This was evidence for the nuclear model of the atom.

Explain the results of the Geiger and Marsden experiments using a nuclear model of the atom.

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

[Total: 13]

[Turn over

2 Cans of 'self-heating' coffee were available until recently.

Inside the can, in separate compartments, were calcium oxide and water. When a button was pressed these reacted together to give enough heat to warm up the coffee.

(a) What term is used to describe a reaction that gives out heat?

..... [1]

(b) The reaction between calcium oxide, CaO, and excess water forms calcium hydroxide solution.

Write a balanced equation for the reaction below. Include state symbols.

[2]

(c) A group of students set out to determine the enthalpy change of this reaction by placing a known mass of calcium oxide into 250 cm³ of water in an insulated flask and measuring the temperature rise.

The group of students recorded the measurements shown in the table below.

mass of calcium oxide used	10 g
volume of water used	250 cm ³
temperature rise	50 °C

Calculate the heat transferred to the water (in kJ) by the reaction of 1.0 mol of CaO(s).

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

specific heat capacity of water = 4.2 kJ K⁻¹ kg⁻¹; density of water = 1.0 g cm⁻³

heat transferred = kJ [4]

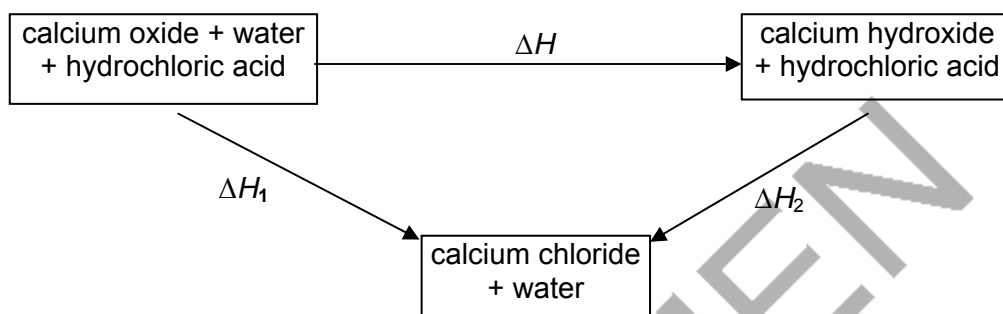
(d) The reaction will produce solid calcium hydroxide if the exact molar ratio of water to calcium oxide is used, as represented by the balanced equation in (b) above.

(i) Suggest **one** reason why it is very difficult to measure this enthalpy change directly.

.....

 [1]

(ii) This enthalpy change can, however, be measured indirectly using an enthalpy cycle as shown below.



Explain how the cycle can be used to calculate the enthalpy change ΔH .

.....

 [2]

(e) Magnesium oxide is a possible alternative substance to use in the self-heating cans.

Use your knowledge of the Periodic Table to suggest why magnesium oxide might be considered a possible alternative to calcium oxide.

.....

 [2]

[Total: 12]

[Turn over

3 Environmental issues are a vital consideration in chemistry, with the idea of 'green chemistry' becoming more and more important.

(a) In the left hand column below are some of the pollutants emitted from car exhausts.

For each pollutant, briefly explain in the right hand column how the pollutants are formed.

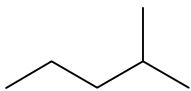

The first one has been done for you.

pollutant	how the pollutants in the exhaust gases are formed
oxides of nitrogen	From the reaction of nitrogen and oxygen gas in the air, at the high temperatures of the combustion chamber.
carbon monoxide	
oxides of sulfur	
hydrocarbons	

[3]

(b) Reforming is a process which converts straight-chain alkanes into new compounds that burn more effectively in engines, reducing pollution. These new compounds include branched alkanes, cycloalkanes and arenes.

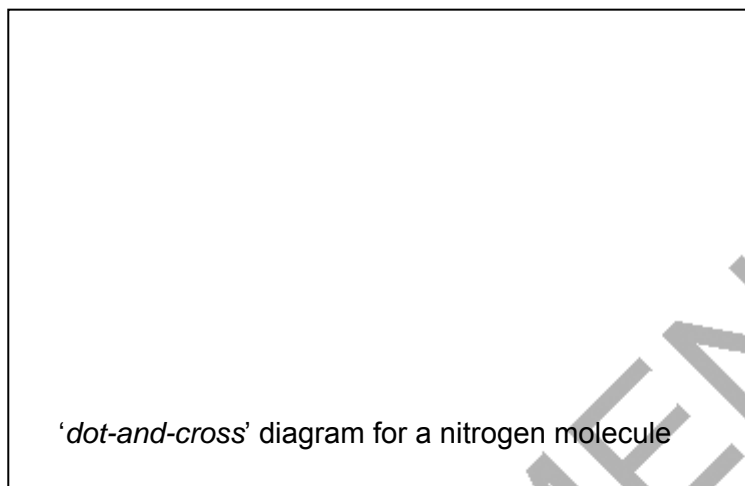
Classify the molecules in the table by ticking the appropriate boxes.

hydrocarbon	straight-chain	branched chain	cycloalkane	arene
				
				
$\text{CH}_3(\text{CH}_2)_5\text{CH}_3$				
C_6H_6				

[2]

- (iv) Emissions of most pollutants are reduced when biodiesel is used instead of petroleum diesel, with one exception. The exception is that levels of nitrogen oxides (NO_x) increase in the exhaust. A reason for this might be that the temperature at which biodiesel burns in the engine is higher than for petroleum diesel.

Draw a 'dot-and-cross' diagram for a nitrogen molecule. Use it to explain why a large amount of energy would be needed to break up the molecule.



.....

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.....

.....

[4]

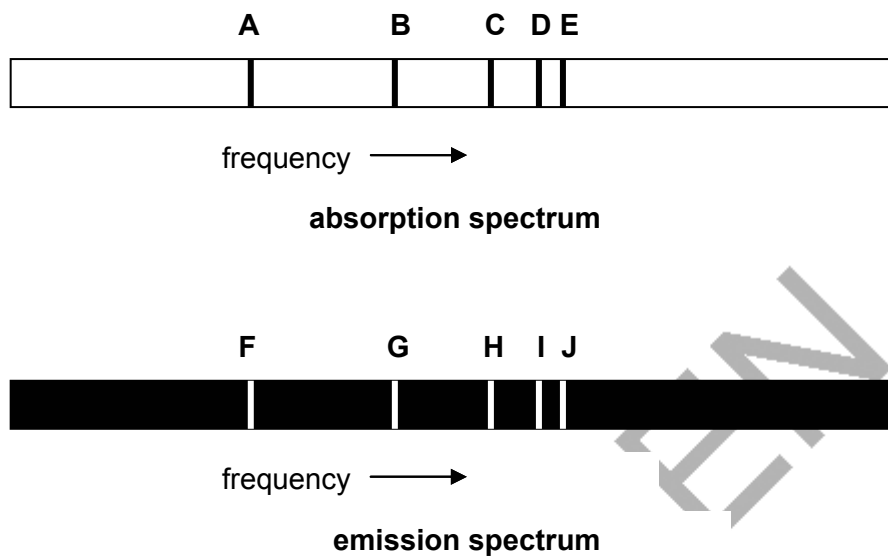
[Total: 19]

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4 Most of the chemical elements found on Earth were produced in stars.

(a) Absorption and emission atomic spectra show the presence of elements in the stars. The wavelengths involved are in the UV or visible portion of the electromagnetic spectrum.

(i) The labelled diagrams below represent part of an atomic absorption spectrum and an atomic emission spectrum, drawn to the same scale.



Using the letters (**A–J**), choose a line from the spectra which would correspond to:

1. the line of lowest frequency in the emission spectrum;

.....

2. the line representing the absorption of the largest amount of energy.

..... [2]

(ii) The emission and absorption spectra shown are for the same element. What evidence is there from the two spectra that this is the case?

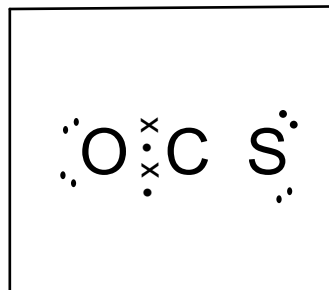
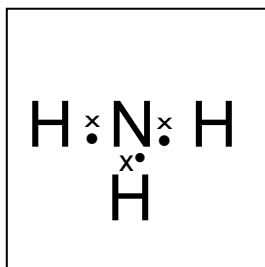
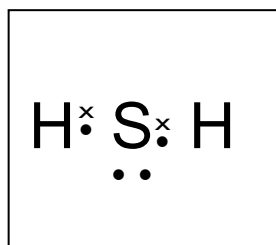
..... [1]

[Turn over

- (b) Elements react together to form molecules in the dense clouds in interstellar space. These molecules can be detected by the characteristic radiowaves they emit.

Molecules of H_2S , NH_3 and OCS (similar to CO_2) have been discovered.

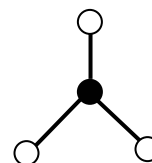
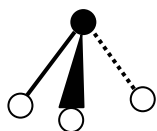
- (i) Complete the 'dot-and-cross' diagram for each molecule in the boxes below.



[3]

- (ii) Use the theory of electron pair repulsion to decide which of the possible shapes below represents the shape of each molecule.

Write the formula of each of the molecules H_2S , NH_3 and OCS underneath its shape.



[3]

- (iii) What is the significance of the wedge (▲) and the dotted line (⋯) in the shape on the left?

.....

.....

.....

[1]

- (c) Radio-astronomy also revealed the possible presence of long chains of carbon atoms in outer space.

In the 1980s, Professor Harry Kroto and other workers were investigating these chains. Professor Kroto was trying to recreate, in the laboratory, conditions that might account for the presence of carbon chains.

He tried vaporising carbon rods in an electric arc and he analysed the soot from the vaporised carbon in a mass spectrometer.

- (i) In a time-of-flight mass spectrometer, how are the ions accelerated and why do they take different times to reach the detector?

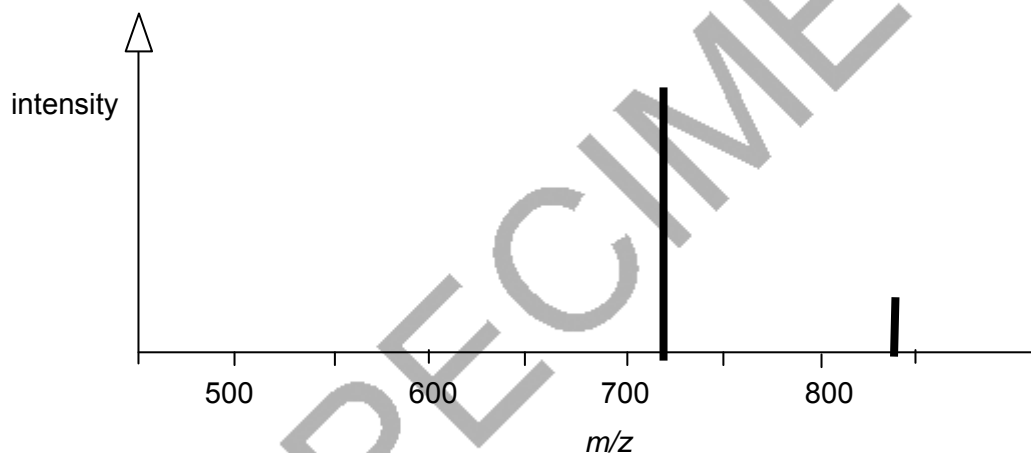
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.....

.....

..... [2]

- (ii) A simplified version of the mass spectrum is shown below. On the basis of this spectrum, Professor Kroto suggested the presence of a C_{60} molecule.



Explain how the mass spectrum indicates the presence of a C_{60} molecule.

.....

.....

..... [2]

[Turn over

- (iii) This C_{60} form of carbon (later named buckminsterfullerene) is unusual in that it is a simple molecule.

Up until this discovery the only two forms of carbon thought to exist were the giant molecular structures of diamond and graphite.

Below is a table showing some physical and chemical properties of the three forms of carbon. Tick **two** boxes in the last column which correspond to a property that supports **only** the simple molecular model for C_{60} .

property	diamond	graphite	C_{60}	property supports simple molecular model
density/g cm ⁻³	3.52	1.9–2.3	1.69	
hardness scale (hardest 10–softest 1)	10	1–2	1–2	
melting point/°C	3550	3652–3697	sublimes around 800	
solubility	insoluble	insoluble	soluble in organic solvents	

[2]

[Total: 16]

Paper Total [60]

END OF QUESTION PAPER

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The maximum mark for this paper is **60**.

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Question Number	Answer	Max Mark
1(a)(i)	53; 78; 53 respectively	[1]
(ii)	Same atomic no./protons (1); different mass no./ neutrons (1)	[2]
(iii)	+2; low/small (1); -1; aluminium/lead (1) (one mark for each column)	[2]
(iv)	average/mean of isotopes (1)	[1]
1(b)(i)	use small doses (1); therefore limited exposure (1)	[2]
(ii)	10,000 to 500 = 5 half-lives (1); 5 x 8days = 40 days (1)	[2]
1(c)	most of atom empty space/very low density electrons allowing particles to pass undeflected(1); positive protons in nucleus (1) deflect α -particles a lot(1) AW	[3]
	Total	[13]
2(a)	exothermic	[1]
2(b)	$\text{CaO(s)} + \text{H}_2\text{O(l)} \rightarrow \text{Ca(OH)}_2\text{(aq)}$ correct equation(1); state symbols(1)	[2]
2(c)	Energy transferred = $250 \times 4.2 \times 50$ (52,500J)(1); moles CaO = $10/56$ (0.179)(1); energy per mole = $52500/0.179$ (293.3kJ)(1); 290 (sig fig mark)(1) allow ecf's	[4]
2(d)(i)	hard to prevent calcium hydroxide dissolving as it is formed	[1]
(ii)	energy change is independent of route (AW) (1); $\Delta H = \Delta H_1 - \Delta H_2$ (1)	[2]
2(e)	Mg in same group(1); therefore would expect similar reactivity of elements/compounds(1)	[2]
	Total	[12]
3(a)	CO – partial/incomplete combustion(1); SO_x – combustion of sulfur impurities/atoms in fuel(1); hydrocarbons – unburnt fuel(1);	[3]
(b)	branched; cycloalkane; straight; arene; four correct 2 marks; 2/3 correct 1 mark	[1]

Question Number	Answer	Max Mark
(c)	Any five from the following: Reactants <i>adsorb</i> on catalyst surface (1) ✎ : <i>must be spelled correctly</i> Bonds in reactants weaken and break (1) New/product bonds form (1) Products diffuse away from surface (1) coke bonds to surface (1) more strongly/irreversibly/coats or blocks surface(1)	[5]
(d)(i)	one of: renewable; non-toxic; biodegradable; lower emissions	[1]
(ii)	entropy increases(1); more ways of arranging/more disorder when mixed (1); than when separate(1) ;	[3]
(iii)	oxygenates	[1]
(iv)	$\begin{array}{c} + \\ + \text{ N } \vdots \text{ N } : \\ + \quad \vdots \\ \quad \quad \cdot \end{array}$ lone pairs(1); six bonding electrons(1); <u>triple</u> bond (1); high bond enthalpy/very strong (1);	[4]
Total		[19]
4(a)(i)	1. F (1) and 2. E (1) respectively	[2]
(ii)	Lines in exactly the same position (1);	[1]
(b)(i)	(H ₂ S) lone pair (two dots) (1); (NH ₃) lone pair (1); OCS (two dots /two crosses) (1)	[3]
(ii)	H ₂ S (bent); NH ₃ (trigonal pyramid); OCS (linear) (one mark each) (3)	[3]
(iii)	wedge: bond sticking out of paper dotted, behind paper (1)	[1]
(c) (i)	accelerated by an electric field/charged plates (1) time depends on mass (1)	[2]

Question Number	Answer					Max Mark
(ii)	Peak at 720(1); must be sixty carbon atoms (12 x 60 = 720) (1);					[2]
(iii)	property	diamond	graphite	C ₆₀	supports simple molecular model	
	density/g cm ⁻³	3.52	1.9–2.3	1.69		
	hardness scale (hardest 10 – softest 1)	10	1–2	1–2		
	melting point/°C	3550	3652–3697	sublimes around 800	√	
	solubility	insoluble	insoluble	soluble in organic solvents	√	
	Total					[16]
	Paper Total					[60]

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Assessment Objectives Grid (includes QWC)

Question	AO1	AO2	AO3	Total
(1)(a)(i)	1			1
(1)(a)(ii)	2			2
(1)(a)(iii)	2			2
(1)(a)(iv)	1			1
1(b)(i)		2		2
1(b)(ii)		2		2
1(c)		3		3
2(a)	1			1
2(b)		2		2
2(c)			4	4
2(d)(i)		1		1
2(d)(ii)	2			2
2(e)		2		2
3(a)	3			3
3(b)	2			2
3(c)	5			5
3(d)(i)	1			1
3(d)(ii)	3			3
3(d)(iii)	1			1
3(d)(iv)		2		2
3(d)(iv)		2		2
4(a)(i)	2			2
4(a)(ii)		1		1
4(b)(i)		3		3
4(b)(ii)	3			4
4(b)(iii)	1			1
4(c)(i)	2			2
4(c)(ii)			2	2
4(c)(iii)		2		2
Totals	32	22	6	60

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