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Examiners' report

A LEVEL

CHEMISTRY B (SALTERS)

OCR Level 3 Advanced GCE in Chemistry B (Salters)

H433

For first teaching in 2015

H433/03 Summer 2025 series

Version 1

Contents

Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates.

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. A selection of candidate responses is also provided. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.

A full copy of the question paper and the mark scheme can be downloaded from Teach Cambridge.

Paper 3 series overview

The H433/03 component assesses content from across all teaching modules but places particular emphasis on practical skills.

Candidates are required to use knowledge and understanding of principles and concepts in the planning of experimental and investigative work and in the analysis and evaluation of data.

Chemical literacy is assessed through extended response questions as well as the comprehension of, and use of, data from a practical insert

Question styles include short answer (structured questions, problem solving, calculations, practical) and extended response questions.

This paper gave a good range of marks among candidates. Lower-attaining candidates gained marks in the late teens and the higher-attaining candidates achieved marks greater than 45.

Level of response questions

Candidates' skills in answering these have continued to improve and they are able to structure their answers in a logical way and address all parts of the question. They also managed to answer succinctly and there were very few instances of extra space being needed.

The level of response question on the thermal stability of group II carbonates (Question 1(e)) proved the more problematic for some candidates, where failure to respond to all parts of the question limited marks. The other LoR (4b) relating to making the solution proved more straight forward and was generally answered well.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• logically addressed all the chemistry knowledge, understanding and practical considerations needed to specifically answer the LoR questions. • laid out calculations carefully, explaining what each step represented, e.g. moles of a reactant or mass of a product. Rearrangement of expressions such as K_c were also clearly shown, allowing for error carried forward marks in some cases.	• did not read the question stem (including the Insert) carefully enough and produced responses which were not addressing the questions asked.

Question 1 (a) (i)

1 This question is about the properties of some Group 2 alkaline earth metals and their compounds.

(a)
(i) The term 'alkaline' refers to oxides and hydroxides of the Group 2 elements.

Explain why calcium oxide is described as alkaline.

Include an appropriate equation.

Explanation: ....

....

Equation:

[2]

A significant minority of candidates did not answer this question using calcium oxide in their explanation and/or equation.

Question 1 (a) (ii)

(ii) Explain why the Group 2 elements are known as **s block** elements.

....

.... **[1]**

Broadly well answered.

Question 1 (b)

(b) Strontium sulfate is used in fireworks. Strontium gives a red colour when ignited.

A frequency of red light from the strontium spectrum is 4.62×10^{14} Hz.

Calculate the energy per mole of photons of this frequency in $kJ\,mol^{-1}$.

Give your answer to an **appropriate** number of significant figures.

Energy = ... $kJ\,mol^{-1}$ **[3]**

Correctly answered by many. Occasionally candidates lost a mark for giving the answer to the wrong number of significant figures.

Question 1 (c) (i)

(c) Barium sulfate is very insoluble in water.

(i) Solutions containing sulfate ions give a white precipitate with barium chloride solution.

Write an **ionic** equation for the formation of this white precipitate.

Include state symbols.

[1]

Some students did not include state symbols but the main error seemed to be including the chloride ion in the equation.

Question 1 (c) (ii)

(ii) A solution has $[SO_4^{2-}] = 0.10\,mol\,dm^{-3}$.

Calculate the smallest $[Ba^{2+}]$ in the solution which will just give a white precipitate.

For barium sulfate, $K_{sp} = 1.0 \times 10^{-10}\,mol^2\,dm^{-6}$.

$[Ba^{2+}]$ = ... $mol\,dm^{-3}$ **[2]**

This question was fairly straightforward for most candidates.

Question 1 (d)

(d) Calcium and potassium are in the same period of the periodic table.

Explain why calcium has the higher melting point.

....

....

....

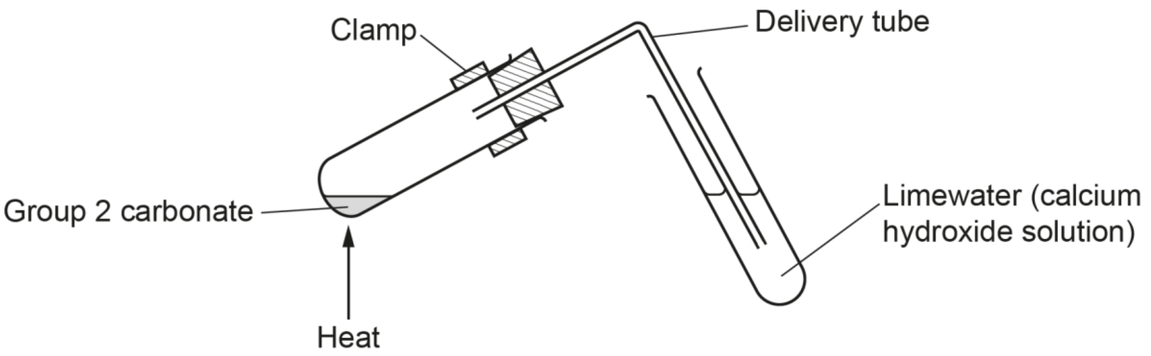
.... **[2]**

Misconception

A significant minority of students tried to answer this in term of ionic bonding or intermolecular forces of attraction, rather than the ideas involved in metallic bonding.

Question 1 (e)*

(e)* A group of students use the apparatus below to show the trend in thermal stability of the Group 2 carbonates.



Describe how the students should use this apparatus **safely** to show the trend.

Describe the observations that the students should obtain and explain the theory behind these observations.

....

....

....

....

....

....

.... **[6]**

Broadly well answered with a range of levels achieved. There were some answers which dealt with a completely different experiment, e.g. adding acid and also only generic safety issues (goggles, hair tied back etc) were often addressed, rather than issues specific to this practical. However, this is an LoR question and therefore not points marked, so it was still possible for candidates to score well with the odd mistake or idea missing.

See exemplar 1 below.

Exemplar 1

Set up the ~~apparat~~ apparatus as shown, with the boiling tube held firmly by a clamp attached to a clamp stand. Use a bunsen burner on a blue flame with the opening half-way so that it is not a roaring flame. The carbonate will produce CO_2 at a rate that ~~is inversely proportional to it's stability~~ increases as stability decreases, so once heating starts a timer should be started. Record the time taken for the limewater to become cloudy enough that a piece of paper with a cross drawn on it is not visible when held behind. Once this is achieved, remove the delivery tube from the limewater while the bunsen burner is still burning to avoid the liquid travelling up the tube during cooling, leading to ~~a possible~~ the glass shattering. Turn off the bunsen burner and allow the boiling tube to cool before resetting the apparatus with a new group 2 carbonate and repeating. Differences in thermal **[6]**

stability between ~~cat~~ group 2 carbonates are caused by differences in charge density, as a larger group 2 ~~~~ cation has a lower charge density so it does not distort the large carbonate ion as much, ~~~~ which ~~~~ requires more energy to remove, leading to a higher thermal stability. Therefore group 2 carbonates going down the group should be expected to have longer times and lower rate of CO_2 production ~~and higher~~ due to their higher thermal stability.

This exemplar clearly addresses all aspects of this well-known practical, including methodology, expected observations, interpretation of said observations and most notably, specific safety issues relevant to this experiment. The answer is well structured and thoroughly deserving of L3 and 6 marks.

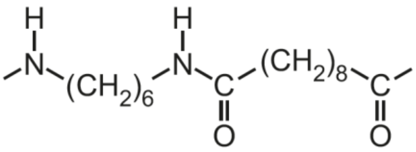
Question 2 (a) (i)

2 This question is about two useful polymers, nylon and polystyrene.

(a) There are several different nylon structures.

One type of nylon can be made in the laboratory by the polymerisation reaction of the two monomers, 1,6-diaminohexane and 'sebacoyl chloride'.

The repeat unit of the nylon formed is shown:



nylon repeat unit

(i) Name the nylon shown in this repeat unit.

.... **[1]**

There appeared be a distinct set of candidates who understood the naming of nylons well, but many candidates were unsure of how to do this.

Question 2 (a) (ii)

(ii) The monomer sebacoyl chloride is an acyl chloride.

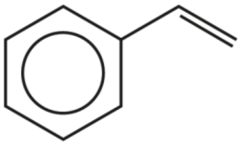
Draw a **skeletal** formula for sebacoyl chloride.
Use the nylon repeat unit above to help you.

[2]

This question was broadly well answered.

Question 2 (b)

(b) The monomer styrene is shown:



styrene

Styrene polymerises to polystyrene.
This type of polymerisation differs from the type of polymerisation that forms nylon.

Name the **types** of polymerisation that form polystyrene and nylon.
Explain how these types of polymerisation differ.

....

....

....

....

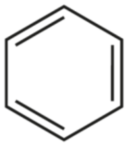
....

.... **[4]**

This question was broadly well answered. A common mistake was quoting water as the small molecule lost in the condensation reaction and there was often difficulty in clearly explaining the nature of addition polymerisation. This question discriminated well between candidates of differing attainments across the paper.

Question 2 (c) (i)

(c) The aromatic ring in styrene can be represented by either of the two structures below.



structure A

structure B

(i) Explain, in terms of bond lengths, why **structure A** is a **less** accurate representation than **structure B**.

....

....

....

.... **[2]**

Unfortunately, a minority of candidates did not answer this question in terms of bond lengths and therefore could not be given marks.

Question 2 (c) (ii)

(ii) The aromatic rings in styrene are stabilised by delocalisation.

Explain what **delocalisation** means.

....

....

....

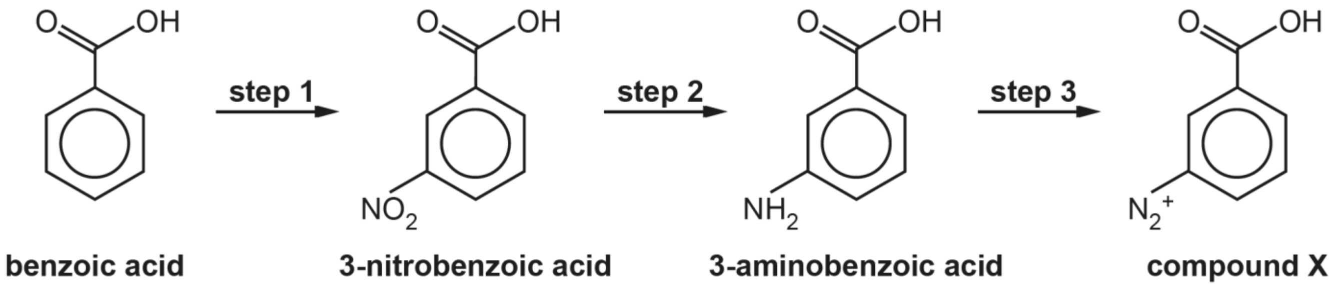
.... **[2]**

Many candidate answers to this question were rather vague and therefore often only scored zero or one mark. A common example was candidates stating that 'the electrons are free to move around the molecule' rather than identifying that one electron from each ring carbon becomes shared around the ring.

Question 2 (d) (i)

(d) Styrene can be oxidised to benzoic acid.

Compound **X** can be made from benzoic acid as shown:



(i) Give the reagents for **steps 1**, **2** and **3**.

(Use the Data Sheet if necessary.)

step 1 ....

step 2 ....

step 3 ....
[3]

Steps 1 and 2 usually well answered with Step 3 less often, with many students not realising the need for sodium nitrite/nitrate(III).

Question 2 (d) (ii)

(ii) Name the functional group shown at the bottom left in compound **X**.

.... **[1]**

Many recognised this as the diazonium group/ion.

Question 2 (d) (iii)

(iii) Suggest a type of useful compound that can be made using compound **X**.

.... **[1]**

This was usually well answered. There was no common pattern to incorrect responses.

Question 3 (a) (i)

3 Methanol, CH_3OH, is produced by the chemical industry as a building block for many everyday products.

(a) Methanol can be made industrially from methane by a two-step process.

The **first step** involves the steam reforming of the methane:

$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$ $\Delta H = +206\,\text{kJ mol}^{-1}$ **Equation 3.1**

(i) For the forward reaction in **Equation 3.1**, $\Delta_{sys}S = +216\,\text{J mol}^{-1}\,\text{K}^{-1}$.

Explain how **Equation 3.1** shows that the value of $\Delta_{sys}S$ will be positive.

....

.... **[1]**

A majority of candidates answered this correctly.

Question 3 (a) (ii)

(ii) A student says that the forward reaction in **Equation 3.1** is feasible at all temperatures.

Comment on the student's statement, giving the correct chemistry where necessary.

....

....

....

....

....

.... **[3]**

?

Some candidates attempted to answer this question in terms of equilibrium rather than the total entropy change involved. Candidates scoring all three marks often did their own calculation showing how temperatures above their value would be feasible and why.

See exemplar 2 below.

Exemplar 2

$\Delta H_{total} S$ must be greater than ~~towards~~ zero.
$\Delta H_{total} S = \Delta_{sys} S - \frac{\Delta H}{T}$
$0 = 216 - \frac{206000}{T}$
$T = 953.7K$
therefore student wrong as forward reaction only feasible above 953.7K **[3]**

This exemplar is typical of the way higher-attaining candidates chose to answer this question. First and foremost, the candidate explains that ΔS_{total} must be positive and then uses the expression.

$\Delta S_{total} = \Delta S_{sys} + \Delta S_{surr}$ where $\Delta S_{surr} = -\Delta H/T$ to calculate the temperature (954K) above which ΔS_{total} will be positive.

Question 3 (b) (i)

(b) The **second step** in the manufacture of methanol involves the reaction:

$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$ $\Delta H = -90\,kJ\,mol^{-1}$ **Equation 3.2**

The process operates at a pressure of 5 MPa and a temperature of 700 K in the presence of a copper-based catalyst.

(i) A mixture containing 3.20 mol of carbon monoxide and 2.50 mol of hydrogen is allowed to reach equilibrium in a container of volume 2.00 dm^3 under the above conditions.
0.488 mol of methanol is formed.

Calculate the value of the equilibrium constant, K_c, for **Equation 3.2** under these conditions.

Give the units.

K_c = ... units ....**[5]**

Candidates have become much better at clearly laying out calculations and certainly this question allowed a range of error carried forward marks when candidates had made one or two mistakes earlier in the question. This question discriminated well between candidates at different grades.

See exemplar 3 below.

Exemplar 3

CO	H_2	CH_3OH
1 :	2	1
3.2	2.5	0
−0.448	−0.448×2	+0.448
2.752	1.604	0.448

$$[CO] = \frac{2.752}{2} = 1.376\ mol\ dm^{-3}$$

$$[H_2] = \frac{1.604}{2} = 0.802\ mol\ dm^{-3}$$

$$[CH_3OH] = \frac{0.448}{2} = 0.224\ mol\ dm^{-3}$$

$$K_c = \frac{[CH_3OH]}{[CO] \times [H_2]^2} = \frac{0.224}{1.376 \times 0.802^2} = 0.2530... \approx 0.253 \ (3\ sf)$$

$$\frac{(\cancel{mol\ dm^{-3}})}{(\cancel{mol\ dm^{-3}}) \times (mol\ dm^{-3})^2} = dm^6\ mol^{-2}$$

K_c = 0.253 units $dm^6\ mol^{-2}$ **[5]**

This exemplar scoring 3 marks illustrates the importance of structuring calculations. The initial concentrations of CO and H_2 are wrong but the expression for K_c is correct and the value of the follow on calculation is also correct, giving two error carried forward marks plus one more for the correct units.

Question 3 (b) (ii)

(ii) Explain, using **Equation 3.2**, why the equilibrium yield of methanol increases with increasing pressure, and suggest why an even higher pressure is **not** used.

....

....

....

....

....

.... **[3]**

This question was well answered.

Question 3 (b) (iii)

(iii) A copper-based catalyst is used in the reaction.
Catalysts speed up reactions.

Explain why catalysts only affect the **rate** at which equilibrium is set up and **not** the equilibrium yield.

....

....

....

.... **[2]**

There were a number of answers which talked generally about the nature of catalysis but did not drill down into the key explanations required to answer the question stem. E.g. Catalysts speed up <u>both</u> the forward and backward reaction <u>equally</u>.

Question 4 (a)

4 This question refers to the **Practical Insert** that is provided with this paper.

(a) In the paperclip solution, IO_4^- ions oxidise Mn^{2+} ions to MnO_4^-, being reduced themselves to IO_3^- ions.

The oxidation and reduction half equations for this reaction are:

$IO_4^- + 2H^+ + 2e^- \rightarrow IO_3^- + H_2O$

$Mn^{2+} + 4H_2O \rightarrow MnO_4^- + 8H^+ + 5e^-$

Write the full ionic equation for the reaction.

[2]

This proved problematic for many candidates. Some did not cancel hydrogen ions and water that were evident on both sides of the equation, and some tried to balance charges using additional electrons.

Question 4 (b)*

(b)* At the end of **Part 1** of their method, the students have a solution of MnO_4^- in a beaker.

They need to make the solution up to 100.0 cm^3.

How should they do this accurately?

....

....

....

....

....

.... **[6]**

This was seemingly a relatively straightforward LoR, and indeed many answers were very good, but nevertheless a range of levels were scored by candidates. Some candidates unfortunately described on the wrong experiment, concentrating on making the solution from paper clips, which prevented achieving marks in the higher levels.

Exemplar 4 below, however, misses one of the key actions in making up homogeneous solution.

Exemplar 4

100.0 cm^3 ?

- Pour solution of MnO_4^- into a volumetric flask ~~of~~.
- Rinse the beaker previously containing MnO_4^- solution with distilled water and pour contents into the volumetric flask so to not leave any behind → all MnO_4^- is in volumetric flask, reducing risk of error ~~a~~ when calculating ~~the~~ concentration.
- Fill volumetric flask up to the line (100 cm^3) using distilled water. It is filled when the meniscus bottom is on the line.
- As ~~the~~ the miniscus approaches the line, use a pipette for better accuracy + precision to ~~get~~ ~~the~~ fill volumetric flask to exactly 100 cm^3.

[6]

This exemplar marked at L2 just misses out on a L3 mark because one of the main points (the mixing/inverting of the solution) is missed. The rest is a succinct description of the expected sequence in preparing an accurate volume of a particular solution.

Question 4 (c)

(c) Explain why a green filter is used in the colorimeter.

[2]

Most candidates identified green as the complementary colour but a much smaller number mentioned maximum absorption.

Question 4 (d)

(d) Use the students' results to calculate the percentage by mass of manganese in a paperclip.

Percentage by mass = ... % **[3]**

Many candidates scored all the marks for this question – those that did not often did not read an accurate concentration value from the graph or used the wrong molar mass in the final stage.

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