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Examiners' report

CHEMISTRY B (SALTERS)

H033
For first teaching in 2015

H033/01 Summer 2019 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. 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 can be downloaded from OCR.

Paper 1 series overview

This synoptic paper targets all three assessment objectives requiring candidates to:

- demonstrate and apply knowledge and understanding of scientific ideas, processes, techniques and procedures in theoretical and practical contexts
- handle qualitative and quantitative data
- analyse, interpret and evaluate scientific information to make judgements and reach conclusions
- show an ability to develop practical procedures.

To do well, candidates needed to demonstrate a broad knowledge and understanding of inorganic, organic and physical chemistry and be able to carry out multi-step calculations.

Candidates who did well on this paper generally produced concise, well-structured written responses to multi-mark questions and demonstrated a methodical approach to mathematical elements.

Candidates who did less well gave long responses which lacked coherence, had limited recall of specific chemical processes and had difficulty remembering and applying mathematical formulae.

In general, candidates demonstrated knowledge and understanding of organic and inorganic reactions and the factors affecting rate and equilibrium. Often candidates found describing laboratory practical procedures and questions relating to the graphical representation of data difficult.

There was little evidence to suggest that candidates had insufficient time for this paper.

Note

From this series students have been provided with a fixed number of answer lines and an additional answer space for level of response questions. The additional answer space will be clearly labelled as additional, and is only to be used when required. Teachers are encouraged to keep reminding students about the importance of being concise in their answers. Please follow this link to our SIU (https://www.ocr.org.uk/administration/support-and-tools/siu/alevel-science-538595/)

Section A overview

The majority of MCQs (Questions 1-20) were answered correctly by the majority of candidates. Candidates should be advised that they should not overwrite the letter in the answer box if they change their mind but should cross out the first response and write the new response alongside the box. A very small number of candidates left questions unanswered. Specific questions, particularly those which candidates found challenging, are indicated below

Question 3

3 Which molecule has no lone pairs?

A $BeCl_2$

B CF_4

C NH_3

D BH_3

Your answer ☐ **[1]**

The prevalence of options A and B among responses suggests that many candidates only considered the electrons on the central atom, ignoring the lone pairs on fluorine and chlorine. Answer C was rarely chosen.

Question 13

13 What is the action (if any) of concentrated sulfuric acid on HBr?

A No reaction

B Forms SO_2

C Forms H_2S

D Forms sulfur

Your answer ☐ **[1]**

The majority of candidates correctly identified hydrogen sulfide but a significant proportion chose sulfur dioxide.

Question 14

14 Which molecule forms permanent dipole – permanent dipole bonds as its strongest intermolecular bond?

A CH_3CHO

B CH_3COOH

C CCl_4

D CO_2

Your answer [ ] **[1]**

The most common response (C) indicates that many candidates considered the polarity of the bond rather than the molecule.

Question 16

16 Which substance **cannot** be made in a single step from C_2H_4?

A C_2H_5OH

B C_2H_5Br

C C_2H_6

D $C_2H_5NH_2$

Your answer [ ] **[1]**

All four possible responses to this question were seen in candidate responses.

Question 17

17 Which substance will **not** give 3-methylpentane when reduced with hydrogen?

A 2-ethylbut-1-ene

B 3-methylpent-2-ene

C 2-methylpent-1-ene

D 3-methylpent-1-ene

Your answer [ ] **[1]**

Many candidates drew structures for the four options but were still unable to identify the correct response.

Question 18

18 What is **not** a reaction of 2-methylpropan-2-ol?

A Reaction with an acid anhydride to form an ester

B Oxidation to a ketone

C Dehydration to an alkene

D Reaction with HCl to form a haloalkane

Your answer [ ] **[1]**

The largest group of responses were correct (B) but all three other options were well represented.

Question 20

20 Which of the following is a redox reaction?

A $2Na + 2H_2O \rightarrow 2NaOH + H_2$

B $2CrO_4^{2-} + 2H^+ \rightarrow Cr_2O_7^{2-} + H_2O$

C $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O$

D $MgCO_3 \rightarrow MgO + CO_2$

Your answer [ ] **[1]**

Candidates who annotated the equations with oxidation numbers were more likely to choose the correct response.

Section B overview

The range of questions in Section B allowed candidates to demonstrate their breadth of knowledge and understanding across the specification.

Question 21 (a)

21 Ammonia is an important chemical used to make fertilisers. It is made in industry by the following equilibrium reaction.

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \quad \Delta_r H^{\ominus} = -92\,kJ\,mol^{-1}$ **Equation 1.1**

(a) Write down the value of $\Delta_f H^{\ominus}$ for $NH_3(g)$.

Include the unit in your answer.

.... **[1]**

In this question, many candidates did not distinguish between the heats of reaction and formation while a significant number gave either 184 (92x2); 30.6(7) (92/3) or 36.8 (92x2/5). Most candidates gave the correct negative sign and the correct units.

Question 21 (b)

(b) State what is happening to the forward and reverse reactions once equilibrium has been reached.

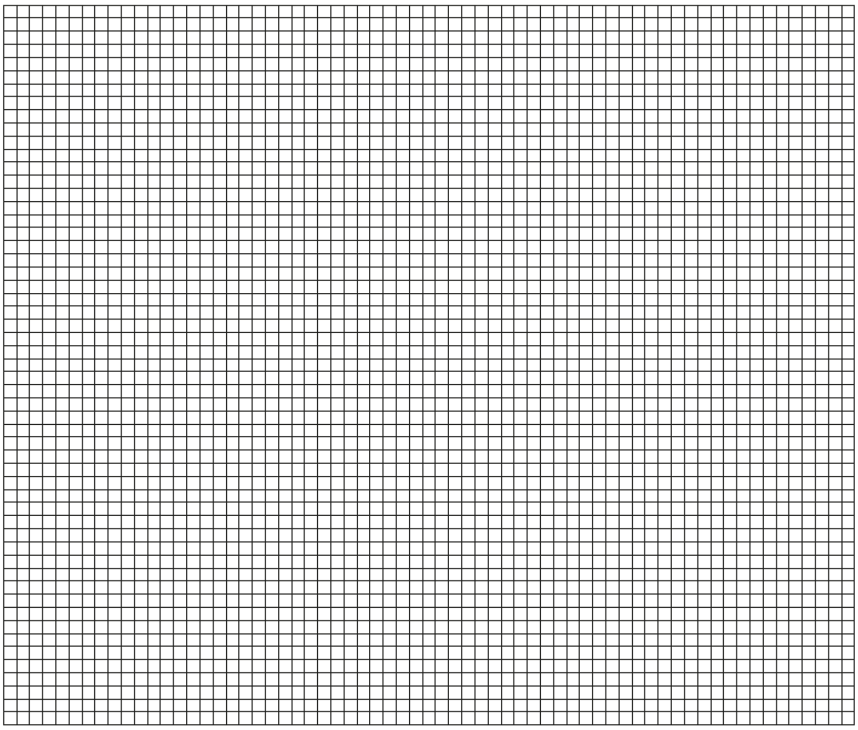
....

.... **[1]**

This was well answered. Candidates generally have a good understanding of the equilibrium position. Some answers only mentioned 'constant' rate which was insufficient to be credited with the mark.

Question 21 (c) (i)

(i) On the graph paper below plot the results in **Table 21.1** and draw lines of best fit.



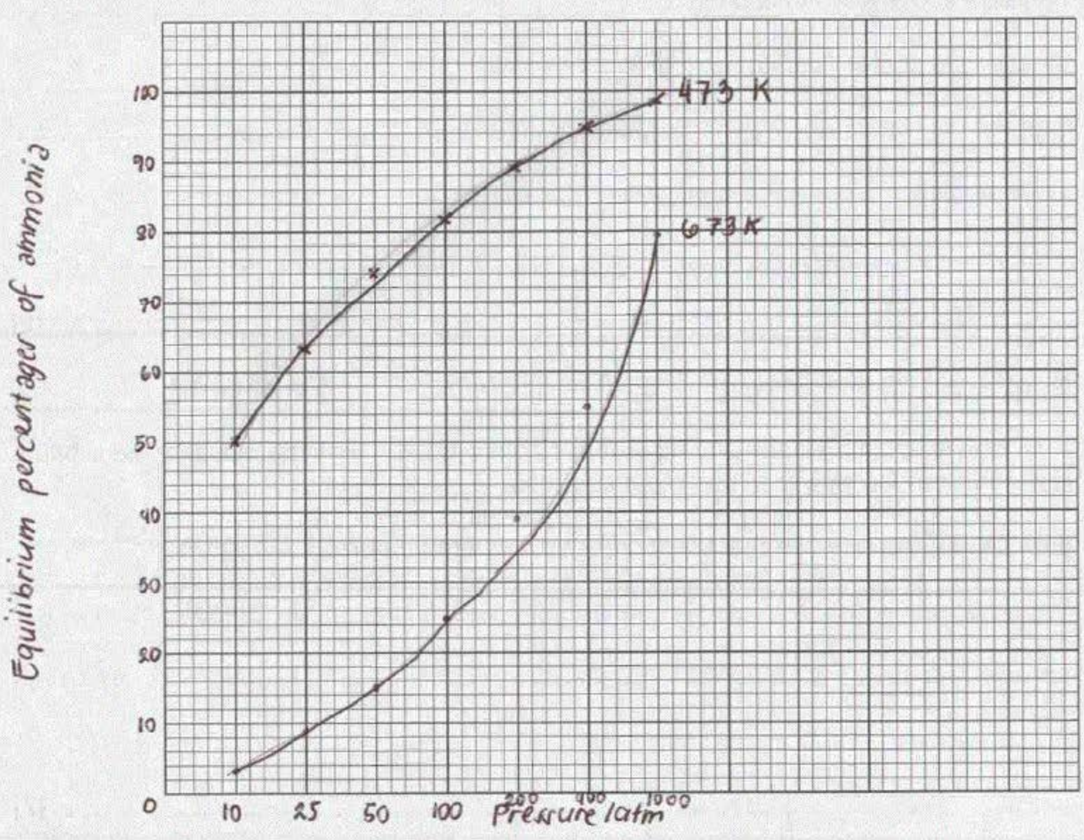
[3]

A large number of candidates gained at least 2 marks. A small number did not identify the independent variable and swapped the axes. Others found drawing lines of best fit difficult. A non-linear scale for the x-axis was sometimes used. A small number of candidates extended the scale on the y-axis beyond 100% and occasional best fit curves rose above 100%. The majority of curves closely followed the plotted points.

i	**OCR support**	Guidance on plotting graphs of two variables from experimental or other data is available in the Mathematical Skills Handbook on the website :- ocr.org.uk/qualifications/as-and-a-level/chemistry-b-salters-h033-h433-from-2015/planning-and-teaching/#as-level

Exemplar 1

(i) On the graph paper below plot the results in **Table 21.1** and draw lines of best fit.



[3]

In this exemplar, the candidate has not used a linear scale on the x-axis and the 'best fit' line for 673K is too far away from the points at 200 and 400 atmospheres.

Question 21 (c) (ii)

(ii) How would the plot for 673 K be different if the iron catalyst had **not** been used?

Explain your answer.

....

....

....

.... **[2]**

A small number of candidates provided concise answers based on equilibrium but the majority based their answer, incorrectly, on the effect of a catalyst on rate of reaction.

Question 21 (c) (iii)

(iii) Explain why the yield is greater at higher pressures.

....

....

.... **[1]**

Most candidates correctly linked the reduction in numbers of moles/particles to the shift in the equilibrium position. As above, some responses focused on rate of forward reaction rather than equilibrium. Candidates can achieve greater clarity if they say 'moves the position of equilibrium to the right' rather than 'favours the forward reaction'.

Question 21 (c) (iv)

(iv) A student says that an industrial firm carrying out the reaction at 473 K would not use a pressure above 400 atmospheres.

Discuss the student's statement, giving reasons.

....

....

....

.... **[2]**

There were many well-structured answers covering the problems of increasing pressure and the minimal gains in yield. Few candidates mentioned increased rate of production at higher pressure even when they had taken this approach in answering 21(c)(iii).

Question 21 (c) (v)

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \quad \Delta_r H^{\ominus} = -92\,kJ\,mol^{-1}$ **Equation 1.1**

(v) Ammonia is not often made at temperatures below 473 K. This is because the equilibrium is established too slowly at lower temperatures.

Explain why the rate of a reaction increases with temperature.

....

....

....

.... **[2]**

It is clear that most candidates have some understanding of collision theory but the language used is often imprecise. The majority of candidates correctly referred to molecules/particles although a small number chose to mention electronic energy. It is good to see an increasing number of candidates specifically mentioning successful collisions or <u>collisions</u> having energy greater than activation enthalpy.

Question 21 (d)

(d) The equilibrium shown in **equation 1.1** is set up.

The data below shows the composition of an equilibrium mixture at 473 K.

Equilibrium component	Equilibrium concentration / mol dm^{-3}
hydrogen	0.128
nitrogen	0.0403
ammonia	0.00271

Calculate the value of K_c for the reaction in **equation 1.1** at 473 K.

value of K_c = ... **[2]**

This item differentiated well between candidates. Successful candidates correctly wrote the K_c expression specific for this reaction and then correctly evaluated. Some candidates wrote the correct expression but then squared rather than cubed the hydrogen concentration. A small number of candidates inverted K_c or added, rather than multiplied, concentrations.

Question 22 (a)

22 Barium oxide, BaO, was once used to make oxygen gas. When heated above 500 °C, it combines with oxygen from the air to form barium peroxide, BaO_2. Above 700 °C, BaO_2 decomposes to give barium oxide and pure oxygen.

$$2BaO + O_2 \rightleftharpoons 2BaO_2$$

The removal of CO_2 from the air enabled the cycle to be carried out many times.

(a) Suggest why the removal of carbon dioxide was necessary.

....

.... **[1]**

Some candidates correctly identified an acid-base reaction but the majority took one of three routes – "carbon dioxide reacted with oxygen"; "carbon monoxide would be formed"; or references to environmental concerns regarding carbon dioxide.

Question 22 (b) (i)

(b) Barium oxide is made by heating barium carbonate.

$BaCO_3 \rightarrow BaO + CO_2$

(i) How does the thermal stability of barium carbonate compare with the thermal stability of calcium carbonate?

Explain your answer.

.... **[4]**

Candidates found this question challenging. Some responses referred to the increase in reactivity of the metals going down group 2 and, as a result, assumed that calcium carbonate was more stable. Very few candidates specifically mentioned the relative sizes of the cations although the concept of charge density was well known. The significance of the polarisation of the anion was rarely expressed well. Candidates sometimes referred to polarisation of the barium carbonate molecule rather than specifically referring to the anion.

Question 22 (b) (ii)

(ii) Why is it valid to compare barium carbonate with calcium carbonate?

....

.... **[1]**

The vast majority of candidates gained this mark.

Question 22 (c) (i)

(c) Barium oxide dissolves in water to form barium hydroxide, $Ba(OH)_2$.

In a titration 25.0 cm^3 of a solution of $Ba(OH)_2$ reacts with 23.6 cm^3 of 0.120 mol dm^{-3} HC*l*.

(i) Write the equation for the reaction in the titration.

[1]

Most candidates can write balanced equations. Many included correct state symbols although these were not required in this case.

Question 22 (c) (ii)

(ii) Calculate the concentration of $Ba(OH)_2$ in mol dm^{-3}.

concentration = ... mol dm^{-3} **[2]**

The majority of candidates calculated an answer consistent with part c(i). Moles of HCl were usually calculated correctly but some candidates did not multiply by 2. Most answers were given to 2 or 3 significant figures.

Question 22 (c) (iii)

(iii) Calculate the concentration of $Ba(OH)_2$ in g dm^{-3}.

concentration = ... g dm^{-3} **[1]**

This calculation differentiated well between candidates.

Question 23 (a) (i)

23 When ammonium nitrate, NH_4NO_3, dissolves in water, the process is endothermic.
This process is used in 'ice packs' that are used for sports injuries.

(a) A group of students dissolve 8.0 g of ammonium nitrate in 200 cm^3 of water. The temperature falls by 3.0 °C.

(i) Calculate the enthalpy change on dissolving 1 mol of ammonium nitrate in water.

Give your answer in kJ mol^{-1} and to an **appropriate** number of significant figures.

ΔH = ... kJ mol^{-1} **[3]**

This calculation differentiated well between candidates. Most candidates correctly calculated the number of moles of ammonium nitrate but many did not use the result appropriately. Many candidates knew the expression for enthalpy change but some substituted the mass of ammonium nitrate for the volume of water. Most correct calculations were expressed to the correct number of significant figures.

Question 23 (a) (ii)

(ii) The students want to get a larger temperature change. Some suggest using a greater mass of ammonium nitrate, others suggest using more water.

Evaluate the students' suggestions.

....

....

....

.... **[2]**

Most candidates gained at least 1 mark for the effect of increasing the mass of ammonium nitrate but there were many who thought that the quantity of water had no effect. A number of responses introduced the concept of limiting reagent which was not relevant to this question. The earlier part of the question clearly refers to the reaction being endothermic and the temperature falling but some candidates referred to 'larger temperature' here.

Question 23(b) (i)

(b) Another group of students investigates the exothermic reaction between zinc and copper sulfate solution.

$Zn(s) + CuSO_4(aq, 0.2\,mol\,dm^{-3}) \rightarrow Cu(s) + ZnSO_4(aq)$

(i) The students are provided with powdered zinc metal and solid $CuSO_4 \cdot 5H_2O$ (M_r = 250).

They measure the temperature rise when 100 cm^3 (an excess) of 0.2 $mol\,dm^{-3}$ copper sulfate is used.

Design a suitable method to investigate this exothermic reaction.

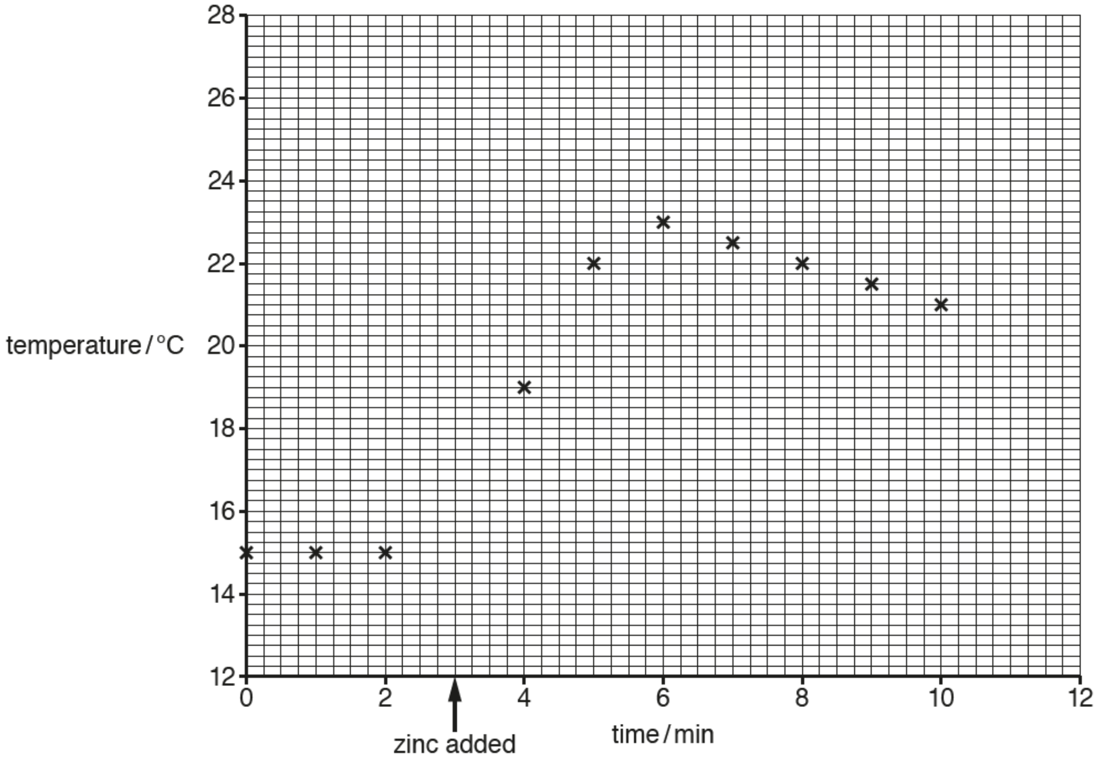
.... **[5]**

Few candidates recognised this as a displacement reaction in solution and only the highest ability candidates made sufficient use of the numerical data provided in the question. A number of responses stated that the hydrated copper sulfate had to be dehydrated before being mixed with the solid zinc. Many candidates indicated that an external heat source was required then stated that the temperature change should be measured.

i	**OCR support**	Guidance on suggested practical activities (PAG3) which cover these techniques is available in the Practical Skills Handbook on the OCR website :- ocr.org.uk/qualifications/as-and-a-level/chemistry-b-salters-h033-h433-from-2015/planning-and-teaching/#as-level

Question 23 (b) (ii)

(ii) The students repeat the experiment, measuring the temperature at different times. They plot the graph shown.

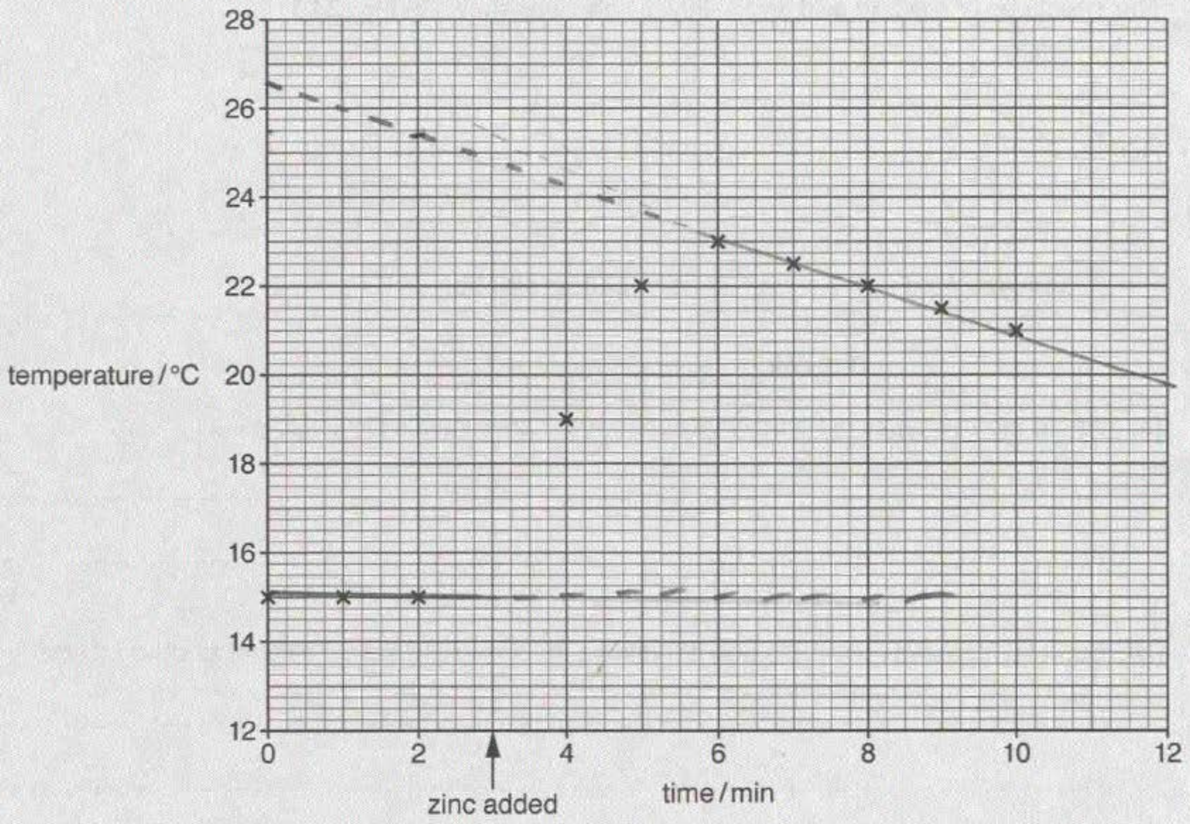


Use the graph to make an accurate measure of the temperature rise.
Show your working on the graph.

temperature rise = ... °C **[2]**

Few candidates extrapolated the line back from 6 minutes to find the peak temperature reached. Some extrapolated to zero time rather than 3 minutes. A large number of responses just subtracted the starting temperature from the highest temperature reached.

Exemplar 2



Use the graph to make an accurate measure of the temperature rise.
Show your working on the graph.

temperature rise = ...10.5.......... °C **[2]**

In this response the extrapolation line drawn does not accurately reflect the trend of the readings but is sufficiently close to allow a final numerical answer within the range allowed (9.25-9.75C). However, the candidate has read the extrapolated value at 2 minutes rather than 3.

Question 24 (a)

24 Willow bark contains salicin. Salicylic acid is obtained from willow bark by first hydrolysing the salicin to salicyl alcohol, which is a solid at room temperature.

The structures of salicylic acid and salicyl alcohol are shown in **Fig. 24.1**.

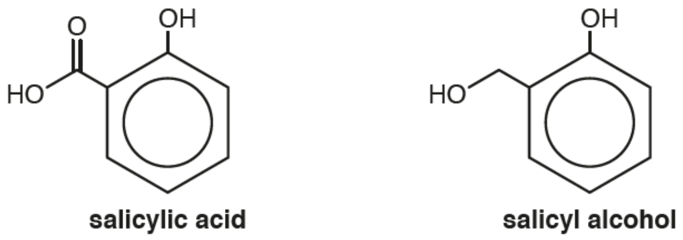


Fig. 24.1

(a) Name the **two** types of hydroxyl group that are present in salicyl alcohol.

1 ....

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

Most candidates identified the alcohol group but fewer recognised the significance of the benzene ring. References to carboxylic acid suggest that some candidate had not read the question carefully.

Question 24 (b)

(b) Suggest laboratory reagents and conditions for converting salicyl alcohol to salicylic acid.

Reagents ....

....

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

This question was a good discriminator. The majority of candidates recognised (potassium) dichromate as the reagent and that heat would be required but a significant number of responses omitted 'acidified'. Despite this being described as a laboratory practical a large number of candidates stated high pressure as a condition. Occasionally temperatures well in excess of 100°C were quoted. 'Reflux' was not required because question 24(f) clearly states that the boiling point of the aldehyde intermediary and the alcohol are both in excess of 100°C.

Question 24 (c) (i)

(c) Some students have an impure sample of salicyl alcohol. They wish to purify it by recrystallisation from water.

(i) Give the **first** step in the recrystallisation process.

....

.... **[2]**

Many candidates chose to 'add' the sample to 'a solvent' rather than dissolve in water as indicated in the stem of the question. Ethanol was a frequent named solvent. Candidates rarely mentioned 'minimum volume'.

Question 24 (c) (ii)

(ii) How would the students show that their recrystallised product was purer than the impure sample?

....

....

.... **[1]**

Candidates need to be aware of the limitations of TLC as a determinant of purity. The preferred method for solid organic compounds is melting point analysis. Many candidates were aware of this but did not indicate how impurities affected the melting point.

Question 24 (d)

(d) The students make some predictions about salicyl alcohol.

They predict that salicyl alcohol will fizz with sodium carbonate solution.

They also predict that salicyl alcohol will dehydrate when heated over Al_2O_3 to give a substance that will decolourise bromine water.

Comment on their predictions, giving chemical explanations.

....

....

....

....

....

.... **[3]**

The reaction of carbonates with carboxylic acids is well known but few candidates recognised that phenols were too weak to react. The dehydration of alcohols using aluminium oxide is also well known but only a very small number of candidates realised that the lack of hydrogen on the adjacent carbon in this case would prevent the reaction.

Question 24 (e) (i)

(e) **(i)** When salicyl alcohol reacts with concentrated hydrochloric acid, only one –OH group reacts.

Write the formula of the product formed.

[1]

Few candidates were able to correctly identify the hydroxyl group to be substituted and many drew the benzene ring by providing structural or molecular formulae with incorrect numbers of hydrogen atoms.

Question 24 (e) (ii)

(ii) Salicyl alcohol reacts with ethanoic acid in the presence of concentrated sulfuric acid.

Draw the **skeletal** formula of the product formed.

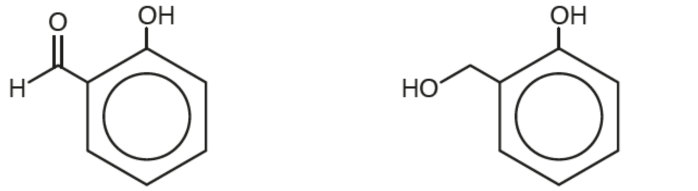
[1]

The majority of candidates drew a skeletal structure. Some identified the alcohol group as the site of esterification but in many cases the link was incorrectly drawn.

Question 24 (f)

(f) The boiling point of salicylaldehyde is 197 °C and the boiling point of salicyl alcohol is 267 °C.

The structures of salicylaldehyde and salicyl alcohol are shown in **Fig. 24.2**.



salicylaldehyde (197 °C) **salicyl alcohol** (267 °C)

Fig. 24.2

Explain the difference in boiling points between salicylaldehyde and salicyl alcohol in terms of intermolecular bonds.

....

....

....

.... **[2]**

This differentiated well between candidates. There were few fully correct responses but most recognised the effect of hydrogen bonding on boiling point. Higher attaining candidates clearly identified the role of the OH group and the greater number of these in salicyl alcohol compared with salicylaldehyde. Lower attaining candidates often did not mention the OH group or indicated that salicylaldehyde only had instantaneous dipole – induced dipole forces of attraction. Frequent comments claimed that salicylaldehyde was more branched than salicyl alcohol.

Exemplar 3

Salicyl alchol has two O-H groups meaning it can have two hydrogen bonds per molecule. Hydrogen bonding makes intermolecular forces harder to break. **[2]**

This exemplar response has identified links between OH groups, hydrogen bonds and intermolecular forces in salicyl alcohol but has made no mention of salicyl aldehyde. Both marking points require reference to both molecules to establish the comparison.

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