Qualification Accredited

OCR
Oxford Cambridge and RSA

A LEVEL

Examiners' report

CHEMISTRY B (SALTERS)

H433

For first teaching in 2015

H433/01 Summer 2024 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 answers 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 OCR.

Paper 1 series overview

Candidates and their teachers are to be congratulated once again on careful preparation for this paper. The range of marks was from 10 – 107/110, although 95% of candidate marks were 35 or above.

There was no evidence of lack of time to complete all the questions and the last question, the extended response, produced many detailed and comprehensive answers.

There continued to be an improvement in the way candidates laid calculations out, aiding the crediting of marks, although centres should note that this was not universal and requires further practice in preparing candidates to sit the examination.

Questions on practical aspects continued to be challenging, especially recalling specific reagents and conditions for reactions.

The representation of molecules proved successful for most candidates; there were far fewer instances of connections being made to the incorrect atom.

There is still some room for improvement in following command words in questions to be sure that all aspects are addressed in the answer, especially in extended responses and commenting on assertions.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• explained the thermal stability of strontium and barium carbonates in terms of ions in Question 32 (d) (ii) • were able to calculate the M_r of **M**CO_3 by back titration in Question 31 (e) (ii) • could suggest a slow step in the mechanism in Question 32 (b) (i) • were able to give the skeletal formulae for 2-methyl propan-2-ol and 2-methyl propan-1-ol in Question 34 (b) • were able to use the equation to determine the position of curly arrows in Question 34 (e) • gave the formulae of both compound A and B with justification in Question 34 (f).	• did not relate the orders of reaction to the results table in Question 32 (a) (i) and did not consider the zero order reagents • did not get the correct units for the rate constant in Question 32 (a) (ii) • were not able to use the gradient of the graph to calculate E_A in Question 32 (b) (ii) • calculated the entropy change of the system but could not calculate the entropy change of the surroundings and hence total entropy change in Question 33 (e).

Section A overview

There was continued improvement in the multiple-choice section and clear evidence of working to find the correct answer in the space around the question. There were very few instances where omitted to provide a response to questions, and the legibility of the choices and clarity of alterations was improved.

Question 3

3 Which species have an electron configuration ending in s^1?

A atoms of some d-block elements

B atoms of Group 13

C ions of Group 2

D ions of Group 16

Your answer ☐ **[1]**

Only just over half of candidates got this question correct; option C was the most frequently seen incorrect response.

Question 4

4 Which row has the radiations arranged in order of **increasing** wavelength?

A infrared < ultraviolet < visible

B infrared < visible < ultraviolet

C ultraviolet < infrared < visible

D ultraviolet < visible < infrared

Your answer ☐ **[1]**

Just under a third of candidates got this question incorrect. Many of the responses were B, in order of decreasing wavelength, showing the need to read the question carefully, but other responses were also seen.

Question 5

5 What is correct about nuclear fusion reactions?

A They are the way in which all elements are formed.

B They join together atoms to make heavier atoms.

C They only occur under conditions of high temperature and pressure.

D They turn neutrons into protons.

Your answer ☐ **[1]**

About a quarter of candidates did not score here. A and B were frequently seen answers, especially B, but it is nuclei, not atoms, that join.

Question 6

6 Which species is present in an acidic solution of glycine, H_2NCH_2COOH?

A $H_3N^+CH_2COOH$

B $H_3N^+CH_2COO^-$

C $H_2NCH_2COO^-$

D $H_2NCH_2COOH_2^+$

Your answer ☐ **[1]**

This was correctly answered by the majority of candidates but in many instances, candidates realised the NH_2 would be protonated in acidic conditions but did not consider the carboxylate group.

Question 9

9 Which compound will react with sodium carbonate?

A CH_3COCH_3

B CH_3COOCH_3

C $CH_3CH_2CH_2OH$

D CH_3CH_2COOH

Your answer ☐ **[1]**

This question was well done with about most answers being correct. Option C was the next most frequently seen.

Question 10

10 Which option occurred first in the discovery of atomic structure?

A the Geiger-Marsden experiment

B the idea of an atom with electrons embedded in positive charge

C the idea that electrons are arranged in shells

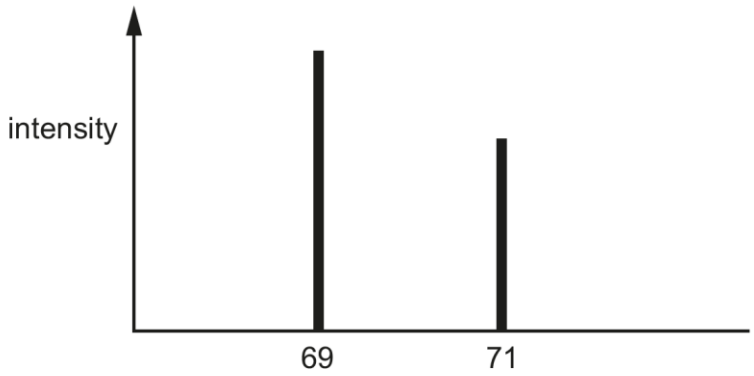
D the idea that the nucleus consists of protons and neutrons

Your answer ☐ **[1]**

This question was very well done, candidates had remembered the sequence of discoveries well.

Question 11

11 The mass spectrum of a sample of an element is shown:



What is the relative atomic mass of the sample?

A 69.2

B 69.5

C 69.8

D 70.0

Your answer ☐ **[1]**

Only slightly over half the candidates scored this mark; the most frequently seen incorrect answer was D, which had not correctly accounted for the relative abundance of the isotopes.

Question 12

12 Which of the following is correct for a C=C bond?

A All the electrons are between the C atoms.

B There are two π-bonds.

C There is one σ-bond.

D The bond can freely rotate.

Your answer ☐ **[1]**

This question was well answered by most candidates; B was sometimes given as the answer.

Question 13

13 The Table shows the concentrations of some noble gases in the atmosphere.

Gas	Concentration by volume
He	5 ppm
Ne	2 parts in 10^5
Kr	0.0001%
Xe	1 part in 10^7

Which gas has the **highest** concentration?

A He

B Ne

C Kr

D Xe

Your answer ☐ **[1]**

This question proved difficult for about half the candidates; the most frequently seen incorrect answer was C where the % was not converted to ppm.

Question 14

14 Which reaction has the **smallest** atom economy for the formation of the organic product?

A $C_2H_4 + HCl \rightarrow C_2H_5Cl$

B $C_2H_4 + HBr \rightarrow C_2H_5Br$

C $C_2H_6 + Cl_2 \rightarrow C_2H_5Cl + HCl$

D $C_2H_6 + Br_2 \rightarrow C_2H_5Br + HBr$

Your answer ☐ **[1]**

There was clear evidence of working here. A and B were eliminated and calculations were done in C and D; consequently around three quarters of candidate answers were correct.

Question 15

15 Which of 1-iodobutane and 1-chlorobutane has the higher boiling point and why?

A 1-Chlorobutane because its molecules have the stronger permanent dipole–dipole bonds.

B 1-Chorobutane because its molecules have the stronger instantaneous dipole–induced dipole bonds.

C 1-Iodobutane because its molecules have the stronger permanent dipole–dipole bonds.

D 1-Iodobutane because its molecules have the stronger instantaneous dipole–induced dipole bonds.

Your answer ☐ **[1]**

Only a third of answers to this question were correct. Many candidates decided the difference in permanent dipole-permanent dipole forces had the greatest effect and selected option A, whereas the difference in instantaneous dipole-instantaneous dipole forces has a greater effect.

Question 16

16 Which reaction has an increase in entropy?

A $H_2O(g) \rightarrow H_2O(l)$

B $N_2O_4(g) \rightarrow 2NO_2(g)$

C $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$

D $C(CH_3)_4(g) \rightarrow CH_3(CH_2)_3CH_3(l)$

Your answer ☐ **[1]**

This question was well done; most candidates could see that there was an increase in gaseous moles in B.

Question 17

17 The compounds below have negative lattice enthalpies.

Which option shows the compounds in order of more negative lattice enthalpies from left to right?

A NaF, KF, RbF

B Na_2O, K_2O, Rb_2O

C Na_2O, MgO, Al_2O_3

D NaF, NaCl, NaBr

Your answer ☐ **[1]**

This question proved quite difficult as candidates had to consider ionic radius and charge. There was evidence from annotations on the paper that they were being considered but D was the most frequently seen answer, suggesting ionic radius was considered more important than charge.

Question 18

18 A colorimeter is used to determine the concentration of copper(II) ions in solution.

What is correct?

A Absorbance increases with the concentration of copper(II) ions.

B In the colorimeter the filter is positioned between the cuvette and the detector.

C The filter should be blue because copper(II) ions are blue.

D The zero reading on the colorimeter is taken using an empty cuvette.

Your answer ☐ **[1]**

Questions on colorimetry are generally well done; most candidate answers were correct with A or D being seen as incorrect answers.

Question 19

19 What is correct about propanal, CH_3CH_2CHO, and propanone, CH_3COCH_3?

A Only propanal can be oxidised by acidified dichromate.

B Only propanal forms a 'silver mirror' with Fehling's solution.

C Only propanone forms a cyanohydrin with hydrogen cyanide.

D Propanal has a higher boiling point than propanone because propanal can form hydrogen bonds.

Your answer ☐ **[1]**

This question required careful reading. Over a third of candidates selected option B, not noticing the observation and reagent did not match.

Question 20

20 A student is measuring the relative rates of reaction of 1-chlorobutane, 1-bromobutane and 1-iodobutane with aqueous silver nitrate.

Which statement is correct?

A 1-Chlorobutane is slowest and gives a white precipitate.

B 1-Bromobutane is slowest and gives a yellow precipitate.

C 1-Iodobutane is fastest and gives a white precipitate.

D 1-Iodobutane is slowest and gives a yellow precipitate.

Your answer ☐ **[1]**

There were two ideas to consider in this question: the speed of reaction and the colour of the silver halide precipitate. In many cases the silver halide colour was correct, but the rate of reaction was not known.

Question 21

21 Wood is used to make a sample of bioethanol. The bioethanol is used to fuel a car engine.

What is correct?

A Carbon dioxide is the only pollutant produced by the car engine.

B The amount of carbon dioxide given out when the fuel is fully burned is equal to the amount of carbon dioxide absorbed when the wood is grown.

C The fuel is made from the wood by cracking.

D The wood is never grown where other crops could be planted.

Your answer ☐ **[1]**

This question was well done.

Question 22

22 Which of the following represents poly(propene)?

A $-CH_2-CH(CH_3)-$

B $-CH_2-CH_2-CH_2-$

C $-CH=C(CH_3)-CH_2-$

D $-C(CH_3)-C(CH_3)-$

Your answer ☐ **[1]**

About a third of candidates did not have the methyl group as a branch on the polymer chain and selected B.

Question 23

23 10 cm^3 of an alkane react exactly with 35 cm^3 oxygen in complete combustion at RTP.

What is the alkane?

A CH_4

B C_2H_6

C C_3H_8

D C_4H_{10}

Your answer ☐ **[1]**

There was clear evidence of working here, some of which showed that candidates had not appreciated that under the same conditions the number of moles of gas is proportional to volume, so extra work was done dividing by 24. Others did not balance the equations for complete combustion correctly so did not get the correct answer. Only half of answers were correct.

Question 24

24 50 cm^3 of 0.30 mol dm^{-3} Fe(II) in acid solution exactly reduces 25 cm^3 of 0.10 mol dm^{-3} $NaClO_3$ solution. Fe(III) is formed.

What is the oxidation state of chlorine in the product?

A +3

B +2

C 0

D –1

Your answer ☐ **[1]**

Half of candidates got this question correct and there was clear working to find the ratio of moles of each substance and hence the number of electrons transferred.

Question 25

25 Methane reacts with chlorine by a radical mechanism.

There is an initiation reaction, two propagation reactions and various termination reactions.

The overall equation for the main reaction is $CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$

Which statement is correct for this reaction?

A CH_3Cl is formed in the first propagation reaction.

B HCl is formed in the second propagation reaction.

C One termination reaction involves the formation of ethane.

D Two radicals react in the first propagation step.

Your answer ☐ **[1]**

Slightly fewer than half of candidate answers were correct. The best answers had written out the steps of the mechanism in the space next to the question before answering.

Question 26

26 The solubility of lead(II) chloride is $0.0388\,mol\,dm^{-3}$ at 293 K.

What is the correct numerical value of the solubility product at this temperature?

A 5.84×10^{-5}

B 2.34×10^{-4}

C 1.51×10^{-3}

D 3.01×10^{-3}

Your answer ☐ **[1]**

Solubility product questions often prove difficult as was the case here. A and C were frequently seen incorrect responses.

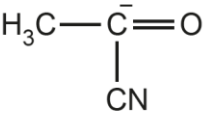
Question 27

27 Ethanal, CH_3CHO, reacts with cyanide in a two-step mechanism.

What is correct about this mechanism?

A In step 1 the nitrogen on the cyanide ion attacks the carbonyl carbon of ethanal.

B In step 2 the intermediate formed in step 1 reacts with H^+.

C The intermediate formed in step 1 has the following structure: 

D The overall reaction is electrophilic addition.

Your answer ☐ **[1]**

A little under two thirds of candidate answers to this question were correct. They usually had the reaction mechanism written out beside the question to help identify the correct answer.

Question 28

28 Which of the following radiations can break covalent bonds?

1 ultraviolet

2 x-rays (which have higher frequency than ultraviolet rays)

3 infrared

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

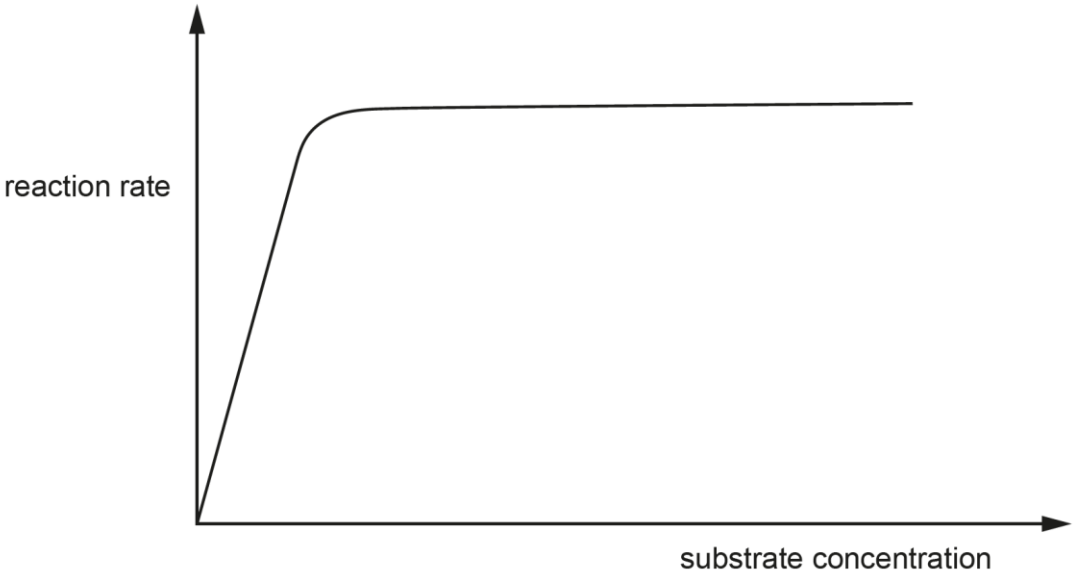
D Only 1

Your answer ☐ **[1]**

Two-thirds of candidate answers were correct. Some candidates did not think X-rays would break bonds.

Question 29

29 The graph shows how the rate of an enzyme catalysed reaction varies with substrate concentration.



At low substrate concentration, which of the following is/are correct?

1 Not all enzyme active sites have a substrate molecule attached.

2 The reaction is first order with respect to substrate.

3 The rate determining step involves both enzyme and substrate.

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

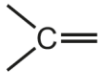
D Only 1

Your answer ☐ **[1]**

Just over half of candidate answers were correct with a variety of incorrect answers seen.

Question 30

30 A carbon atom has the bonding shown.



Which of the following is/are correct for this carbon atom?

1 The shape is trigonal around the carbon atom.

2 The atoms attached to the bonds are all in the same plane.

3 The angle between the single bonds is 109°.

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer ☐ **[1]**

This was answered correctly by just under half of the candidates, many not realising statement 2 was also correct.

Section B overview

It was good to see that calculations were generally well done, with the exception of 31(e)(ii) which proved difficult. The setting out of calculations clearly allowed the award of some of the marks even if the answer was not correct.

Recall of reagents and conditions for some of the reactions and the content on sulfonation of benzene and azo dyes proved difficult for many candidates.

The extended response questions, 34(f) and 35(f), showed some good knowledge and understanding, but in some cases a lower level was achieved as not all parts of the question had been addressed.

Question 31 (a)

31 Fireworks contain metal compounds that produce intense colours when they are burned.

(a) Give the colour from a firework containing barium carbonate.

..... **[1]**

Almost three-quarters of candidates had correctly recalled the flame colour.

Question 31 (b)

(b) The atomic **emission** spectrum of barium appears as a series of coloured lines at specific frequencies on a black background.

Describe the appearance of the atomic **absorption** spectrum of barium.

How is the absorption spectrum related to the emission spectrum?

.....

.....

.....

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

Well over half of candidates scored both marks here. In a few cases, the second part of the question had not been addressed.

Question 31 (c)

(c) One line in the barium spectrum has a wavelength of 5.54×10^{-5} cm.

Calculate the frequency of this line (in Hz).

frequency = ... Hz **[2]**

Almost half the candidates scored both marks but a third of candidates only scored 1 mark as they had not converted the wavelength to metres. Only a few candidates scored no marks due to incorrect rearrangement of the equation linking frequency and wavelength.

Question 31 (d) (i)

(d) Strontium carbonate is another compound used in fireworks.

(i) Write the equation for the thermal decomposition of $SrCO_3$.

[1]

Over a third of candidates did not score this mark due to having oxygen as a reagent or splitting strontium carbonate into its ions.

Question 31 (d) (ii)

(ii) There is a trend in the stability of the Group 2 carbonates.

A student says:

- Barium carbonate decomposes at a higher temperature than strontium carbonate.
- This is because the carbonate ion has a stronger bond to the more reactive barium ion.

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

.....

.....

.....

.....

.....

.....

.....

..... **[4]**

This was a high demand question in which most candidates scored 0 or 1 mark.

Exemplar 1

The student is correct, the barium carbonate does decompose at a higher temperature than strontium carbonate however it is not due to barium being more reactive. It is due to barium having higher ~~ow~~ mat stability as it causes less distortion to the carbonate ion than strontium as it has a lower charge density than strontium because barium is bigger. **[4]**

This response has correctly addressed the candidate's first bullet point but has not scored further marks because of lack of clarity over which species are present; to score marking points 2 and 3, strontium or barium **ions** need to be mentioned. Examples which just said barium and strontium, or the atoms or molecules were seen. In the majority of cases, the second bullet point had not been addressed.

Assessment for learning

It is important to refer to the correct species. When considering charge density, it must be ions, not just atoms, or the name of the element.

Some answers to this question lacked clarity and correct terminology or had misunderstood and discussed ease of forming ions due to atomic radius and shielding.

Question 31 (e) (i)

(e) A group of students identify an insoluble Group 2 carbonate, **M**CO_3, by calculating its M_r.

The students' procedure and results are:

- They weigh out 3.02 g of **M**CO_3.
- They add the **M**CO_3 to 50.0 cm^3 of 2.00 mol dm^{-3} HC*l* (an excess).
- When the reaction has finished they make the solution up to 250 cm^3 in a volumetric flask.
- They titrate 25.0 cm^3 of the diluted solution with 0.108 mol dm^{-3} NaOH.
- Their mean titre is 26.15 cm^3.

The reaction between HC*l* and NaOH is:

$NaOH + HCl \rightarrow NaCl + H_2O$

The reaction between **M**CO_3 and HC*l* is:

M$CO_3 + 2HCl \rightarrow$ **M**$Cl_2 + CO_2 + H_2O$

(i) Describe the procedure they should use for weighing out the 3.02 g of **M**CO_3.

.....

.....

.....

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

A large majority of candidates correctly adopted the use of a weighing boat; however many candidates only described 'zeroing' the balance and adding the solid and not weighing by difference to account for particles adhering to the weighing boat once the solid had been tipped out.

Question 31 (e) (ii)

(ii) Calculate the M_r of $\mathbf{M}CO_3$.

M_r = ... **[5]**

Only around a fifth of candidates scored full marks on this question, but many scored some of the marks, especially marking points 1, the moles of NaOH used in the titration and marking point 3, the initial moles of HCl. In some cases, the volumes of acid and alkali were reversed so careful reading of the question was needed.

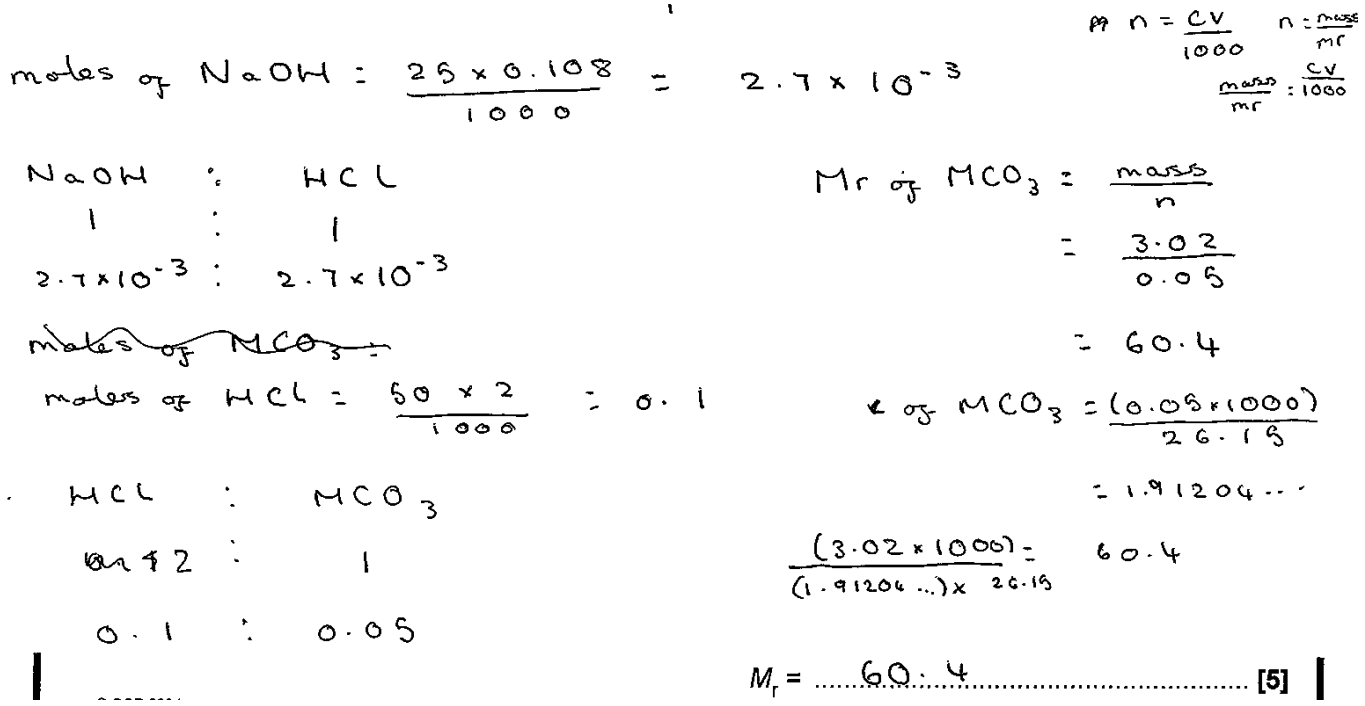
Assessment for learning

The ideas of this back titration were difficult for candidates. There were several steps to the calculation, so a logical approach was needed.

The first mark, the moles of sodium hydroxide, was scored in many cases. This was equal to the moles of HCl in the titration, but candidates did not always scale it up for the 250 cm^3 flask. The original moles of HCl was calculated but it was not always realised that the remaining moles should be subtracted from it, or the incorrect number of moles by a factor of 10 was subtracted.

This number should then have been divided by 2 and divided into 3.02 to get the M_r.

Exemplar 2



This candidate response has been very clearly set out so it was possible to identify correct steps even though the final answer is incorrect.

They have the wrong volume for sodium hydroxide so have not scored the first marking point.

They have not multiplied by 10 to find the moles in 250 cm^3 so do not score marking point 2.

They have the original moles of HCl so score the third point.

There is no subtraction so do not score point 4.

They have divided their number of moles by 2 and divided into 3.02, so score point 5. We ignored extra working as we could see that the answer on the line came from a correct step.

Question 31 (e) (iii)

(iii) The 25.0 cm^3 of the solution used for the titration is measured using a volumetric pipette.

The uncertainty in reading the volumetric pipette is 0.06 cm^3.

Calculate the percentage uncertainty in using this pipette.

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

percentage uncertainty = ... % **[1]**

Only a small proportion of candidates scored here as many candidates quoted the uncertainty to 2 significant figures. Some answers confused the pipette with the burette and doubled the uncertainty for two readings.

Question 32 (a) (i)

32 Chemists study the rates of reactions that occur in car engines.

(a) **Equation 32.1** shows a reaction that occurs in catalytic converters.

$NO(g) + CO(g) + O_2(g) \rightarrow NO_2(g) + CO_2(g)$ **Equation 32.1**

A chemist measures the initial rate of reaction for different initial concentrations of reactants at constant temperature.

The results are given in the table.

Experiment number	[NO] / mol dm^{-3}	[CO] / mol dm^{-3}	[O_2] / mol dm^{-3}	Initial rate / mol dm^{-3} s^{-1}
1	2.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}	0.17
2	6.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}	1.53
3	2.0×10^{-2}	2.0×10^{-2}	1.0×10^{-2}	0.17
4	4.0×10^{-2}	1.0×10^{-2}	2.0×10^{-2}	0.68

(i) Use the results to show that the rate equation is:

Rate = $k[NO]^2$

.....

.....

.....

.....

.....

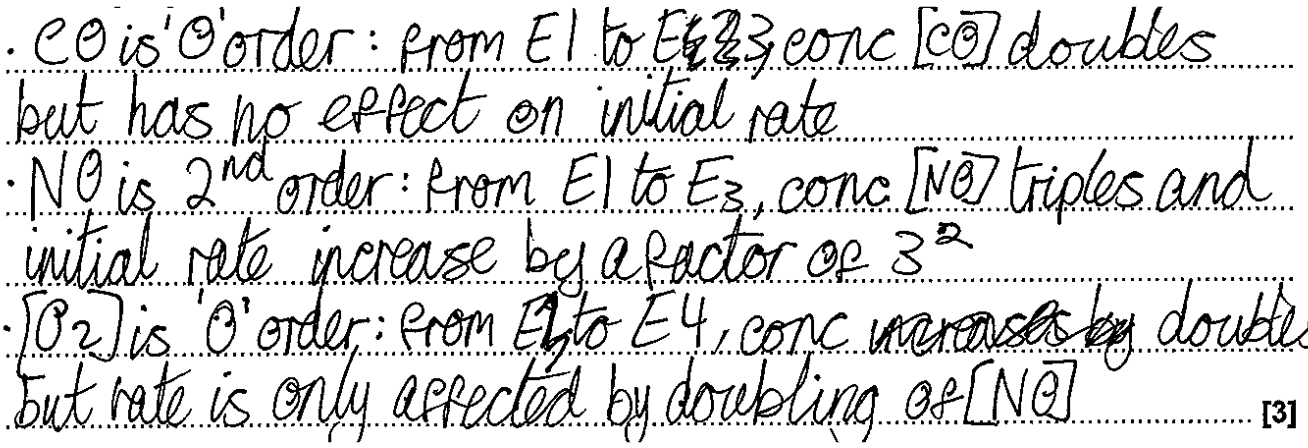
..... **[3]**

The most frequently seen scores were 1 or 3. 3 marks were gained if the order with respect to each reagent was justified with reference to results; we accepted annotation on the table for this. 1 mark was scored if only the order with respect to [NO] was considered or if there was not a clear reference to the results for any substance.

Assessment for learning

Using the results to justify the rate equation means it is necessary to refer to experiment numbers or concentrations given in the results table. We accepted annotation on the table. It is necessary to include justification for the species that do not appear in the rate equation as well as [NO].

Exemplar 3



In this example all 3 marks have been given.

For experiments 1 and 3 [CO] doubles but no effect on rate so zero order.

The justification for [NO] should be experiments 1 and 2, not 1 and 3 as stated, but we accepted the correct annotation on the table.

The effect of $[O_2]$ would have been better using experiments 1 and 4, but the reasoning was clear.

Question 32 (a) (ii)

(ii) Calculate the rate constant, *k*, for the reaction in **Equation 32.1** and give its units.

k = ... units ..... **[2]**

Over half of candidates scored both marks. There were some instances where the units were incorrect such as omitting the s^{-1}.

Question 32 (b) (i)

(b) Another reaction that occurs in a catalytic converter is shown in **Equation 32.2**.

$NO_2(g) + CO(g) \rightarrow NO(g) + CO_2(g)$ **Equation 32.2**

(i) The rate equation for this reaction is:

Rate = $k[NO_2]^2$

A student says that this reaction takes place in a single step.

Explain why this cannot be correct and give a possible mechanism for the reaction, indicating the rate-determining step.

.....

.....

.....

.....

.....

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

This is a demanding topic and candidates found it to be so, with the majority scoring 0 or 1. It proved difficult to explain the rate equation clearly and proposed mechanisms did not match the data.

Misconception

The answer must make it clear that CO is not in the rate equation so must be in a fast step. When proposing a mechanism it is important to remember that the steps must add up to the balanced equation.

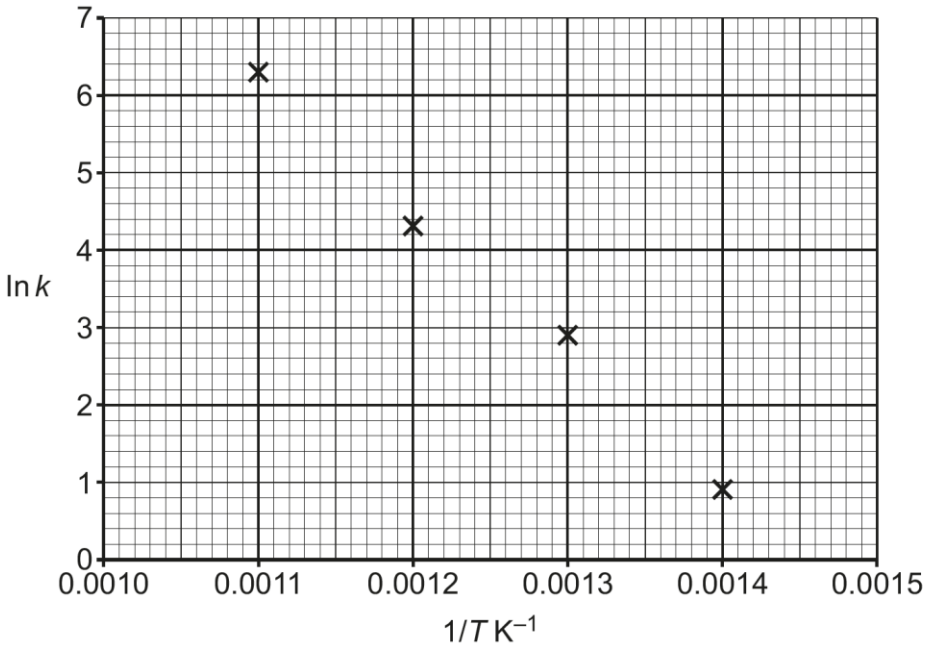
Quite a few answers suggested $2NO_2 \rightarrow 2NO + O_2$ as the rate determining step which was acceptable but then gave the second step as $2CO + O_2 \rightarrow 2CO_2$. This unfortunately doesn't add up to the balanced equation, whereas $CO + NO + O_2 \rightarrow NO_2 + CO_2$ does.

We didn't accept slow steps producing oxygen and nitrogen, as N_2 would never react in a fast step.

Question 32 (b) (ii)

(ii) A chemist studies the reaction in **Equation 32.2** and measures the rate constant, k, at different temperatures.

The chemist plots $\ln k$ against $1/T$ on a graph as shown.



Calculate the activation enthalpy (in $kJ\,mol^{-1}$) for the reaction in **Equation 32.2**.

activation enthalpy = ... $kJ\,mol^{-1}$ **[4]**

In this question just under a third of candidates scored all 4 marks. We were expecting a line of best fit, which was not always seen, and then finding the gradient to get E_A. Some answers tried to substitute the co-ordinates for a single point to get the answer and there were some incorrect signs which caused marks to be lost.

Question 33 (a)

33 Ammonium nitrate, NH_4NO_3, is a fertiliser.

One of the steps in the manufacture of NH_4NO_3 is the oxidation of NO by the reaction in **Equation 33.1**.

$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g) \quad \Delta H = -114\,kJ\,mol^{-1}$ **Equation 33.1**

(a) Give the appearance of $NO_2(g)$.

..... **[1]**

This question was well done with over two-thirds of answers providing the correct colour.

Question 33 (b)

(b) Give the test and its result that shows that a solid contains nitrate ions.

.....

.....

.....

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

Candidates did not remember this test; more than half the answers scored 0 marks. Some had minor inaccuracies in the test such as not warming, in which case marking point 2 was available. Some got the test correct but had the litmus paper being bleached.

Question 33 (c) (i)

(c) The reaction in **Equation 33.1** is an example of a chemical equilibrium.

(i) A student says that once the position of equilibrium has been reached, the reaction has stopped so the concentration of $NO_2(g)$ remains constant.

Evaluate what the student says and give correct chemistry where necessary.

.....

.....

.....

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

This question was well answered. The only misconception was that a number of answers said forward and reverse reactions were occurring at a constant rate instead of an equal rate.

Question 33 (c) (ii)

(ii) For the reaction in **Equation 33.1** at a certain temperature,

$K_c = 6.9 \times 10^2\,dm^3\,mol^{-1}$

In an industrial plant, operating at that temperature:

Equilibrium concentration, $[NO(g)] = 0.250\,mol\,dm^{-3}$

Equilibrium concentration, $[O_2(g)] = 0.180\,mol\,dm^{-3}$

Write the expression for K_c and calculate the equilibrium concentration of $NO_2(g)$.

equilibrium concentration, $[NO_2(g)]$ = ... $mol\,dm^{-3}$ **[3]**

This question was excellently done with most candidates scoring full marks.

Question 33 (c) (iii)

(iii) Explain how increasing temperature affects the value of K_c for the reaction in **Equation 33.1**.

.....

.....

.....

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

This was well done with many answers scoring both marks. In some cases, the shift in position of equilibrium and hence effect on K_c was the incorrect direction.

Question 33 (d) (i)

Equation 33.1 is repeated: $2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$ $\Delta H = -114\,kJ\,mol^{-1}$ **Equation 33.1**

(d) The reaction in **Equation 33.1** uses a heterogeneous catalyst.

(i) Explain the meaning of the term **heterogeneous** here.

.....

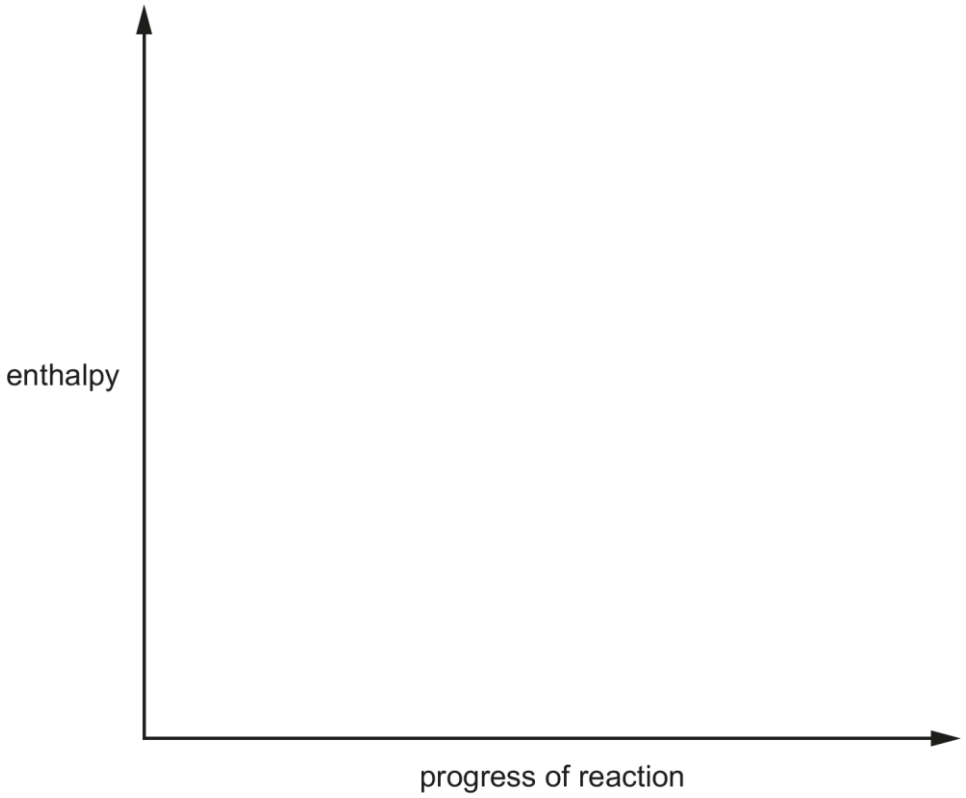
..... **[1]**

This question was very well done; only the occasional response had the same state or didn't specify what the catalyst was in a different state to.

Question 33 (d) (ii)

(ii) Draw an enthalpy profile diagram for the reaction in **Equation 33.1** and label the catalysed and uncatalysed reactions.

Show the reactants and products and the activation enthalpies. **[2]**



This question was expected to be high-scoring but only a little over a third of answers scored both marks. This was partly because they did not specify reactants and products on the initial and final lines or because they did not clearly label E_A for the catalysed and uncatalyzed reaction with a vertical line from the reactant line to the peak of the curve in each case.

Question 33 (d) (iii)

(iii) The catalyst used in the reaction in **Equation 33.1** is a solid mixture of platinum and rhodium.

Explain why this solid is able to behave as a catalyst.

.....

.....

.....

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

This proved to be a difficult question. A considerable number of answers described reactants adsorbing to the surface of the catalyst but did not explain the role of the d electrons on this.

Question 33 (e)

(e) The standard entropies of the substances involved in **Equation 33.1** are shown in the table.

Substance	$S^{\ominus}$ / J mol^{-1} K^{-1}
$O_2(g)$	205.0
NO(g)	210.7
$NO_2(g)$	240.0

Calculate the total entropy change, $\Delta_{tot}S$, (in J mol^{-1} K^{-1}) for the reaction in **Equation 33.1** at 50 °C.

$\Delta_{tot}S$ = ... J mol^{-1} K^{-1} **[4]**

A little under half of candidate answers scored 4 marks. Of those not scoring full marks, some had signs incorrect or only calculated the entropy change of the system.

Question 34 (a)

34 The plastic welding agent butanone, $CH_3CH_2COCH_3$, is sold as "model cement" and used for joining the plastic parts of scale model kits.

(a) Butanone can be formed by the oxidation of the alcohol $CH_3CH_2CH(OH)CH_3$.

Classify this alcohol as primary, secondary or tertiary.

Give the structural reason for the classification you have chosen.

Classification: .....

Reason: .....

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

This question was well done with most candidates scoring full marks. Some gave the reason as secondary alcohols are oxidised to ketones which was not quite sufficient.

Question 34 (b)

(b) There are other alcohols that are structural isomers of $CH_3CH_2CH(OH)CH_3$.

Draw the **skeletal** formulae for the **two branched-chain** isomers.

[2]

Candidates did not always follow the instruction to draw a skeletal formula or to give the branched chain isomers. The bond from the C should go to the O in the OH group, not the H.

Question 34 (c)

(c) The alcohol $CH_3CH_2CH(OH)CH_3$ can be made by reacting $CH_3CH_2CHBrCH_3$ with aqueous sodium hydroxide.

Name the mechanism of this reaction.

..... **[1]**

This question was well done; most candidates scored this mark.

Question 34 (d)

(d) Alcohols can be dehydrated by heating with concentrated sulfuric acid.

When dehydrated, $CH_3CH_2CH(OH)CH_3$ produces a mixture of three isomeric products.

Draw the structures of these **three** isomeric products.

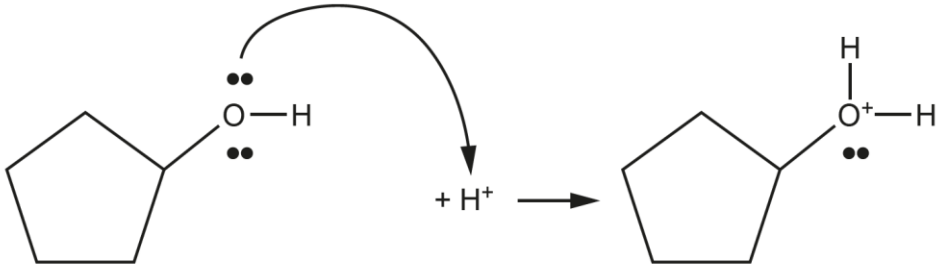
[3]

Candidates often got two isomers but-1-ene and one of the geometric isomers of but-2-ene but then gave a branched isomer which could not have come from butan-2-ol.

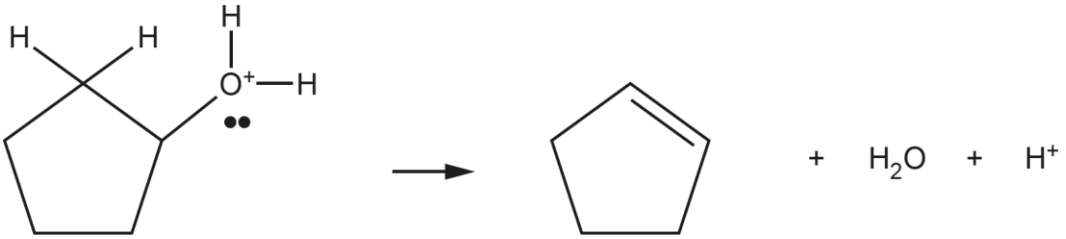
Question 34 (e)

(e) The mechanism for the dehydration of a cyclic alcohol using concentrated sulfuric acid takes place in two steps.

Step 1:



Step 2:



Add curly errors to **Step 2** to show the electron movements in the mechanism. **[2]**

Half of candidates did not score here, but scores of 1 and 2 were equally distributed amongst the rest, the arrow to the O being more frequently scored.

An erratum was issued for this question; asking candidates to replace the word 'errors' with 'arrows'.

Erratum

Open the question paper to **Page 29**.

Look at **Question 34 (e)**.

At the bottom of **Question 34 (e)** is an instruction, which reads:
Add curly errors to **Step 2** to show the electron movements in the mechanism.

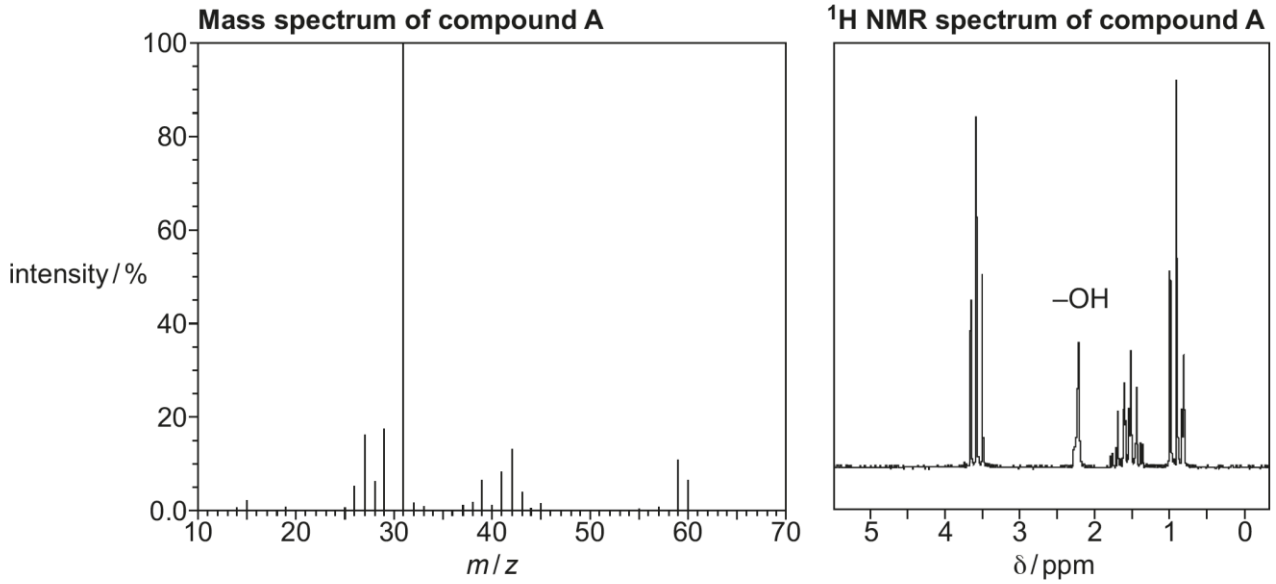
Cross out the third word in the instruction, 'errors'.

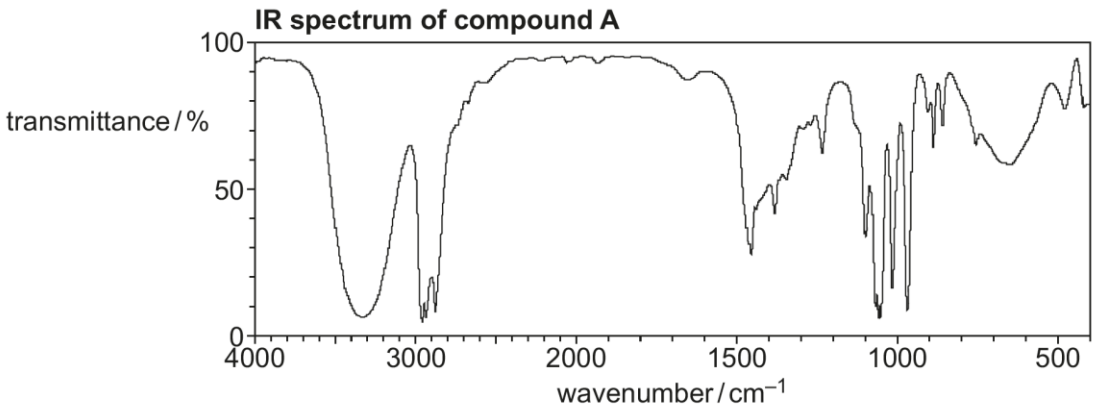
Replace it with 'arrows' so that the instruction reads:
Add curly arrows to **Step 2** to show the electron movements in the mechanism.

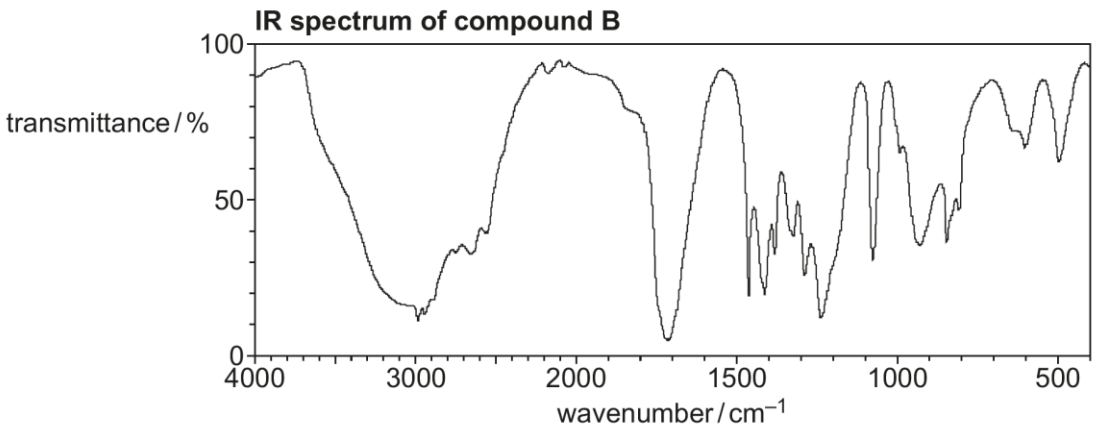
Question 34 (f)*

(f)* A chemist sets out to identify **compound A** and its oxidation product, **compound B**.

The chemist has the mass spectrum, the IR spectrum and the ^{1}H NMR spectrum of **compound A**, and the IR spectrum of **compound B**.







You may do working on this page but it will not be marked.

Use evidence from **all** the spectra to identify the formulae for **compound A** and **compound B**.

.....

.....

.....

.....

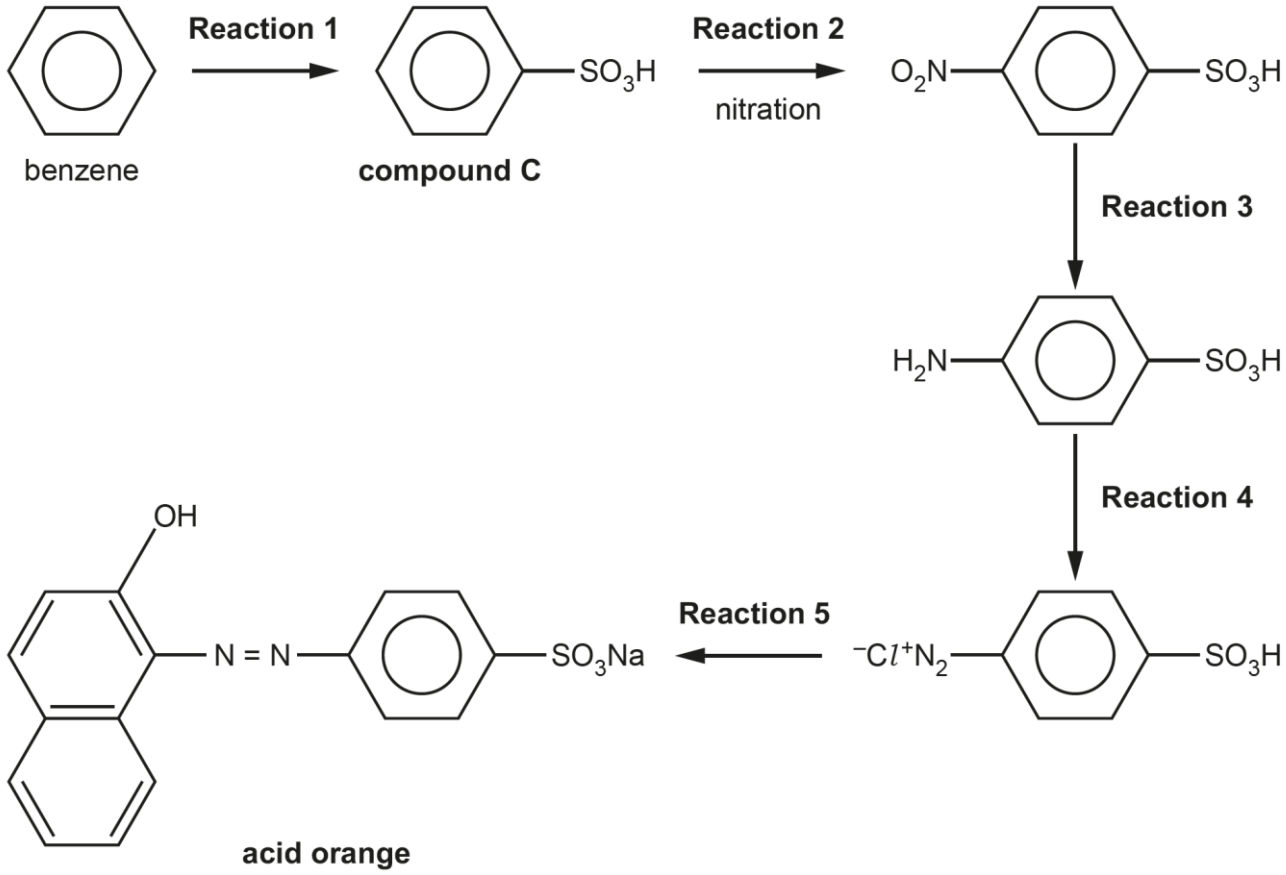
.....

..... **[6]**

There were some excellent answers seen but also many that did not include enough evidence from the spectra to justify their structures. The infra-red spectra were well interpreted. In the mass spectrum some candidates thought the M_r was 59 and that the peak at 60 was a M+1 peak. Others had The M_r as 31 as it was the tallest peak in the spectrum, others correctly identified it as a fragment CH_2OH. In the NMR spectrum, the 4 proton environments were linked with the structure from the chemical shift but there was a lack of detail on the splitting pattern leading to propan-1-ol as the structure.

Question 35 (a) (i)

35 Acid orange is a soluble azo dye that can be made from benzene by the following route:



(a)
(i) Name **compound C**.

..... **[1]**

The whole area of benzenesulfonic acid was not well remembered; only a minority of candidates could name compound C.

Question 35 (a) (ii)

(ii) **Reaction 1** is an electrophilic substitution using concentrated sulfuric acid.

Give the formula of the electrophile.

..... **[1]**

Even fewer candidates could remember the electrophile in this question.

Question 35 (b)

(b) Use the Data Sheet to give reagents and conditions for **reaction 3**.

.....

..... **[1]**

This question was excellently answered.

Question 35 (c)

(c) **Reaction 4** forms a diazonium salt.

Give the reagents and conditions for this reaction.

Reagents: .....

.....

Conditions: .....

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

Many candidates had recalled all the details, but many had nitric(V) acid instead of nitric(III) acid or sodium nitrite. Others had confused the reaction completely giving HCl, $AlCl_3$ and below 55^0C. in this case they could score for HCl.

Question 35 (d)

(d) **Reaction 5** is a coupling reaction, using a phenol and sodium hydroxide.

Give the formula of the phenol.

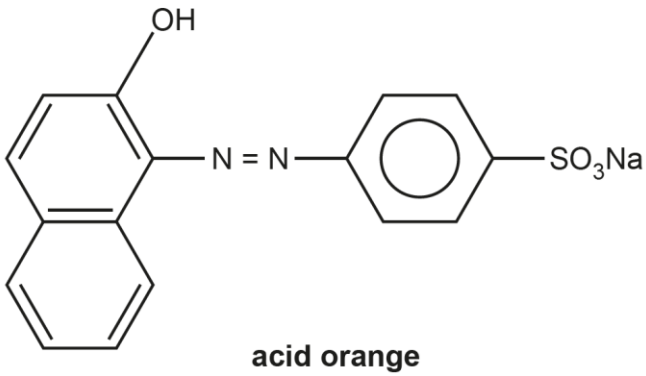
[1]

Many candidates simply drew the molecule phenol, others drew the correct phenol with an amine substituent.

Question 35 (e) (i)

(e)

(i) Draw a (ring) around the **chromophore** of acid orange.



acid orange

[1]

This question proved very difficult. Answers circled the N=N group or either one of the ring systems. Those that did circle both often included the H in the OH group.

Question 35 (e) (ii)

(ii) One part of its structure makes acid orange more soluble than many other azo dyes.

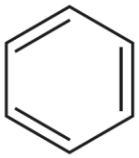
Give the formula of this part.

..... **[1]**

The majority of answers were correct; however some suggested the OH group.

Question 35 (f)*

(f)* A scientist called Kekulé proposed a structure for benzene as shown:



The enthalpy change data below shows that this is not entirely correct:

benzene + $3H_2$  $\Delta_{hydrogenation}H = -208\,kJ\,mol^{-1}$

- Explain why the data does not match the Kekulé structure.
- Describe a different model for the benzene structure.
- Explain how this different model accounts for the reaction of benzene with bromine better than the Kekulé structure.

.....

.....

.....

.....

..... **[6]**

The answers to this question were sound but the level of detail provided meant that 4 was the most commonly scored mark. The majority of candidates mentioned the discrepancy in enthalpies of hydrogenation, but some omitted to mention that this meant that benzene was more stable than Kekulé's structure. There was a lack of detail in the description of the origin of the delocalized pi system in benzene, simply stating that it has a ring of delocalized electrons above and below the plane. Many candidates mentioned the inability of benzene to decolorize bromine water and suggesting that Kekulé's structure would be able to, without mentioning the name of the mechanisms and the fact that benzene underwent electrophilic substitution to preserve the pi system and needed a halogen carrier.

Copyright information

Question 34f

Fig 34.2 shows the IR spectrum of compound A (propan-1-ol)

Fig 34.3 shows the H NMR spectrum of compound A (propan-1-ol)

Fig 34.4 shows the IR spectrum of the oxidation product of compound A (propanoic acid)

Fig 34.1 shows the mass spectrum of compound A (propan-1-ol)

Supporting you

Teach Cambridge

Make sure you visit our secure website **Teach Cambridge** to find the full range of resources and support for the subjects you teach. This includes secure materials such as set assignments and exemplars, online and on-demand training.

Don't have access? If your school or college teaches any OCR qualifications, please contact your exams officer. You can forward them this link to help get you started.

Reviews of marking

If any of your students' results are not as expected, you may wish to consider one of our post-results services. For full information about the options available visit the OCR website.

Access to Scripts

We've made it easier for Exams Officers to download copies of your candidates' completed papers or 'scripts'. Your centre can use these scripts to decide whether to request a review of marking and to support teaching and learning.

Our free, on-demand service, Access to Scripts is available via our single sign-on service, My Cambridge. Step-by-step instructions are on our website.

Keep up-to-date

We send a monthly bulletin to tell you about important updates. You can also sign up for your subject specific updates. If you haven't already, sign up here.

OCR Professional Development

Attend one of our popular professional development courses to hear directly from a senior assessor or drop in to a Q&A session. Most of our courses are delivered live via an online platform, so you can attend from any location.

Please find details for all our courses for your subject on **Teach Cambridge**. You'll also find links to our online courses on NEA marking and support.

Signed up for ExamBuilder?

ExamBuilder is a free test-building platform, providing unlimited users exclusively for staff at OCR centres with an Interchange account.

Choose from a large bank of questions to build personalised tests and custom mark schemes, with the option to add custom cover pages to simulate real examinations. You can also edit and download complete past papers.

Find out more.

Active Results

Review students' exam performance with our free online results analysis tool. It is available for all GCSEs, AS and A Levels and Cambridge Nationals (examined units only).

Find out more.

You will need an Interchange account to access our digital products. If you do not have an Interchange account please contact your centre administrator (usually the Exams Officer) to request a username, or nominate an existing Interchange user in your department.

Need to get in touch?

If you ever have any questions about OCR qualifications or services (including administration, logistics and teaching) please feel free to get in touch with our customer support centre.

Call us on
01223 553998

Alternatively, you can email us on
support@ocr.org.uk

For more information visit
ocr.org.uk/qualifications/resource-finder
ocr.org.uk
facebook.com/ocrexams
twitter.com/ocrexams
instagram.com/ocrexaminations
linkedin.com/company/ocr
youtube.com/ocrexams

We really value your feedback

Click to send us an autogenerated email about this resource. Add comments if you want to. Let us know how we can improve this resource or what else you need. Your email address will not be used or shared for any marketing purposes.

I like this **I dislike this**

Please note – web links are correct at date of publication but other websites may change over time. If you have any problems with a link you may want to navigate to that organisation's website for a direct search.

CAMBRIDGE
UNIVERSITY PRESS & ASSESSMENT