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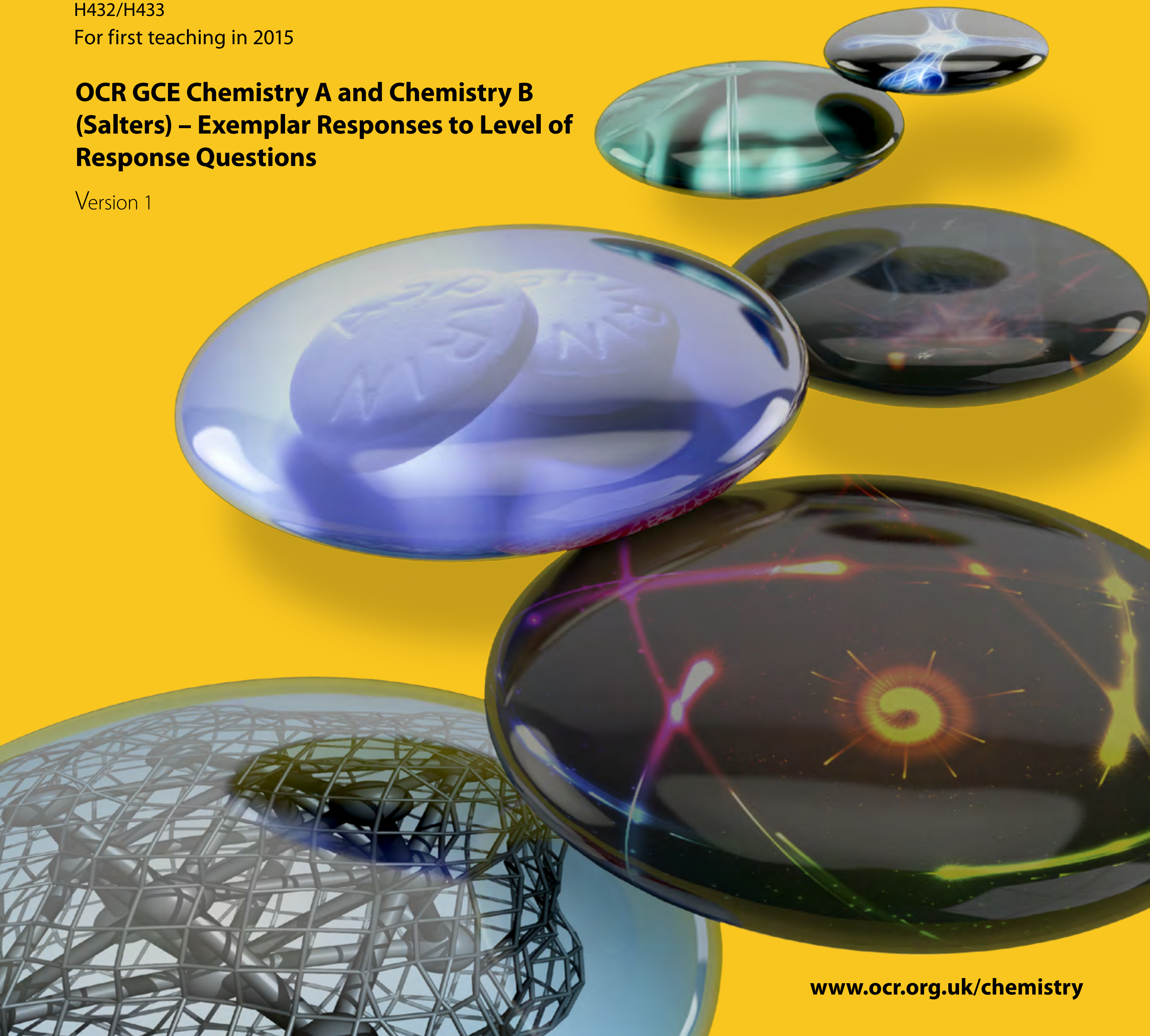
CHEMISTRY A AND B (SALTERS)

H432/H433
For first teaching in 2015

OCR GCE Chemistry A and Chemistry B (Salters) – Exemplar Responses to Level of Response Questions

Version 1



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Contents

Introduction

Extended response questions with mark-schemes based on 'Level of Response' (LoR) criteria were used in Chemistry AS level papers for the first time in June 2016, and will be used from 2017 onwards at both AS and A level. LoR questions are indicated in question papers with an asterisk (*) after the question number. These questions are generally less structured than most other questions in the papers and allow candidates to choose their own route through an answer. The use of level of response allows more flexible credit to be given when candidates have answered in a slightly different way or done much better in one part of an answer than another.

A similar resource to this one was produced in 2015/16, based on the AS Sample Assessment Materials, and is available at http://www.ocr.org.uk/Images/285009-as-a-level-exemplar-learner-responses-to-level-of-response-questions.pdf.

LoR questions allow candidates to be credited for both:

- their scientific knowledge, understanding and ability to apply these to familiar and unfamiliar situations, and
- their ability to communicate in a clear, coherent and logical manner.

Mark schemes for LoR questions therefore detail both the 'science content' and the 'communication' aspects of expected answers.

Examiners are told to read through an answer once to decide which of four 'Levels' (including zero) it matches on a 'best fit' basis. There are descriptors on the left-hand side of the mark-scheme corresponding to each level. The 'indicative scientific points' on the right-hand side of the mark-scheme are used here. They then read the answer again to decide whether the 'quality of written communication' statement (in italic on the left-hand side for each scoring level) is matched. This often refers to a logical presentation of the points made. If the statement is matched, the higher mark in the level is awarded, eg 6 marks for Level 3, 4 marks for Level 2, etc. Otherwise the lower mark in the band is awarded.

The indicative scientific points that are included in mark schemes are neither exhaustive nor a list of all of the scientific points that have to be included in an answer to gain a particular mark. Indeed, the mark schemes that are used to assess candidates' responses in live examinations are finalised only after examiners have looked at and discussed a wide range of candidates' responses. This is a key aspect of ensuring that all candidates are awarded marks and final grades in a fair and credit-worthy manner. The senior examiner commentary included within this resource should therefore be seen within this context.

Further senior examiner commentary and guidance on answering all styles of questions is made available in Examiner's Reports (via www.ocr.org.uk, under 'Past papers, mark schemes and reports' on the qualification pages) and in CPD materials published following each series of examinations (available securely to teachers via www.cpdhub.ocr.org.uk under 'GCE Chemistry', or www.ocr.org.uk/interchange under 'Resources and Materials'/'Past Papers and Mark Schemes').

For this resource, candidate responses and candidate-style responses to the LoR questions from the A Level Chemistry Sample Assessment papers have been marked and commented on by senior examiners. As can be seen from these questions, a variety of different chemical concepts can be assessed by LoR question. For example, reactivity series, structures of compounds, organic synthesis, compound analysis and spectroscopy, reaction kinetics and problem solving are covered in these papers. Additionally, the demand of the questions can vary from low demand to high demand.

For each question, four responses have been selected, exemplifying a Level 3, a Level 2 and a Level 1 response, and one that would gain no marks. Commentary is provided on why the Level was selected and the mark awarded, and what extra was needed in the response to move to the next Level.

Some advice on answering LoR questions

The following is some advice to candidates, based on the 2016 AS papers.

Read the Question! It is important that every part of the question is answered. Even if the candidate is unsure on a point, they should write something relevant. Examples should be given if asked for. Material that is not required by the question is not penalised (unless it is chemically incorrect) but it wastes the candidate's time. Candidates should be advised to pick out the individual sub-questions in the stem of the question and tick each one off as they answer it.

Analyse/Interpret: Interrogate any data included in the stem, in the context of the question asked – for example, what are the reasons for trends seen within the data? Annotation of the data can be helpful.

Be logical: Candidates are advised to plan their answers (in some blank space near the question), so that they can arrange their points in a logical sequence. This planning should then be crossed–out so that examiners can ignore it and concentrate on the main answer.

Although we have been advising this approach to planning for years, examiners still see very little evidence of it. The communication statement, which gives the mark within the level, depends particularly on logical presentation, at every level.

Use correct technical terms: Chemists (and Chemistry examiners) are very attentive to the use of correct terminology and the communication mark often depends on this.

Don't be vague! There are several places in the exemplar answers where answers are basically correct but too vague to score. The number of dotted lines given in examination papers for the answers is indicative of the length of answer expected for the question. Candidates can use the extra space provided within a paper if necessary. They should, however, be cautious about writing very long answers, as this can increase the possibility of contradicting themselves and can reduce the clarity and coherence of their answers. Finally, any rough working/notes should be clearly crossed out.

Reviewing answer: Finally, re-read the question and their answer, checking that the question has been fully answered, and that the answer doesn't contain contradictions.

This resource contains all six LoR questions from the H432 Chemistry A Sample Assessment papers (Question 1-6) and all six from the H433 Chemistry B (Salters) Sample Assessment papers (Questions 7-12). They have all been included in the same document, as most of the twelve questions cover chemistry relevant to both specifications.

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http://www.ocr.org.uk/Images/171722-unit-h432-02-synthesis-and-analytical-techniques-sample-assessment-materials.pdf

http://www.ocr.org.uk/Images/171749-unit-h432-03-unified-chemistry-sample-assessment-materials.pdf

http://www.ocr.org.uk/Images/171724-unit-h433-01-fundamentals-of-chemistry-sample-assessment-materials.pdf

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http://www.ocr.org.uk/Images/171753-unit-h433-03-practical-skills-in-chemistry-sample-assessment-materials.pdf

Generic marking guidance provided in all mark schemes:

For answers marked by levels of response: Read through the whole answer from start to finish, concentrating on features that make it a stronger or weaker answer using the indicative scientific content as guidance. The indicative scientific content indicates the expected parameters for candidates' answers, but be prepared to recognise and credit unexpected approaches where they show relevance. Using a 'best-fit' approach based on the science content of the answer, first decide which set of level descriptors, Level 1, Level 2 or Level 3, **best** describes the overall quality of the answer using the guidelines described in the level descriptors in the mark scheme. Once the level is located, award the higher or lower mark. **The higher mark** should be awarded where the level descriptor has been evidenced and all aspects of the communication statement (in italics) have been met. **The lower mark** should be awarded where the level descriptor has been evidenced but aspects of the communication statement (in italics) are missing.

In summary:

- **The science content determines the level.**
- **The communication statement determines the mark within a level.**

Chemistry A

Question 1

H432/01: Chemistry A – Paper 1 – Question 19(d)

(d)* Describe and explain the relative reactivity of the halogens, chlorine, bromine and iodine, in their redox reactions with halides, using reactions on a test-tube scale.

Include reaction equations and observations in your answer.

Question			Answer	Marks	Guidance
19	(d)*		*Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** Describes and explains concisely the trend in reactivity of the halogens. **AND** Full observations of redox reactions backed up by at least two equations. *There is a well-developed explanation which is clear and logically structured. The observations and equations are relevant to those trends explained. Clear and confident knowledge of relevant technical language.* **Level 2 (3–4 marks)** Describes and explains the trend in reactivity of the halogens. **AND** Is able to recall a redox reaction by suitable observations and correctly link to an equation. *There is an explanation with some structure. The observations and equations are in the most-part relevant to the trend explained. Sound grasp of relevant technical language* **Level 1 (1–2 marks)** Describes the trend in reactivity of the halogens with some attempt at explanation. **AND** Is able to recall a redox reaction either by suitable observation or by equation. *The information about the trend is basic and communicated in an unstructured way. The information is supported by only observation or equation and the relationship to the trend may not be clear. Basic grasp of relevant technical language.* **0 marks** No response or no response worthy of credit.	6	**Indicative scientific points may include:** **Trend in reactivity** • More shells or increasing radius down the group • Increasing shielding down the group • More difficult to gain an electron **Observations** • Reaction of Cl_2 or Br_2 with I^-: orange/brown solution **OR** purple in organic • Reaction of Cl_2 with Br^-: yellow solution **OR** orange in organic **Reaction equations** • $Cl_2 + 2Br^- \rightarrow Br_2 + 2Cl^-$ • $Cl_2 + 2I^- \rightarrow I_2 + 2Cl^-$ **OR** $Br_2 + 2I^- \rightarrow I_2 + 2Br^-$ • Order of reactivity linked to observations

Chemistry A

Question 1, sample answer 1

The reactivity of halogens decreases as you go down the group. The ability of a halogen to act as an oxidising agent also decreases as you progress further down group 7. This is because the halogen has to gain electrons. As you go further down the group the halogen has more shells of electrons. This means there is increased shielding, making it harder to gain an electron.

For example – $Cl_2 + 2Br^- \rightarrow Br_2 + 2Cl^-$ → An orange solution of Bromine is observed.

[6]

$Br_2 + 2I^- \rightarrow I_2 + 2Br^-$ → Iodine is observed as a red solution.

– Both of these reactions happen because the Halogen is being reduced (acting as an oxidising agent)

Commentary

This is a Level 3 response and has been awarded 5 out of 6 marks.

The trend in reactivity is explained well in terms of number of shells, shielding and the increased difficulty to gain an electron down the group.

Observations and equations are described for two of the three redox reactions taking place but it is unclear how the observations (and the 'non-reactions') would allow the reactivity trend to be confirmed.

Overall this response is at Level 3, let down by the incomplete observations and explanation of the redox reactions.

Question 1, sample answer 2

More shells as you go down group 7 means the halogen is ~~more~~ less able to gain electrons, and so less able to act as an oxidising agent. As you go down the group there are more shells of electrons, and increased shielding. This makes it harder for the halogen to gain electrons and become reduced.

$Cl_2 + 2Br^- \rightarrow Br_2 + 2Cl^-$ → orange (Bromine)

Commentary

This is a Level 2 response and has been awarded 4 out of 6 marks.

There is a good explanation of the reactivity trend down the group in terms of shells, shielding and increased difficulty to gain an electron.

The candidate has only provided observations and an equation for one redox reaction and has not explained how the redox reactions would confirm the reactivity trend.

The response is a clear Level 2. The candidate has a good grasp of relevant technical language. The response is clear and well structured, allowing the upper 4 marks to be awarded at Level 2.

The response could have been improved by providing more detail of the redox reactions.

Question 1, sample answer 3

Reactivity goes down as you go down the group. The atom finds it harder to get electrons, as it is bigger. Also, as you go down the group the atom is reduced.

$Cl_2 + 2I^- \rightarrow I_2 + 2Cl^-$

Commentary

This is a Level 1 response and has been awarded 2 out of 6 marks.

The candidate has provided an incomplete explanation for the trend in reactivity down the group. There is a correct equation for one redox reaction but no explanation of its relevance to the reactivity trend.

The response is just worthy of the upper 2 marks in the Level 1 band.

The response could be improved by providing a complete explanation of the redox reactions and describing how this is linked to relative reactivity.

Question 1, sample answer 4

Halogens displace other halogens if they are more reactive and the colour of the mixture changes so you know a reaction has happened.

Commentary

This is a Level 0 response and has been awarded 0 out of 6 marks.

The response is very vague and fails to state or explain the trend in reactivity down the group. There is no explanation of the colour changes, no link to redox and no equation.

This response fails to meet any of the criteria for Level 1 and is not worthy of any credit.

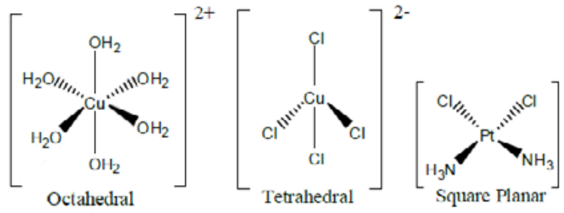
The answer would be improved by providing some facts rather than general statements. The candidate does not seem to have learnt this section of the specification.

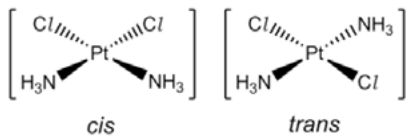
Question 2
H432/01: Chemistry A – Paper 1 – Question 22(b)

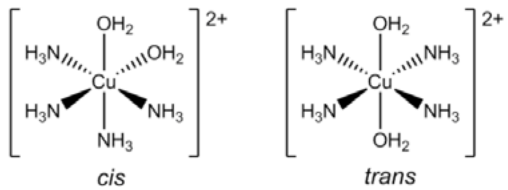
(b)* Transition metal complexes often have different shapes and may form a number of stereoisomers.

Describe the different shapes and the different types of stereoisomerism found in transition metal chemistry.

Use suitable examples and diagrams in your answer.

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr>
<td>22</td><td>(b)*</td><td></td>
<td>
Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.
Level 3 (5–6 marks)
Links together names of shapes with correct 3-D diagrams
AND
Appreciates the two different types of isomerism and labels diagrams appropriately
There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.
Demonstrates clear and confident knowledge of relevant technical language using the terms
non-superimposable mirror images within optical isomerism
opposite and adjacent/same side in cis-trans
Level 2 (3–4 marks)
Names and labels at least two of the shapes appropriately giving 3-D diagrams
AND
Appreciates that two types of isomerism exist in transition metal chemistry, gives diagrams to illustrate at least one pair of isomers and names them correctly
There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.
Answers question with a sound grasp of relevant technical language using the terms
tetrahedral, octahedral
cis-trans OR optical
</td>
<td>6</td>
<td>
Indicative scientific points may include:
Shapes of complex ions
six coordinate bonds: octahedral
four coordinate bonds: tetrahedral or square planar
3-D diagrams with charges linked to shapes


cis-trans isomerism
found in octahedral and square planar complexes
trans – opposite; cis – adjacent/same side
3-D diagrams to illustrate


OR


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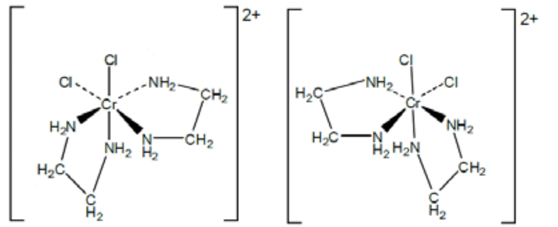
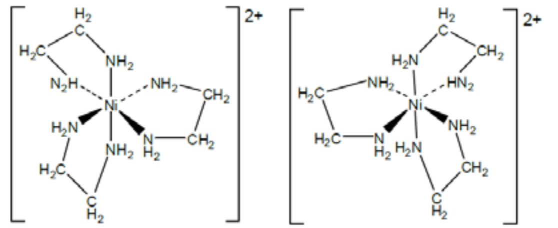
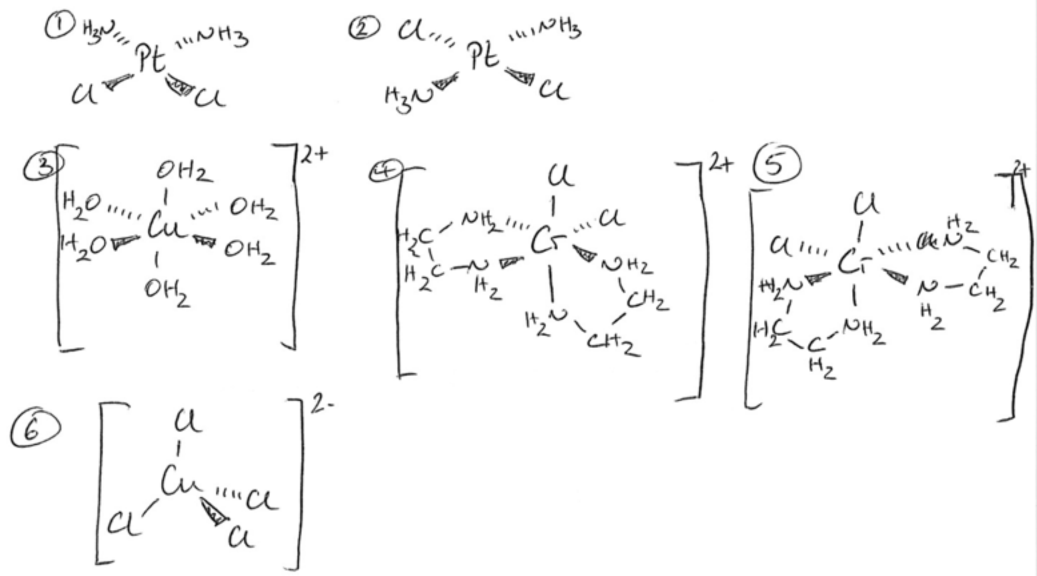
Question			Answer	Marks	Guidance
22	(b)*		**Level 1 (1–2 marks)** Names and draws structures of two of the shapes **AND** Appreciates one type of isomerism that can be seen in transition metal chemistry *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.* *Answers question with a basic grasp of relevant technical language* • *links octahedral to six ligands and tetrahedral to four ligands either in word or by diagram* • *correctly links one type of isomerism to a structure* **0 marks** No response or no response worthy of credit.		**Optical isomerism** • Found in octahedral complexes when bidentate ligands are present • Isomers are non-superimposable mirror images • 3-D diagrams to illustrate  **OR** 

Question 2, sample answer 1



Transition metal complexes can be square planar (1) octahedral (3) or tetrahedral (6) depending on the metal ion & the number and nature of the ligands.

There are two types of isomerism

i) cis-trans, eg (1) & (2) where ligands are either on the same side of the complex (1) or opposite sides (2)

ii) optical isomerism (eg (4) & (5)) where two non-superimposable mirror image complexes can form. **[6]**

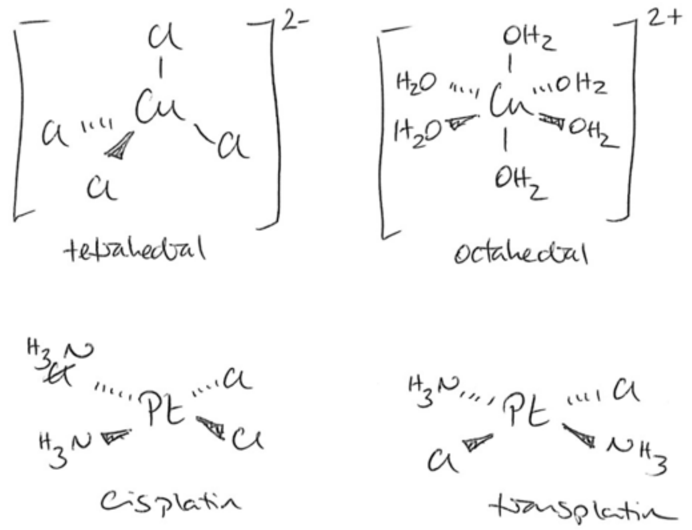
Commentary

This is a Level 3 response and has been awarded 6 out of 6 marks.

The response satisfies all aspects of the question. The candidate has described all three shapes: octahedral, tetrahedral, and square planar. *cis–trans* and optical isomerism has also been described with appropriate examples and excellent use of diagrams using wedges to show the 3D arrangements.

The response is logically structured and shows excellent understanding of transition element stereoisomerism.

Question 2, sample answer 2



Transition metal complexes can have different shapes if they have different numbers of ligands. $[CuCl_4]^{2-}$ is tetrahedral while $[Cu(H_2O)_6]^{2+}$ is octahedral (see above). When there are different ligands in the complex there can be isomerism. For example in $PtCl_2NH_3$ the chlorides can be on the same side of the complex (cisplatin) or on opposite side (transplatin). If there are bidentate ligands then you can also get optical isomers.

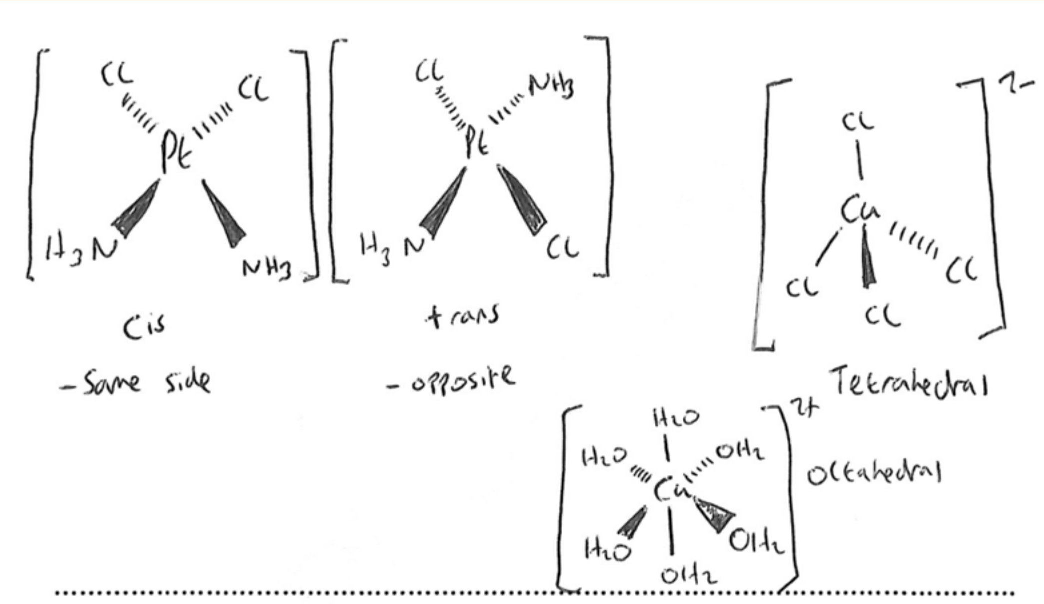
Commentary

This is a Level 2 response and has been awarded 4 out of 6 marks.

The candidate has described all three shapes: octahedral, tetrahedral, and square planar. *cis–trans* isomerism has been described with appropriate examples and excellent use of diagrams using wedges to show the 3D arrangements. The candidate has mentioned optical isomerism from bidentate ligands but has not linked this isomerism to an octahedral shape and there are no examples.

The response is logically structured and well communicated. The response could be improved by also discussing optical isomerism. Consequently, Level 2 has been achieved and the good communication allows 4 marks to be awarded.

Question 2, sample answer 3



Commentary

This is a Level 1 response and has been awarded 2 out of 6 marks.

The candidate has drawn clear 3D diagrams of the three shapes: octahedral, tetrahedral, and square planar. *cis–trans* isomerism has also been described with appropriate examples. The diagrams make good use of wedges to show the 3D arrangements.

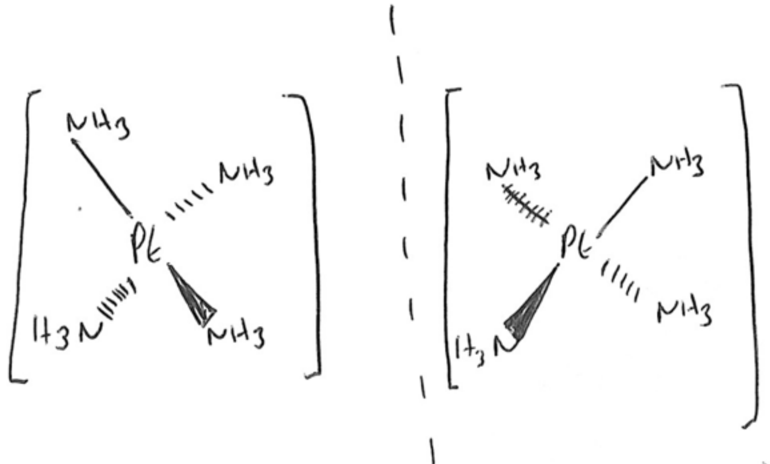
However, the candidate has omitted optical isomerism entirely.

The key points have been made using correct technical language but solely as annotations to diagrams so the response lacks structure.

Despite the absence of any cohesive text, the clear communication of the key points just allows 2 marks to be awarded at Level 1.

The response could be improved by completely answering the question with inclusion of optical isomerism and explanatory text to explain the relevance of the annotations to the diagrams.

Question 2, sample answer 4



Optical isomers (mirror images)

The shape is tetrahedral

Commentary

This is a Level 0 response and has been awarded 0 out of 6 marks.

Unfortunately, there is nothing here that can be credited. The candidate has attempted to draw 3D diagrams but wedges have been used poorly. The candidate has muddled optical isomerism with *cis–trans* isomerism and the example used, $Pt(NH_3)_4$, would have a 2– charge and would not display stereoisomerism at all. The shape is incorrectly named.

This appears to be the response of a poorly prepared candidate.

Chemistry A

Question 3
H432/02: Chemistry A – Paper 2 – Question 20(a)

20 Cyclohexanone can be prepared in the laboratory by reacting cyclohexanol with concentrated sulphuric and sodium dichromate.

Ethanedioic acid is added to the reaction mixture to react with excess dichromate.

The mixture is then distilled. The impure distillate is a mixture of cyclohexanone and water.

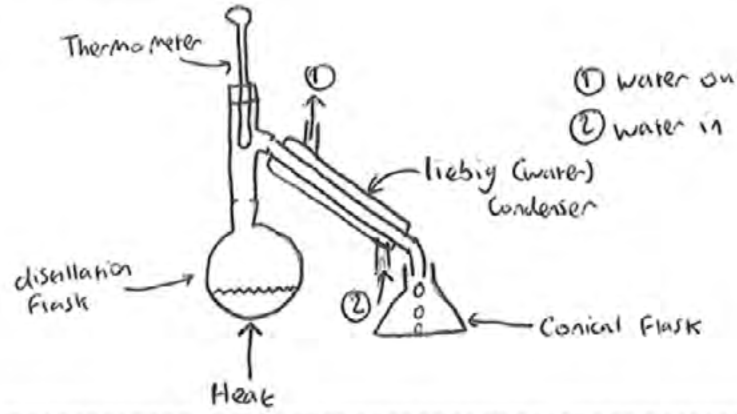
You will need to refer to some or all of the following data to answer these questions.

	Boiling point/^{o}C	**Density/g cm^{-3}**	M_r
Cyclohexanol	161	0.962	100.0
Cyclohexanone	156	0.948	98.0

(a)* Draw a labelled diagram to show how you would safely set up apparatus for distillation and describe a method to obtain a pure sample of cyclohexanone from the distillate.

Question			Answer	Marks	Guidance
20	(a)*		*Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** Correctly labelled diagram of apparatus that works, with no safety problems **AND** Full appreciation of further two steps required to gain pure sample *There is a well-developed diagram which is clear and structured. The information on further purification is detailed and relevant.* **Level 2 (3–4 marks)** Labelled diagram of apparatus but with safety/procedural problems **OR** clear diagram of functional apparatus without labelling **AND** Some details of further purification steps *The diagram presents apparatus that is in the most-part relevant with some correct labelling, and supported by some details of further purification steps.* **Level 1 (1–2 marks)** Diagram of apparatus drawn with no labelling **OR** labelled diagram with significant safety/procedural problems **AND** Few or imprecise details about further purification stages *The diagram is basic and unstructured. Any mention of purification steps is limited to generic term, e.g. 'drying', without relevant detail.* **0 marks** No response or no response worthy of credit.	6	**Indicative scientific points may include:** **Diagram** <u>Includes following components:</u> distillation flask heat source thermometer at outlet (bulb **level** with outlet) still-head water condenser (**correct direction** of water flow) receiving vessel **open** system Further purification Shake and leave to settle in a separating funnel Separate layers by tapping off Add (a small amount of) anhydrous magnesium sulfate/ anhydrous calcium chloride to organic layer (in a dry concil flask) (Re)distill the organic layer Collect fraction distilling at (between 150 °C and) 156 °C

Question 3, sample answer 1



Heat carefully using apparatus above. After disillation pour disilled Solution into a ~~sp~~ seperating Funnel. Shake + leave to settle, then tap off the seperate layers. Remove water by adding anhydrous Calcium chloride to organic layer in a dry Conical Flask.

Re-distill in the apparatus above, collect the product at a temperature of between 152-156 °C.

Commentary

This is a Level 3 response and has been awarded 6 out of 6 marks.

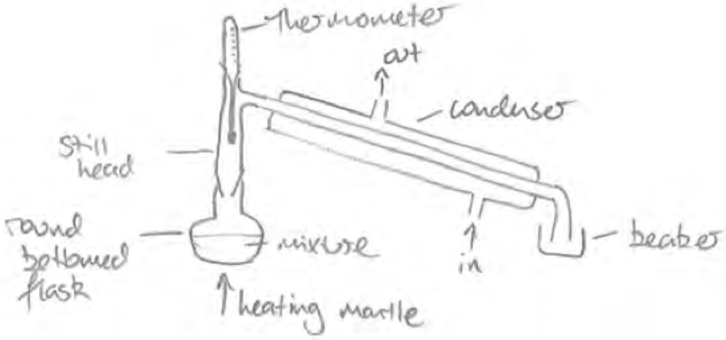
The candidate has drawn a clear, correctly-labelled diagram with no safely issues. The only issue is the very small gap between the still-head and the condenser but the overall quality is good. This demonstrates a general issue and candidates do need to take more care with such fine detail when drawing diagrams. Had this gap been larger, the response would have been limited to Level 2.

All three purification steps: use of separating funnel, drying, and redistillation, have been explained using fine detail including settling of layers and running off from the funnel, the name of a suitable drying agent and boiling point ranges.

Despite the small issue with the diagram, the candidate has produced a very good response, addressing all chemical points required for Level 3. The clear communication allows all 6 marks to be awarded.

Chemistry A

Question 3, sample answer 2



To separate the water, shake in a separating funnel and when two layers appear, run off and collect the cyclohexanone layer (top). Then distill it again collecting at 156°C.

Commentary

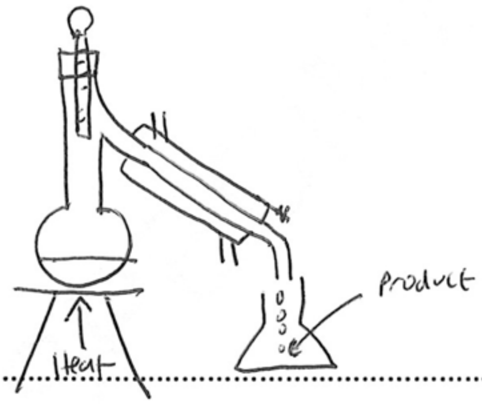
This is a Level 2 response and has been awarded 4 out of 6 marks.

The diagram is clear and correctly labelled with no safety issues. Ideally the thermometer should be placed in line with the outlet from the still-head and the water outlet appears to be close to the centre of the condenser.

Some purification steps have been explained but the drying stage has been omitted entirely. This omission limits the response to Level 2. The clear communication allows 4 marks to be awarded.

Had all purification stages been included, this response would have at Level 3.

Question 3, sample answer 3



Disall, then dry with Calcium chloride + filter. Shake mixture.

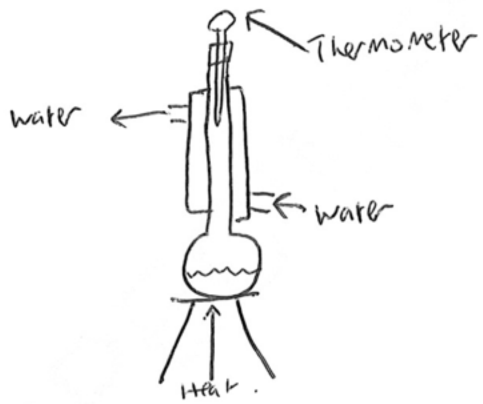
Commentary

This is a Level 1 response and has been awarded 1 out of 6 marks.

The apparatus shown in the diagram appears to be safe with an open system but has very few labels (the apparatus is not labelled at all). There is some attempt to include purification steps but they are in random order. There is no real indication of the purification steps and lack of any detail.

This is a Level 1 response; the poor communication and the overall response is worthy of 1 mark only.

Question 3, sample answer 4



Disall Product at 156°C, Shake + filter, remove water.
Do not let near flames

Commentary

This is a Level 0 response and has been awarded 0 out of 6 marks.

The candidate has confused reflux with distillation and the setup shows an unsafe closed system. The purification steps are in random order and offer no real indication of the procedure.

This weak Level 0 response seems to be that of a very poorly prepared candidate. There is nothing worthy of credit and 0 marks have been awarded.

Chemistry A

Question 4
H432/02: Chemistry A – Paper 2 – Question 21

21* A chemist isolates compound **L**, with empirical formula C_3H_6O, and sends a sample for analysis.

The analytical laboratory sends back the following spectra.

Mass spectrum

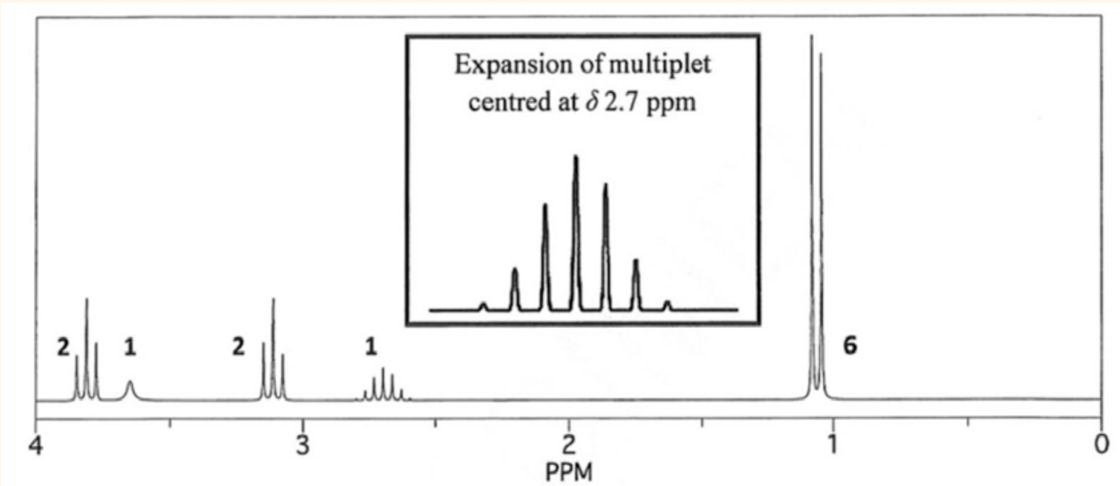
Molecular ion peak at m/z = 116.0.

^{1}H NMR spectra

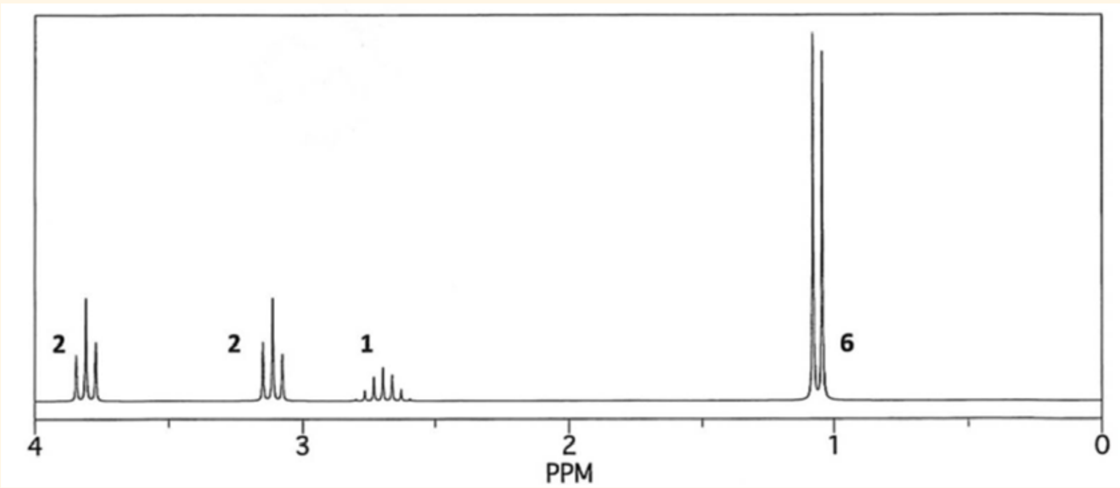
The numbers next to each signal represent the number of ^{1}H responsible for that signal.

Two ^{1}H NMR spectra were obtained: one without D_2O and one with D_2O added.

^{1}H NMR spectrum with no D_2O:

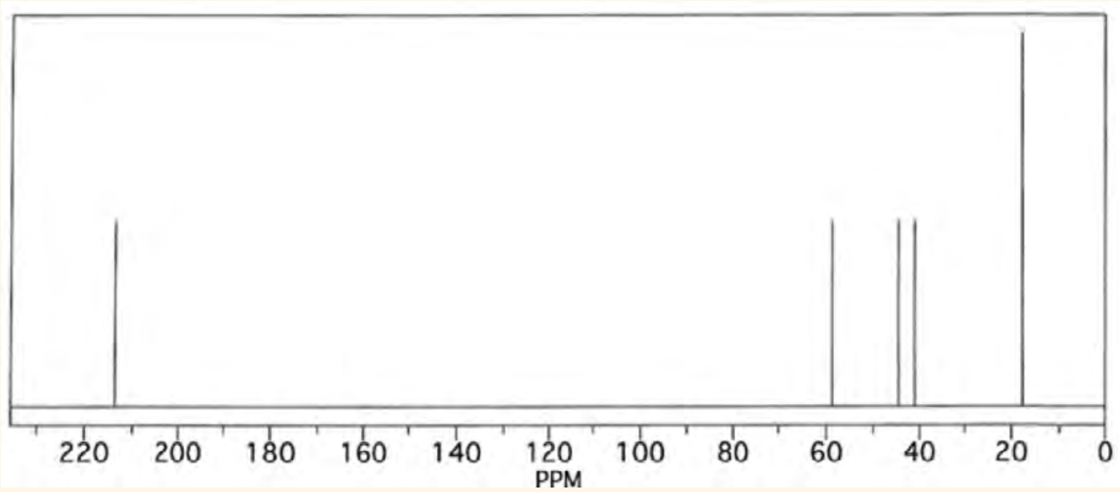


^{1}H NMR spectrum with D_2O added:



Question 4
H432/02: Chemistry A – Paper 2 – Question 21

^{13}C NMR spectrum:



Use the information provided to suggest a structure for compound **L**.

Give your reasoning.

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr>
<td>21*</td><td></td><td></td>
<td>

Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.

Level 3 (5–6 marks)
Structure correct
AND
Analysed all ^1H NMR signals with at least two supporting statements made.

The analysis is clear and logically structured. The supporting statements are relevant to the correct structure drawn.

Level 2 (3–4 marks)
Structure has correct molecular formula **AND** C=O **AND** OH but in incorrect positions
AND
Analysed at least three ^1H NMR signals with one or two supporting statements made.

The analysis is presented with some structure. The supporting statements are in the most-part relevant to the structure drawn.

Level 1 (1–2 marks)
Structure has correct molecular formula **AND** C=O **OR** OH but in incorrect positions
AND
Analysed at least two ^1H NMR signals with no or one supporting statements made

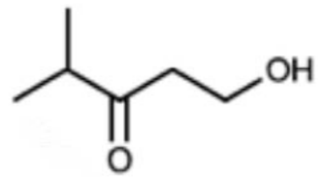
The analysis is basic and communicated in an unstructured way. The relationship of the supporting evidence to the structure may not be clear.

0 marks
No response or no response worthy of credit.

</td>
<td>6</td>
<td>

Indicative scientific points may include:

Structure



L =

^{1}H NMR spectrum
δ = 3.8 ppm, triplet, 2H $CH_2\mathbf{-CH_2-O}$
δ = 3.7 ppm, singlet, 1H $O\mathbf{-H}$
δ = 3.1 ppm, triplet, 2H $CH_2-\mathbf{CH_2C{=}O}$
δ = 2.7 ppm, septet, 1H $(CH_3)_2\mathbf{CHC{=}O}$
δ = 1.0 ppm, doublet, 6H $\mathbf{(CH_3)_2}CH$

Supporting statements
δ = 3.7 ppm lost after D_2O, indicating —O**H**
δ = 213 ppm in ^{13}C NMR but no δ = 9-10 ppm in ^1H NMR so ketone, **not** aldehyde
$M_r(C_3H_6O) = 58$ 116/58 → $2\ C_6H_{12}O_2$

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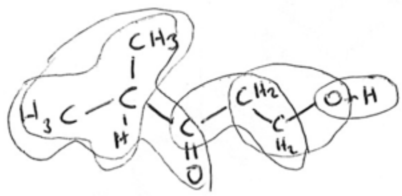
Question 4, sample answer 1

Give your reasoning.



$M_r = 116$

Signals

3.8 ppm – triplet – 2H – CH_2-CH_2-O

3.7 ppm – Singlet – 1H – O–H

3.1 ppm – triplet – 2H – $CH_2-CH_2C=O$

2.7 ppm – Septet – 1H – $(CH_3)_2CHC=O$

1.0 ppm – doublet – 6H – $(CH_3)_2CH$

lost with D_2O spectra so OH

Is a ketone as shift at $\delta = 214$ ppm on ^{13}C, no shift at 9–10 ppm on ^1H NMR, indicating no aldehyde present **[6]**

Commentary

This is a Level 3 response and has been awarded 6 out of 6 marks.

The candidate has obtained the correct structure and has analysed all the ^1H NMR peaks.

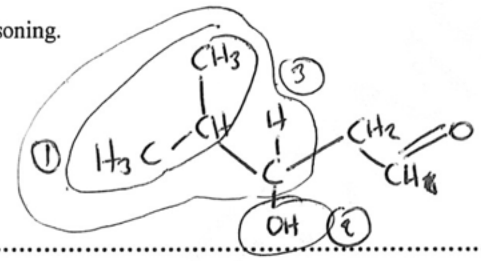
There are two supporting statements: the loss of one peak with D_2O and analysis of the **C**=O peak in the ^{13}C NMR spectrum.

All criteria have been met for Level 3 and communication is clear and logically structured overall. The response could have been improved had the protons been labelled on the structure (as in the next sample answer), allowing them to be better linked to the explanation. It was not always clear which proton was being referred to in the explanation, particularly for the two CH_2 peaks.

Overall, communication is just sufficient for all 6 marks to be awarded.

Question 4, sample answer 2

Give your reasoning.



① Shift at δ = 1.0 ppm (Daslet, 6 Hydrogens)

② Shift at δ = 3.7 ppm, (singlet, 1 Hydrogen)

③ Shift at δ = 2.7 ppm (septet, 1 Hydrogen)

–OH is present as in D_2O spectra the signal at 3.7 ppm is lost.

[6]

Commentary

This is a Level 2 response and has been awarded 4 out of 6 marks.

The candidate has provided a structure with the correct molecular formula, with –OH and C=O functional groups, but wrongly positioned on the molecule.

Only 3 of the 4 ^{1}H NMR peaks had been discussed. The two peaks resulting from the $(CH_3)_2CH$ group have been correctly linked to the structure, with numerical labels helping the explanation.

Only one supporting statement has been included and the ^{13}C NMR spectrum has been ignored.

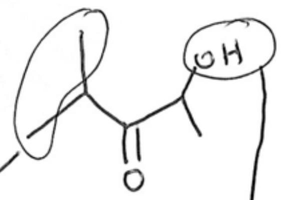
This response has met the criteria for Level 2 and has been well communicated, allowing 4 marks to be awarded.

The response could be improved by analysing all the information provided, especially all ^{1}H NMR peaks and the ^{13}C NMR spectrum.

Question 4, sample answer 3

Give your reasoning.

molecular formula $C_6H_{12}O_2$



$\delta = 1.1$, doublet

$\delta = 3.8ppm$; singlet

Commentary

This is a Level 1 response and has been awarded 1 out of 6 marks.

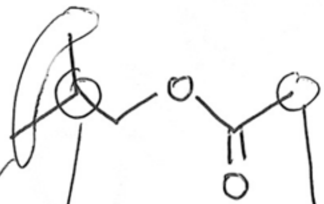
The response shows a structure with the correct molecular formula and –OH and C=O functional groups, but wrongly positioned on the molecule.

Communication is poor, going little beyond annotations on the structure, which presumably apply to the ^1H NMR spectrum.

This is a Level 1 response. The lack of any explanation excludes any credit for communication and 1 mark has been awarded.

Question 4, sample answer 4

Give your reasoning.



1 H

6 H

3 H

Commentary

This is a Level 0 response and has been awarded 0 out of 6 marks.

This is a weak response. The candidate has drawn an incorrect structure with the correct molecular formula. The annotations go little beyond stating the number of protons in each environment of the structure drawn and do not match the pattern in the ^1H NMR spectrum.

Consequently, there seems to be no analysis of the spectra and there is nothing that can be credited.

The response could be improved by matching the structure drawn to specific peaks in the spectra.

Question 5
H432/03: Chemistry A – Paper 3 – Question 2(a)

2 This question looks at ions and complexes.

(a)* You are provided with two boiling tubes containing solutions of the same ionic compound. The compound contains one cation and one anion from the lists below.

- cations: Fe^{2+}, Mn^{2+}, NH_4^+
- anions: Cl^-, CO_3^{2-}, SO_4^{2-}

Solutions of common laboratory reagents are available.

Plan a series of tests that you could carry out on the samples to identify the ionic compound. Your tests should produce at least one positive result for each ion.

For each test,

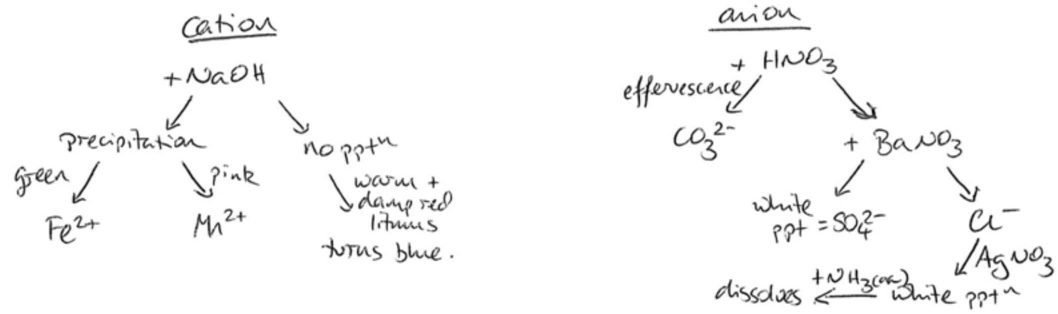
- include details of reagents, relevant observations and equations
- explain how your observations allow the ions to be identified.

You may include flowcharts or tables in your answer.

Question			Answer	Marks	Guidance
2	(a)*		*Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** Develops a plan that allows identification of all six ions **AND** includes essential detail and equations for all test procedures and observations, with three anion tests in the correct sequence, CO_3^{2-}, SO_4^{2-} then Cl^- **AND** includes cation test with essential detail and all equations *There is a well-developed, detailed plan which is clear and logically structured. The plan is substantiated with relevant information, e.g. justification of the sequence of anion tests. There is a clear explanation of how the observations allow the ions to be identified.* **Level 2 (3–4 marks)** Develops a plan that allows identification of at least three ions **AND** includes detail of at least three test procedures and observations, and three equations *There is an appropriate plan presented with some structure. Parts of the fine detail, correct sequence, or reference to use of both samples may be missing. There is some attempt to explain how the observations allow the ions to be identified.* **Level 1 (1–2 marks)** Develops a plan that allows identification of at least two ions **AND** includes detail of at least two test procedures and observations, and one equation *The plan is basic and communicated in an unstructured way. The response lacks fine detail and no reference to correct sequence of anion tests. There is little or no attempt to explain how the observations allow the ions to be identified.* **0 marks** No response or no response worthy of credit.	6	**Indicative scientific points may include:** Use one sample for cation test, other sample for anion tests **Details of tests** *Cation test* add Aqueous sodium hydroxide Positive observations • for Mn^{2+} : pink/buff precipitate • for Fe^{2+} : green precipitate • for NH_4^+ : litmus paper held over the opening of the tube turns blue Fine detail: • (gentle) heating for NH_4^+ test Equations: $Mn^{2+} + 2OH^- \rightarrow Mn(OH)_2$ $Fe^{2+} + 2OH^- \rightarrow Fe(OH)_2$ $NH_4^+ + OH^- \rightarrow NH_3 + H_2O$ *Anion tests* CO_3^{2-}: • add nitric acid; positive observation: effervescence SO_4^{2-}: • add aqueous barium nitrate; positive observation: white precipitate Cl^-: • add silver nitrate solution; positive observation: white precipitate

Question			Answer	Marks	Guidance
2	(a)*				Fine detail for Cl^-: • subsequent addition of dilute ammonia solution positive observation: precipitate dissolves. Fine detail: correct sequence of all three anion tests • carbonate test followed by sulfate test followed by halide test • justification of sequence • **ALLOW** splitting of solution over three boiling tubes/test tubes and performing each test on a different sample. Equations: $CO_3^{2-} + 2H^+ \rightarrow CO_2 + H_2O$ $Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4$ $Ag^+ + Cl^- \rightarrow AgCl$

Question 5, sample answer 1



Cations: transition metal ions generally insoluble with hydroxide
$Fe^{2+} + 2OH^- \rightarrow Fe(OH)_2(s)$, $Mn^{2+} + 2OH^- \rightarrow Mn(OH)_2(s)$.
Ammonium ion is an acid, neutralised by hydroxide to produce basic ammonia gas, which reacts with the red litmus.
$NH_4^+ + OH^- \rightarrow NH_3 + H_2O$.
Anions: CO_3^{2-} & SO_4^{2-} can give false positives with Ba^{2+} & Ag^+ so test in order CO_3^{2-} then SO_4^{2-} then halides.
$CO_3^{2-} + 2H^+ \rightarrow H_2O + CO_2$ - observe the effervescence.
Add the Ba^{2+} which precipitates the SO_4^{2-}
$Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4(s)$.

 H432/03

Halide ions precipitate with silver ions
$Ag^+ + Cl^- \rightarrow AgCl(s)$
with characteristic colours ($AgCl(s)$ is white). This is confirmed with dissolving in ammonia. $AgCl(s)$ is soluble

Commentary

This is a Level 3 response and has been awarded 6 out of 6 marks.

The candidate has provided full details of tests that would enable all six ions to be identified, with clear flowcharts that summarise the required tests for identifying all six ions, including the correct sequence for anion tests. All observations have been included.

The explanation explains the underlying chemistry and includes all equations.

This is an excellent response at Level 3 that is very clear and logically structured throughout. This allows all 6 marks to be awarded.

Question 5, sample answer 2

Fe^{2+} – Add NaOH – ~~Black~~ Green

Mn^{2+} – Add NaOH – Pink

NH_4^+ – Add NaOH – Litmus paper blue over tube

Cl^- – Add Silver nitrate – White precipitate

CO_3^{2-} – Add Nitric acid – fizzes

SO_4^{2-} – Add Barium nitrate – White ppt.

Heat

$Fe^{2+} + 2OH^- \rightarrow Fe(OH)_2$

$Mn^{2+} + 2OH^- \rightarrow Mn(OH)_2$

$NH_4^+ + 2OH^- \rightarrow NH_3 + H_2O$

Commentary

This is a Level 2 response and has been awarded 3 out of 6 marks.

The plan would allow identification of most ions but essential detail is missing, e.g. 'precipitate' for the metal cation tests, use of ammonia for confirming Cl^-, and the correct $CO_3^{2-}/SO_4^{2-}/Cl^-$ sequence for the anion tests. Three equations are shown but the equation for NH_4^+ is incorrectly balanced.

There is some attempt to explain how the observations would allow the ions to be identified.

Overall, this response has just met the criteria for Level 2 but the incomplete communication strand restricts the mark to the 3 marks.

Question 5, sample answer 3

Fe^{2+} → Add NaOH → Green Precipitate
$Fe^{2+} + 2OH^- \rightarrow Fe(OH)_2$

Mn^{2+} → NaOH → pink precipitate

NH_4^+ → NaOH → litmus turns blue

Cl^- → AgNH$_3$ → white ppt.

Commentary

This is a Level 1 response and has been awarded 1 out of 6 marks.

This is a minimalist response and it is assumed that NaOH refers to the reagent for the cation tests. The observations for cations would allow correct identification and one correct equation has been provided. The Cl^- test has a correct observation but the reagent is incorrect.

The response provides no explanation and the poor communication requires much to be read into what the response means.

This is a Level 1 response and the poor communication restricts the answer to 1 mark only.

This response could be improved by being structured into sections, with an explanation of each test. The candidate appears to know more that is being communicated.

The response could be improved by checking equations and inclusion of fine detail.

Question 5, sample answer 4

Add ~~NaOH~~ NaOH to solutions, look at the colour of the precipitate formed (for example, Fe^{2+} forms green precipitates → $Fe^{2+} + OH^- \rightarrow Fe(OH)_2$

Commentary

This is a Level 0 response and has been awarded 0 out of 6 marks.

The response contains details of one test and provides the observation for only Fe^{2+}. The equation given is incorrectly balanced.

The criteria for Level 1 have not been met and the response is not worthy of any credit.

Chemistry A

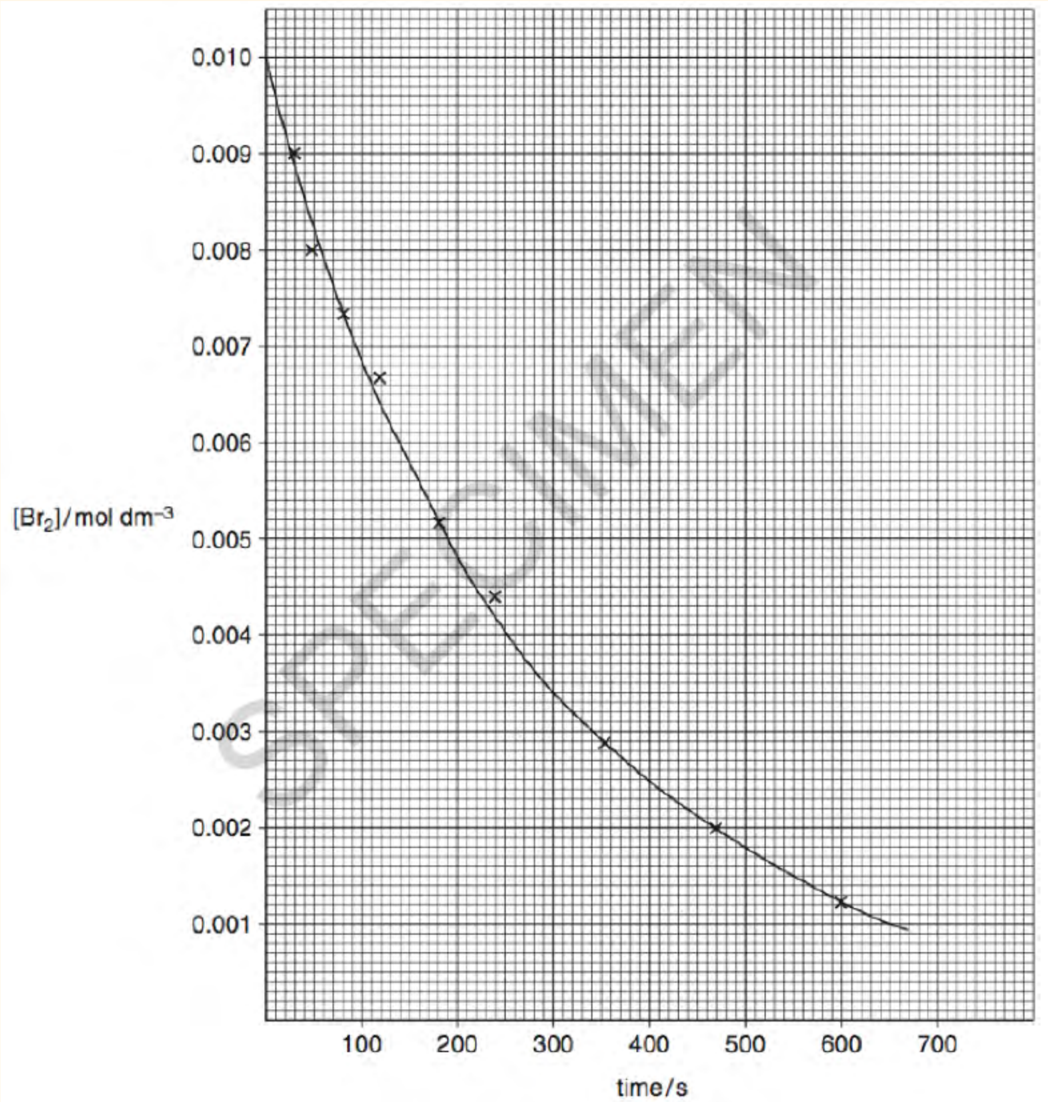
Question 6
H432/03: Chemistry A – Paper 3 – Question 4(d)

4 Methanoic acid and bromine react as in the equations below.

$$Br_2(aq) + HCOOH(aq) \rightarrow 2H^+(aq) + 2Br^-(aq) + CO_2(g)$$

A student investigates the rate of this reaction by monitoring the concentration of bromine over time. The student uses a large excess of HCOOH to ensure that the order with respect to HCOOH will be effectively zero.

From the experimental results, the student plots the graph below.



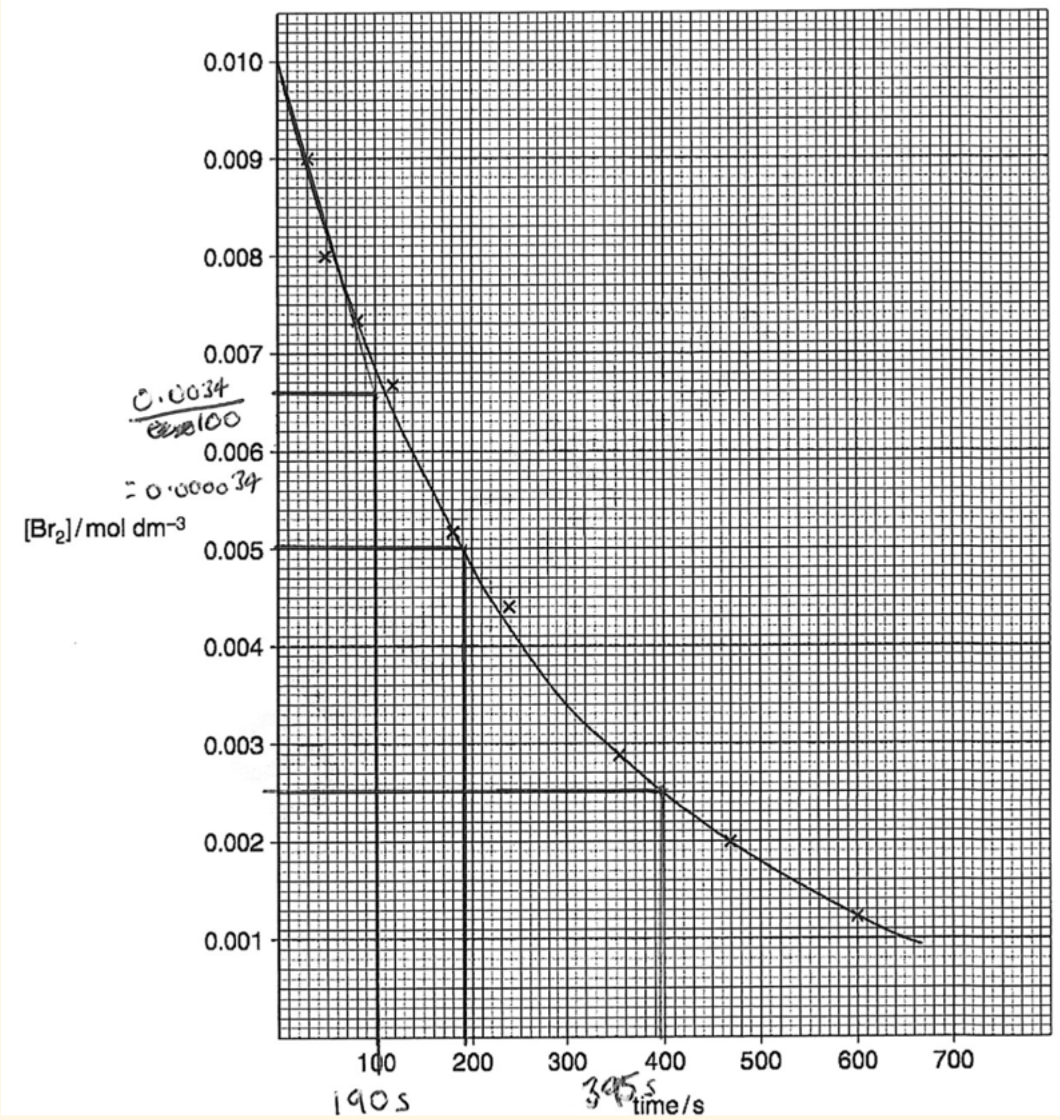
(d)* Using the graph, determine

- the initial rate of reaction
- the rate constant.

Your answer must show full working using the graph and the lines below as appropriate

Question			Answer	Marks	Guidance
4	(d)*		*Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** A comprehensive conclusion which uses quantitative data from the graph to correctly identify and calculate initial rate **AND** half lives and reasoned order of Br_2 **AND** determination of *k* with units *There is a well-developed conclusion showing a line of reasoning which is clear and logically structured. The working for initial rate, half life and order are clearly shown. Determination of k is clear and correct.* **Level 2 (3–4 marks)** Reaches a sound, but not comprehensive, conclusion based on quantitative data from the graph. Correctly identifies and calculates initial rate **AND** half lives and reasoned order of Br_2 *The conclusion has a line of reasoning presented with some structure. The initial rate and order is relevant and supported by correct evidence from the graph. There may be errors in the calculations which prevent the correct determination of k.* **Level 1 (1–2 marks)** Reaches a simple conclusion using at least one piece of quantitative data from the graph. Attempts calculation of initial rate **OR** half lives and reasoned order of Br_2. *The information selected from the graph is basic and communicated in an unstructured way. The calculations may not be clear and the evidence used from the graph may not be clearly shown.* **0 marks** No response or no response worthy of credit.	6	**Indicative scientific points may include:** **Initial rate** • Evidence of tangent on graph drawn to line at t = 0 s AND gradient determined in range $4 \pm 1 \times 10^{-5}$ • *initial rate* expressed as gradient value with units of mol dm^{-3} s^{-1}, e.g. initial rate = 4×10^{-5} mol dm^{-3} s^{-1} **Half lives and reasoned order of Br_2** • Half life measured on graph **OR** within text **OR** stated in range 180–200 s • Constant half life **OR** two stated half lives within ±20 s **AND** conclusion that Br_2 is 1st order **Determination of *k* with units** • Rate constant k clearly linked to initial rate **OR** half-life: $k = \frac{rate}{[Br_2]}$ **OR** $k = \frac{\ln 2}{t_{1/2}}$ • *k* determined correctly from measured initial rate or measured half life with units of s^{-1}, e.g. $k = 4 \times 10^{-3}$ s^{-1} from initial rate of 4×10^{-5} mol dm^{-3} s^{-1} **OR** $t_{1/2}$ of 175 s

Question 6, sample answer 1



gradient (initial rate) = 3.4×10^{-5} mol dm^{-3} s^{-1}

Half life (0.005) = 190s

205s

Half life (0.0025) = 395s

roughly same gap = 1st order

1st order rate equation

rate = $k[Br_2]$

$\therefore k = \frac{\text{rate}}{[Br_2]} = \frac{3.4 \times 10^{-5}}{0.010}$ **[6]**

$= 3.4 \times 10^{-3}$ s^{-1}

Commentary

This is a Level 3 response and has been awarded 6 out of 6 marks.

On the graph, the candidate has drawn a tangent at $t = 0$ s. The initial rate has then been calculated to produce an answer within the allowed range, with correct units.

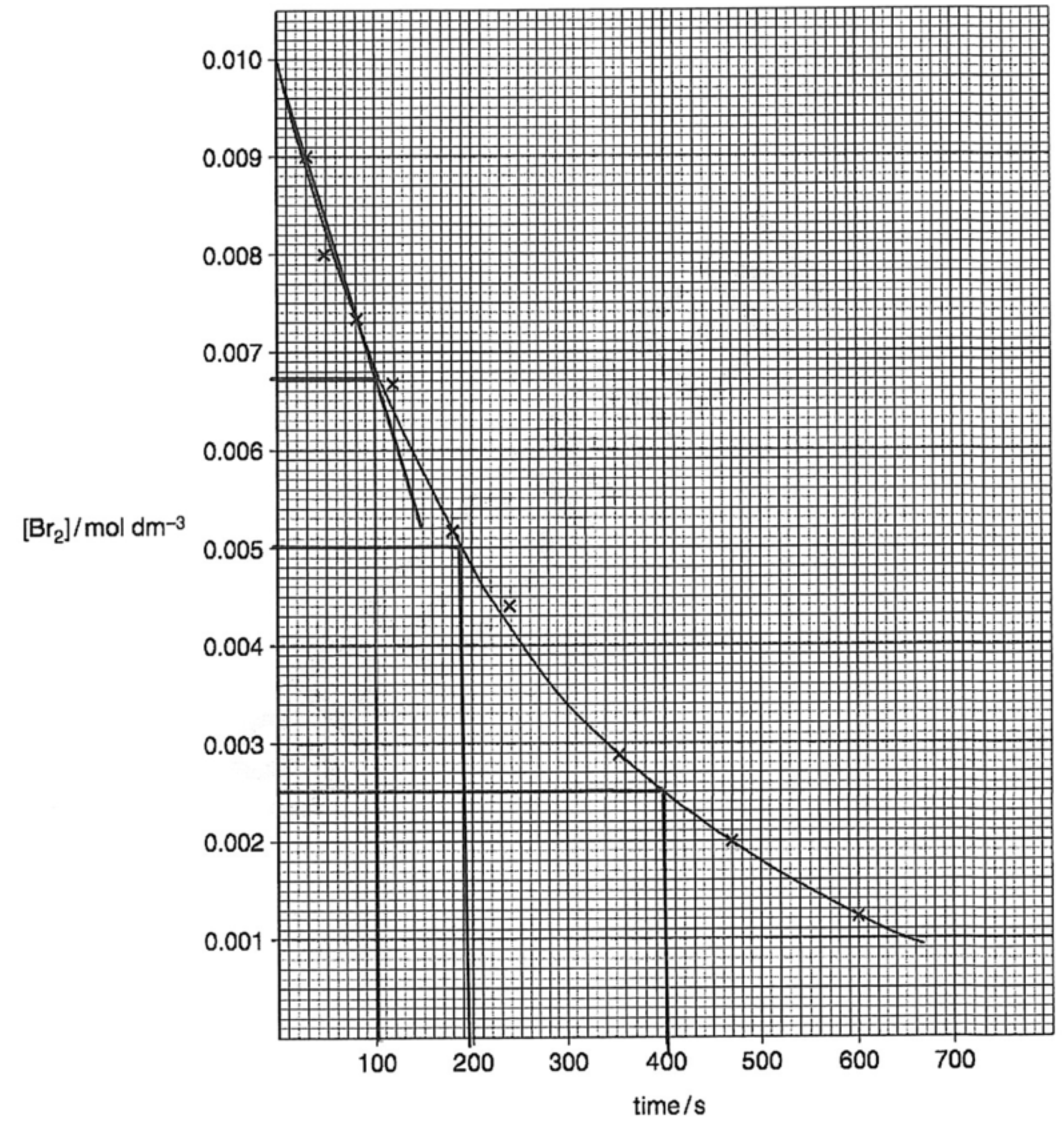
On the graph, the candidate has shown working for two half-lives. On the answer lines, these have been shown to be roughly equal leading to the conclusion that the reaction is first order with respect to Br_2.

The candidate has then written a rate equation from which the correct value of the rate constant has been calculated, with correct units.

The response has met all criteria for Level 3. Communication is clear and well-structured with correct use of units throughout. The response is worthy of all 6 marks.

Chemistry A

Question 6, sample answer 2



rate = $\frac{0.0034}{100}$ = 3.4×10^{-5} moldm^{-3}s^{-1}

Half life - 0.005 - 190s } roughly same gap (210s)
Half life - 0.0025 - 400s → 1st order.

$K = \frac{\text{rate}}{t_{1/2}} = \frac{3.4 \times 10^{-5}}{210}$

$= 1.6 \times 10^{-7}$ moldm^{-3}

[6]

Commentary

This is a Level 2 response and has been awarded 4 out of 6 marks.

On the graph, the candidate has drawn a tangent at $t = 0$ s. The initial rate has then been calculated within the allowed range and with correct units.

On the graph, the candidate has shown working for two half-lives which are shown to be roughly equal on the answer lines. The order with respect to Br_2 has then been shown to be first order.

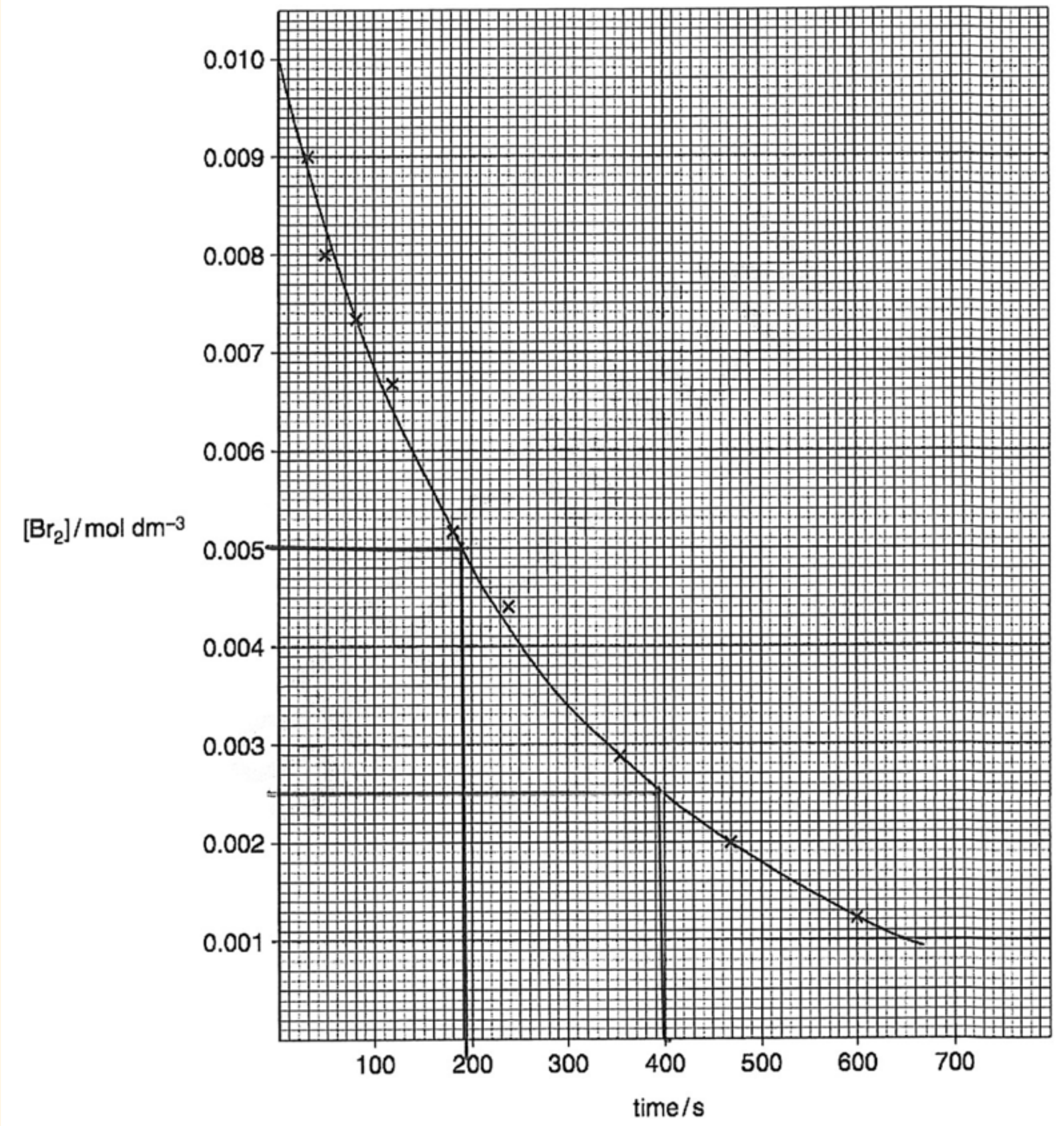
The candidate has been unable to calculate the correct value of the rate constant and the units are incorrect.

The response has clearly met the criteria for Level 2. Communication is clear and well-structured and the response is worthy of 4 marks.

The candidate seems to have got confused between the two methods for calculating *k*: from the initial rate and using half-life. A correct calculation would have allowed access to Level 3.

Chemistry A

Question 6, sample answer 3



Half life at 1/2 0.010 = 0.005 → 190s

Half life at 1/2 0.005 = 0.0025 → 395

gap is 205 s each time → 1st order

roughly

~~rate~~ rate = $K[Br_2]^1$

Commentary

This is a Level 1 response and has been awarded 2 out of 6 marks.

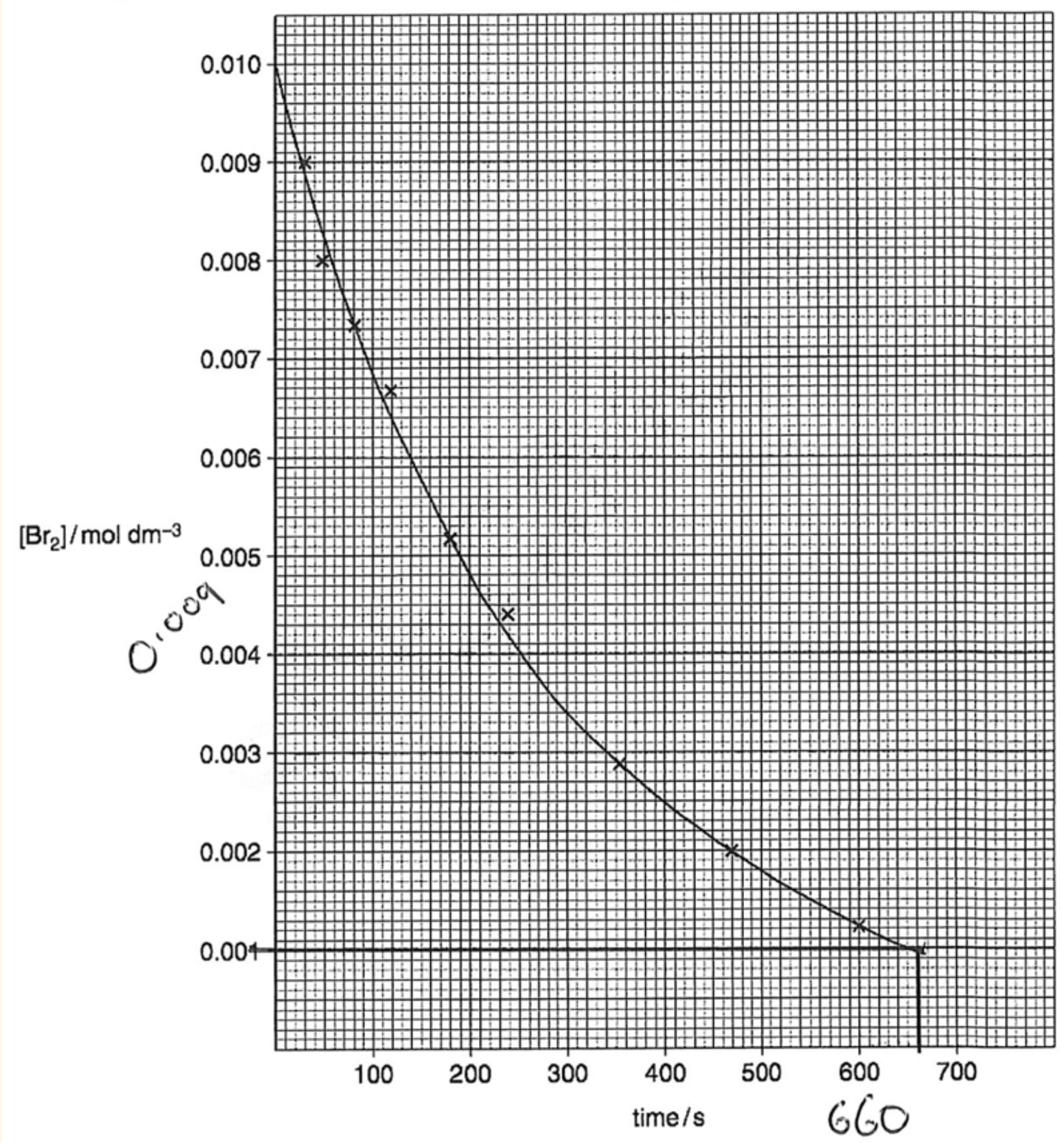
The candidate has provided evidence of measuring two half-lives on the graph. These are shown as being roughly equal, allowing Br_2 to be shown as first order, leading to a correct rate equation.

The candidate has not drawn a tangent at $t = 0$ s and the initial rate has not been determined. The rate constant has also not been calculated.

The response has met the criteria for Level 1 and the communication for constant half-life is reasonably clear. Consequently, 2 marks have been awarded.

It is difficult to see why the candidate has not attempted all parts of the question. The candidate may have not learnt this part of the specification or may not have read the requirements of the question thoroughly.

Question 6, sample answer 4



Your answer must show full working using the graph and the lines below as appropriate.

Gradient = rate

gradient = $\frac{a}{s}$

$= \frac{0.009}{660}$

$= 1.364 \times 10^{-5}$ moldm^{-3} s^{-1}

Commentary

This is a Level 0 response and has been awarded 0 out of 6 marks.

The candidate has attempted only the initial rate but no tangent has been drawn and calculation shows the average rate over the course of the reaction instead.

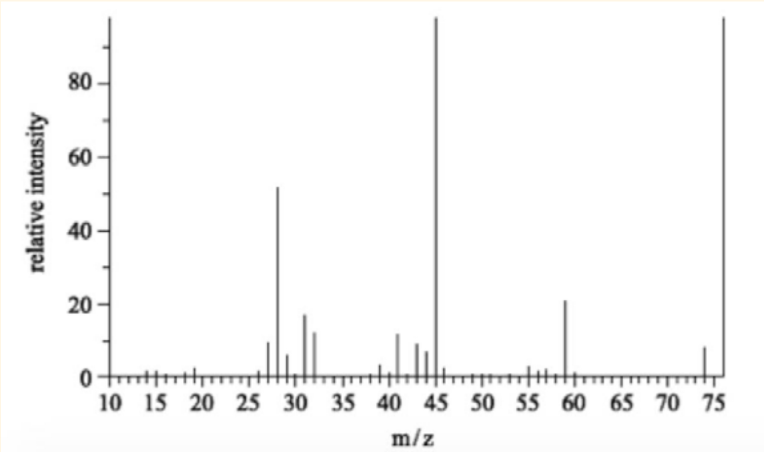
The candidate seems to be poorly prepared. There criteria for Level 1 have not been met and no marks can be awarded.

Chemistry B (Salters)

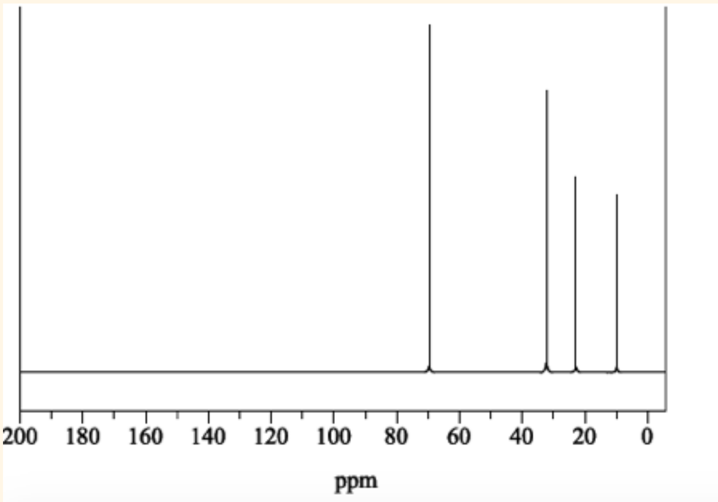
Question 7
H433/01: Chemistry B (Salters) – Paper 1 – Question 32(b)(ii)

(ii)* The mass spectrum and ^{13}C NMR spectrum for compound **A** are given below.

Mass spectrum (Compound A)



^{13}C NMR Spectrum (Compound A)



Use the information and spectral data given above to work out the **structures** of **A**, **B**, **C** and **D**.

Compound **A** has the molecular formula C_xH_yO.
Compound **A** reacts when heated with acidified $K_2Cr_2O_7$ to form compound **B**.
Compound **B** does **not** react with Tollens' reagent or NaOH.
Compound **A** reacts with heated Al_2O_3 to form two unsaturated compounds, **C** and **D**.

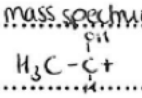
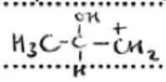
Include evidence to support your choice of structures.

Question			Answer	Marks	Guidance
32	(b)	(ii)	*Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** Analyses information **AND** spectral data to provide evidence to support the correct and full identification of all compounds **A**, **B**, **C** and **D**. Evidence from reactions of **A AND** no reaction of **B** with Tollens' reagent or NaOH **AND** MS spectrum **AND** ^{13}C NMR spectrum. *The information and evidence used is relevant and fully supports the identification. The answer is clear and logically structured.* **Level 2 (3–4 marks)** Analyses information **AND** data to provide evidence to support the partial identification of compound **A** as a secondary alcohol, **B** as a ketone and **C** and **D** as alkenes. Evidence from reactions of **A AND** no reaction of **B** with Tollens' reagent or NaOH **AND EITHER** MS spectrum **OR** ^{13}C NMR spectrum *The information and evidence used is in the most-part relevant and supports the identification. The answer is presented with some structure.* **Level 1 (1–2 marks)** Analyses information **OR** data to provide evidence allowing partial identification of the compounds **A** **AND** **B OR C AND D** using reactions of **A OR** no reaction of **B** with Tollens' reagent or NaOH **OR** using information from MS Spectrum **OR** ^{13}C NMR spectrum *The information and evidence is used to make a partial identification of* ***A AND B OR C*** *and* ***D****. The evidence chosen does not fully support the identification and is not presented in a logical order.* **0 marks** No response or no response worthy of credit.	6	**Indicative scientific points may include:** Full identification Compound **A** is $CH_3CH_2CH(OH)CH_3$ Compound **B** is $CH_3CH_2COCH_3$ Compounds **C & D** are $CH_3CH_2CH{=}CH_2$ and $CH_3CH{=}CHCH_3$ **Evidence from spectral data** **MS Spectrum:** • $M_r\ (C_xH_yO) = 74$ $M_r\ (C_xH_y)\ 74 - 16 = 58$ so $x = 4$ and $y = 10$. **^{13}C NMR:** *2 from* • 4 carbon environments • no C=O or C=C • C–O (and C–C) present. **Evidence from the Reactions:** • **A** is alcohol from formula plus $H^+/Cr_2O_7^{2-}$ reaction • Heating **A** with Al_2O_3 results in elimination of water from **A** forms 2 different alkenes, **C** and **D** • Thus **A** secondary and **B** a ketone. • **A** is alcohol from formula plus $H^+/Cr_2O_7^{2-}$ when heated → **B** is aldehyde, ketone or carboxylic acid • No reaction with Tollens' → **B** is **NOT** an aldehyde • No reaction with NaOH → **B** is **NOT** a carboxylic acide • Conclusion: **B** is a ketone **AND A** a secondary alcohol. For Level 1: partial identification of **A** required. May be supplemented by partial identification of **B OR** partial identification of **C** and **D**.

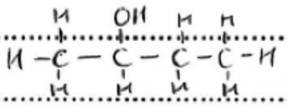
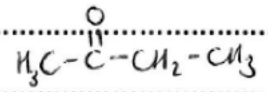
Question 7, sample answer 1

A reacts with $K_2Cr_2O_7$ to form B, but B is not an aldehyde (doesn't react with Tollens') and is not a carboxylic acid (doesn't react with NaOH) ⇒ A is a secondary alcohol. B is a ketone

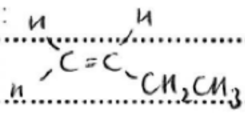
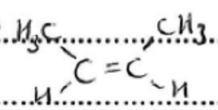
Highest peak on mass spectrum is at 74 ⇒ M_r = 74 ⇒ molecular formula $C_4H_{10}O$

Peak at: 45 due to  , 59 due to 

Peaks in C^{13} nmr: ~70ppm due to C–O, 3 other peaks due to C–C bonds with each C in a different environment.

⇒ A is  and B is 

A can be dehydrated by Al_2O_3 to form 2 different alkenes:

eg C:  D: 

Commentary

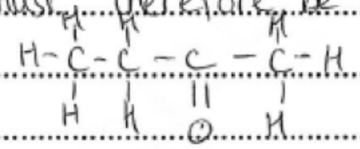
This answer is in Level 3, since it identifies compounds A – D correctly, citing reactions of A and B. It gives full supporting evidence from ^{13}C NMR and mass spectrometry.

There is a good logical flow through this answer so it is worth the full six marks.

Question 7, sample answer 2

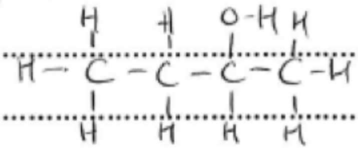
Mass spec shows Mr = 74 and A contains one oxygen atom. 74-16 = 58 so formula is $C_4H_{10}O$ which is an alcohol.
If A was a primary alcohol it would make an aldehyde or ~~Ketone~~ carboxylic acid. Aldehydes react with Tollen's to make a silver mirror + carboxylic acids react with NaOH to make a salt.

B must therefore be a ketone so



butanone

A must be a secondary alcohol so the only structure with 4 carbons is



butan-2-ol

And it makes two different alkenes when reacting with Al_2O_3. [6]

Commentary

This answer identifies compounds A and B, using reactions and mass spectrometry data. Fortunately, it mentions alkenes at the end which enables it to be considered for Level 2. The order in which the points are made is not very logical, however, so the mark is 3, not 4. An improvement would be to identify A before B. Candidates are advised to write out their points in rough and then arrange them in the most logical order when writing their answer.

To reach Level 3, reference to the ^{13}C NMR would have been necessary and the structures of the alkenes. Candidates should note that it is important to answer every part of such questions. Here this would involve considering all the evidence.

Question 7, sample answer 3

$C_xH_yO \xrightarrow{K_2Cr_2O_7} B$

13 C 4 environments

$4 \times 12 = 48$ O = 16

$$\frac{\begin{array}{r}48\\16\end{array}}{64} = 10 \text{ hydrogens}$$

$C_4H_{10}O$ 4 enviromments = straight chain primary or secondary not tertiary ($K_2Cr_2O_7$)

B not aldehyde or carboxylic acid

So B is ketone – butanone

Commentary

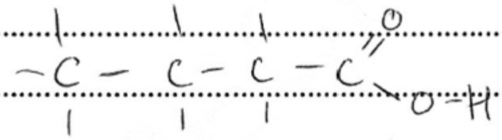
Here, compound A is not identified as a secondary alcohol and there is no mention of alkenes, so Level 2 cannot be awarded. There is sufficient analysis to match Level 1, as the candidate attempts to identify A (by implication) and B using evidence from the mass spectrometry (74 is used but not stated) and the NMR. The italicised 'quality' statement is also matched, so this answer scores 2 marks.

This candidate could have reached Level 2 if they had been more specific (with reasons) that A was a secondary alcohol and mentioned that alkenes were formed. Once again, the importance of considering all the evidence should be noted.

Question 7, sample answer 4

A is butanol from the formula C_xH_yO = 4 carbons

B is a carboxylic acid so butanoic acid which is shown from ^{13}C NMR 4 environments and NaOH reaction



No reaction with Tollen's because butanoic acid is not able to be oxidised.

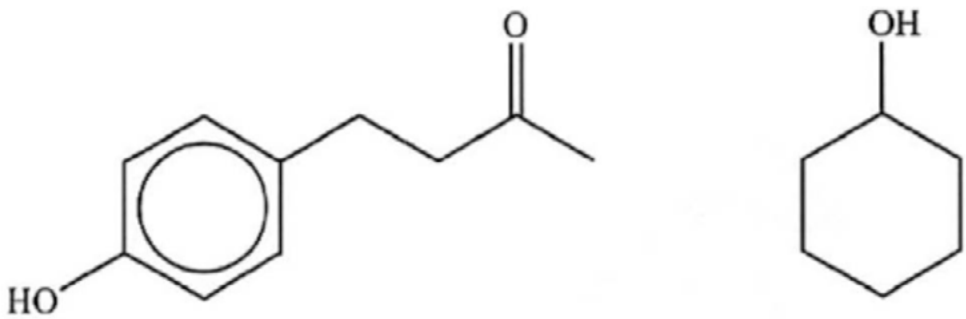
Commentary

While examiners look for correct statements to reward, rather than incorrect ones to penalise, there is so much wrong here, especially about B, that the few partially correct statements are not worth anything.

To reach Level 1, the candidate would have had to describe B as a ketone rather than an acid and distinguished between the evidence from the NMR and mass spectrometry.

Question 8
H433/01: Chemistry B (Salters) – Paper 1 – Question 34(b)

(b)* The structures of raspberry ketone and cyclohexanol are shown below.



raspberry ketone　　cyclohexanol

The difference between the structures of the carbon ring in raspberry ketone and cyclohexanol has an effect on the chemical properties of the hydroxyl group.

Describe the difference between the structures of the two carbon rings and how the reactions of the hydroxyl group are different in the two compounds.

Include examples, and at least two equations.

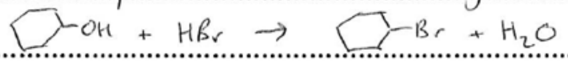
Question			Answer	Marks	Guidance
34	**(b)***		*Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** Fully describes the differences between the two compounds in detail with both ring descriptions correct. Describes at least three reactions with examples and equations. *The full description is detailed and correct. There is a clear and logical structure. The reactions are relevant and fully supported with examples and equations.* *Demonstrates a clear and confident knowledge of relevant technical language (names of compounds, 'substitution', 'elimination', 'delocalisation').* **Level 2 (3–4 marks)** Describes the differences between the two compounds in detail including electron delocalisation in phenol. Describes at least two reactions with equations but not necessarily showing reactions for both structures. *The description is detailed and is presented with some structure. The reactions are in the most-part relevant and support by equations.* *Demonstrates ability to answer question with some indications of a sound grasp of technical language.* **Level 1 (1–2 marks)** Identifies the differences between the two structures mentioning phenol and alcohol. Describes at least two reactions. *The description is basic and communicated in an unstructured way. The reactions are relevant but lack detail. Demonstrates a basic grasp of relevant technical language.* **0 marks** No response or no response worthy of credit.	**6**	**Indicative scientific points may include:** **Ring structures** • saturated ring of 6 carbons in alcohol • unsaturated ring of 6 carbons in phenol with 6 delocalised electrons **Reactions of –OH group:** • acidic in phenol neutral in alcohol e.g. with alkalis* (NOT with carbonates) • nucleophilic substitution in alcohol e.g. with halide* • elimination in alcohol not in phenol e.g. form alkenes* with Al_2O_3/H_2SO_4 • phenol give purple colour with $FeCl_3$ • phenols will not react with carboxylic acids but alcohols will* * an equation can be written here If other correct reactions are given which are **NOT** different between the two compounds mark lower at each level.

Question 8, sample answer 1

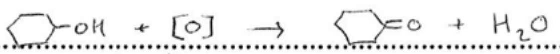
Raspberry ketone is a phenol – the circle represents a delocalised ring of 6 e^-s causing the ring to be planar. The delocalised structure of the ring results in electrophilic substitution reactions but also in the OH group being acidic: $C_6H_5OH + NaOH \rightarrow C_6H_5O^-Na^+ + H_2O$

Because the ring is already unsaturated the OH group in phenol cannot undergo elimination – however this can happen with cyclohexanol with ~~a~~ conc H_2SO_4:

The OH group in the aliphatic alcohol also undergoes nucleophilic substitution:



And oxidation:



(with acidified dichromate) **[6]**

the phenol OH can't do this as it can't form C=O.

Commentary

This answer uses correctly the terms 'phenol', 'alcohol', 'unsaturated' and 'delocalised' and gives four correct reactions with equations. Thus we are looking at Level 3. The mention of electrophilic substitution in the phenol ring is often found in these answers though it is not relevant to the question which asks about the reactions of the –OH group. This does not count against candidates, but it wastes their time. This answer only makes the point about cyclohexanol being saturated by implication and isn't quite a 'full' and 'detailed' description, so would be awarded 5 rather than 6 marks. Explicit statement of the saturated nature of cyclohexanol would have allowed 6 marks to be awarded.

Question 8, sample answer 2

In raspberry ketone the lone pair on the oxygen are delocalised into the aromatic ring system through resonance delocalisation. This doesn't happen in cyclohexanol as the ring is saturated and has no delocalised electrons. This means the conjugate base of raspberry ketone is more stable than that of cyclohexanol, so raspberry ketone will react with bases where cyclohexanol won't:

$$CH_3COCH_2CH_2C_6H_5OH + NaOH \longrightarrow CH_3COCH_2CH_2C_6H_5ONa + H_2O$$

Due to the high electron density in the aromatic ring, raspberry ketone is more likely to undergo electrophilic substitution, whereas cyclohexanol is more likely to undergo nucleophilic substitution (electron withdrawing O causes δ^+ on C bonded to OH group) $CH_3COCH_2CH_2C_6H_5OH + HBr \longrightarrow CH_3COCH_2CH_2C_6H_4(OH)(Br)$ **[6]**

$$C_6H_{11}OH + HBr \rightarrow C_6H_{11}Br + H_2O$$

Commentary

This answer only gives two correct reactions. The description of the delocalisation in phenol does not give the full detail expected, nor are the terms 'alcohol' and 'phenol' used. However, the descriptor for Level 2 is met, including the two correct reactions. Electrophilic substitution of the ring can be ignored, as above. However, here an incorrect equation is given, implying that HBr is an electrophile. This reduces the quality of communication in the answer, so the mark is 3.

Question 8, sample answer 3

Cyclohexanol is saturated but raspberry ketone is unsaturated so R.K. will react with Br_2 but cyclohexanol won't

The OH in R.K. is enough to be an acid but the OH in cyclohexanol is not an acid so won't react with hydroxide.

The OH in ~~[illegible]~~ RK is a phenol, in cyclohexanol it is a secondary alcohol so you can test for phenol with ~~[illegible]~~ iron (III) chloride → purple.

Phenol has free electrons which can react with electrophiles. **[6]**

Commentary

Delocalisation is not mentioned and no equations are given so the answer does not reach Level 2. The mention of 'phenol' and 'alcohol' and the description of two reactions support Level 1. Again, the reaction with bromine can be ignored as irrelevant to the question.

Within the limits of what is written, the answer is logical and demonstrates a grasp of technical language, so the mark is 2.

To reach Level 2, 'delocalisation' should be mentioned and equations should be given for the reaction of phenol with NaOH and one extra reaction.

Question 8, sample answer 4

Raspberry ketone is a ketone so it will react with Brady's to make a red precipitate but cyclohexanol will not.

In raspberry ketone there is a carbon attached on the 4 position so the NMR will be different

Cyclohexanol can form hydrogen bonds but raspberry ketone can't.

Commentary

This answer definitely starts with a correct chemical statement so should it be considered for some marks? The answer, unfortunately, is 'no', because the chemistry is not relevant to the question. There are no descriptions of the rings and no reactions of the –OH group in either compound. So the answer scores zero.

This is an extreme case of failing to 'Read The Question', though we have seen other examples above.

In particular the description of electrophilic substitution in the ring has been mentioned in all the other answers. The question does not say 'compare the structure and reactions of raspberry ketone and cyclohexanol'. It asks for specific comparisons and candidates must be taught to read questions carefully before starting.

Chemistry B (Salters)

Question 9
H433/02: Chemistry B (Salters) – Paper 2 – Question 3(c)

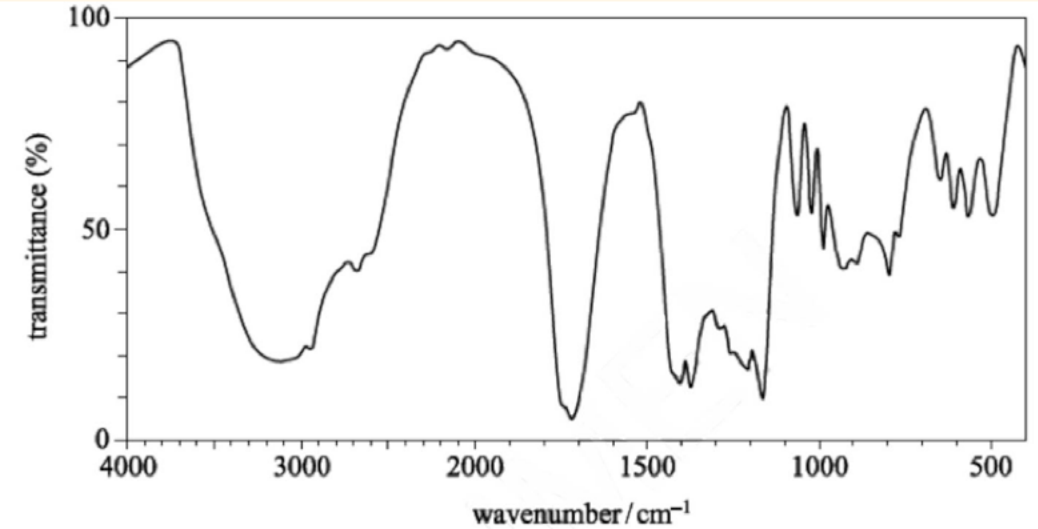
(c)* Compound **G** is an intermediate in the manufacture of GMV from glucose.

Compound **G** has the following composition by mass:

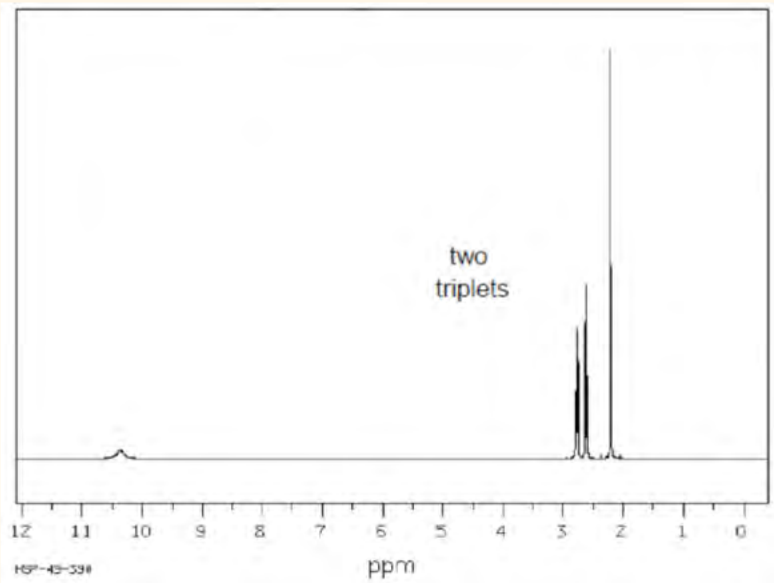
C, 51.72%; H, 6.90%; O, 41.38%

Compound **G** has IR and ^{1}H NMR spectra as shown below.

IR spectrum:



^{1}H NMR spectrum:



Use **all** this information to work out the structure of compound G.

In your answer give evidence to support your choice of structure.

Question			Answer	Marks	Guidance
3	(c)*		*Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** Candidate identifies the structure of the compound correctly, the evidence for this identification uses information from composition by mass **AND** IR spectrum **AND** proton NMR spectrum. *The identification is clear and logically structured. The evidence selected is relevant and fully supports the identification.* **Level 2 (3–4 marks)** Candidate identifies the compound as a keto-acid, the evidence for this identification uses information from composition by mass **AND EITHER** IR spectrum (both points) **OR** proton NMR spectrum **OR** using information from IR spectrum **AND** proton NMR spectrum. *The identification has a logical structure. The evidence selected is in the most-part relevant and supports the identification.* **Level 1 (1–2 marks)** Candidate makes an attempt at identifying the compound and the evidence to support this identification uses **EITHER** information from composition by mass **OR** IR spectrum **OR** proton NMR spectrum *The identification is basic and communicated in an unstructured way. The evidence selected is limited and the relationship to the identification may not be clear.* **0 marks** No response or no response worthy of credit.	6	**Indicative scientific points may include:** Compound is $CH_3COCH_2CH_2COOH$ **Composition by mass** • $C_5H_8O_3$ calculated **IR spectrum:** • COOH from IR at 3200–3600 (• no OH at 3200–3600/3640) **Proton NMR: (any 3)** • 4 proton environments • peak at 10.5 indicates COOH • peaks at 2.2–2.7 indicate (three) Cs next to (a single) C=O • singlet at 2.2 indicates C with no Hs on adjacent carbons **AND** triplets at 2.6 and 2.8 indicate Cs with one adjacent CH_2.

Question 9, sample answer 1

	C	H	O	
m/g	51.72	6.90	41.38	
mol	4.31	6.90	2.58625	
ratio	1.67	2.67	1	
	5	8	3	

$C_5H_8O_3$ Normally $C_5 = H_{12}$ so 2 double bonds.

IR shows C=O at 1700-1720 and O-H at 2800-3600

~~On~~ So must contain COOH as 'HNMR shows small peak at 10.5 ppm. 4 hydrogen environments - one is on O-H of COOH. One environment must be separated from other hydrogen environments by C=O as it is not split by other H so $CH_3-C{=}O$. Two other environments are split into triplets so 2 adjacent CH_2 groups:

$CH_3COCH_2CH_2COOH$. **[6]**

Commentary

This answer gives the correct structure, using evidence from the composition by mass, the IR and plenty from the proton NMR. The organisation of the answer is extremely clear and logically structured. Therefore it scores all 6 marks.

Question 9, sample answer 2

C: 51.72/12 ~~f~~ 4.31 5 $C_5H_8O_3$

H 6.90 6.90 8

O 41.38/16 2.59 3

NMR shows 4 H environments

So one C has no H attached - C=O CH_3 next to this has no splitting as C=O stops interactions with neighbouring H / no carbon neighbouring with H.

Two enviroments triplets - next to CH_2 so both CH_2 next to each other and COOH on end

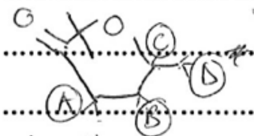
so $CH_3COCH_2CH_2COOH$ **[6]**

Commentary

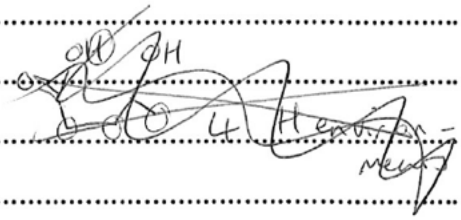
This is a good answer giving the correct structure. Unfortunately, it does not consider the IR spectrum, so it only reaches Level 2 where evidence from *either* spectrum is allowed. There is definitely a line of reasoning in the identification, so it scores 4 marks.

To gain Level 3 (and probably 6 marks) a mention of the IR spectrum with COOH identified would have been necessary. The point to stress to candidates is that all parts of the question must be dealt with and here the question asks for ALL the evidence to be considered.

Question 9, sample answer 3



= $C_5H_8O_2$



4 H environments

C is @ 10.5

A+B are triplets D is a singlet

C=O on IR.

Commentary

The candidate has made an attempt to identify the compound and this is justified by some evidence, so we look at Level 1. It cannot reach Level 2, since the structure is incorrect and a keto-acid is not identified. Two pieces of evidence are correct and related to the structure: 4 hydrogen environments and the fact that A and B are triplets and the C=O from the IR. However, the molecular formula is wrong and much of the evidence is jumbled and only partially accurate. Thus 1 mark is awarded.

To reach 2 marks, more clarity would have been needed in the evidence from the NMR. To reach Level 2, a keto-acid would need to be identified and the spectroscopic data laid out more carefully.

Question 9, sample answer 4

	C	H	O
	51.72	6.9	41.38
÷12	4.31	6.9	2.58625
~~÷2.58625~~	~~1.6666~~	~~2.666~~	~~1~~
~~÷6.9~~		~~0.625~~	
÷ 6.9	0.625	1	0.375
	1	1.6	0.6
	×5	×5	×5
	5	8	3

$C_5H_8O_3$ carboxylic acid? **[6]**

Commentary

This answer does not reach Level 1 as it does not make an attempt to identify the structure. The only evidence is the molecular formula which is not sufficient unless linked to a structure. So the answer scores zero. The question makes it clear that a structure should be suggested and candidates would be well-advised to write a structure, even if they were very unsure of it.

The answer would have reached Level 1 if some suggested structure corresponding to the formula $C_5H_8O_3$ had been given.

Question 10
H433/02: Chemistry B (Salters) – Paper 2 – Question 5(d)(iv)

(iv)* Discuss examples from the article that support Turin's theory and **not** the 'lock and key' theory.

Refer to http://www.ocr.org.uk/Images/171725-unit-h433-02-scientific-literacy-in-chemistry-sample-assessment-materials.pdf pages 25-32 for the full text of the article referred to in this question.

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>5</td><td>(d)</td><td>(iv)*</td><td>Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.

Level 3 (5–6 marks)
Supporting evidence for Turin’s theory AND evidence to discredit the lock and key theory have been correctly identified. There is a clear discussion related to both theories.

The evidence selected is relevant and substantiated. The discussion shows a well-developed line of reasoning for the choices of evidence, which is clear and logically structured.

Candidate demonstrates a clear and confident knowledge of relevant technical language (names of compounds, ‘deuterated’, ‘vibrate’).

Level 2 (3–4 marks)
Supporting evidence for Turin’s theory AND evidence to discredit lock and key theory have been correctly identified although there is a limited attempt to discuss them.

The evidence selected is in the most-part relevant. The discussion has some structure but is limited in scope.

Candidate demonstrates a sound grasp of technical language (one spelling error).

Level 1 (1–2 marks)
Evidence for Turin’s theory has been identified OR
Evidence against lock and key theory.

The information is supported by limited evidence and the relationship to the evidence may not be clear. The discussion is basic and communicated in an unstructured way.

Candidate demonstrates a basic grasp of relevant technical language (several spelling errors).

0 marks
No response or no response worthy of credit.</td><td>6</td><td>Indicative scientific points may include:

Statements to support Turin’s theory
• deuterated acetophenone smells different (from non-deuterated from)
• deuterated benzaldehyde smells different (from non-deuterated form)
• because H and D have different masses and hence C–D and C–H vibrate differently
• C^{12} and C^{13} exchange does not affect smell, since masses only differ slightly
• structures of deuterated acetophenone and benzaldehyde given.

Statements to discredit Lock and Key
• since structures are similar, lock and key theory would not predict difference (AW).
• structurally related molecules can smell utterly different.</td></tr>
</table>

Question 10, sample answer 1

Molecules such as timberol, cedramber and ambrinol have very different shapes so the lock and key theory suggests they would smell different but in fact they smell similar. By contrast, diols like ethylene glycol smell completely different to dithiols despite very similer shapes. S + O have different masses and so their bonds with carbon + ~~oxyg~~ hydrogen vibrate at different frequencies – Turin's theory states that this is more important than shape. This is supported by the fact that substituting ^1H in acetephenone and benzaldehyde for deuterium (^2H) results in a change in smell despite having identical shapes and electron **[6]** structure. Substituting ^{12}C for ^{13}C has little effect because there is a smaller % increase in mass and therefore

END OF QUESTION PAPER

less effect on the vibrational frequency of the bond.

Commentary

This answer is operating at Level 3 since it gives supporting evidence for Turin's theory (including the crucial point about bonds vibrating that is missing in many answers) and evidence to discredit the lock and key theory. There is clear discussion of both theories. There is a well-developed line of reasoning and a good use of technical language. The answer scores 6 marks.

Question 10, sample answer 2

- Ethylene glycol and ethane dithiol have very similar ~~shapes~~ structures but very different smells; in the 'lock and key' theory these two molecules would have very similar smells as both molecules could fit in the same 'lock'.
- When atoms were replaced with their isotopes in molecules there was a 'subtle' change in smell. In the 'lock and key' theory the smell would remain the same as ~~the~~ both structures could fit in the same lock. This would indicate that the mass of the bonded atoms does affect the smell, as predicted by Turin. Timberol, Cedramber and ambrinol all have ~~ver~~ very different structures which would cause them to have very different smells in the 'lock and key' theory. They have very similar smells in reality, which goes against the 'lock and key' theory. **[6]**

Commentary

There are several pieces of evidence to discredit the lock and key theory in this answer but less to support Turin. However, there is just enough to reach Level 2 and the masses of atoms have been mentioned, even if vibrating bonds have not.

The logic of the answer is rather 'random' and it does not look as though the candidate has planned the answer before starting writing. Thus this answer scores 3 marks. To score 4 marks, a more logical flow of points would have been necessary.

To reach Level 3, the answer would need to be better structured and give more coherent evidence for Turin's theory, including a mention of bonds vibrating.

Question 10, sample answer 3

Lock and key depends on shape, but molecules such as ethylene glycol and ethanedithiol are similar shapes but smell very different. Then there are molecules with different shapes but the same smell.

Some molecules have the same shape but if you change the size of the atoms you get a different smell and also there are atoms which give you a different smell if you mix them together like vanillin.

Commentary

There is some evidence against the lock and key theory, so Level 1 has been reached. The second paragraph is too vague to be described as evidence for Turin's theory so the answer does not reach Level 2. The points that have been made are in a logical sequence, so 2 marks are scored.

To reach Level 2, the candidate would have needed to back up the vague statements in the second and subsequent sentences with examples from the article.

Question 10, sample answer 4

Lock and Key theory states that the shape of a molecule is what tells your brain what something smells like.

If you change a hydrogen ~~&~~ atom which has a mass of 1 for a deutenium atom which has a mass of 2, you are putting in bigger atoms so this will affect the shape because a bigger atom will repel the other atoms more. **[6]**

Commentary

There is no evidence either against the lock and key or for Turin here. The example given is incorrect, so this answer scores no marks.

To reach Level 1, the answer would have had to give the correct explanation (change of mass, rather than change of structure) for the example in the second paragraph.

Question 11
H433/03: Chemistry B (Salters) – Paper 3 – Question 2(a)(i)

(a) A group of students set out to investigate the heating effect of volcanic lava on any carbonate rocks that it may flow over. They decide to devise an experiment to compare the thermal stability of magnesium carbonate and calcium carbonate.

The students have access to magnesium carbonate powder, lumps of calcium carbonate, calcium hydroxide powder, distilled water and whatever apparatus they need.

(i)* Describe how the students could carry out their experiment.

You should include in your answer:

- a labelled diagram of the apparatus used to safely heat the carbonate compounds
- the main steps in the experimental procedure and the names of the key apparatus (not included in the labelled diagram)
- the observations and measurements that should be recorded
- how to ensure the comparison is fair and the results are as accurate as possible.

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>2</td><td>(a)</td><td>(i)</td><td>Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.

Level 3 (5–6 marks)
Develops a safe, fully detailed and accurate method that correctly includes apparatus. The full accurately labelled diagram reflects the method. The accurate observations/measurements recorded allow for a fair and accurate comparison between $MgCO_3$ and $CaCO_3$

The method is detailed, clear and logically structured. Accuracy is discussed in terms of the apparatus chosen. Observations/measurements are detailed and allows for a full comparison.

Level 2 (3–4 marks)
Develops a safe, detailed method that includes relevant apparatus. The diagram reflects this method and is labelled correctly. Details refer to accurate measurements. The observations/measurements recorded allow for a fair comparison between $MgCO_3$ and $CaCO_3$.

The method is detailed and logical. Relevant apparatus is identified and there is reference to the accuracy of the measurements to be taken. The observations/measurements are relevant and supply evidence to allow a fair comparison.

Level 1 (1–2 marks)
Develops a basic safe method that includes relevant apparatus either in a correctly labelled diagram or named in the method. Suggests which observation(s)/ measurement(s) need to be recorded to allow some comparison between $MgCO_3$ and $CaCO_3$.

The method is basic and unstructured. Although relevant apparatus is labelled/referred to it lacks detail and accuracy. The observations/measurements are relevant but do not supply sufficient evidence to ensure a fair comparison .

0 marks
No response or no response worthy of credit.</td><td>6</td><td>Indicative scientific points may include:

Method with details
• Crush lumps of calcium carbonate to a powder using a pestle and mortar
• Add calcium hydroxide to distilled water and filter
• Glass test tube/boiling tube to contain the solid fitted with a bung carrying a delivery tube which dips into a solution of calcium hydroxide in a test tube/boiling tube.
• Tube is heated and is approximately horizontal,
• solid (metal carbonate) and solution (calcium hydroxide) are clearly labelled in diagram.

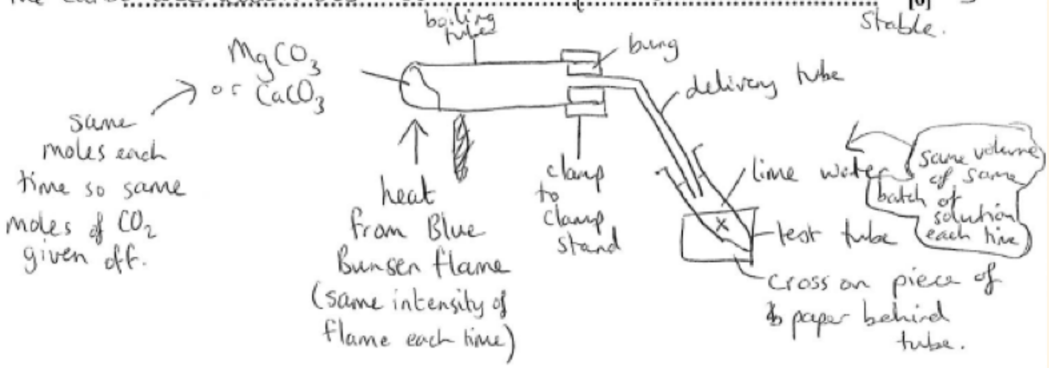
Measurements
• Measure time for cloudiness to first appear.
• Measure time taken to obscure a cross on paper OR alternative way of measuring relative thickness of ppt (of calcium carbonate)

Fair comparison
• Equal mass of $MgCO_3$ and $CaCO_3$
• Same volume and concentration of calcium hydroxide solution</td></tr>
</table>

Question 11, sample answer 1

When heating do not remove heat while tube is in lime water or suck back may happen. Make lime water by adding excess $Ca(OH)_2$ to distilled water + filter to make a saturated solution. Add a fixed mass of one carbonate to the boiling tube (weighed accurately on 2dp balance). (for $CaCO_3$, grind up using pestle + mortar to ensure same surface area). Heat with blue flame as shown in diagram and time how long it takes for cross to disappear as lime water goes cloudy. Repeat with same number of moles of other carbonate. Use same apparatus (cleaned). Repeat to ensure there are no anomolous results and the carbonate which obscures the cross quickest is the least thermally stable.

[6]



 H433/03

Commentary

This has a great deal of detail and reaches Level 3. However, the organisation is poor and the candidate should have planned the answer first. Thus it scores 5 marks, not 6.

To score 6, the answer could have been reversed, with the diagram at the top. The detail that is given in the first two sentences could well have come later.

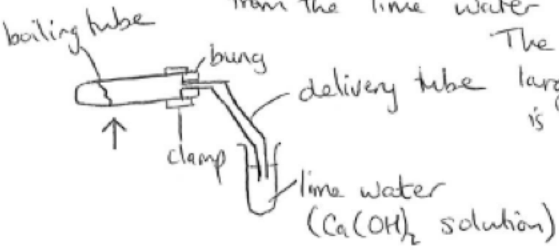
Question 11, sample answer 2

Grind up $CaCO_3$ with pestle + mortar + use same number of moles of $CaCO_3$ and $MgCO_3$ in the experiment.

Safety – must keep heating tube ~~t~~ while delivery tube is in lime water to prevent suck-back. The boiling tube should be clamped horizontally with the clamp away from the heat.

Lime water should be same volume + concentration each time. ~~Not~~

Heat for the same amount of time with same Bunsen flame. After heating, filter out the precipitate **[6]** from the lime water tube + weigh it out.



The solid that produces the largest mass of precipitate is the least thermally stable. ~~taking~~ Repeat 3 times + average results.

Commentary

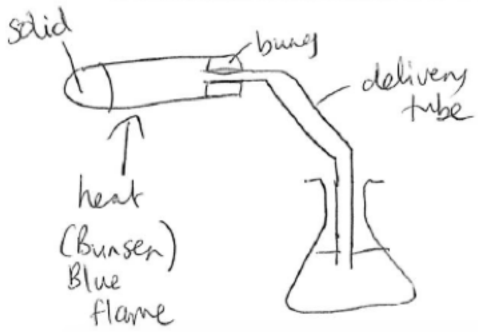
This does not reach Level 3 as the method for drying and weighing the precipitate is not mentioned and thus it does not allow for an accurate comparison. At Level 2 it has all the other requirements (with more in some areas) and it is quite logically expressed so it scores 4.

To achieve Level 3, more should have been said about drying and weighing the precipitate (or another method used and described – while inventing new methods in the examination is praiseworthy, candidates should be aware of the 'usual' method of following this experiment.)

Question 11, sample answer 3

Use the same mass of solid each time.
The lime water will go cloudy – whichever one goes cloudy quickest is the least thermally stable.
Repeat the experiment to make sure it is fair + use the same Bunsen and equipment.
You make the lime water with the calcium hydroxide and distilled water.

[6]



Commentary

This matches the descriptors for Level 1 as it gives a diagram but does not describe the method. An observation is mentioned that will allow some comparison between the carbonates. There is sufficient evidence in the candidate's writing to fully meet the communication statement, so 2 marks are awarded.

To reach Level 2, a description of the method would be needed. Recording the time taken for each limewater tube to go cloudy would also need to be mentioned.

Question 11, sample answer 4

I would place $MgCO_3$ and $CaCO_3$ in two test tubes and heat them. I would see which turned limewater cloudy fastest.

Commentary

The observation given matches the 'some comparison' requirement for Level 1. However, the description of the apparatus is not sufficient to meet the 'includes relevant apparatus' requirement, so this answer scores 0 marks.

To achieve Level 1, a simple diagram of the experimental set up could have been provided labelling the carbonate, delivery tube, Bunsen burner and the limewater.

Question 12
H433/03: Chemistry B (Salters) – Paper 3 – Question 4(b)(iii)

4 This question refers to the ***Practical Insert*** that is provided as an insert to this paper.

(iii)* Describe how the student could use the '2% Mn' solution and a colorimeter to produce a calibration curve suitable for finding the concentration of manganese in the paper clip solution.

Please refer to http://www.ocr.org.uk/Images/171753-unit-h433-03-practical-skills-in-chemistry-sample-assessment-materials.pdf pages 13–16 for a copy of the Practical Insert.

Chemistry B (Salters)

Question			Answer	Marks	Guidance
4	(b)	(iii)*	*Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** Applies knowledge of colorimetry to give a detailed step by step method to allow the production of suitable calibration curve over a suitable range of data. Detail about the dilutions and filters required will be included. *The method is detailed, clear and logically structured. The measurements are carefully considered to ensure the calibration curve covers the appropriate range.* **Level 2 (3–4 marks)** Applies knowledge of colorimetry to give steps which allow the production of a suitable calibration curve from the 2% Mn solution over a suitable range of data. *The method is suitable and in a logical order. Measurements are included to allow an appropriate calibration curve to be produced. Response may lack the fine details of dilution/appropriate filter.* **Level 1 (1–2 marks)** Applies knowledge of colorimetry to give a basic set of steps to produce a calibration curve from the 2% Mn solution. *The method is basic and unstructured. There is little or no detail in the description of steps.* **0 marks** No response or no response worthy of credit.	6	**Indicative scientific points may include:** Steps (italics indicate details that would differentiate higher level from lower level answers): • Dilute 2% Mn solution *using burettes and pipettes* • To include range 0.1 to 0.4% *includes volumes to achieve dilution (these could include 2 cm^3 of 2% + 8 cm^3 of water to give 0.4%, or details of a serial dilution)* • Mix each dilution thoroughly *to ensure standard solution* • Makes a zero reading (on the colorimeter) *using water/base solvent* • Selects an appropriate filter/wavelength *chooses green-blue filter OR sets (spectrophotometer) to green-blue* • Measures absorbance of diluted solutions *ensure each sample is in a clean cuvette* • Plot absorbance against dilution *and draw line of best fit*

Question 12, sample answer 1

Take the 2% Mn solution and add water to make the following concentrations:

Conc:	0.1%	0.2%	0.3%	0.4%	0.5%
Vol 2% solution/cm³	1.0	2.0	3.0	4.0	5.0
Vol water/cm³	19.0	18.0	17.0	16.0	15.0

Use graduated pipettes to measure the volumes accurately and shake solutions well before using so concentration is same throughout. Put water in the cuvette to produce a zero reading. Use the highest conc solution to select a filter that gives max absorbance - blue-green (complementary to purple Manganate). Use clean cuvette each time to measure absorbance at each concentration. Plot conc against absorbance + draw a straight line of best fit. **[6]**

Commentary

This answer is clearly Level 3 as it matches all the indicative points including the extra detail.

It has the detail and there is a logical flow, so it is worth 6 marks.

Question 12, sample answer 2

Make a series of dilutions of known concentration between 0.1 and 0.5 % going up in 0.1. Make sure all solutions are shaken before using. Put water in a clean cuvette to use as a reference/zero. Choose a filter than (complementary colour) then measure absorbance at the five different concentrations and plot. Draw a line of best fit through the points.

Commentary

This is a Level 2 answer. It covers virtually all the indicative points but gives very little extra detail.

The method is suitable and in logical order so it scores 4 marks.

To reach Level 3 more detail should have been given, eg the method of dilution and the detail of what is plotted on the graph.

Question 12, sample answer 3

- Make a series of dilutions of the solution
- Plot concentration (in percentage) against absorbance* which you would read from the colorimeter *of the diluted solutions
- Plot the curve and you would read off from the absorbance of the paper clip solution (which you would read from the same colorimeter with the same filter) to tell you the concentration. **[6]**

For fair test repeat the readings, and use a zero.

Commentary

This is a basic method so it is operating at Level 1. Even at this Level, the steps could have been arranged in a more logical order, so it scores 1 mark rather than 2.

To reach Level 2, more of the indicative points would have been needed, eg the range of solutions required and how to zero the colorimeter. (There is no need, however, to mention the paper clip solution, as this is not required by the question.)

Question 12, sample answer 4

Put the 2% solution in various test-tubes and add water. Put the test tubes into the colorimeter and take readings. Use these readings to plot a calibration curve.

Commentary

This answer is far too vague to reach Level 1, which requires a 'basic set of steps', so this answer does not score. This is a shame, as the candidate probably knows what to do but has just not expressed his or her understanding in sufficient detail.

To reach Level 1, the candidate would have needed to give a bit more detail about the range of solutions to be made and a lot more detail over what constitutes the calibration graph.