Example Candidate Responses

Cambridge International AS & A Level

Cambridge International AS & A Level Chemistry

9701

Paper 3 – Advanced Practical Skills

For examination from 2016

Cambridge Advanced

CAMBRIDGE International Examinations

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Contents

Introduction

The main aim of this booklet is to exemplify standards for those teaching Cambridge International AS and A Level Chemistry (9701), and to show how different levels of candidates' performance (high, middle and low) relate to the subject's curriculum and assessment objectives.

In this booklet candidate responses have been chosen to exemplify a range of answers. Each response is accompanied by a brief commentary explaining the strengths and weaknesses of the answers.

For each question, each response is annotated with a clear explanation of where and why marks were awarded or omitted. This, in turn, is followed by examiner comments on how the answer could have been improved. In this way it is possible for you to understand what candidates have done to gain their marks and what they will have to do to improve their answers. At the end there is a list of common mistakes candidates made in their answers for each question.

This document provides illustrative examples of candidate work. These help teachers to assess the standard required to achieve marks, beyond the guidance of the mark scheme. Some question types where the answer is clear from the mark scheme, such as short answers and multiple choice, have therefore been omitted.

The questions, mark schemes and pre-release material used here are available to download as a zip file from Teacher Support as the Example Candidate Responses Files. These files are:

Question Paper 22, June 2016	
Question paper	9701_s16_qp_22.pdf
Mark scheme	9701_s16_ms_22.pdf
Question Paper 33, June 2016	
Question paper	9701_s16_qp_33.pdf
Mark scheme	9701_s16_ms_33.pdf
Question Paper 42, June 2016	
Question paper	9701_s16_qp_42.pdf
Mark scheme	9701_s16_ms_42.pdf
Question Paper 52, June 2016	
Question paper	9701_s16_qp_52.pdf
Mark scheme	9701_s16_ms_52.pdf

Past papers, Examiner Reports and other teacher support materials are available on Teacher Support at **https://teachers.cie.org.uk**

How to use this booklet

Example candidate response – high	Examiner comments
3 Acidified potassium dichromate(VI) can oxidise ethanedioic acid, $H_2C_2O_4$. The relevant half-equations are shown. $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$ $(H_2C_2O_4 \rightarrow 2CO_2 + 2H^+ + 2e^-) \times 3$ $3H_2C_2O_4 \rightarrow 6CO_2 + 6H^+ + 6e^-$ (a) State the overall equation for the reaction between acidified dichromate(VI) ions and ethanedioic acid. $Cr_2O_7^{2-} + 14H^+ + 3H_2C_2O_4 \rightarrow 2Cr^{3+} + 7H_2O + 6CO_2 + 6H^+$ [2] **1** … ted ethanedioic acid, $H_2C_2O_4.xH_2O$, was reacted … tassium dichromate(VI). … e(VI) solution was required for complete oxidation … omate(VI) ions used to react with the sample of … $= 6.4 \times 10^{-4}$ amount = 6.4×10^{-4} mol [1]	**1** This equation contains all the correct species from the half-equations given so one mark has been awarded. The …

Answers by real candidates in exam conditions. These show you the types of answers for each level.
Discuss and analyse the answers with your learners in the classroom to improve their skills.

Examiner comments are alongside the answers, linked to specific part of the answer. These explain where and why marks were awarded. This helps you to interpret the standard of Cambridge exams and helps your learners to refine their exam technique.

How the candidate could have improved their answer

In **(a)** the candidate needed to remember that the key … loss in one half-equation must balance the electron ga…

In **(b)(iii)** the candidate used the correct method but n… number of significant figures in the answer must corre… provided.

This explains how the candidate could have improved their answer and helps you to interpret the standard of Cambridge exams and helps your learners to refine exam technique.

Common mistakes candidates made in this question

(a) The skills needed to combine two half-equations and … tricky for many candidates. Good candidates often got … them out, while weaker candidates failed to recognise th…

(b) The first two parts of the calculation were generally … the M_r calculation depended on the previous answer tog…

This lists the common mistakes candidates made in answering each question. This will help your learners to avoid these mistakes at the exam and give them the best chance of achieving a high mark.

Assessment at a glance

Candidates for Advanced Subsidiary (AS) certification take Papers 1, 2 and 3 (either Advanced Practical Skills 1 or Advanced Practical Skills 2) in a single examination series.

Candidates who, having received AS certification, wish to continue their studies to the full Advanced Level qualification may carry their AS marks forward and take Papers 4 and 5 in the examination series in which they require certification.

Candidates taking the full Advanced Level qualification at the end of the course take all five papers in a single examination series.

Candidates may only enter for the papers in the combinations indicated above.

Candidates may not enter for single papers either on the first occasion or for resit purposes.

All components are externally assessed.

Component	Weighting	
	AS Level	A Level
Paper 1 Multiple Choice **1 hour** This paper consists of 40 multiple choice questions, 30 of the direct choice type and 10 of the multiple completion type, all with four options. All questions will be based on the AS Level syllabus content. Candidates will answer all questions. Candidates will answer on an answer sheet. [40 marks]	31%	15.5%
Paper 2 AS Level Structured Questions **1 hour 15 minutes** This paper consists of a variable number of questions of variable mark value. All questions will be based on the AS Level syllabus content. Candidates will answer all questions. Candidates will answer on the question paper. [60 marks]	46%	23%
Paper 3 Advanced Practical Skills **2 hours** This paper requires candidates to carry out practical work in timed conditions. Candidates will be expected to collect, record and analyse data so that they can answer questions related to the activity. The paper will consist of two or three experiments drawn from different areas of chemistry. Candidates will answer all questions. Candidates will answer on the question paper. [40 marks]	23%	11.5%
Paper 4 A Level Structured Questions **2 hours** This paper consists of a variable number of free response style questions of variable mark value. All questions will be based on the A Level syllabus but may require knowledge of material first encountered in the AS Level syllabus. Candidates will answer all questions. Candidates will answer on the question paper. [100 marks]	–	38.5%
Paper 5 Planning, Analysis and Evaluation **1 hour 15 minutes** This paper consists of a variable number of questions of variable mark value based on the practical skills of planning, analysis and evaluation. The context of the questions may be outside the syllabus content, but candidates will be assessed on their practical skills of planning, analysis and evaluation rather than their knowledge of theory. Candidates will answer all questions. Candidates will answer on the question paper. [30 marks]	–	11.5%

Teachers are reminded that the latest syllabus is available on our public website at **www.cie.org.uk** and Teacher Support at **https://teachers.cie.org.uk**

Paper 3 – Advanced Practical Skills

Question 1(a) and 1(b)

Example candidate response – high	Examiner comments

1 You will determine the concentration of a solution of hydrochloric acid by diluting it and then titrating the diluted solution against an alkali.

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$$

FA 1 was made by dissolving 1.06 g of sodium hydroxide, NaOH, in distilled water to make 250 cm³ of solution.
FA 2 is hydrochloric acid, HC*l*.
bromophenol blue indicator

(a) Method

- Pipette 25.0 cm³ of **FA 2** into the 250 cm³ volumetric flask. **Keep remaining FA 2 for use in Question 2.**
- Add distilled water to make 250 cm³ of solution and shake the flask thoroughly. Label this solution **FA 3**.
- Fill the burette with **FA 3**.
- Use the second pipette to transfer 25.0 cm³ of **FA 1** into a conical flask.
- Add about 10 drops of bromophenol blue.
- Perform a rough titration and record your burette readings in the space below. The end point is reached when the solution becomes a permanent yellow colour.

Initial vol. FA3 (cm³)	Final vol. FA3 (cm³)	Volume of FA3 (cm³)
0.00	22.00	22.00

The rough titre is 22.00 cm³.

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Make certain any recorded results show the precision of your practical work.
- Record, in a suitable form below, all of your burette readings and the volume of **FA 3** added in each accurate titration.

Trial No.	Initial vol. FA3 (cm³)	Final vol. FA3 (cm³)	Volume of FA3 (cm³) **1**
1	0.00	22.00	22.00
2	0.00	22.10	22.10 ✓
3	0.00	22.10	22.10 ✓

I	✓
II	✗
III	✓
IV	✓
V	✓
VI	✓
VII	✓

[7] 6

(b) From your accurate titration results, obtain a suitable value for the volume of **FA 3** to be used in your calculations. Show clearly how you obtained this value.

$\frac{22.10 + 22.10}{2} = 22.10$ cm³ **2**

25.0 cm³ of **FA 1** required 22.10 cm³ of **FA 3**. [1] ✓ 1

(21.9) δ = 0.2

Examiner comments

1 It is simpler to write 'titre / cm³' or 'titre (cm³)'.

Mark for (a) = 6/7

2 Any pair or all of the titres shown can be used in this part, as all were within 0.20 cm³.

Mark for (b) = 1/1

Total marks awarded = 7 out of 8

How the candidate could have improved their answer

(a) The word ‘added’ or ‘used’ was needed with ‘volume of FA 3’.

Mark awarded = **(a) 6/7**
Mark awarded = **(b) 1/1**

Total marks awarded = 7 out of 8

Example candidate response – middle

1 You will determine the concentration of a solution of hydrochloric acid by diluting it and then titrating the diluted solution against an alkali.

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$$

FA 1 was made by dissolving 1.06 g of sodium hydroxide, NaOH, in distilled water to make 250 cm³ of solution.
FA 2 is hydrochloric acid, HC*l*.
bromophenol blue indicator

(a) Method

- Pipette 25.0 cm³ of **FA 2** into the 250 cm³ volumetric flask. **Keep remaining FA 2 for use in Question 2.**
- Add distilled water to make 250 cm³ of solution and shake the flask thoroughly. Label this solution **FA 3**.
- Fill the burette with **FA 3**.
- Use the second pipette to transfer 25.0 cm³ of **FA 1** into a conical flask.
- Add about 10 drops of bromophenol blue.
- Perform a rough titration and record your burette readings in the space below. The end point is reached when the solution becomes a permanent yellow colour.

1 The rough titre is ......16.65...... cm³.

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Make certain any recorded results show the precision of your practical work.
- Record, in a suitable form below, all of your burette readings and the volume of **FA 3** added in each accurate titration.

2

No.	volume / cm³
1	16.65
2	16.40.
3	16.55

16.55
16.60
δ = 0.05

I	✗
II	✗
III	✗
IV	✓
V	✓
VI	✓
VII	✓

[7] 4

(b) From your accurate titration results, obtain a suitable value for the volume of **FA 3** to be used in your calculations. Show clearly how you obtained this value.

3 25.0 cm³ of **FA 1** required ......16.50...... cm³ of **FA 3**. [1] 0

Examiner comments

1 The titre for the rough titration does not have to be precise.

2 The third titre is within 0.10 cm³ of the first and the mean shows good agreement with the supervisor's value.

Mark for (a) = 4/7

3 The answer given is not an arithmetic mean of any combination of the three accurate titres, and no working is shown.

Mark for (b) = 0/1

Total marks awarded = 4 out of 8

How the candidate could have improved their answer

(a) Burette readings should have been shown for the rough titration.

(a) With no accurate burette readings, tabulated with suitable headings and units, two marks are unavailable. The examiner was also unable to check the working for calculating the value to use for the accuracy marks.

(b) The titres used for calculating the mean should have been indicated, either by showing the working in the space or by ticks next to the values selected.

Mark awarded = **(a) 4/7**
Mark awarded = **(b) 0/1**

Total marks awarded = 4 out of 8

Example candidate response – low

1 You will determine the concentration of a solution of hydrochloric acid by diluting it and then titrating the diluted solution against an alkali.

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$$

FA 1 was made by dissolving 1.06 g of sodium hydroxide, NaOH, in distilled water to make 250 cm³ of solution.
FA 2 is hydrochloric acid, HC*l*.
bromophenol blue indicator

(a) Method

- Pipette 25.0 cm³ of **FA 2** into the 250 cm³ volumetric flask. **Keep remaining FA 2 for use in Question 2.**
- Add distilled water to make 250 cm³ of solution and shake the flask thoroughly. Label this solution **FA 3**.
- Fill the burette with **FA 3**.
- Use the second pipette to transfer 25.0 cm³ of **FA 1** into a conical flask.
- Add about 10 drops of bromophenol blue.
- Perform a rough titration and record your burette readings in the space below. The end point is reached when the solution becomes a permanent yellow colour.

initial volume / cm³	2.40
final volume / cm³	29.40
FA3 used / cm³	27.00

1

The rough titre is ....27.00.... cm³.

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Make certain any recorded results show the precision of your practical work.
- Record, in a suitable form below, all of your burette readings and the volume of **FA 3** added in each accurate titration.

Repeat time	1	2	3
Initial volume / cm³	0.40	0.80	1.20
Final volume / cm³	26.60	27.60	27.60
FA3 used / cm³	26.20	26.80	26.40

27·00
26·30
25·45 δ = 0·85

I	✓
II	✓
III	✓
IV	x
V	x
VI	x
VII	x

[7] 3

(b) From your accurate titration results, obtain a suitable value for the volume of **FA 3** to be used in your calculations. Show clearly how you obtained this value. 2

$$\frac{26.20+26.80+26.40}{3} = 26.47\ cm^3$$ x subtraction

25.0 cm³ of **FA 1** required ....26.47.... cm³ of **FA 3**. [1] 0

Examiner comments

1 The subtraction error is not penalised here.

Mark for (a) = 3/7

2 Working is shown but the subtraction error in (a) negates the mark.

Mark for (b) = 0/1

Total marks awarded = 3 out of 8

How the candidate could have improved their answer

(a) The candidate did not achieve concordant titres so was not awarded the fourth mark here. The last titre must be within 0.10 cm³ of any other accurate value. The mean of the closest pair (calculated by the examiner) gave a value too far from that of the supervisor to gain any marks for accuracy of titration (quality marks). A greater number of titrations were needed to achieve consistent titres.

(b) The total spread of titres used here was 0.60 cm³ which is greater than the 0.20 cm³ allowed.

Mark awarded = **(a) 3/7**
Mark awarded = **(b) 0/1**

Total marks awarded = 3 out of 8

Common mistakes candidates made in this question

(a) A substantial minority of candidates did not record burette readings for the rough titration.
Some headings were incorrect, for example, 'IBR' for 'initial burette reading' and 'amount' instead of 'volume', or the units were omitted.

Many candidates did not record all their accurate burette readings to #.#0 or #.#5, especially when starting at the zero mark.

Some candidates did not perform an additional titration when their final titre was not within 0.10 cm^3 of any previous value.

(b) The most common errors were not indicating which titres were to be used in the calculation and not giving the answer correct to two decimal places.

Question 1(c)

Example candidate response – high	Examiner comments
(c) Calculations Show your working and appropriate significant figures in the final answer to **each** step of your calculations. **(i)** Calculate the concentration, in mol dm^{-3}, of sodium hydroxide in **FA 1**. Use the data in the Periodic Table on page 12. $n(NaOH) = \frac{1.06}{23+16+1} = 0.0265$ mol $[NaOH] = \frac{0.0265}{250 \div 1000} = 0.106$ mol dm^{-3} concentration of NaOH in **FA 1** = 0.106 mol dm^{-3}	Mark for (c) (i) = 1/1
(ii) Calculate the number of moles of sodium hydroxide present in 25.0 cm^3 of **FA 1**. $n(NaOH) = \frac{(0.106)(25)}{1000} = 0.00265$ mol moles of NaOH = 0.00265 mol **(iii)** Deduce the number of moles of hydrochloric acid present in the volume of **FA 3** you have calculated in **(b)**. $n(HCl) = n(NaOH) = 0.00265$ mol moles of HC*l* = 0.00265 mol	Mark for (c) (ii) & (iii) = 1/1
(iv) Calculate the concentration, in mol dm^{-3}, of hydrochloric acid in **FA 2**. $[HCl] = \frac{0.00265}{26.3 \div 1000} = 0.101$ mol dm^{-3} **1** concentration of HC*l* in **FA 2** = 0.101 mol dm^{-3} [5] 4 sf	**1** The factor of × 10 for the dilution carried out in (a) has been omitted. Mark for (c) (iv) = 2/3 **Total marks awarded = 4 out of 5**

How the candidate could have improved their answer

(c) (iv) More careful reading of the questions was needed, as part (iii) is about **FA 3** but part (iv) requires the concentration of **FA 2**.

Mark awarded = **(c) (i) 1/1, (ii) & (iii) 1/1, (iv) 2/3**

Total marks awarded = 4 out of 5

Example candidate response – middle

(c) Calculations

Show your working and appropriate significant figures in the final answer to **each** step of your calculations.

(i) Calculate the concentration, in $mol\,dm^{-3}$, of sodium hydroxide in **FA 1**.
Use the data in the Periodic Table on page 12.

$\frac{1.06}{250} = 4.24 \times 10^{-3}\ g\,dm^{-3}$ $\frac{4.24 \times 10^{-3}}{40} = 1.06 \times 10^{-4}\ mol\,dm^{-3}$

$Mr = 23 + 16 + 1$
$= 40$

concentration of NaOH in **FA 1** = 1.06×10^{-4} $mol\,dm^{-3}$ ✗ **1**

(ii) Calculate the number of moles of sodium hydroxide present in $25.0\,cm^3$ of **FA 1**.

~~$250\,cm^3 = 1.06 \times 10^{-4}\ mol\,dm^{-3}$~~
~~$25\,cm^3 = \frac{25}{250} \times 1.06 \times 10^{-4}$~~
~~$= 1.06 \times 10^{-5}$ moles~~

$1\,dm^3 = 1.06 \times 10^{-4}$ moles
$250\,cm^3 = \frac{250}{1000} \times 1.06 \times 10^{-4}$
$= 2.65 \times 10^{-5}$ moles
$25\,cm^3 = 2.65 \times 10^{-6}$ mol

moles of NaOH = 2.65×10^{-6} mol

(iii) Deduce the number of moles of hydrochloric acid present in the volume of **FA 3** you have calculated in **(b)**.

HCl : NaOH
1 : 1
$2.65 \times 10^{-6} : 2.65 \times 10^{-6}$

moles of HC*l* = 2.65×10^{-6} mol ✓ ecf.

(iv) Calculate the concentration, in $mol\,dm^{-3}$, of hydrochloric acid in **FA 2**.

$24.80\,cm^3 = 2.65 \times 10^{-6}$ mol

concentration = $\frac{2.65 \times 10^{-6}}{\frac{24.80}{1000}}$ ✓ **2**

$= 1.07 \times 10^{-4}$ ∧

concentration of HC*l* in **FA 2** = 1.07×10^{-4} $mol\,dm^{-3}$

[5] 3

sf ✓

Examiner comments

1 It is simpler to keep the mass terms and volume terms together: 1.06/40 followed by ×1000/250.

Mark for (c) (i) = 0/1

Mark for (c) (ii) & (iii) = 1/1

2 All working is clearly shown and the final answers are displayed to the expected three or four significant figures.

Mark for (c) (iv) = 2/3

Total marks awarded = 3 out of 5

How the candidate could have improved their answer

(c) (i) The unit in the first stage of the calculation should have been $g\,cm^{-3}$ as the factor of ×1000 is missing.

The dilution factor of ×10 was also missing in **(c) (iv)**.

Mark awarded = **(c) (i) 0/1, (ii) & (iii) 1/1, (iv) 2/3**

Total marks awarded = 3 out of 5

Example candidate response – low

(c) Calculations

Show your working and appropriate significant figures in the final answer to **each** step of your calculations.

(i) Calculate the concentration, in mol dm^{-3}, of sodium hydroxide in **FA 1**.
Use the data in the Periodic Table on page 12.

n NaOH = 1.06 / (23+16+1) = 0.0265 mol

0.0265 / (250/1000) = 0.106 mol dm^{-3}

concentration of NaOH in **FA 1** = ~~0.0265~~ 0.106 ✓ mol dm^{-3}

(ii) Calculate the number of moles of sodium hydroxide present in 25.0 cm^3 of **FA 1**.

~~250 cm^3 →~~ (0.106)(~~250~~)

1 250 cm^3 → ~~0.0265~~ 0.106 mol

25 cm^3 → ~~0.00265~~ mol 0.0106

moles of NaOH = ~~0.00265~~ 0.0106 ✗ mol

(iii) Deduce the number of moles of hydrochloric acid present in the volume of **FA 3** you have calculated in **(b)**.

Mole ratio = HCl : NaOH = 1 : 1

n_{HCl} = ~~0.00265~~ mol 0.0106

moles of HCl = ~~0.00265~~ 0.0106 mol

(iv) Calculate the concentration, in mol dm^{-3}, of hydrochloric acid in **FA 2**.

2 ~~0.00265~~ 0.0106 / (25/1000) ✗ = ~~0.106~~ mol dm^{-3} 0.424

concentration of HC*l* in **FA 2** = 0.424 mol dm^{-3}

sf ✓ [5] 2

Examiner comments

Mark for (c) (i) = 1/1

1 A check on the units for the answer in (c) (i) might have helped.

Mark for (c) (ii) & (iii) = 0/1

2 Careful reading of the question helps avoid this type of error.

Mark for (c) (iv) = 1/3

Total marks awarded = 2 out of 5

How the candidate could have improved their answer

(c) (ii) More careful reading of the question was needed here, as there appeared to be confusion between the 250 cm^3 of solution FA 1 given in the information in (a) with the 1 dm^3 from the answer in (c) (i).

(c) (iv) The volume of FA 1 pipetted was used rather than the volume of FA 3 calculated in (b). The dilution factor was also omitted.

Mark awarded = **(c) (i) 1/1, (ii) and (iii) 0/1, (iv) 1/3**

Total marks awarded = 2 out of 5

Common mistakes candidates made in this question

The most common mistake was to ignore the dilution factor of x 10 used in making FA 3 from FA 2. This was needed in (c) (iv).

Other errors included giving answers to two significant figures and incorrect rounding of answers: figures of 5 and above are always rounded up.

Question 2(a) & (b)

Example candidate response – high	Examiner comments
(see below)	Mark for (a) = 2/2

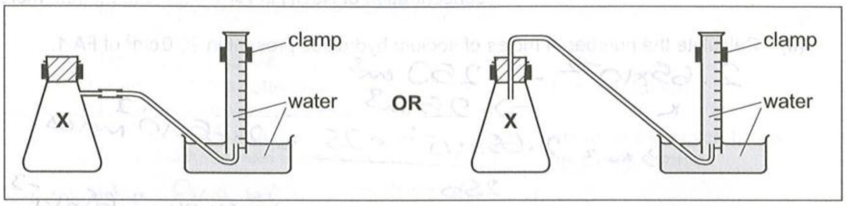
2 Metal carbonates react with dilute acids to produce carbon dioxide. You will identify the metal, **M**, in a metal carbonate, M_2CO_3, by measuring the volume of carbon dioxide produced during the reaction of M_2CO_3 with excess hydrochloric acid.

$$M_2CO_3(s) + 2HCl(aq) \rightarrow 2MCl(aq) + CO_2(g) + H_2O(l)$$

FA 2 is hydrochloric acid, HC*l*, as used in **Question 1**.
FA 4 is M_2CO_3.

(a) Method

Read **all** instructions before starting your practical work.
The diagrams below may help you in setting up your apparatus.



- Fill the tub with water to a depth of about 5 cm.
- Fill the 250 cm³ measuring cylinder **completely** with water. Hold a piece of paper towel firmly over the top, invert the measuring cylinder and place it in the water in the tub.
- Remove the paper towel and clamp the inverted measuring cylinder so the open end is in the water just above the base of the tub.
- Use the 50 cm³ measuring cylinder to place 50 cm³ of **FA 2** into the reaction flask, labelled **X**.
- Check that the bung fits tightly in the neck of flask **X**, clamp flask **X**, and place the end of the delivery tube into the inverted 250 cm³ measuring cylinder.
- Weigh the container with **FA 4** and record the mass in the space below.
- Remove the bung from the neck of the flask. Tip all the **FA 4** into the acid in the flask and replace the bung **immediately**. Remove the flask from the clamp and swirl it to mix the contents.
- Swirl the flask occasionally until no more gas is evolved. Replace the flask in the clamp.
- Reweigh the container and record the mass, and the mass of **FA 4** used, in the space below.
- When no more gas is collected, measure and record the final volume of gas in the measuring cylinder in the space below.

(tube + FA4) mass (g)	mass of tube (g)	mass of FA4 (g)	Initial vol. of CO_2 (cm³)	Final vol. of CO_2 (cm³)	Vol. of CO_2 (cm³)
33.87	32.96	33.87 − 32.96 = 0.91	0.0	110.0	110.0
				121 (84–127)	✓✓

2

[2]

Mark for (a) = 2/2

Example candidate response – high, continued

(b) Calculations

Show your working and appropriate significant figures in the final answer to **each** step of your calculations.

(i) Use the volume of gas you collected to calculate the number of moles of gas produced. [Assume that 1 mole of gas occupies 24.0 dm^3 under these conditions.]

Vol. of gas → $110.0 \times 10^{-3} dm^3$ $= 4.58 \times 10^{-3}$
1 mole → $24.0 dm^3$ $= 4.60 \times 10^{-3}$
x → $110.0 \times 10^{-3} dm^3$
⇒ $x = \frac{110.0 \times 10^{-3}}{24.0} = 4.583 \times 10^{-3}$

moles of gas = 4.60×10^{-3} mol ✗ RE **1**

(ii) Use your answer to **(i)** to deduce the number of moles of M_2CO_3 used in the reaction.

~~Mr = 2x + 12.0 + (16.0 × 3) = 2x~~
~~moles of gas = moles of~~
4.60×10^{-3} moles of CO_2 → 1
x moles of M_2CO_3 → 1
⇒ $x = 4.60 \times 10^{-3}$

moles of M_2CO_3 = 4.60×10^{-3} mol

(iii) Use your answer to **(ii)** and the mass of **FA 4** used to calculate the relative formula mass, M_r, of M_2CO_3.

Mr = 2x + 12.0 + (16.0 × 3) = 2x + 60
$4.60 \times 10^{-3} = \frac{0.91}{(2x + 60)}$ ⇒ 2x + 60 = 197.8260 = 197.83 ✓
⇒ 2x = 137.826
⇒ x = 68.913
= 68.91
~~Mr = (2 × 68.91)~~

M_r of M_2CO_3 = ...

(iv) Use your answer to **(iii)** and the Periodic Table on page 12 to identify metal **M**. Explain your answer.

Mr = 197.83
⇒ 2x + 60 = 197.83
⇒ $x = \frac{137.83}{2} = 68.915$ ✓

M is Rb (rubidium)

since 68.915 is closer to Ar of Rb (85.5) than to the Ar of K (39.1) and it is a group I metal. ✓

[4] 3

Examiner comments

1 The second decimal place indicates this answer is shown to three significant figures.

Mark for (b) (i) & (ii) = 0/1

Mark for (b) (iii) = 1/1

Mark for (b) (iv) = 2/2

Total marks awarded = 5 out of 6

How the candidate could have improved their answer

(b) (i) The answer should have been rounded correctly: 4.58×10^{-3} was correct to three significant figures but the answer given would only have been correct if quoted to two significant figures: 4.6×10^{-3}.

Mark awarded = **(a) 2/2**
Mark awarded = **(b) (i) & (ii) 0/1, (iii) 1/1, (iv) 2/2**

Total marks awarded = 5 out of 6

Example candidate response – middle

2 Metal carbonates react with dilute acids to produce carbon dioxide. You will identify the metal, **M**, in a metal carbonate, M_2CO_3, by measuring the volume of carbon dioxide produced during the reaction of M_2CO_3 with excess hydrochloric acid.

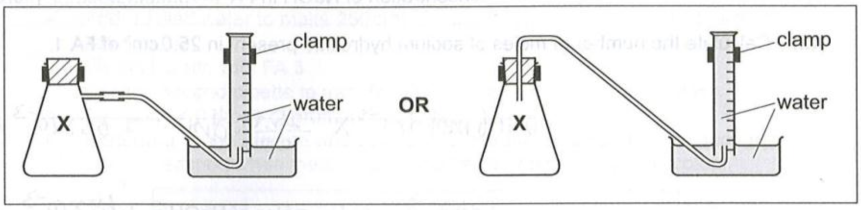
$$M_2CO_3(s) + 2HCl(aq) \rightarrow 2MCl(aq) + CO_2(g) + H_2O(l)$$

5.25×10^{-3} mol

FA 2 is hydrochloric acid, HC*l*, as used in **Question 1**.
FA 4 is M_2CO_3.

(a) Method

Read **all** instructions before starting your practical work.
The diagrams below may help you in setting up your apparatus.



- Fill the tub with water to a depth of about 5 cm.
- Fill the 250 cm³ measuring cylinder **completely** with water. Hold a piece of paper towel firmly over the top, invert the measuring cylinder and place it in the water in the tub.
- Remove the paper towel and clamp the inverted measuring cylinder so the open end is in the water just above the base of the tub.
- Use the 50 cm³ measuring cylinder to place 50 cm³ of **FA 2** into the reaction flask, labelled **X**.
- Check that the bung fits tightly in the neck of flask **X**, clamp flask **X**, and place the end of the delivery tube into the inverted 250 cm³ measuring cylinder.
- Weigh the container with **FA 4** and record the mass in the space below.
- Remove the bung from the neck of the flask. Tip all the **FA 4** into the acid in the flask and replace the bung **immediately**. Remove the flask from the clamp and swirl it to mix the contents.
- Swirl the flask occasionally until no more gas is evolved. Replace the flask in the clamp.
- Reweigh the container and record the mass, and the mass of **FA 4** used, in the space below.
- When no more gas is collected, measure and record the final volume of gas in the measuring cylinder in the space below.

1 137 196

FA4 and its container /g	39.70
Container of FA4 /g	38.78
FA 4 Used /g	0.92
Final Reading in cylinder /cm³	126.00

[2]

Examiner comments

1 The ratio of volume of gas/mass FA 4 is lower than the range of acceptable values (157 – 235), using the supervisor's results.

Mark for (a) = 1/2

Example candidate response – middle, continued	Examiner comments
(b) Calculations Show your working and appropriate significant figures in the final answer to **each** step of your calculations. **(i)** Use the volume of gas you collected to calculate the number of moles of gas produced. [Assume that 1 mole of gas occupies 24.0 dm^3 under these conditions.] $V = 126.00\ cm^3 = 0.1260 dm^3$ $n = \frac{0.1260 dm^3}{24.0 dm^3 mol^{-1}} = 5.25 \times 10^{-3} mol$ moles of gas = 5.250×10^{-3} mol **(ii)** Use your answer to **(i)** to deduce the number of moles of M_2CO_3 used in the reaction. moles of M_2CO_3 = 5.250×10^{-3} mol	Mark for (b) (i) & (ii) = 1/1
(iii) Use your answer to **(ii)** and the mass of **FA 4** used to calculate the relative formula mass, M_r, of M_2CO_3. $Mr = \frac{m}{n} = \frac{0.92 g}{5.25 \times 10^{-3} mol} = 175.2 g mol^{-1}$ M_r of M_2CO_3 = 175.2 g mol^{-1}	Mark for (b) (iii) = 1/1
(iv) Use your answer to **(iii)** and the Periodic Table on page 12 to identify metal **M**. Explain your answer. $Mr = \frac{175.2 - 12 - 16 \times 3}{2} = 57.6$ ~~mol~~ g mol^{-1} M is ~~Cobalt~~ Nickel **2** The atomic mass obtained is closest to ~~Cobalt~~ Nickel's atomic mass of 58.7 g mol^{-1} [4] 3	**2** The metal M is potassium for the value of A_r calculated. Mark for (b) (iv) = 1/2 **Total marks awarded = 4 out of 6**

How the candidate could have improved their answer

(a) The gas collection technique needed to be practised as an individual task so that less gas was lost to the surroundings.

(b) (iv) The white colour of FA 4 and its formula should have suggested M is a group 1 metal.

Mark awarded = **(a) 1/2**
Mark awarded = **(b) (i) & (ii) 1/1, (iii) 1/1, (iv) 1/2**

Total marks awarded = 4 out of 6

Example candidate response – low

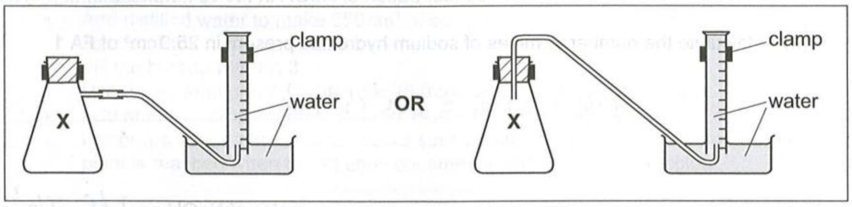
2 Metal carbonates react with dilute acids to produce carbon dioxide. You will identify the metal, **M**, in a metal carbonate, $\mathbf{M_2CO_3}$, by measuring the volume of carbon dioxide produced during the reaction of $\mathbf{M_2CO_3}$ with excess hydrochloric acid.

$$M_2CO_3(s) + 2HCl(aq) \rightarrow 2MCl(aq) + CO_2(g) + H_2O(l)$$

FA 2 is hydrochloric acid, HC*l*, as used in **Question 1**.
FA 4 is $\mathbf{M_2CO_3}$.

(a) Method

Read **all** instructions before starting your practical work.
The diagrams below may help you in setting up your apparatus.



- Fill the tub with water to a depth of about 5 cm.
- Fill the 250 cm³ measuring cylinder **completely** with water. Hold a piece of paper towel firmly over the top, invert the measuring cylinder and place it in the water in the tub.
- Remove the paper towel and clamp the inverted measuring cylinder so the open end is in the water just above the base of the tub.
- Use the 50 cm³ measuring cylinder to place 50 cm³ of **FA 2** into the reaction flask, labelled **X**.
- Check that the bung fits tightly in the neck of flask **X**, clamp flask **X**, and place the end of the delivery tube into the inverted 250 cm³ measuring cylinder.
- Weigh the container with **FA 4** and record the mass in the space below.
- Remove the bung from the neck of the flask. Tip all the **FA 4** into the acid in the flask and replace the bung **immediately**. Remove the flask from the clamp and swirl it to mix the contents.
- Swirl the flask occasionally until no more gas is evolved. Replace the flask in the clamp.
- Reweigh the container and record the mass, and the mass of **FA 4** used, in the space below.
- When no more gas is collected, measure and record the final volume of gas in the measuring cylinder in the space below.

1 m_1 2.84 g ✗ volume of gas collected /cm³

m_2 1.9 g 130 cm³

mass of FA4 used 0.94 g ✗ 138 (160 – 240)

2 ✗

✓

[2] 0

Examiner comments

1 It is important to use the same balance throughout an experiment to avoid any difference in zero error.

2 It's important to practise calculations.

Mark for (a) = 0/2

Example candidate response – low, continued	Examiner comments
(b) Calculations Show your working and appropriate significant figures in the final answer to **each** step of your calculations. **(i)** Use the volume of gas you collected to calculate the number of moles of gas produced. [Assume that 1 mole of gas occupies 24.0 dm^3 under these conditions.] 0.13 ÷ 24 = ~~5.23~~ mol 5.42 × 10^{-3} moles of gas = 5.42 × 10^{-3} mol **(ii)** Use your answer to **(i)** to deduce the number of moles of M_2CO_3 used in the reaction. moles of M_2CO_3 = 5.42 × 10^{-3} mol	Mark for (b) (i) & (ii) = 1/1
(iii) Use your answer to **(ii)** and the mass of **FA 4** used to calculate the relative formula mass, M_r, of M_2CO_3. 0.94 ÷ (5.42 × 10^{-3}) = 173.5 M_r of M_2CO_3 = 173.5	Mark for (b) (iii) = 1/1
(iv) Use your answer to **(iii)** and the Periodic Table on page 12 to identify metal **M**. Explain your answer. **3** **M** is Fe the atomic mass of M is 56.77 which is close to the atomic mass of Fe. [4] 2	**3** Working must be shown in calculations. Mark for (b) (iv) = 0/2 **Total marks awarded = 2 out of 6**

How the candidate could have improved their answer

(a) The headings for the weighings were incomplete and the two weighings were not to the same number of decimal places. The volume of gas collected was lower than the range from the supervisor's value.

(b) (iv) All the relevant information given in the question needed to be considered when coming to a conclusion: iron has oxidation states II and III in compounds and forms coloured compounds.

Mark awarded = **(a) 0/2**
Mark awarded = **(b) (i) & (ii) 1/1, (iii) 1/1, (iv) 0/2**

Total marks awarded = 2 out of 6

Common mistakes candidates made in this question

(a) The most common error in this part was the collection of a gas volume which was smaller than expected. Candidates need to check their apparatus before beginning to make sure the bung fits securely. If there is air in the measuring cylinder before the start, it should only be a small volume but should be at a level where the scale has started.

(b) The most common error was in identifying the metal ion, M, in FA 4. A common response was to look for the element with the nearest A_r regardless of group, normal oxidation state(s) or colour. The information given should have led candidates to consider Group 1 or silver, and the latter could be discounted as hydrochloric acid would have precipitated the silver ions, so preventing the carbonate from reacting fully.

Question 2(c)

Example candidate response – high	Examiner comments
(c) (i) A 250 cm^3 measuring cylinder can be read to $\pm 1\,cm^3$. Calculate the maximum percentage error in your reading of the volume of gas. $100 \times \frac{(1.0)\times 2}{110.0 - 0.0} = \frac{2.0 \times 100}{110.0} = 18.181\% \approx 18.18\%$ **1** maximum percentage error = 18.18 (x) % **(ii)** It is likely that the volume of carbon dioxide that you collected was less than the theoretical volume. Give **two** reasons why this volume is likely to be less than the theoretical volume. In each case, suggest and explain a modification to the practical procedure that could help to reduce the difference in volume. reason bung couldn't be place as soon as reactants were added modification place the reactants in the flask such a that they do not react until bung is placed **2** reason CO_2 is slightly soluble in water modification usage of a gas syringe. 4 [5]	**1** Doubling the error is correct here, as both initial and final measuring cylinder readings are considered. Mark for (c) (i) = 1/1 **2** Greater detail about the practical procedure is needed here. Mark for (c) (ii) = 3/4 **Total marks awarded = 4 out of 5**

How the candidate could have improved their answer

(c) (i) The final answer was incorrect by a power of 10. However, enough correct working was shown for this mark to be awarded.

(c) (ii) In the first modification, a method of keeping the two reactants separate until the bung is inserted needed to be clearly stated.

Mark awarded = **(c) (i) 1/1, (ii) 3/4**

Total marks awarded = 4 out of 5

Example candidate response – middle	Examiner comments
(c) (i) A 250 cm^3 measuring cylinder can be read to ±1 cm^3. Calculate the maximum percentage error in your reading of the volume of gas. **1** $\frac{0.5}{145} \times 100 = 0.34\%$ ✗ maximum percentage error = 0.34 % **(ii)** It is likely that the volume of carbon dioxide that you collected was less than the theoretical volume. Give **two** reasons why this volume is likely to be less than the theoretical volume. In each case, suggest and explain a modification to the practical procedure that could help to reduce the difference in volume. reason Carbon dioxide is slighty soluble in water and may have reacted with the water in the measuring cylinder. ✓ modification Fully saturate the water of the measuring cylinder with carbon dioxide by pumping it through the water before beginning the experiment. ✓ reason Carbon dioxide may have been lost to the surroundings before the bung was placed on the conical flask. ✓ modification **2** Get help from a second person to place the bung quicky and repeat the experiment several times to obtain an average reading to plot a graph. ✗ [5] 3	**1** The error in a scale reading is usually taken to be ± half a division and 250 cm^3 measuring cylinders are not calibrated at 1 cm^3. Mark for (c) (i) = 0/1 **2** Human error or seeking help from others never gains marks in this type of question. Mark for (c) (ii) = 3/4 **Total marks awarded = 3 out of 5**

How the candidate could have improved their answer

(c) (i) As only the volume of gas collected was given in (a) no doubling of the error was needed. However, halving the error was not correct.

(c) (ii) In the second modification, a method detailing how the two reactants can be kept separate until the bung is inserted was needed. Repeating the experiment several times does not help reduce the gas lost while using the method given in (a).

Mark awarded = **(c) (i) 0/1, (ii) 3/4**

Total marks awarded = 3 out of 5

Example candidate response – low

(c) (i) A 250 cm³ measuring cylinder can be read to ±1 cm³.

Calculate the maximum percentage error in your reading of the volume of gas.

% error = $\frac{1}{250} \times 100$ = 0.4%

1

maximum percentage error = 0.4 %

(ii) It is likely that the volume of carbon dioxide that you collected was less than the theoretical volume.

Give **two** reasons why this volume is likely to be less than the theoretical volume.

In each case, suggest and explain a modification to the practical procedure that could help to reduce the difference in volume.

reason: Part of the CO_2 evolved is dissolved in water.

modification: Replace water with an acidic solution. Acidic solution will prevent acidic CO_2 from dissolving into solution.

reason: Not all of the ~~CO_2 is completely delivered into measuring cylinder~~ M_2CO_3 is reacted (some sticks to flaskwall)

2

modification: Ensure that ~~delivery tube is empty when inserted into measuring cylinder~~ reaction mixture is swirled to react with all sticking M_2CO_3.

[5] 2

Examiner comments

1 The use of ‘1’ as the error is correct as only the ‘volume of gas’ was given in (a), so the examiner assumes the measuring cylinder was full of water before starting the experiment.

Mark for (c) (i) = 0/1

2 Poor technique is a human error so is not credited.

Mark for (c) (ii) = 2/4

Total marks awarded = 2 out of 5

How the candidate could have improved their answer

(c) (i) Careful reading of the question was needed here: 250 cm³ is the highest calibration mark on the measuring cylinder and not ‘your reading of the volume of gas’.

(c) (ii) The second reason given here was not valid, as any solid sticking to the side of the flask would indicate poor handling of the chemicals.

Mark awarded = **(c) (i) 0/1, (ii) 2/4**

Total marks awarded = 2 out of 5

Common mistakes candidates made in this question

(c) (i) The use of 250 cm³ instead of the volume of gas collected was a fairly frequent error. A significant minority of candidates used an incorrect numerator in the calculation for the data given in (a).

(c) (ii) ‘Solid sticks to the sides of the flask’ and ‘gas remains in the delivery tube’ were two reasons that were not given credit here. Although stating that ‘the bung does not fit properly’ was not creditworthy on its own (as the fit of the bung should be checked prior to starting the procedure), candidates who wrote this gained one mark out of the two if they also suggested a sensible way of stopping the gas leaking out.

Question 3(a)

Example candidate response – high	Examiner comments
3 Qualitative Analysis At each stage of any test you are to record details of the following. • colour changes seen • the formation of any precipitate • the solubility of such precipitates in an excess of the reagent added Where gases are released they should be identified by a test, **described in the appropriate place in your observations**. You should indicate clearly at what stage in a test a change occurs. Marks are **not** given for chemical equations. **No additional tests for ions present should be attempted.** **If any solution is warmed, a boiling tube MUST be used.** Rinse and reuse test-tubes and boiling tubes where possible. **Where reagents are selected for use in a test, the name or correct formula of the element or compound must be given.** **(a)** **FA 5**, **FA 6**, **FA 7** and **FA 8** are aqueous solutions of organic compounds. All of **FA 5, FA 6, FA 7** and **FA 8** contain carbon, hydrogen and oxygen only. Half fill the 250 cm^3 beaker with water and heat it to about 80 °C. Turn off the Bunsen burner. This will be used as a water bath. To a 2 cm depth of aqueous silver nitrate in a boiling tube add 2 drops of aqueous sodium hydroxide and then add ammonia dropwise until the brown solid just disappears. This solution is Tollens' reagent and is needed in a test in **(i)**.	

Example candidate response – high, continued

(i) Carry out the following tests on **FA 5**, **FA 6**, **FA 7** and **FA 8** and record your observations in the table.

test	*observations*			
	FA 5	**FA 6**	**FA 7**	**FA 8**
To a 1 cm depth in a test-tube, add a small spatula measure of sodium carbonate.	Efferverscence occur ❶	Efferverscence occur	No observable change	No observable change
To a few drops in a test-tube, add a 1 cm depth of Tollens' reagent. Place the tube in the water bath and leave to stand. **When you have completed this test rinse all tubes used.**	❷ A Grey precipitate formed	No observable change	~~Grey~~ Grey solution form ~~produced~~	Silver mirror formed
To a 1 cm depth in a test-tube, add a few drops of acidified potassium manganate(VII). Place the tube in the water bath and leave to stand.	Purple decolourise	No observable change	Purple decolourise	Purple decolourise

(ii) Using your observations from the table, what functional group is present in both **FA 5** and **FA 6**?

carboxylic acid

(iii) Using your observations from the table, what functional group is present in both **FA 5** and **FA 8**?

alkene aldehyde

(iv) What **type** of reaction is occurring in the potassium manganate(VII) test?

redox

(v) Using your observations from the table, what functional group is present in **FA 7**?

alkene ❸

(vi) Suggest a test that would confirm the presence of the functional group in a pure sample of **FA 7**. Include the result you would expect the test to give.

Do not carry out this test.

Add bromine solution. Brown colour will decolourise.

[9]

7

Examiner comments

❶ Use of sodium carbonate suggests limewater should be ready for use in testing any gas evolved.

Mark for (a) (i) = 2/4

❷ If the tube is not very clean in a positive Tollens' test, then a black or dark grey precipitate is likely to form, rather than the silver mirror expected.

Mark for (a) (ii) = 1/1

Mark for (a) (iii) = 1/1

Mark for (a) (iv) = 1/1

❸ Alkenes will decolourise acidified potassium manganate(VII), as well as primary and secondary alcohols. Relevant correct chemistry is always awarded marks.

Mark for (a) (v) = 1/1

Mark for (a) (vi) = 1/1

Total marks awarded = 7 out of 9

How the candidate could have improved their answer

(a) (i) The description of the precipitate formed with FA 5 needed greater precision.

(a) (v) This answer did not take into account that the compound contains C, H and O.

Mark awarded = **(a) (i) 2/4, (ii) 1/1, (iii) 1/1, (iv) 1/1, (v) 1/1, (vi) 1/1**

Total marks awarded = 7 out of 9

Example candidate response – middle	Examiner comments
3 Qualitative Analysis At each stage of any test you are to record details of the following. • colour changes seen • the formation of any precipitate • the solubility of such precipitates in an excess of the reagent added Where gases are released they should be identified by a test, **described in the appropriate place in your observations**. You should indicate clearly at what stage in a test a change occurs. Marks are **not** given for chemical equations. **No additional tests for ions present should be attempted.** **If any solution is warmed, a boiling tube MUST be used.** Rinse and reuse test-tubes and boiling tubes where possible. **Where reagents are selected for use in a test, the name or correct formula of the element or compound must be given.** **(a)** **FA 5**, **FA 6**, **FA 7** and **FA 8** are aqueous solutions of organic compounds. All of **FA 5**, **FA 6**, **FA 7** and **FA 8** contain carbon, hydrogen and oxygen only. Half fill the 250 cm^3 beaker with water and heat it to about 80 °C. Turn off the Bunsen burner. This will be used as a water bath. To a 2 cm depth of aqueous silver nitrate in a boiling tube add 2 drops of aqueous sodium hydroxide and then add ammonia dropwise until the brown solid just disappears. This solution is Tollens' reagent and is needed in a test in **(i)**.	

Example candidate response – middle, continued

(i) Carry out the following tests on **FA 5**, **FA 6**, **FA 7** and **FA 8** and record your observations in the table.

test	*observations* FA 5	FA 6	FA 7	FA 8
To a 1 cm depth in a test-tube, add a small spatula measure of sodium carbonate.	$NaCO_3$ dislove some bubble given out react volently red limus paper turn blue ✗	$NaCO_3$ disslove some gas produce **1** the tube become warm give white ppt with $Ca(OH)_2$	No reaction $NaCO_3$ not disslove	$NaCO_3$ dissolve.
To a few drops in a test-tube, add a 1 cm depth of Tollens' reagent. Place the tube in the water bath and leave to stand. **When you have completed this test rinse all tubes used.**	liquid become milkly after ~~burn~~ warm it turn brown and black **2**	liquid become milkly after warm it turn pink ✗	liquid still colourless after warm it turn deep-yellow	~~Same order~~ ~~Simile~~ like ~~NH3~~ liquid turn yellow after warm it just like a mirror
To a 1 cm depth in a test-tube, add a few drops of acidified potassium manganate(VII). Place the tube in the water bath and leave to stand.	add $KMnO_4$ then liquid is pupple pupple limus paper turn red liquid become colourless	add $KMnO_4$ then liquid is pupple pupple limus paper turn red colour unchange ✓	add $KMnO_4$ then liquid is yellow liquid become colourless (after water bath)	add $KMnO_4$ then liquid is colourless liquid still colourless

(ii) Using your observations from the table, what functional group is present in both **FA 5** and **FA 6**?

~~Acid~~ COOH ✓

(iii) Using your observations from the table, what functional group is present in both **FA 5** and **FA 8**?

CHO ✓

(iv) What **type** of reaction is occurring in the potassium manganate(VII) test?

endothemic ✗ **3**

(v) Using your observations from the table, what functional group is present in **FA 7**?

alcohol ✓

(vi) Suggest a test that would confirm the presence of the functional group in a pure sample of **FA 7**. Include the result you would expect the test to give.

Do not carry out this test.

Add $CuSO_4(aq)$ to FA7, and shack. Then it produce blue ppt. **4**

✗

[9] 5

Examiner comments

1 'Bubbles' is an observation; 'gas produced' is a deduction. The incorrect formula for sodium carbonate is ignored here as it is not part of the observation nor a reagent selected by the candidate.

2 The change of state is not recorded with FA 5 and Tollens' reagent.

Mark for (a) (i) = 2/4

Mark for (a) (ii) = 1/1

Mark for (a) (iii) = 1/1

3 'Endothermic' shows some logical thinking as the instruction was to heat the reactants.

Mark for (a) (iv) = 0/1

Mark for (a) (v) = 1/1

4 It is possible that this is an attempt to describe the Fehling's test, which is not valid for an alcohol. If it were valid, then greater detail of method (heating) would be needed, as well as a correct observation to gain the mark.

Mark for (a) (vi) = 0/1

Total marks awarded = 5 out of 9

How the candidate could have improved their answer

(a) (i) The observation of ‘bubbles’ was not given in the first test with FA 6. In the tests using Tollens’ reagent with FA 6 and FA 7, some unexpected and incorrect colour changes were given. Several spellings were incorrect but the meaning was clear so there was no penalty.

(a) (iv) FA 8 reacted fully before the stage of being heated so ‘endothermic’ did not follow from the observations.

(a) (vi) A test suitable for confirming the presence of an alcohol (in part (v)) was needed here. The method (conditions for the reaction) and result should also have been given.

Mark awarded = **(a) (i) 2/4, (ii) 1/1, (iii) 1/1, (iv) 0/1, (v) 1/1, (vi) 0/1**

Total marks awarded = 5 out of 9

Example candidate response – low	Examiner comments
3 Qualitative Analysis At each stage of any test you are to record details of the following. • colour changes seen • the formation of any precipitate • the solubility of such precipitates in an excess of the reagent added Where gases are released they should be identified by a test, **described in the appropriate place in your observations**. You should indicate clearly at what stage in a test a change occurs. Marks are **not** given for chemical equations. **No additional tests for ions present should be attempted.** **If any solution is warmed, a boiling tube MUST be used.** Rinse and reuse test-tubes and boiling tubes where possible. **Where reagents are selected for use in a test, the name or correct formula of the element or compound must be given.** **(a)** **FA 5**, **FA 6**, **FA 7** and **FA 8** are aqueous solutions of organic compounds. All of **FA 5**, **FA 6**, **FA 7** and **FA 8** contain carbon, hydrogen and oxygen only. Half fill the 250 cm^3 beaker with water and heat it to about 80 °C. Turn off the Bunsen burner. This will be used as a water bath. To a 2 cm depth of aqueous silver nitrate in a boiling tube add 2 drops of aqueous sodium hydroxide and then add ammonia dropwise until the brown solid just disappears. This solution is Tollens' reagent and is needed in a test in **(i)**.	

Example candidate response – low, continued

(i) Carry out the following tests on **FA 5**, **FA 6**, **FA 7** and **FA 8** and record your observations in the table.

test	*observations*			
	FA 5	**FA 6**	**FA 7**	**FA 8**
To a 1 cm depth in a test-tube, add a small spatula measure of sodium carbonate.	Effervescence occur. The colourless gas turn lime water cloudy CO_2 is present	Effervescence occur The colourless gas produced does not turn lime water cloudy.	No ppt	No ppt
To a few drops in a test-tube, add a 1 cm depth of Tollens' reagent. Place the tube in the water bath and leave to stand. **When you have completed this test rinse all tubes used.**	Silver mirror is formed	Silver mirror is formed.	Black solution.	Silver mirror is formed.
To a 1 cm depth in a test-tube, add a few drops of acidified potassium manganate(VII). Place the tube in the water bath and leave to stand.	Purple solution turn brown ppt colourless turn no ppt	Purple solution remains purple after heating	Purple solution remain purple.	Purple solution turn colourless

(ii) Using your observations from the table, what functional group is present in both **FA 5** and **FA 6**?

aldehyde

(iii) Using your observations from the table, what functional group is present in both **FA 5** and **FA 8**?

aldehyde

(iv) What **type** of reaction is occurring in the potassium manganate(VII) test?

oxidation

(v) Using your observations from the table, what functional group is present in **FA 7**?

ketone

(vi) Suggest a test that would confirm the presence of the functional group in a pure sample of **FA 7**. Include the result you would expect the test to give.

Do not carry out this test.

DNPH. DNPH turn orange ppt.

[9] 3

Examiner comments

1 The result of the gas test for FA 6 and sodium carbonate contradicts that for FA 5. The use of sodium carbonate should suggest the possibility of CO_2 being evolved.

2 The observations with FA 5 and FA 8 are correct. It is important to avoid contamination of samples.

3 It is easy to add too much acidified potassium manganate(VII) in one go, so the colour change can be missed.

Mark for (a) (i) = 1/4

4 'Aldehyde' appears logical from the reported reactions with Tollens' reagent.

Mark for (a) (ii) = 0/1

Mark for (a) (iii) = 1/1

5 A simpler correct response is 'redox'.

Mark for (a) (iv) = 0/1

6 Although 'ketone' has not come from any positive test, it is still possible to gain the mark for a correct confirmatory test and result.

Mark for (a) (v) = 0/1

Mark for (a) (iv) = 1/1

Total marks awarded = 3 out of 9

How the candidate could have improved their answer

(a) (i) When testing with sodium carbonate, if both gas tests are carried out, they both need to be correct. The observations for Tollens' reagent and FA 6 and FA 7 were unexpected and incorrect, although those with FA 5 and FA 8 were fully correct.
When adding acidified potassium manganate(VII) it is important to add the few drops one at a time with shaking so that any colour change is easy to see.

(a) (ii) It is important to consider all the observations when making conclusions: aldehydes do not effervesce with sodium carbonate.

(a) (iv) Only half the answer was given here, as both oxidation and reduction were occurring; it is the organic compound that is being oxidised.

(a) (v) The lack of reaction with any of the given reagents with FA 7 rule out carboxylic acid, aldehyde, primary and secondary alcohol and alkene, so ketone seems a logical choice. However, the deductions have to come from some positive observation.

Mark awarded = **(a) (i) 1/4, (ii) 0/1, (iii) 1/1, (iv) 0/1, (v) 0/1, (vi) 1/1**

Total marks awarded = 3 out of 9

Common mistakes candidates made in this question

(a) (i) Many candidates omitted the gas test in the reactions with sodium carbonate. They need more practice making Tollens' reagent, as it was clear that this was an unfamiliar exercise.
It is important for candidates to follow very carefully the instruction to add only a few drops when using acidified potassium manganate(VII), as a significant number of candidates reported the solution remaining purple when it should have turned colourless.

(a) (iii) A significant minority of candidates concluded 'aldehyde' here, when only one of FA 5 and FA 8 gave positive results with Tollens' reagent. The mark could not be awarded as the conclusion contradicted the observations.

(a) (iv) The most common error was to write 'oxidation'. This was an incomplete response; 'oxidation of organic compound' or 'redox' was needed.

(a) (vi) A significant minority of candidates did not say how the test chosen would be carried out. Some left out any observation that would be made, gave an incorrect colour or omitted a change of state.

Question 3(b)

Example candidate response – high	Examiner comments
(b) **FA 9** and **FA 10** are solids that each contain one anion from those listed in the Qualitative Analysis Notes on page 11. **(i)** Carry out the following tests on **FA 9** and **FA 10** and record your observations in the table.	

test	*observations* FA 9	FA 10
To a spatula measure of solid in a boiling tube, add a 1 cm depth of aqueous sodium hydroxide. Warm, then,	white ppt was observed.	No change was observed
add a small piece of aluminium foil.	Effervescense. Damp red litmus turned blue.	Effervescense. Damp red litmus turned blue.
Place a spatula measure of solid in a hard-glass test-tube. Heat gently at first and then more strongly.	Solid turned into liquid. Effervescence took place and damp red litmus turned blue. ✗ **1**	Effervescense. Salt melted and turned into a transparent solution.

(ii) Using your observations from the table, which **two** anions could be present in **FA 9** and **FA 10**?

anion Nitrate (NO_3^-) or Nitrite (NO_2^-) ✓

(iii) Suggest a test that would allow you to decide which of the anions is present. State what observations you would expect.

Add dilute acid and heat. If ammonia gas is released ✗ the presence of nitrite can be confirmed. **2**

(iv) Carry out this test on **FA 9** and **FA 10** to decide which anion is present in each.

observation for **FA 9** NO change anion in **FA 9** is Nitrate (NO_3^-) ✓

observation for **FA 10** NO change anion in **FA 10** is Nitrate (NO_3^-)

[7] 5

Examiner comments

1 Stronger heating should have led to observations of a brown gas or the solid turning yellow.

Mark for (b) (i) = 3/4

Mark for (b) (ii) = 1/1

2 There may be confusion between the test to distinguish between nitrate and nitrite using acid and the test to show the presence of either anion using aqueous sodium hydroxide and aluminium.

Mark for (b) (iii) = 0/1

Mark for (b) (iv) = 1/1

Total marks awarded = 5 out of 7

How the candidate could have improved their answer

(b) (i) As this section is about the identity of anions, red litmus turning blue (incorrect observation) indicated an ammonium cation, so further heating should have been carried out.

(b) (iii) The name of the acid must be given to identify the reagent to be used. While only nitrite will give a gas with a dilute acid, ammonia was incorrect.

Mark awarded = **(b) (i) 3/4, (ii) 1/1, (iii) 0/1, (iv) 1/1**

Total marks awarded = 5 out of 7

Example candidate response – middle

(b) **FA 9** and **FA 10** are solids that each contain one anion from those listed in the Qualitative Analysis Notes on page 11.

(i) Carry out the following tests on **FA 9** and **FA 10** and record your observations in the table.

test	*observations*	
	FA 9	**FA 10**
To a spatula measure of solid in a boiling tube, add a 1 cm depth of aqueous sodium hydroxide. Warm, then,	The ~~so~~ colorless solution turn ~~white~~ milky	~~no ol~~ ~~to~~ colorless solution formed
add a small piece of aluminium foil.	slow fizzing pop sound when lighted (1)	vigorous fizzing with pungent smell, damp blue litmus to red
Place a spatula measure of solid in a hard-glass test-tube. Heat gently at first and then more strongly.	solid turn into ~~solu~~ colorless liquid (2)	solid turn to colorless liquid

(ii) Using your observations from the table, which **two** anions could be present in **FA 9** and **FA 10**?

anion NO_2^- or NO_3^-

(iii) Suggest a test that would allow you to decide which of the anions is present. State what observations you would expect.

Add the a few drops of solutions of FA 9 or FA 10 to dilute H_2SO_4 ~~HCl~~

If there is brown gas formed after fizzing then the anion is NO_2^-

(iv) Carry out this test on **FA 9** and **FA 10** to decide which anion is present in each.

observation for **FA 9** no observation anion in **FA 9** is NO_3^-

observation for **FA 10** bubbles formed (3) anion in **FA 10** is NO_2^-

[7] 3

Examiner comments

(1) The presence of hydrogen formed by the reaction between aqueous sodium hydroxide and aluminium is shown.

(2) Both solids melting is correct, but the effect of stronger heating is not shown.

Mark for (b) (i) = 1/4

Mark for (b) (ii) = 1/1

Mark for (b) (iii) = 1/1

(3) Bubbles should not have formed.

Mark for (b) (iv) = 0/1

Total marks awarded = 3 out of 7

How the candidate could have improved their answer

(b) (i) The combination of aqueous sodium hydroxide and aluminium is a test for nitrate and nitrite so the gas evolved with both FA 9 and FA 10 needed to be tested with (damp) red litmus paper.
There was no clear distinction between the effect of heating gently and strongly and only one observation for each solid (change of state) was given.

(b) (iv) Assumptions should not be made about the identities of the ions and the ‘observations’ fitting these identities should not be recorded.

Mark awarded = **(b) (i) 1/4, (ii) 1/1, (iii) 1/1, (iv) 0/1**

Total marks awarded = 3 out of 7

Example candidate response – low	Examiner comments
See below	See below

Example candidate response – low

(b) **FA 9** and **FA 10** are solids that each contain one anion from those listed in the Qualitative Analysis Notes on page 11.

(i) Carry out the following tests on **FA 9** and **FA 10** and record your observations in the table.

test	*observations*	
	FA 9	**FA 10**
To a spatula measure of solid in a boiling tube, add a 1 cm depth of aqueous sodium hydroxide. Warm, then,	no change	no change
add a small piece of aluminium foil.	**1** damp red litmus paper turns blue	damp red litmus paper turns blue
Place a spatula measure of solid in a hard-glass test-tube. Heat gently at first and then more strongly.	condensation at the top of the tube **2**	condensation at the top of the tube

(ii) Using your observations from the table, which **two** anions could be present in **FA 9** and **FA 10**?

anion ... NO_3^- ... or ... NO_2^- ... ✓

(iii) Suggest a test that would allow you to decide which of the anions is present. State what observations you would expect.

3 add dilute acid, if the gas produced has brown color, it should contain NO_2^-, otherwise it should contain NO_3^-

(iv) Carry out this test on **FA 9** and **FA 10** to decide which anion is present in each.

observation for **FA 9** ... brown gas is produced ... anion in **FA 9** is **4** NO_2^-

observation for **FA 10** ... no change ... anion in **FA 10** is NO_3^-

[7]

Examiner comments

1 The candidate observes that damp red litmus paper has turned blue but needed to add 'gas' or 'ammonia'.

2 The observation of 'condensation' shows careful heating, but there is no observation made on stronger heating.

Mark for (b) (i) = 0/4

Mark for (b) (ii) = 1/1

3 Reagents selected to be used in tests must be given their full names or the correct formula.

Mark for (b) (iii) = 0/1

4 An incorrect observation shows possible guesswork in the final part.

Mark for (b) (iv) = 0/1

Total marks awarded = 1 out of 7

How the candidate could have improved their answer

(b) (i) While red litmus turning blue is correct, it must be clear that it is the gas reacting with the litmus paper and not splashes of the alkaline solution. The observation of 'effervescence', 'bubbles', or 'fizzing' was missing here.
There were several possible observations to be made on heating the two solids and a greater number of observations needed to be recorded.

(b) (iii) This part was answered well, apart from not naming the acid reagent, as instructed at the start of Question 3.

(b) (iv) As both FA 9 and FA 10 were nitrates, no brown gas should have been detected.

Mark awarded = **(b) (i) 0/4, (ii) 1/1, (iii) 0/1, (iv) 0/1**

Total marks awarded = 1 out of 7

Common mistakes candidates made in this question

(b) (i) Some candidates noted red litmus turning blue on warming with aqueous sodium hydroxide. As there was no ammonium ion present, this could only have resulted from poor technique: candidates may have allowed the solution to touch the litmus paper.

There were many candidates who wrote ‘gas evolved’ or similar when asked for an observation. ‘Gas evolved’ is a deduction and the observation should have been ‘effervescence/bubbling/bubbles/fizzing/fizz’. The mark for red litmus turning blue when testing for ammonia will only be awarded if it is clear that the ‘gas’ or ‘ammonia’ is reacting with the litmus paper.

Many candidates gave only one observation on heating each of FA 9 and FA 10. It was apparent from many of the answers that the solids were not heated sufficiently strongly or for long enough.

(b) (ii) Only a small number of candidates suggested cations instead of anions (such as ammonium) or gave an anion other than nitrate/nitrite.

(b) (iii) Many candidates omitted the name of the acid to be used in the test. This was contrary to the instruction given on page 7: ‘where reagents are selected for use in a test, the name or correct formula of the element or compound must be given’.
A significant number of candidates also omitted to state which of nitrate or nitrite reacted to produce the brown gas.

(b) (iv) ‘Observing’ a brown gas with either FA 9 or FA 10 was a common error. It is possible that some of these candidates were short of time so tested one of the unknowns with acid and found no brown gas and decided that the other unknown would contain the other anion.

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