OCR
Oxford Cambridge and RSA

Accredited

A Level Chemistry B (Salters)
H433/03 Practical skills in chemistry
Sample Question Paper

Date – Morning/Afternoon
Version 2.0

Time allowed: 1 hour 30 minutes

You must have:
- the Insert
- the Data Sheet for Chemistry B (Salters)

You may use:
- a scientific or graphical calculator

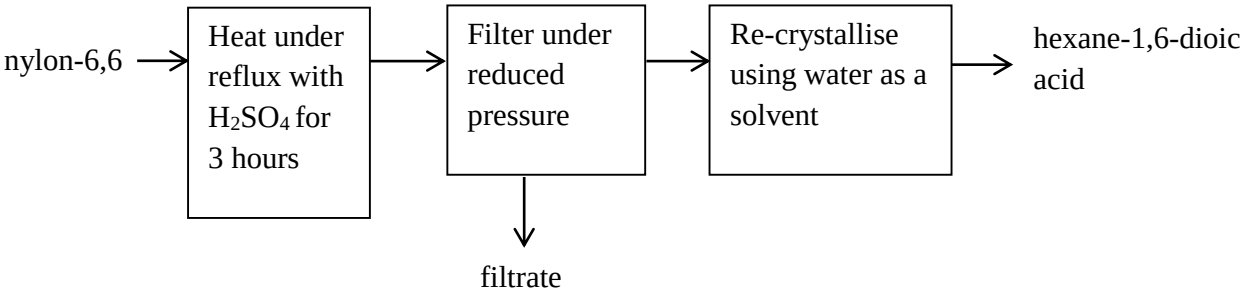
First name											
Last name											
Centre number						**Candidate number**					

INSTRUCTIONS
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Where appropriate, your answers should be supported with working. Marks may be given for a correct method even if the answer is incorrect.
- Write your answer to each question in the space provided.
- Additional paper may be used if required but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the barcodes.

INFORMATION
- The total mark for this paper is **60**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended responses will be assessed in questions marked with an asterisk (*).
- This document consists of **16** pages.

Answer **all** the questions.

1 **(a)** Scientists are investigating how best to recycle polymers including nylon-6,6. One approach is to break the polymer down into its monomers which can be re-used. The following flow chart shows how hexane-1,6-dioic acid can be produced from nylon-6,6.



(i) What is meant by *heating under reflux*?

……

…… **[2]**

(ii) Draw a labelled diagram to show how crystals of hexane-1,6-dioic acid can be collected by filtration under reduced pressure.

[3]

(iii) Describe the main steps involved in carrying out the recrystallization of hexane-1,6-dioic acid using water as a solvent.

In your account, describe what property of hexane-1,6-dioic acid this process depends upon.

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…… **[4]**

(iv) 0.40 g of pure hexane-1,6-dioic acid (M_r = 146) are obtained from 2.0 g of nylon-6,6.

Calculate the percentage yield of the reaction.

yield = …… % **[2]**

(b) The student adds excess sodium hydroxide solution to the filtrate. The student notices that the mixture develops a 'fishy' smell characteristic of an amine.

Suggest the shortened structural formula of the compound responsible for the 'fishy' smell.

…… **[1]**

2 (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.

[6]

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Additional answer space if required.

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(ii) The students find that the magnesium carbonate decomposes more readily than calcium carbonate and believe this can be explained by the difference in *charge density* of the magnesium and calcium ions.

What is meant by the term *charge density*?

……

…… **[1]**

(iii) Explain, in terms of the charge densities of the cations, the relative thermal stabilities of magnesium carbonate and calcium carbonate.

……

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…… **[2]**

(iv) The enthalpy change of reaction, $\Delta_r H$, for the decomposition of magnesium carbonate is +118 kJ mol^{-1}.

The entropies for the compounds in this reaction are given in the table below.

	$MgCO_3$	**MgO**	**CO_2**
***S* / J mol^{-1} K^{-1}**	66	27	214

What is the minimum temperature to which the students must heat the magnesium carbonate powder for decomposition to occur?

Include units in your answer.

minimum temperature = **…….** **[3]**

(b) The students also investigate the volume of carbon dioxide released when carbonate rocks decompose.

They carry out an experiment in which a known mass of magnesium carbonate is heated and the gas evolved is collected in a 100 cm^3 gas syringe. The apparatus is allowed to cool to room temperature and the volume of the gas collected is measured.

(i) What is the maximum mass of magnesium carbonate that could be used in this experiment?

maximum mass = **……** g **[1]**

(ii) The students repeat the experiment using the same mass of calcium carbonate instead of magnesium carbonate.

Describe and explain how the volume of gas collected will compare to the volume collected when magnesium carbonate was decomposed.

……

……

…… **[2]**

3 A student investigates the use of spirit burners as alternative heating sources for laboratories without a gas supply.

A spirit burner containing ethanol is weighed. 100 cm^3 of water are measured into a beaker clamped above the spirit burner. The temperature of the water is recorded. The spirit burner wick is lit and allowed to heat the water. The thermometer is used to stir the water. After about 5 minutes the flame of the burner is extinguished, the maximum temperature reached by the water is recorded and the spirit burner is re-weighed.

The student records the following results.

Mass of spirit burner and ethanol before burning / g	20.33
Mass of spirit burner and ethanol after burning / g	18.92
Initial temperature of the water / ºC	17.5
Maximum temperature reached by the water / ºC	88.0

(a) (i) The temperatures are measured using a thermometer that has graduation marks at every 1 °C.

Calculate the percentage error associated with the temperature difference in the above results.

Give your answer to **two** significant figures.

percentage error = **……** % **[1]**

(ii) Using the student's results, calculate the enthalpy change of combustion of ethanol.

Assume that the density of water is 1.00 g cm^{-3}.

enthalpy change of combustion = **……** kJ mol^{-1} **[3]**

(b) (i) The student repeats the experiment using a spirit burner containing methanol instead of ethanol. The same mass of fuel is burned in both experiments.

Suggest **two** reasons why the total energy transferred from the spirit burner is different in the two experiments.

……

……

…… **[2]**

(ii) Describe how the student can ensure that the same amount of energy is transferred from the spirit burner in the experiment using methanol as is transferred in the experiment described in **(a)(ii)**.

State the assumption you have made.

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…… **[2]**

(c) At the end of the experiments the student notices that there is a black deposit on the bottom of the beaker.

Suggest what this might be and why it might have been formed.

……

……

…… **[2]**

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

(a) **(i)** Name a suitable piece of apparatus (with its size) that could be used to measure 25 cm^3 of dilute sulfuric acid into the conical flask in **Part 1**.

…… **[1]**

(ii) Suggest **two** reasons why the conical flask in **Part 1** was fitted with a bung carrying a capillary tube, apart from loss of spray.

……

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…… **[2]**

(iii) Use the student's results in **Part 1** to calculate the percentage of iron in the paper clip.

percentage of iron = **……** % **[4]**

(b) (i) In **Part 2**, the student was given a solution labelled '2% Mn'.

Calculate the concentration (in g dm^{-3}) of a solution of potassium manganate(VII) that contains the same concentration of Mn as would be in 100 cm^3 of a solution made from 0.25 g of paper clips if they contained '2% Mn' by mass.

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

(ii) Explain why a '2% Mn' solution made by dissolving potassium manganate(VII) crystals would be more accurate than a '0.5% Mn' solution made using the same method.

.....

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

(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.

[6]

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Additional answer space if required.

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(iv) How could the student have improved the line drawn on the calibration graph in **Part 2** without doing further experiments?

……

…… **[1]**

(v) Use the line drawn by the student on the calibration graph to read off a value for the % Mn in the paper clip solution.

…….. **[1]**

(c) (i) In which titration could some of the paper clip solution have been spilled from the pipette onto the bench while it was being transferred to the conical flask?

Explain your answer.

……

……

…… **[2]**

(ii) The student suggests that the concentration of the MnO_4^- ions in the solution made from the paper clips could be determined by titrating it against a standard solution of Fe^{2+} ions.

Why would this method **not** give an accurate result?

……

…… **[1]**

(d) Suggest another method, other than using a titration or a colorimeter, that the student could use to find the concentration of Fe^{2+} ions in a solution made from paper clips.

……

…… **[1]**

END OF QUESTION PAPER

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A Level Chemistry B (Salters)

H433/03 Practical skills in chemistry

Sample Practical Insert

Date – Morning/Afternoon

Time allowed: 1 hour 30 minutes

INFORMATION FOR CANDIDATES

- This document consists of **4** pages. Any blank pages are indicated.

INSTRUCTIONS TO EXAMS OFFICER/INVIGILATOR

- Do not send this insert for marking; it should be retained in the centre or destroyed.

Iron and manganese in paper clips

A student describes below a project to find the amount of iron and manganese in some paper clips:

- To find the amount of iron in the paper clips, I decided to use a titration with potassium manganate(VII) solution.
- To find the amount of manganese in the paper clips, I found out that I could oxidise it in solution to potassium manganate(VII) and then use a colorimeter because the intensity of the purple colour I get depends on its concentration of MnO_4^- ions.

Part 1: Determination of iron in paper clips

I found the following method in an old book and decided to use it to find the amount of iron in the paper clips.

Determination of the percentage of iron in iron wire

Weigh out accurately about 1.4 g of iron wire and transfer it to a conical flask containing 25 cm^3 of dilute sulfuric acid and a few cm^3 of concentrated sulfuric acid to accelerate the reaction. Fit the flask with a rubber bung containing a short length of capillary tubing.

Warm the flask carefully to maintain a steady reaction and, when all the iron has reacted leaving only particles of carbon, cool the flask. Transfer the solution quantitatively to a 250 cm^3 volumetric flask and make up to the mark with dilute sulfuric acid and water. Pipette 25 cm^3 of this solution into a conical flask, add about 25 cm^3 of dilute sulfuric acid and titrate with standard potassium manganate(VII) solution (about 0.02 mol dm^{-3}).

[Reference: STARK, J G (1971): *Titrimetric analysis for A & S levels SI Edition* London, John Murray, 27]

The reaction of iron with sulfuric acid is:

$Fe + H_2SO_4 \rightarrow FeSO_4 + H_2$

The half-equations for the titration reaction are:

$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$
$Fe^{2+} \rightarrow Fe^{3+} + e^-$

I had to ask what a 'capillary' tube was and was told that it is a glass tube with a small internal diameter.

These are my results:

Mass of paper clips added to the conical flask = 1.28 g
Concentration of manganate(VII) solution = 0.0200 mol dm^{-3}

	Titration 1	**Titration 2**	**Titration 3**	**Titration 4**	**Titration 5**
Final burette reading / cm^3	22.90	45.40	22.55	43.05	24.00
Initial burette reading / cm^3	0.00	22.90	0.00	20.95	1.55

Part 2: Determination of manganese in paper clips

I found a website that said that steel normally contains between 0.1 and 0.4% manganese. I was given the following worksheet that I could follow to find the amount of manganese in the paper clips. It involves reacting pieces of paper clip with nitric acid to produce a solution containing Mn^{2+} ions. The Mn^{2+} are then oxidised with potassium iodate(VII) to MnO_4^- ions.

Method for the determination of manganese in paper clips:

1 Weigh accurately about 0.25 g of cut-up paper clip.
2 Put it into approximately 70 cm^3 of 2.0 mol dm^{-3} nitric(V) acid in a beaker.
3 In a fume cupboard, warm but do not boil the acid to help the paper clip to dissolve. The nitric(V) acid oxidises the manganese to $Mn^{2+}(aq)$ ions.
4 Add about 10 cm^3 of phosphoric(V) acid to the beaker, followed by about 10 cm^3 of potassium iodate(VII) solution. Boil the solution carefully for 10 minutes. Allow the mixture to cool. [The phosphoric(V) acid prevents the precipitation of insoluble iron(III) salts.]
5 When the solution is cool pour it into a 100 cm^3 volumetric flask using a small funnel. It is important not to lose any of the solution. Rinse the remaining solution from the beaker and funnel into the flask with distilled water and add further distilled water to bring the solution in the flask exactly up to the mark.
6 Stopper the flask and shake it to ensure that the solution is uniform. All the manganese that was in the 0.25 g of paper clip is now in the purple solution as the manganate(VII) ion, $MnO_4^-(aq)$.

(Reference: DENBY, Derek, OTTER, Chris, STEPHENSON, Kay (eds) (2009), *Salters Advanced Chemistry Support Pack*, Heinemann, 71)

I was given a solution of MnO_4^- ions, labelled '2% Mn', which had the same concentration as one that would be produced in my experiment from 0.25 g of steel containing 2% manganese by mass. The solution was actually made up by dissolving potassium manganate(VII) crystals in distilled water in a 1 dm^3 volumetric flask. Starting with this solution, I produced the calibration curve (**Fig. 1**) using a colorimeter. I would have preferred to start with a '0.5% Mn' solution, but my teacher said that it wouldn't be as accurate as the '2% Mn' solution.

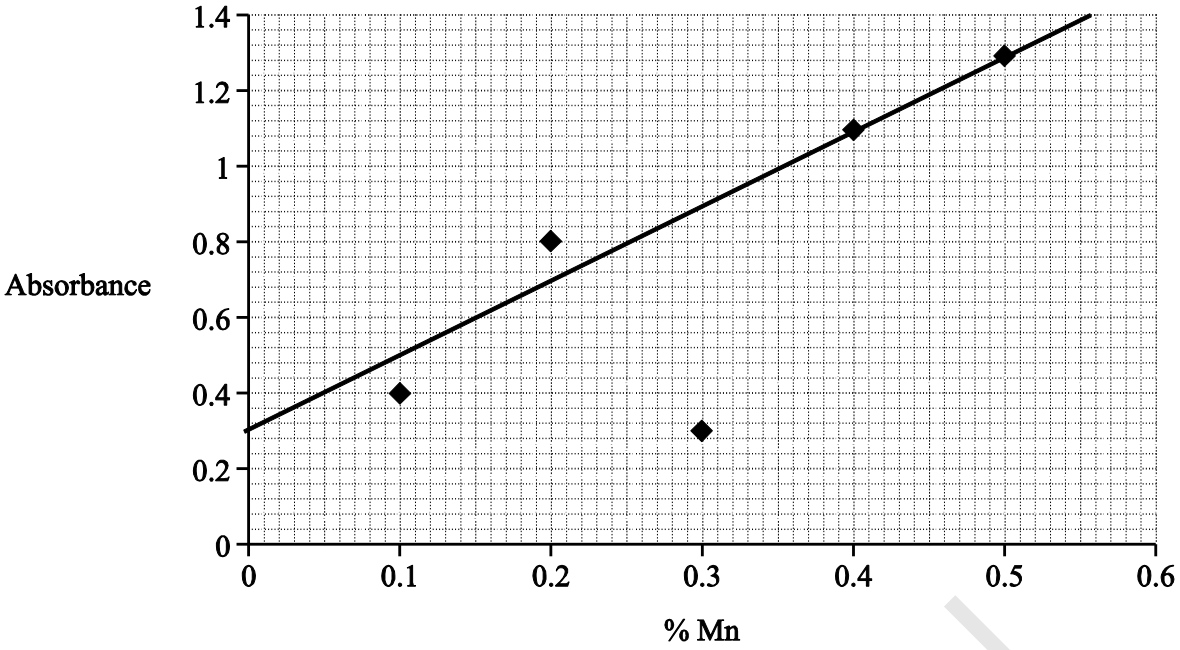

Fig. 1 % Mn against absorbance

The solution that I made from the paper clips gave an absorbance reading on the colorimeter of 0.64.

Comments on my experiments

I thought that my experiments went well. During the titration I had a bit of a problem with the pipette filler and I think I spilled some of the paper clip solution onto the bench as I was transferring it to the conical flask in one of my titrations.

One extra thing I could have done was to check the concentration of the MnO_4^- ions in the solution that I made from the paper clips by titrating it against a standard solution of Fe^{2+} ions.

END OF PRACTICAL INSERT

OCR
Oxford Cambridge and RSA

…day June 20XX – Morning/Afternoon

A Level Chemistry B (Salters)

H433/03 Practical skills in chemistry

SAMPLE MARK SCHEME

Duration: 1 hour 30 minutes

MAXIMUM MARK 60

This document consists of 16 pages

MARKING INSTRUCTIONS

PREPARATION FOR MARKING

SCORIS

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *scoris assessor Online Training*; *OCR Essential Guide to Marking*.

2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are posted on the RM Cambridge Assessment Support Portal http://www.rm.com/support/ca

3. Log-in to scoris and mark the **required number** of practice responses ("scripts") and the **required number** of standardisation responses.

   YOU MUST MARK 10 PRACTICE AND 10 STANDARDISATION RESPONSES BEFORE YOU CAN BE APPROVED TO MARK LIVE SCRIPTS.

MARKING

1. Mark strictly to the mark scheme.

2. Marks awarded must relate directly to the marking criteria.

3. The schedule of dates is very important. It is essential that you meet the scoris 50% and 100% (traditional 50% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.

4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone, email or via the scoris messaging system.

5. Work crossed out:

   a. where a candidate crosses out an answer and provides an alternative response, the crossed out response is not marked and gains no marks

   b. if a candidate crosses out an answer to a whole question and makes no second attempt, and if the inclusion of the answer does not cause a rubric infringement, the assessor should attempt to mark the crossed out answer and award marks appropriately.

6. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there then add a tick to confirm that the work has been seen.

7. There is a NR (No Response) option. Award NR (No Response)

   - if there is nothing written at all in the answer space
   - OR if there is a comment which does not in any way relate to the question (e.g. 'can't do', 'don't know')
   - OR if there is a mark (e.g. a dash, a question mark) which isn't an attempt at the question.

   Note: Award 0 marks – for an attempt that earns no credit (including copying out the question).

8. The scoris **comments box** is used by your Team Leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**

   If you have any questions or comments for your Team Leader, use the phone, the scoris messaging system, or email.

9. Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

10. 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.**

Level of response questions on this paper are **2(a)(i)** and **4(b)(iii)**.

11. **Annotations**

Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument
✓	Marking point

12. **Subject-specific Marking Instructions**

INTRODUCTION

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.

You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New Examiners**.

Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

Question			Answer	Marks	Guidance
1	(a)	(i)	Boiling a mixture ✓ **AND** condensing/cooling the vapour to return it to the flask ✓	**2**	
		(ii)	Diagram showing a funnel with a filter paper above a perforated plate ✓ fitting into a flask or tube with a side arm ✓ indication of removal of air from the flask through the side arm ✓	**3**	**ALLOW** water flow through a tube connected to the side arm
		(iii)	Dissolve crystals in minimum of hot water ✓ Cool solution (to produce crystals) ✓ Filter off crystals **AND** wash with cold solvent ✓ Hexane-1,6-dioic acid is more soluble in hot water than in cold water ✓	**4**	'Minimum' amount of water **MUST** be stated
		(iv)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** yield = 31% award 2 marks M_r (repeat unit) = 226 n(nylon-6,6) = 2.0/226 = 0.00885 (mol) ✓ n(hexane-1,6-dioic acid) = 0.40/146 = 0.00274 (mol) 0.00274/0.00885 × 100 = 31 (%) **OR** theoretical yield of acid = 0.00885 × 146 = 1.29 g yield = $\frac{0.40}{1.29} \times 100 = 31$ (%) ✓	**2**	**ALLOW ECF** from first marking point **ALLOW** 31.0
	(b)		('Fishy smell' caused by) $H_2N(CH_2)_6NH_2$ ✓	**1**	
			Total	**12**	

Question			Answer	Marks	Guidance
2	(a)	(i)*	*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.*	6	**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

Question			Answer	Marks	Guidance
			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.* *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** No response or no response worthy of credit.		
		(ii)	The ratio of charge on ion to its volume ✓	**1**	**ALLOW** charge/volume **ALLOW** size instead of volume
		(iii)	Magnesium carbonate is less thermally stable than calcium carbonate (because) the smaller magnesium (Mg^{2+}) ion ✓ distorts the (large) carbonate (CO_3^{2-}) ion ✓	**2**	**ORA**

Question			Answer	Marks	Guidance
		(iv)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** minimum temperature = 674 K award 3 marks $\Delta_{sys}S$ = 27 + 214 – 66 = +175 J mol K^{-1} ✓ Minimum temperature is where $\Delta_{sys}S = \Delta_{surr}S$ $-\frac{118000}{T} = 175$ ✓ T = 11800 / 175 = 674 K ✓	3	**ALLOW ECF** from first marking point Correct unit required for mark. **ALLOW** 401 °C
	(b)	(i)	$(\frac{100}{24000} \times 84.3 =)$ 0.351 g ✓	1	
		(ii)	The volume of gas collected will be smaller ✓ (because) the molar mass/M_r of calcium carbonate is bigger than that of magnesium carbonate so a smaller number of moles of calcium carbonate is contained (in the same mass) ✓	2	
			Total	15	

Question			Answer	Marks	Guidance
3	(a)	(i)	% error = $\frac{2 \times 0.5}{88.0 - 17.5} \times 100 = \frac{1.0}{70.5} \times 100$ = 1.4 % ✓	1	Mark is for the answer, not the working out.
		(ii)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** enthalpy change of combustion = –960 **OR** –961 (kJ mol^{-1}) award 3 marks ***ΔH calculation from experiment*** From results table (or from **(i)**) ΔT = 88.0 – 17.5 = 70.5 °C q = 100 × 4.18 × 70.5 = 29469 J **OR** 29.469 kJ ✓ From results table mass of ethanol = 20.33 – 18.92 = 1.41 g M_r of ethanol = 46.0 Amount of ethanol = $\frac{1.41}{46.0}$ = 0.0307 mol ✓ ΔH = 29.469/0.0307 = –960 **OR** –961 (kJ mol^{-1}) ✓	3	**ALLOW** 0.0306521 as this depends on rounding **ECF** from first marking point and second marking point
	(b)	(i)	A different number of moles of alcohol are burnt ✓ The alcohols have different enthalpy changes of combustion ✓	2	
		(ii)	Use the same start and end temperatures of water ✓ (Assume) the same proportion of energy transferred to the surroundings is transferred to the water (**AW**) ✓	2	**ALLOW** use same temperature change of water
	(c)		Black solid is carbon ✓ Due to incomplete combustion (of the fuel) ✓	2	
			Total	10	

Question			Answer	Marks	Guidance
4	(a)	(i)	25/50/100 cm^3 measuring cylinder ✓	1	Capacity of measuring cylinder **MUST** be given **DO NOT ALLOW** pipette or burette or syringe
		(ii)	To allow hydrogen to escape ✓ To prevent air getting in (and oxidising Fe^{2+} to Fe^{3+}) ✓	2	**IGNORE** to stop spray escaping
		(iii)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** percentage of iron = 98.1% award 4 marks Select appropriate titres $\frac{22.50 + 22.55 + 22.45}{3}$ = 22.50 ✓ $n(MnO_4^-) = 22.50 \times \frac{0.02}{1000}$ = 0.00045 (mol) ✓ $n(Fe^{2+})$ in 250 cm^3 = 0.00045 × 5 × 10 = 0.0225 (mol) ✓ % iron = $\frac{0.0225 \times 55.8}{1.28} \times 100$ = 98.1 % ✓	4	**ALLOW ECF** from incorrect selection of data **ALLOW** 98% or 98.09%
	(b)	(i)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** concentration = 0.14 (g dm^{-3}) award 3 marks Mass of Mn = $\frac{2}{100} \times 0.25$ = 0.005 g ✓ $n(KMnO_4)$ in 100 cm^3 = n(Mn) = 0.005/54.9 = 0.000091 mol ✓ concentration of $KMnO_4$ = 0.000091 × 158 × 10 = 0.14 (g dm^{-3}) ✓	3	**ALLOW ECF** from first marking point **ALLOW** 0.144 (g dm^{-3})

Question			Answer	Marks	Guidance
		(ii)	(Larger mass of $KMnO_4$ dissolved so) smaller weighing error ✓	1	

Question	Answer	Marks	Guidance
(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.* *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.*	**6** **14**	**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			Answer	Marks	Guidance
			0 marks No response or no response worthy of credit.		
		(iv)	The line should be drawn through the zero–zero point ✓	**1**	
		(v)	0.17% ✓	**1**	**ALLOW** between 0.16 and 0.18%
	(c)	**(i)**	Titration 4 ✓ (because) it requires the smallest volume of $KMnO_4$ solution ✓	**2**	
		(ii)	The solution contains nitric acid/potassium iodate(VII) that would also oxidise Fe^{2+} ✓	**1**	**ALLOW** the solution contains other oxidising agents
	(d)		Use the solution in an electrochemical cell ✓	**1**	
			Total	**23**	

Summary of updates

Date	Version	Change
January 2019	2.0	Minor accessibility changes to the paper: i) Additional answer lines linked to Level of Response questions ii) One addition to the rubric clarifying the general rule that working should be shown for any calculation questions