NAME		Class	

ST ANDREW'S JUNIOR COLLEGE

JC2 PRELIMINARY EXAMINATION

Chemistry (9729) **17 August 2020**

Paper 4 Practical **2 hours 30 minutes**

Candidates answer on the Question Paper.

Additional Materials : As listed in the Confidential Instructions

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READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in.
Give details of the practical shift and laboratory in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Shift
Laboratory

Answer **all** the questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.
Qualitative Analysis Notes are printed on pages **21** and **22**.

The number of marks is given in the brackets [ ] at the end of each question or part question.

For Examiners' Use	1	2	3	4	Total

This document consists of **22** printed pages.

1 Investigation of the concentration of potassium manganate(VII)

Potassium manganate(VII) is a very useful oxidising agent. It oxidises iron(II) ions in acidic medium according to **equation 1**.

MnO_4^- (aq) + $5Fe^{2+}$ (aq) + $8H^+$ (aq) → Mn^{2+} (aq) + $5Fe^{3+}$ (aq) + $4H_2O$ (*l*) **equation 1**

In solution, ammonium iron(II) sulfate, $(NH_4)_2SO_4 \bullet FeSO_4 \bullet 6H_2O$, dissociates into iron(II), sulfate and ammonium ions according to **equation 2**.

$(NH_4)_2SO_4 \bullet FeSO_4 \bullet 6H_2O$ (s) → $2NH_4^+$ (aq) + $2SO_4^{2-}$ (aq) + Fe^{2+} (aq) + $6H_2O$ (*l*) **equation 2**

You are provided with

FA 1, ammonium iron(II) sulfate crystals,
FA 2, potassium manganate(VII) solution,
1.0 mol dm^{-3} sulfuric acid.

(a) (i) Preparation of standard solution of FA 3 and titration of FA 3 against FA 2

In an appropriate format in the space provided on page **3**, prepare tables in which to record results for your experiment in **(a)**:

- All weighings to an appropriate level of precision
- All burette readings and the volume of **FA 2** added

1. Weigh the capped bottle containing **FA 1**.
2. Dissolve this in about 50 cm^3 of 1.0 mol dm^{-3} sulfuric acid in a 100 cm^3 beaker.
3. Transfer the solution and washings into a 250 cm^3 standard flask.
   Make up to the mark with deionised water and shake well to obtain a homogeneous solution, **FA 3**.
4. Reweigh the emptied bottle and its cap.
5. Fill a burette with **FA 2**.
6. Pipette 25.0 cm^3 of **FA 3** prepared into a conical flask.
7. Add about 10 cm^3 of aqueous sulfuric acid into the conical flask.
8. Run **FA 2** from the burette into the flask. The end-point is reached when the solutions changes from pale green to orange.
9. Repeat steps 6 to 8 until consistent titres are obtained.

Results

Mass of weighing bottle + **FA1** /g	15.35
Mass of emptied weighing bottle /g	6.16
Mass of **FA1** /g	9.19

Burette readings

	1	2
Final burette reading / cm^3	23.50	47.00
Initial burette reading / cm^3	0.00	23.50
Volume of **FA 2** / cm^3	23.50	23.50
Values used	√	√

[4]

- correct headers and units
- 2 dp for mass (according to mass balance)
- 2 dp for burette readings and volume of FA 2
- 2 consistent titre readings within +/- 0.10 cm^3

(ii) From your titrations, obtain a suitable volume of **FA 2** to be used in your calculations. Show clearly how you obtained this volume.

(23.50 + 23.50)/2 = **23.50 cm^3 (2dp)**

Volume of **FA 2** = ...

[1]

(b) [A_r of K: 39.1; Mn: 54.9; O: 16.0; N: 14.0; H: 1.0; Fe: 55.8; S:32.1]

(i) Calculate the number of moles of **FA 1** in the weighed sample and hence calculate the number of moles of Fe^{2+} ions used during the titration.

No. of moles of $(NH_4)_2SO_4 \cdot FeSO_4 \cdot 6H_2O$ = (mass of FA 1) /392 = **0.02344 mol**

No. of moles of Fe^{2+} in 250 cm^3 = 0.02344 mol

No. of moles of Fe^{2+} used during titration = 0.02344 x (25/250) = **0.00234 mol**

number of moles of **FA 1** = ...

number of moles of Fe^{2+} ions used = ...

[2]

(ii) Calculate the number of moles of MnO_4^- reacted during titration and hence the mass of potassium manganate (VII), $KMnO_4$, in 1 dm^3 of **FA 2**.

No. of moles of MnO_4^- reacted = (b)(i) / 5 = **4.688 X 10^{-4} mol**

Concentration of MnO_4^- reacted = $\frac{4.688 \times 10^{-4}}{(a)(ii)}$ = 0.01995 mol dm^{-3}

Mass of $KMnO_4$ reacted in 1 dm^3 = 0.01995 X 158 = **3.15 g**

number of moles of MnO_4^- reacted = ...

mass of $KMnO_4$ in **FA 2** = ...

[3]

(c) A student performed the same experiment, using the quantities described earlier, and obtained a mean titre volume of 25.45 cm^3.

The errors (uncertainties) associated with each reading is shown below:

Apparatus	Uncertainties
volumetric flask	±0.15 cm^3
pipette	±0.1 cm^3
burette	±0.05 cm^3

Calculate the maximum percentage error (uncertainty) of this mean titre volume.

Percentage error of volumetric flask = $\frac{\pm 0.15 \times 100}{250} = \pm 0.060\%$

Percentage error of pipette = $\frac{\pm 0.10 \times 100}{25.0} = \pm 0.40\%$

Error in titre (2 burette readings) = 2 X $\pm$ 0.05 = $\pm$ 0.1 cm^3

Percentage error of burette = $\frac{\pm 0.1 \times 100}{25.45} = \pm 0.39\%$

Total error = $\pm$ (0.06 + 0.4 +0.39) = $\pm$ 0.85 %

maximum percentage error = ...%

[2]

(d) The teacher informed the student who performed the experiment in **(c)** that the titre volume should have been 26.00 cm^3 instead.

(i) Calculate the percentage error in the student's result.

Difference in titre volume = 26.00 – 25.45 = 0.55 cm^3

Percentage error in the student's result = 0.55 / 26.00 x 100%

= **2.12% (3 s.f.)**

percentage error = ……..%

[1]

(ii) Using your answers in **(c)** and **(d)(i)**, comment on the accuracy of the student's result.

Since the **percentage error is larger than the apparatus error**, the student's result is **not accurate**.

[1]

[Total: 14]

2 Investigation of the effect of temperature on chemical reactions

Potassium manganate(VII) is widely used as a strong oxidising agent. It can oxidise both organic and inorganic compounds. Besides oxidising iron(II) ions, it can also oxidise ethanedioate ions.

$2MnO_4^-$ (aq) + $5C_2O_4^{2-}$ (aq) + $16H^+$ (aq) → $2Mn^{2+}$ (aq) + $10CO_2$ (g) + $8H_2O$ (*l*) **equation 3**

In this experiment, the effect of temperature on the rate of this reaction is studied by measuring the time taken for the purple solution to turn colourless.

You will perform a series of four experiments. Then, you will graphically analyse your results to determine the effect of temperature on the rate of the reaction between potassium manganate(VII) and ethanedioate ions.

For each experiment, you will note the time taken, *t*, for the reaction mixture to become colourless.

You will use the same potassium manganate(VII) solution, **FA 2**, and 1.0 mol dm^{-3} sulfuric acid, H_2SO_4, in **Question 1**.

You are also provided with

FA 4, 0.1 mol dm^{-3} sodium ethanedioate, $Na_2C_2O_4$.

(a) Prepare a table in the space provided on **page 9** in which to record for each experiment, with the appropriate level of precision:

- temperature of the solution inside the boiling tube,
- time taken for solution to turn colourless, *t, to the nearest second,*
- calculated values of 1/*t* and lg (1/*t*).

It is recommended for you to draw this table after step 6 of experiment 1 on page 8.

Safety notes

Hot water to be collected from the metal dispenser is heated to 90 °C. **Use a Styrofoam cup placed in a 250 cm^3 beaker to collect the hot water (according to step 4 of experiment 1 on the next page) to prevent your hands from being scalded.**

Gently pull/push the tap of the dispenser to prevent the hot water from spurting/splashing out.

Experiment 1

1. Using a measuring cylinder, add 5.0 cm^3 of **FA 2** to a boiling tube.
2. Using the same measuring cylinder, add 10.0 cm^3 of 1.0 mol dm^{-3} $H_2SO_4(aq)$ to the boiling tube.
3. Using another measuring cylinder, measure 5.0 cm^3 of **FA 4**. Do not add it to the boiling tube yet.
4. Place a Styrofoam cup inside a 250 cm^3 beaker. Dispense hot water from the metal dispenser into the Styrofoam cup until it is half-filled.
5. **This hot water is reused for subsequent experiments. Do not discard it.**
6. Place the thermometer inside the boiling tube containing **FA 2** and place the boiling tube inside the Styrofoam cup containing hot water.
7. **While waiting for the temperature of the solution inside the boiling tube to increase to around 70 °C**, **you should prepare the table to record your measurements.**
8. It should take about two to three minutes for the temperature to stabilise. Once the temperature reading hardly increases or stays almost constant, note the temperature and remove the boiling tube from the Styrofoam cup and place it in a test tube rack.
9. Pour **FA 4** from step 3 **rapidly** into the boiling tube. Start the stopwatch during this addition.
10. Mix the contents thoroughly by stirring gently with the thermometer but do not read the temperature. Then hold the boiling tube over a while tile.
11. Stop the stopwatch when the solution turns colourless.
12. Record the time taken, *t*, to the nearest second.
13. Discard the reaction mixture. Wash out the boiling tube and stand it upside down in the test tube rack to drain.
14. Wash the thermometer and dry it on a paper towel.

Experiments 2 to 4

Using the same Styrofoam cup of hot water, repeat experiment 1 until a total of **four** experiments at different temperatures are conducted between 40 °C and 70 °C, and their results recorded. You should alternate the use of the two boiling tubes.

(i) Results

Experiment	Temperature of solution inside boiling tube / °C	Time taken, t / s	$1/t$ / s^{-1}	lg ($1/t$)
1	65.6	8	0.125	−0.903
2	58.0	16	0.0625	−1.20
3	49.0	35	0.0286	−1.54
4	41.8	56	0.0179	−1.75

- Temperature for experiment 1 should be between **65°C and 70°C**, and the **other 3** temperatures should between **40°C and 70°C**.
- Temperature recorded to 1 d.p. and time taken recorded as whole number
- Correctly calculated values for $1/t$ and lg($1/t$) and recorded to 3 s.f.

[4]

(b) (i) Plot a graph of lg($1/t$) on the y-axis against temperature on the x-axis on the grid in **Fig 2.1**.

Draw the best-fit curve taking into account all of your plotted points.

- **Graph should show an increasing trend.**
- Correct axes, labels and units
- Appropriate scale to allow plotted points to occupy at least half the graph grid in both axes
- Correctly plotted points (within ½ small square) [3]

(ii) Suggest the significance of $1/t$ in this series of experiments.

$1/t$ is proportional to **rate** of each experiment.

[1]

(iii) With reference to the Arrhenius equation shown below, explain why a curve should be obtained in **(b)(i)**.

$$k = Ae^{-\frac{Ea}{RT}}$$

where:

k = rate constant, A = Arrhenius constant, E_a = activation energy, R = molar gas constant, T = temperature.

EITHER

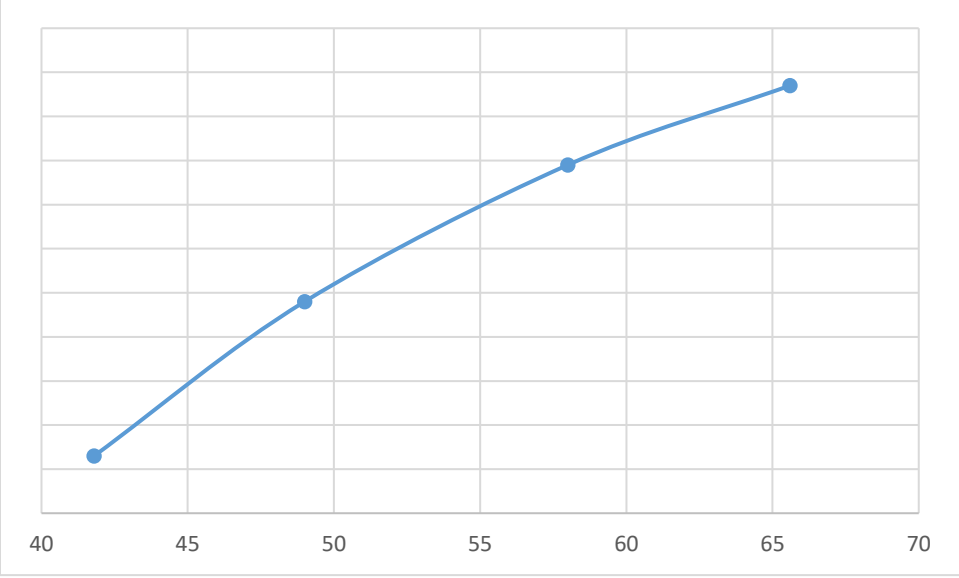
As temperature increases, **rate does not increase proportionally**.

OR

As temperature increases, rate (1/t) **increases at a decreasing rate.**

FYI: Assuming A, Ea and R are constant in each expt, k = e^(-1/T). Rate can be taken to be similar to the rate constant.

Using values in (a), graph of k vs temperature is obtained (y-axis is e^(-1/T) and x-axis is temperature):



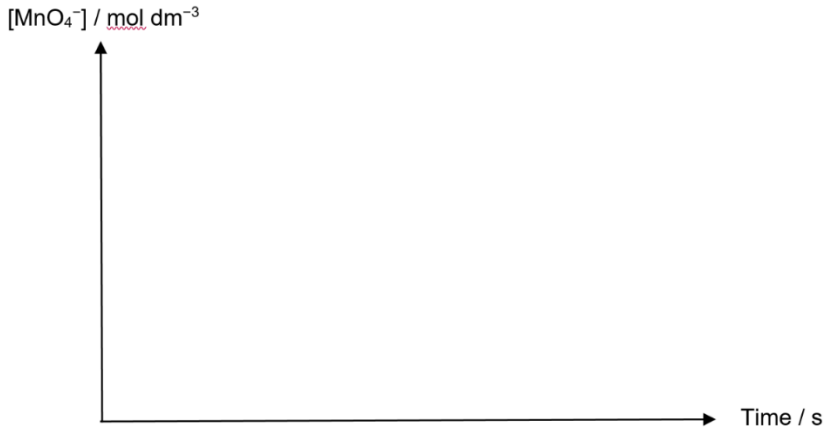
From the graph, as T increases, k increases at a decreasing rate.

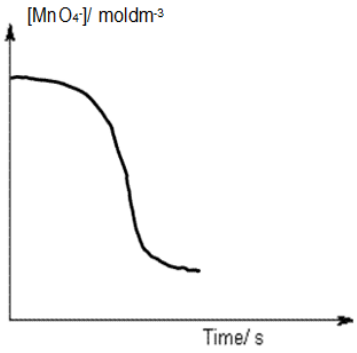
(c) Suggest why it is important to alternate the use of the two boiling tubes and the effect on the measurements collected if this was not carried out.

Residual water will **lower the concentration** of the reactants, leading to **longer time taken**.

[1]

(d) The product, Mn^{2+} ions, can act as a catalyst for the reaction in **equation 3**. This is an example of 'autocatalysis'. On the axes below, sketch and explain the shape of the graph for the reaction between MnO_4^- and $C_2O_4^{2-}$ at a fixed temperature.





(The gradient of the graph gives the rate of the reaction)

At the start, the reaction starts slowly because no Mn^{2+} ion was produced yet.

As reaction progress, Mn^{2+} ions are formed and the rate increases.

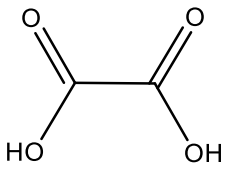
As reaction nears completion, rate decreases as reactants are gradually used up.

[2]

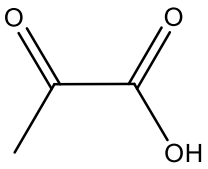
(e) Planning

Potassium manganate(VII) can also oxidise organic compounds.

Plan a simple chemical test, using the reagents provided in **2(a)**, to help you distinguish between the pair of organic compounds below.



Compound A



Compound B

Your plan should include:

- details of the reagents and conditions to be used,
- an outline of the sequence of steps you would follow.

Test	Observations	Deductions
Using a dropper, add **1 cm^3** of each compound into 2 separate test tubes. To each test tube, add 10 drops of **dilute H_2SO_4** followed by 1 drop of **potassium manganate(VII) solution**. Shake well. Heat the mixture in a **water bath** for 5 min. Remove the test tube which shows decolourisation of purple solution. Stopper it with a delivery tube and pass the gas into another test tube with 1 cm^3 of limewater.	Purple solution decolourised in one of the test tubes. Effervescence seen, gas evolved forms white ppt in limewater. Purple solution remained in the other test tube.	Compound A present. Compound B present.

[3]

[Total: 15]

3 Planning

A common method to determine the concentration of ethanedioic acid solution is to titrate it with a standard solution of an alkali, such as barium hydroxide. This requires the use of an indicator to determine the equivalence point of the titration.

$$H_2C_2O_4\,(aq) + Ba(OH)_2\,(aq) \rightarrow BaC_2O_4\,(aq) + 2H_2O\,(l)$$

Neutralisation reactions are exothermic. A *thermometric titration* can also be carried out to determine the equivalence point of the reaction described above, without the use of an indicator. In this method, the temperature is monitored throughout the experiment where small volumes of the solution being analysed are progressively added to the standard solution until the equivalence point is reached and passed.

To determine the concentration of the solution being analysed, data obtained is plotted on a graph. One best-fit line is drawn through the data before the equivalence point is reached, and the second best-fit line is drawn through the remaining data. These two lines are then extrapolated (extended) until they cross.

(a) Using the information given above, you are required to write a plan for a thermometric titration in which ethanedioic acid is added to aqueous barium hydroxide to determine the concentration of ethanedioic acid.

You may assume that the original solutions are at 25 °C and that the maximum temperature rise obtained in this experiment is between 8 °C and 10 °C.

You may also assume that you are provided with:

- 1.00 mol dm^{-3} aqueous $Ba(OH)_2$,
- $H_2C_2O_4$ of approximate concentration 1.0 mol dm^{-3},
- the equipment normally found in a school or college laboratory.

In your plan you should include brief details of:

- a justification of the quantities you would use,
- the apparatus you would use,
- the procedure you would follow,
- how you would ensure that your results are **accurate** and **reliable**.

[7]

Justification of quantities

Volume of $Ba(OH)_2$ used = 25.0 cm^3

Amount of $Ba(OH)_2$ = 0.025 mol

Amount of $H_2C_2O_4$ = 0.025 mol

Approx volume of $H_2C_2O_4$ required to reach the equivalence point = 25.00 cm^3 (Add more than 25.00 cm^3 as experiment requires equivalence point to be passed)

Volume of $H_2C_2O_4$ to be added = 40.00 cm^3 (for enough data points after the equivalence point to draw best-fit line) → minimum 3 data points to draw

- Accept any acceptable volume between 25 – 50 cm^3 of $Ba(OH)_2$.
- Cannot use V $Ba(OH)_2$ = 10.0 cm^3 (cannot cover bulb)
- V $H_2C_2O_4$ > V $Ba(OH)_2$

Procedure

1. Fill a 50.00 cm^3 burette with $H_2C_2O_4$.
2. Place a Styrofoam cup (inside a second Styrofoam cup) in a 250 cm^3 beaker for support.
3. Using a 25.0 cm^3 pipette, transfer 25.0 cm^3 of $Ba(OH)_2$ into the cup and record its temperature with a thermometer.
4. From the burette, add 5.00 cm^3 of $H_2C_2O_4$ to the cup and stir the mixture thoroughly with the thermometer.
5. Read and record the maximum temperature of the mixture.
6. Repeat points 4 and 5 until a total of 40.00 cm^3 of $H_2C_2O_4$ has been added.

Accuracy and reliability of results (to minimise heat loss to surroundings)

- Cover the Styrofoam cup with a plastic **lid**.
- Conduct experiment in a **draught free environment**

Marking annotations:

A	Apparatus
J	Justification of quantities
P	Procedure
R	Accuracy and reliability

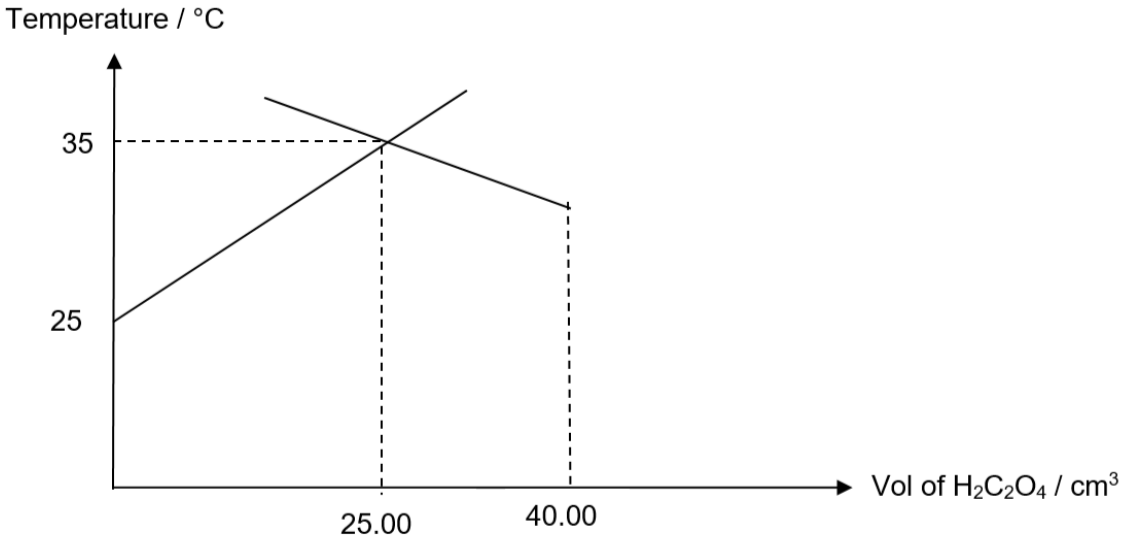
Answer	Marking annotations	Remarks
Candidate shows calculations to conclude that a volume greater than 25.00 cm^3 of ethanedioic acid should be used.	J	Equivalence point must be passed. Cannot use exactly 25.00 cm^3.
Fill a burette with $H_2C_2O_4$.	A P	A for burette. If candidate uses the wrong solution in the burette, P is not awarded here.
Using a pipette / burette to transfer 25.0 / 25.00 cm^3 respectively of $Ba(OH)_2$ into the cup.	A	A for pipette + V (to 1 dp). A for burette + V (to 2 dp). If candidate uses the wrong solution in the pipette, P was already penalised above.
and record its initial temperature with a thermometer.	A P	A for thermometer. Record initial temperature.
Add a small volume of $H_2C_2O_4$ to the cup and stir.	P	
Read and record the maximum / highest temperature of the mixture.	P	Read maximum / highest temperature.
Repeat until sufficient volume of acid has been added.	P	
Any reasonable suggestion.	R	

[Total: 7 marks]

(b) On the axes below, sketch a labelled graph you would expect to obtain from the thermometric titration you planned in **3(a)**. Hence, explain how the data obtained from the graph would be used to determine the concentration of ethanedioic acid.

[2]

[Total: 9]



Use of data to determine concentration of ethanedioic acid

The intersection point gives the equivalence volume.

Let the equivalence point be V cm^3 (or whatever value that candidate suggested on the graph).

[ethanedioic acid] = 0.025 / (V/1000) mol dm^{-3}

4 Investigation of some inorganic reactions

You are given three different pure solid samples **FA 5**, **FA 6** and **FA 7**.

(a) Perform the tests described in Table 4.1 and record your observations in the tables. In all the tests, the reagent should be added gradually until no further change is observed, with shaking after each addition. No additional or confirmatory tests for ions present should be attempted.

Table 4.1 - Tests on FA 5, FA 6 and FA 7

Tests		Observations for FA 5	Observations for FA 6	Observations for FA 7
1.	Add 1 cm^3 of dilute hydrochloric acid to ½ spatula of the solid sample in a test tube and warm. You **do not** need to test for any gas evolved.	Blue / Blue-green / green **solution** is observed. Upon warming, solution turns green.	White / Cream / Off-white ppt is observed. Yellow ppt / solid is formed on warming. (No need to test for SO_2) FYI: $Na_2S_2O_3 + 2HCl \rightarrow 2NaCl + S + SO_2 + H_2O$	Colourless solution is formed.
2.	Add 1 cm^3 of silver nitrate solution to ½ spatula of the solid sample in a test tube.	A blue solution is obtained.	A white / yellow ppt and eventually forms black / brown ppt.	A black / grey ppt is formed.
3.	Add 1 cm^3 of aqueous iodine to ½ spatula of the solid sample in a test tube.		Brown solution decolourises.	

4.	Add 1 cm^3 of potassium iodide solution to ½ spatula of the solid sample in a test tube. If need be, filter the resultant mixtures. For the test tube involving **FA 7** only, add 1 cm^3 of barium nitrate solution to the resultant mixture, followed by 1 cm^3 of dilute nitric acid.	A white / cream ppt is formed in brown solution. FYI: $2CuSO_4 + 4KI \rightarrow 2CuI + I_2 + 2K_2SO_4$	A colourless solution is formed.	A brown solution is formed. FYI: $S_2O_8^{2-} + 2I^- \longrightarrow 2SO_4^{2-} + I_2$ persulfate iodide sulfate iodine A cream / white ppt is obtained in a brown solution. It is insoluble in dilute nitric acid.

[7]

(b) In test 1 for **FA 6**, sulfur dioxide is also produced. Suggest a chemical test to test for its presence. State the expected observation.

……..

…….. [2]

Add a **few drops of sulfuric acid to a piece of filter paper**, followed by **2 – 3 drops of $KMnO_4$**. **Pass the gas evolved through this filter paper**.

Bubble the gas into acidified $KMnO_4$

H_2SO_4 (aq), $KMnO_4$

The **purple solution will decolourise**.

(c) The chemical formula of the salt in **FA 7** is $Na_2X_2O_8$. The half equation and the standard reduction potential for $X_2O_8^{2-}$ is as given.

$$X_2O_8^{2-} + 2\ e^- \rightleftharpoons 2\ XO_4^{2-} \quad E^o = +\ 2.01V$$

In test 1, $X_2O_8^{2-}$ undergoes reduction to produce colourless gas. Given the following data, suggest an equation to explain this observation. Explain your answer with relevant calculations.

$O_2 + 4\ H^+ + 4\ e^- \rightleftharpoons 2\ H_2O$ $\quad E^o = +\ 1.23\ V$

$2\ H^+ + 2\ e^- \rightleftharpoons H_2$ $\quad E^o = 0.00\ V$

$Cl_2 + 2\ e^- \rightleftharpoons 2\ Cl^-$ $\quad E^o = +\ 1.36\ V$

$2\ H_2O + 2\ e^- \rightleftharpoons H_2 + 2\ OH^-$ $\quad E^o = +\ 1.23\ V$

[2]

$2\ X_2O_8^{2-} + 2\ H_2O \rightarrow O_2 + 4\ H^+ + 4\ XO_4^{2-}$

$E^o_{cell} = +2.01 – (+1.23) = +\ 0.78\ V$ > 0 (reaction is spontaneous)

(d) In test 2 for **FA 6**, the following equation represents one of the reactions that occurred. $X_2O_3^{2-}$ is the anion found in **FA 6**. There is no change to the oxidation state of silver throughout the test.

$$Ag_2X_2O_3 + H_2O \rightarrow Ag_2X + H_2XO_4$$

State the type of reaction. Explain your answer.

[2]

Disproportionation

Oxidation state of X **increases from +2 in $X_2O_3^{2-}$ to +6 in XO_4^{2-} and decreases from +2 in $X_2O_3^{2-}$ to -2 in X^{2-}**.

(e) From your observations in test 3, suggest the nature of **FA 6**. [1]

Reducing agent

(f) From your observations in test 4, suggest the nature of **FA 7**. [1]

Oxidising agent

(g) In test 4 for **FA 7**, a solid is formed after adding barium nitrate solution. Suggest the identity of this solid. State the purpose of adding dilute nitric acid. [2]

$BaSO_4$

Dilute nitric acid is to **remove any carbonate** so as to confirm the solid is $BaSO_4$.

[Total: 17]

Qualitative Analysis Notes

[ppt. = precipitate]

(a) Reactions of aqueous cations

Cation	***reaction with***	
	NaOH(aq)	NH_3(aq)
aluminium, Al^{3+}(aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH_4^+(aq)	ammonia produced on heating	–
barium, Ba^{2+}(aq)	no ppt. (if reagents are pure)	no ppt.
calcium, Ca^{2+}(aq)	white ppt. with high [Ca^{2+}(aq)]	no ppt.
chromium(III), Cr^{3+}(aq)	grey-green ppt. soluble in excess giving dark green solution	grey-green ppt. insoluble in excess
copper(II), Cu^{2+}(aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe^{2+}(aq)	green ppt. turning brown on contact with air insoluble in excess	green ppt. turning brown on contact with air insoluble in excess
iron(III), Fe^{3+}(aq)	red-brown ppt. insoluble in excess	red–brown ppt. insoluble in excess
magnesium, Mg^{2+}(aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn^{2+}(aq)	off-white ppt. rapidly turning brown on contact with air insoluble in excess	off-white ppt. rapidly turning brown on contact with air insoluble in excess
zinc, Zn^{2+}(aq)	white ppt. soluble in excess	white ppt. soluble in excess

(b) Reactions of anions

ion	*reaction*
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, Cl^-(aq)	gives white ppt. with Ag^+(aq) (soluble in NH_3(aq))
bromide, Br^-(aq)	gives pale cream ppt. with Ag^+(aq) (partially soluble in NH_3(aq))
iodide, I^-(aq)	gives yellow ppt. with Ag^+(aq) (insoluble in NH_3(aq))
nitrate, NO_3^-(aq)	NH_3 liberated on heating with OH^-(aq) and Al foil
nitrite, NO_2^-(aq)	NH_3 liberated on heating with OH^-(aq) and Al foil NO liberated by dilute acids (colourless NO $\rightarrow$ (pale) brown NO_2 in air)
sulfate, SO_4^{2-}(aq)	gives white ppt. with Ba^{2+}(aq) (insoluble in excess dilute strong acids)
sulfite, SO_3^{2-}(aq)	SO_2 liberated on warming with dilute acids; gives white ppt. with Ba^{2+}(aq) (soluble in dilute strong acids)

(c) Tests for gases

gas	*test and test result*
ammonia, NH_3	turns damp red litmus paper blue
carbon dioxide, CO_2	gives a white ppt. with limewater (ppt. dissolves with excess CO_2)
chlorine, Cl_2	bleaches damp litmus paper
hydrogen, H_2	"pops" with a lighted splint
oxygen, O_2	relights a glowing splint
sulfur dioxide, SO_2	turns aqueous acidified potassium manganate(VII) from purple to colourless

(d) Colour of halogens

Halogen	*colour of element*	*colour in aqueous solution*	*colour in hexane*
chlorine, Cl_2	greenish yellow gas	pale yellow	pale yellow
bromine, Br_2	reddish brown gas / liquid	orange	orange-red
iodine, I_2	black solid / purple gas	brown	purple