

2019 JC2 PRELIMINARY EXAMINATIONS

HIGHER 2

CANDIDATE NAME						
CIVICS GROUP		/				
CENTRE NO. / INDEX NO.			/			

CHEMISTRY

Paper 4 Practical

9729/04 2 September 2019 2 hours 30 minutes

Candidates answer on the Question Paper.

READ THESE INSTRUCTIONS FIRST

Write your Civics Group and name on all the work you hand in.

Give details of the practical shift and laboratory where appropriate, 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.

Answer **all** 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 17 and 18.

At the end of the examination, fasten all your work securely together.

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

Shift
Laboratory

For Examiner's Use		
1	/ 18	
2	/12	
3	/15	
4	/ 10	
Total	/ 55	

This document consists of 18 printed pages and 2 blank pages.

2

Answer all the questions in the spaces provided.

1 Determination of the concentration of a solution of hydrogen peroxide

Hydrogen peroxide, H_2O_2 , can be oxidised to give oxygen, O_2 . This reaction happens rapidly in the presence of acidified potassium manganate(VII), KMnO₄.

 $2MnO_{4}(aq) + 5H_{2}O_{2}(aq) + 6H^{+}(aq) \longrightarrow 2Mn^{2+}(aq) + 5O_{2}(g) + 8H_{2}O(I)$

To determine the concentration of a solution of hydrogen peroxide, you will first dilute the solution and then carry out a titration using acidified potassium manganate(VII), KMnO₄.

FA 1 is aqueous hydrogen peroxide. FA 2 is 0.0200 mol dm⁻³ potassium manganate(VII), KMnO₄. FA 3 is 1.0 mol dm⁻³ sulfuric acid, H_2SO_4 .

Keep FA 1 for use in Question 4.

(a) Method

Dilution

- Pipette 25.0 cm³ of FA 1 into the 250 cm³ volumetric flask.
- Add distilled water to make 250 cm³ of solution and shake the flask thoroughly.
- Label this diluted solution of hydrogen peroxide as FA 4.

Titration

- Fill the burette with **FA 2**.
- Pipette 25.0 cm³ of **FA 4** into a conical flask.
- Use the measuring cylinder to add 25 cm³ of **FA 3** to the conical flask.
- Titrate FA 4 against FA 2 and record your readings in the space below.
- Carry out as many accurate titrations as you think necessary.

Results

Final burette reading /cm ³	20.70	20.80
Initial burette reading /cm ³	0.00	0.00
Volume of FA 2 /cm ³	20.70	20.80
	1	1

- Appropriate headings and units.
- All accurate burette readings recorded to 0.05 cm³.
- Has two uncorrected, accurate titres value within ±0.10 cm³.
- 2m accuracy

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

• Average titre =
$$\frac{20.70+20.80}{2}$$

= 20.75 cm³

25.0 cm³ of **FA 4** required 20.75 cm³ of **FA 2** for titration [1]

(c) Calculations

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

- (i) Calculate the amount of potassium manganate(VII) present in the volume of **FA 2** calculated in (b).
 - Amount of MnO₄⁻ present in 20.75 cm³ of FA 2 = $\frac{20.75}{1000} \times 0.0200$ = 4.15 x 10⁻⁴ mol

amount of KMnO₄ = 4.15×10^{-4} mol [1]

(ii) Calculate the amount of hydrogen peroxide present in 25.0 cm³ of FA 4. $2MnO_{4}(aq) \equiv 5H_{2}O_{2}(aq)$

- Amount of H₂O₂ in 25 cm³ of FA 4
- = 4.15 x 10⁻⁴ x $\frac{5}{2}$
- $= 1.04 \times 10^{-3} \text{ mol} (3 \text{ sf})$

amount of H_2O_2 in 25.0 cm³ of **FA4** = 1.04 x 10⁻³ mol [1]

(iii) Calculate the concentration, in mol dm⁻³, of H_2O_2 in **FA 4**.

• Concentration of H₂O₂ in FA 4 = $1.04 \times 10^{-3} \times \frac{1000}{25}$ = 0.0415 mol dm⁻³ (3sf) concentration of H₂O₂ in FA 4 = 0.0415 mol dm⁻³ [1] (iv) Calculate the concentration, in mol dm⁻³, of H_2O_2 in FA 1.

Amount of H_2O_2 in 250 cm³ of FA 4 = Amount of H_2O_2 in 25 cm³ of FA 1 = 1.04 x 10⁻³ x $\frac{250}{25}$ mol = 0.0104 mol • Concentration of H_2O_2 in FA 1 = 0.0104 x $\frac{1000}{25}$ = 0.415 mol dm⁻³ (3sf) OR Dilution factor = 250 / 25 = 10 • Concentration of H_2O_2 in FA 1 = 0.0415 x 10 = 0.415 mol dm⁻³

(d) Another experiment was conducted to determine the concentration of hydrogen peroxide. Different volumes of hydrogen peroxide were added to identical 25.0 cm³ samples of 0.0400 mol dm⁻³ aqueous iron(II) solution. Iron (II) is oxidised by hydrogen peroxide as shown by the following equation.

$$2Fe^{2+} + H_2O_2 + 2H^+ \rightarrow 2Fe^{3+} + 2H_2O$$

concentration of H_2O_2 in **FA 1** = 0.415 mol dm⁻³

The remaining iron(II) ions in each of the resulting mixtures were then titrated against potassium manganate(VII) and the results are shown in the table below:

Volume of H ₂ O ₂ added / cm ³	Volume of KMnO ₄ / cm ³
2.00	11.60
12.00	5.20
16.00	2.60
25.00	3.40
30.00	6.70
35.00	10.00

(i) Plot, on the grid on page 5, your values for the volume of potassium manganate(VII) (*y-axis*) against the volume of hydrogen peroxide added (*x-axis*).

Draw two straight lines of best fit, taking into account all of your plotted points.

Your graph should enable you to determine the values for (d)(ii).

[1]

- (ii) Hence obtain values for
 - the volume of potassium manganate(VII) required, V_{max}(KMnO₄), to react completely with 25.0 cm³ of iron(II) solution if no hydrogen peroxide is added.
 - the volume of hydrogen peroxide required, V_{max}(H₂O₂), to react completely with 25.0 cm³ of iron(II) solution if no potassium manganate(VII) is added.



•Clearly labelled axes. Appropriate scale starting from origin and allowing the plotted points to be more than half given grid.

- correctly plotted points
- 2 best-fit straight lines

 $V_{max}(KMnO_4) = 12.8 \text{ cm}^3$

 $V_{max}(H_2O_2) = 20.0 \text{ cm}^3$

• 1 mark for both values (only if the 2 lines intersect at x-axis)

(iii) Determine the concentration of hydrogen peroxide in mol dm⁻³ in this experiment.

 $\begin{aligned} &2\text{Fe}^{2+} \equiv \text{H}_2\text{O}_2 \\ &\text{Amount of Fe}^{2+} \text{ in } 25.0 \text{ cm}^3 \text{ of solution} = \frac{25}{1000} \times 0.04 = 1.00 \text{ x } 10^{-3} \text{ mol} \\ &\text{\bullet} \text{Amount of H}_2\text{O}_2 \text{ in } 20 \text{ cm}^3 \text{ of solution} = 1.00 \text{ x } 10^{-3} \text{ x } \frac{1}{2} = 5.00 \text{ x } 10^{-4} \text{ mol} \\ &\text{(\bullet using Vmax(H_2\text{O}_2)) Concentration of H}_2\text{O}_2 \text{ solution} = 5.00 \text{ x } 10^{-4} \text{ x } \frac{1000}{20} \\ &= 0.0250 \text{ mol dm}^{-3} \end{aligned}$

(allow ecf from (ii))

- All calculations to 3 significant figures
- correct units for all calculated values

Concentration of hydrogen peroxide =	0.0250 mol dm ⁻³	
		[4] [Total: 18]

2 Determination of the enthalpy change of reaction, ΔH_r

You are to determine the enthalpy change of reaction, ΔH_r , for the following reactions:

$$Na_2CO_3(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + CO_2(g) + H_2O(l) \qquad \Delta H_1$$

 $NaHCO_3(s) + HCl(aq) \rightarrow NaCl(aq) + CO_2(g) + H_2O(l)$ ΔH_2

FA 5 is anhydrous sodium carbonate, Na₂CO₃

FA 6 is solid sodium hydrogen carbonate, NaHCO3

You are also provided with 2.0 mol dm⁻³ HCl

(a) Reaction of FA 5, Na₂CO₃, with an excess of 2.0 mol dm⁻³ hydrochloric acid

Method

Read through the instructions carefully before starting any practical work.

- 1. Support the styrofoam cup in the 250 cm³ beaker.
- 2. Use the measuring cylinder to transfer 50 cm³ of 2.0 mol dm⁻³ hydrochloric acid into the styrofoam cup.
- 3. Place the thermometer in the styrofoam cup and record the temperature of the solution.
- 4. Weigh the weighing bottle containing **FA 5**, anhydrous sodium carbonate.
- 5. With the aid of a dry spatula, add the contents of the weighing bottle to the styrofoam cup in **three separate portions**, taking care that the mixture does not overflow.

[Safety precaution: DO NOT add FA 5 all at once. The reaction is very vigourous.]

- 6. Stir and record the highest temperature obtained.
- 7. Reweigh the weighing bottle containing residual FA 5.

Record in an appropriate form below, all of your weighings and temperature measurements together with the mass, m_1 , of **FA 5** added and the maximum temperature rise, ΔT_1 .

<u>Results</u>

Mass of weighing bottle and FA 5	/ g	51.64
Mass of weighing bottle and residual FA 5	/ g	45.60
Mass of FA5 (Na ₂ CO ₃) added to acid (m ₁)	/ g	6.04

Initial temperature of HCl	/ °C	29.5
Maximum temperature	/ °C	37.5
Maximum temperature rise (ΔT ₁)	/ °C	8.0

• (for both (a) and (c)): mass table and table recording temperature changes with appropriate headers

• Record every mass reading to 2 dp and temperature recorded to 1dp

[2]

(b) (i) Calculate the temperature rise per gram of **FA 5**, Na₂CO₃, used in the experiment.

•
$$\frac{\Delta T_1}{m_1}$$
 = 8.0 / 6.04 = 1.32 °C g⁻¹

Accuracy

Calculate the difference between the Supervisor and candidate values of Δ T/m. Give 1 mark for a difference up to ±0.2 °C g⁻¹.

$$\frac{\Delta T_1}{m_1} = \frac{1.32 \ ^{\circ}\text{C g}^{-1}}{[2]}$$

(ii) Calculate the enthalpy change, ΔH_1 , for the reaction

Na₂CO₃(s) + 2HC*l*(aq)
$$\rightarrow$$
 2NaC*l* (aq) + CO₂ (g) + H₂O(l)
 $\Delta H_1 = -(22.79 \text{ x} \frac{\Delta T_1}{2}) \text{ kJ mol}^{-1}$

 $\Delta H_1 = - (22.79 \text{ x} \frac{\Delta T_1}{m_1})$ • $\Delta H_1 = - (22.79 \text{ x} 1.32) = - 30.2 \text{ kJ mol}^{-1}$

 $\Delta H_1 = -30.2 \text{ kJ mol}^{-1}$

[1]

(c) Reaction of FA 6, NaHCO₃, with an excess of 2.0 mol dm⁻³ hydrochloric acid

Method

Read through the instructions carefully before starting any practical work.

- 1. Support another styrofoam cup in the 250 cm³ beaker provided.
- 2. Use the measuring cylinder to transfer 50 cm³ of 2.0 mol dm⁻³ hydrochloric acid into the styrofoam cup.
- 3. Place the thermometer in the styrofoam cup and record the temperature of the solution.
- 4. Weigh the empty weighing bottle labelled "FA 6".
- 5. Weigh approximately 7.0 8.0 g of **FA 6**, anhydrous sodium hydrogen carbonate into the empty weighing bottle labelled "**FA 6**".
- 6. With the aid of a dry spatula, add the contents of the weighing bottle to the styrofoam cup in **three separate portions**, taking care that the mixture does not overflow.

[Safety precaution: DO NOT add FA6 all at once. The reaction is very vigourous.]

- 7. Stir and record the lowest temperature obtained.
- 8. Reweigh the weighing bottle containing residual FA 6.

Record in an appropriate form below, all of your weighings and temperature measurements together with the mass, m_2 , of **FA 6** added and the maximum temperature fall, ΔT_2 .

<u>Results</u>

Mass of empty weighing bottle	/ g	44.89
Mass of weighing bottle and FA 6	/ g	52.49
Mass of weighing bottle and residual FA 6	/ g	44.90
Mass of FA 6 (NaHCO ₃) added to acid (m ₂)	/ g	7.59

Initial temperature of HC/	/ °C	29.5
Minimum temperature	/ °C	18.0
Fall in temperature (ΔT ₂)	/ °C	11.5

[Marks awarded together with (a)]:

mass table and table recording temperature changes with appropriate headers Record every mass reading to 2 dp and temperature recorded to 1dp

(d) (i) Calculate the temperature fall per gram of **FA 6**, NaHCO₃, used in the experiment.

Accuracy

Calculate the difference between supervisors' value and the candidate's value of $\Delta T/m.$

Give 1 mark for a difference up to ±0.2 °C g⁻¹

 $\frac{\Delta T_2}{m_2} = \frac{1.52 \text{ °C g}^{-1}}{[2]}$

(ii) Calculate the enthalpy change, ΔH_2 , for the reaction

 $NaHCO_3(s) + HCl(aq) \rightarrow NaCl(aq) + CO_2(g) + H_2O(I)$

$$\Delta H_2 = + (18.06 \text{ x} \frac{\Delta T_2}{m_2}) \text{ kJ mol}^{-1}$$

 $\Delta H_2 = + (18.06 \text{ x} \frac{\Delta T_2}{m_2})$ • $\Delta H_2 = + (18.06 \text{ x} 1.52) = + 27.5 \text{ kJ mol}^{-1}$

 $\Delta H_2 = + 27.5 \text{ kJ mol}^{-1}$

[1]

(e) (i) The smallest graduation in reading a -10 °C to +110 °C thermometer is 1.0 °C
 Suggest the maximum error of the temperature change calculated with two temperature readings.

Error = ½ of smallest graduation = ±0.5 °C • Maximum error = 2 x 0.5 = ±1.0°C

Maximum error = ±1.0°C

[1]

(ii) The expected fall in temperature when 1.0 g of NaHCO₃(s) is added to 50 cm³ of 2.0 mol dm⁻³ hydrochloric acid is approximately 1.5°C

Determine the maximum percentage error in the calculated temperature change when 1.0 g of NaHCO₃ is added to 50 cm³ of 2.0 mol dm⁻³ hydrochloric acid.

•% error = $\frac{1.0}{1.5}$ x 100% = 66.7%

Maximum percentage error = **66.7%**

[1]

(f) It is not possible to measure experimentally the enthalpy change, ΔH_3 , for the following reaction as it does not take place in the laboratory.

 $Na_2CO_3(s) + CO_2(g) + H_2O(I) \rightarrow 2NaHCO_3(s)$

It is possible, however, to calculate a "theoretical" value of ΔH_3 for this reaction from the results of the experiments you have carried out.

Using an energy cycle and your results from (b)(ii) and (d)(ii), calculate a value for $\Delta H_{3.}$



 $\Delta H_3 = -85.2 \text{ kJ mol}^{-1}$

[2] [Total: 12]

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 reagents are selected for use in a test, the **name or correct formula** of the element or compound must be given.

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.

No additional tests for ions present should be attempted.

Rinse and reuse test-tubes and boiling tubes where possible.

(a) FA 7, FA 8 and FA 9 are aqueous solutions that each have an ion containing one of the metals from those listed in the Qualitative Analysis Notes.

FA 1 from Question 1 are to be used in some of these tests.

Carry out the following tests and record your observations.

	Test	Observation
(i)	To a 1 cm depth of FA 7 in a test-tube, add a 1 cm depth aqueous sodium hydroxide.	$\sqrt{\frac{\text{Off-white ppt}}{\text{formed turns brown}}}$ on contact with air, <u>insoluble</u> in <u>excess</u> <u>NaOH</u>
	Then odd on oral drama of FA 1	√ <u>Black or brown solid (ppt)</u> formed
	Then, and several drops of FA 1.	Effervescence seen.
		relights a glowing splint
(ii)	To a 1 cm depth of FA 8 in a test-tube, add a few drops of aqueous sodium hydroxide.	√ <u>Green ppt</u> formed, <u>turns brown</u> on standing, <u>insoluble in excess NaOH</u>
	Then, add excess aqueous sodium hydroxide.	
(iii)	To a 1 cm depth of FA 8 in a test-tube, add several drops of FA 1 , and then add aqueous sodium hydroxide.	√ Solution turned darker <u>yellow</u> . √ <u>Red-brown</u> ppt formed <u>insoluble in</u> <u>excess NaOH</u>
		Effervescence seen.
		(colourless, odourless) gas evolved relights a glowing splint
(iv)	To a 1 cm depth of FA8 in a test-tube, add a 1 cm depth of dilute sulfuric acid, and then a few drops of FA9 .	√ Purple FA 9 decolourises to form a <u>colourless</u> / (pale-yellow/ pale-orange) solution.
(v)	To a 1 cm depth of aqueous potassium iodide in a test-tube, add a few drops of FA 9 .	 √ <u>Brown solution</u> formed / <u>black ppt</u> formed. √Solution turned <u>blue-black</u>
	Then, add a few drops of starch solution	Every 2 √ = 1m

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[5]

(b) Identify the cation present in FA 7 and FA 8.

The cation present in **FA 7** is •Mn²⁺

The cation present in **FA 8** is

•Fe²⁺

(c) Explain the chemistry involved in the effervescence observed in both (a)(i) and (a)(iii).

12

[1]

•Gas evolved is O_2 . Mn^{2+} and Fe^{3+} present in the solution <u>acts as a catalyst for the</u> <u>decomposition of H_2O_2 .</u> Hence, O_2 is produced.

(d) A student added 1 cm³ of **FA 9** to a test-tube containing **FA 8**. A strip of magnesium ribbon was then added to the mixture. Effervescence was observed.

Deduce the identity of the gas evolved and explain the chemistry involved in this reaction.

[3]

•Gas evolved is <u>H₂.</u>

•Fe²⁺ in FA 8 was <u>oxidized to Fe³⁺</u> by FA 9 (oxidizing agent)

•Fe³⁺ has a <u>high polarizing power</u> (high charge density), thus <u>polarize the electron</u> <u>cloud of water</u>, <u>weaken the O-H bond</u>, <u>releasing H⁺</u> into the solution, thus FA8 is acidic. <u>Reactive metal Mg reacts with an acidic solution</u> to release H₂ (g).

(e) Figure 1 below shows the process of thermal decomposition of FA 10, which is a solid sample of the compound present in the aqueous solution of FA 9.



Figure 1

Consider the observations in **Figure 1**, suggest the identity of the manganese-containing species in the green solution and the residue.

• MnO₄²⁻(solution) and MnO₂(residue)

[1]

(f) **FA 8** contains one of the anions Cl^- , Br^- , I^- , SO_4^{2-} or SO_3^{2-} .

Plan an experiment to determine the reagents you would use to identify which anion is present in **FA 8**.

Carry out your tests on **FA 8** to identify the anion present. Record your observations in the table below.

	Test	Observations
(i)	To a 1 cm depth of FA 8, add 1 cm ³ of aqueous silver nitrate.	No ppt formed
(ii)	To a 1 cm depth of FA 8, add 1 cm ³ of $$ aqueous barium nitrate, followed by nitric acid.	 √ White ppt formed, √ insoluble in HNO₃.
	[Note: cannot use sulfuric acid. Hydrochloric acid is acceptable]	

Suggest the identity of the anion present in FA 8.

• sulfate / SO4²⁻

[3] [Total:15]

4 (a) This question is about the electrolysis of different compounds. During the electrolysis of dilute sulfuric acid using a current of 0.75 A for 90 minutes, the volume of oxygen gas collected was recorded and is shown in the graph below.



·	
Electrode reaction	E⊖ / V
$2H^+ + 2e^- \rightleftharpoons H_2$	0.00
$O_2 + 4H^+ + 4e^- \rightleftharpoons 2H_2O$	+1.23
$O_2 + 2H_2O + 4e^- \rightleftharpoons 4OH^-$	+0.40
$2H_2O + 2e^- \rightleftharpoons H_2 + 2OH^-$	-0.83

(i) Table 1 below gives some standard electrode potential values

Table 1

+0.17

+2.01

With reference to the values in the Table 1, write equations for the reactions that occur at each electrode in the electrolysis of sulfuric acid.

[2]

• Cathode : $2H^+(aq) + 2e \longrightarrow H_2(g)$ • Anode : $2H_2O(I) \longrightarrow O_2(g) + 4H^+(aq) + 4e$

On the graph on page 14,

(ii) Draw a straight line to show the volume of hydrogen evolved in the same experiment. Label the line as "hydrogen".

[1]

• Straight line drawn from origin that has double the volume of oxygen at a given time.

(iii) Draw a straight line to show the volume of oxygen evolved if a current of 0.45 A was used instead of the 0.75 A used in the original experiment. Label the line as "oxygen".

[1]

• Straight line drawn from origin which has 0.45/0.75 x volume of oxygen at a given time.

(b) During the electrolysis of potassium butanedioate, the following reaction occurs.

$$\begin{array}{c} CH_2COO^- \ K^+ \\ | \\ 2H_2O \ + \ CH_2COO^- \ K^+ \ \rightarrow \ C_2H_4 \ + \ 2CO_2 \ + \ H_2 \ + \ 2KOH \\ potassium \\ butanedioate \end{array}$$

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 $SO_4^{2-} + 4H^+ + 2e^- \rightleftharpoons SO_2 + 2H_2O$

 $S_2O_8^{2-}$ + $2e^ \rightleftharpoons$ $2SO_4^{2-}$

An experiment can be conducted to verify the stoichiometric ratio between hydrogen gas and ethene gas collected using the following set-up.



potassium butanedioate solution

Hydrogen is produced at one electrode, ethene and carbon dioxide are produced at the other. The carbon dioxide can be separated from the ethene by absorbing it using a suitable reagent before the volume of ethene is measured.

- (i) Complete the diagram on page 15 to show how:
 - the hydrogen could be collected and its volume measured,
 - the carbon dioxide could be removed,
 - the volume of ethene could be measured.

Your diagram should include appropriate apparatus and the identity of the suitable reagent used to remove carbon dioxide.

[3]

Answers:



 \checkmark Gases are released at the correct electrode (polarity) \checkmark Diagram shows collection of hydrogen using a means of measuring the volume of the gas \checkmark Diagram shows carbon dioxide from the anode being absorbed using an alkaline solution \checkmark Diagram shows ethene being collected using a means of measuring the volume of the gas $4\sqrt{:3}$ m $2-3\sqrt{:2m}$ $1\sqrt{:1}$ m If use limewater not penalised here.

(ii) Calculate the number of coulombs, **N**, that would be required to produce **V** cm³ of hydrogen at room temperature and pressure.

[1]

```
Amount of hydrogen = V/24000 mol

2H_2O + 2e \longrightarrow H_2 + 2OH^-

Amount of electrons required = 2 x V/24000
```

• N = 2 x V/24000 x 96500 C = 8.04V C (iv) Write the equation for the reaction that takes place for the removal of carbon dioxide.

[1]

• 2NaOH + CO₂ \longrightarrow Na₂CO₃ + H₂O

(vi) Predict the organic product that would be obtained at the electrode when a solution of potassium *hexanedioate* is electrolysed.

[1]

• But-2-ene

[Total: 10]

17

Qualitative Analysis Notes

[ppt. = precipitate]

(a) Reactions of aqueous cations

antian	reaction with		
cauon	NaOH(aq)	NH ₃ (aq)	
aluminium, Al ³⁺ (aq)	white ppt. soluble in excess	white ppt. insoluble in excess	
ammonium, NH₄⁺ (aq)	ammonia produced on heating	-	
barium, Ba²⁺(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), Cu²⁺(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), Mn²⁺(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, Zn²⁺(aq)	white ppt. soluble in excess	white ppt. soluble in excess	

(b) Reactions of anions

anion	reaction	
carbonate, CO ₃ ²⁻	CO ₂ liberated by dilute acids	
chloride, C <i>l⁻</i> (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, NO₃ [−] (aq)	NH_3 liberated on heating with $OH^-(aq)$ and Al foil	
nitrite, NO₂ [−] (aq)	NH_3 liberated on heating with OH ⁻ (aq) and A <i>l</i> foil; NO liberated by dilute acids (colourless NO \rightarrow (pale) brown NO ₂ in air)	
sulfate, SO₄ ^{2−} (aq)	gives white ppt. with Ba ²⁺ (aq) (insoluble in excess dilute strong acids)	
sulfite, $SO_3^{2^-}$ (aq)	SO ₂ liberated 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) Colours 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

Apparatus List

- 1. In addition to the fittings ordinarily contained in a chemical laboratory, the apparatus, and materials specified below will be necessary.
- 2. Pipette fillers (or equivalent safety devices), safety goggles and disposable plastic gloves should be used where necessary.

3. For each candidate

For each candidate

- 1 x burettes (50 cm³);
- 1 x pipette (25.0 cm³);
- 1 x pipette filler;
- 1 x retort stands and burette clamps;
- 1 x 50 cm³ measuring cylinder;
- 1 x funnels (for filling burette);
- 1 x 250cm³ volumetric (graduated) flask
- 2 x 250 cm³ conical flasks;
- 1 x 250cm³ beaker
- 1 x white tile;
- 1 x thermometer with range -10 °C to +110 °C, graduated to 1 °C;
- 2 x styrofoam cup
- 4 plastic dropping pipettes;
- 5 test-tubes;
- 1 x test-tube rack;
- 1 x test-tube holder;
- 1 x delivery-tube (small one for test-tube)
- 1 x small spatula
- 1 x wash bottle containing deionised water;
- 1 x Bunsen burner;
- 1 x lighter (per bench)
- Water-soluble marker
- wooden splinters
- red and blue litmus paper
- paper towels

Additional pipette filler, test-tubes and dropping pipettes should be available.

Chemicals Required

Question 1-3:

Label	Per	Identity	Notes (preparation)
	candidate		
FA 1	70 cm ³	5 'vol' hydrogen	Dilute 50cm ³ of 100 'vol' hydrogen
		peroxide	peroxide to 1 dm ³
FA 2	150 cm ³	0.02 mol dm ⁻³	
		potassium	
	000 3	managanate (VII)	
FA 3	200 cm ³	1.0 mol dm ^{-s} sulturic	
FA 5	6.0 a – 7.0 a	Anhydrous sodium	Between 6.0 - 7.0 g of powdered
		carbonate	Na_2CO_3 in a stoppered weighing bottle, labelled FA 5.
FA 6	6.0 g – 7.0 g	Sodium hydrogen carbonate	Place powdered NaHCO ₃ beside weighing balance in lab (4 weighing balance in each lab). Each student would have 1 <u>empty</u> stoppered weighing bottle, labelled FA6 .
2.0 mol dm ⁻³	150 cm ³	2.0 mol dm ⁻³ HC <i>l</i>	Bottled and labelled separately from
HCI			QA reagents
			Labelled as '2.0 mol dm ⁻³ HC <i>l</i> '.
FA7	10 cm ³	0.2 mol dm ⁻³	Dissolve 25.2 g of MnCl ₂ (or 39.6g of
		manganese (II)	$MnCl_2 \cdot 4H_2O$) in each dm ³ of solution
		chloride	,
FA 8	20 cm ³	0.1 mol dm ⁻³ iron (II)	Dissolve 39.2 g of
		ammonium sulfate	$Fe(NH_4)_2(SO_4)_2 \bullet 6H_2O$ in acid
			Note: Cannot not prepare in acid as the
			solution gets oxidized quickly. If
			dissolve in acid, the solution is
			colourless
FAQ	10 cm^3	0.02 mol dm^{-3}	Labelled separately as ' FA 9 ' Different
IAJ			from EA 2 labels
	– 3		
Aqueous Starch	5 cm ³	Starch solution	
Potassium	5 cm ³	0.1 mol dm ⁻³	
iodide		potassium iodide	

QA reagents required:

- 1. Dilute HCl
- 2. Dilute HNO_3
- 3. Dilute H_2SO_4
- 4. Aqueous NH_3
- 5. Aqueous NaOH
- 6. 0.1 mol dm⁻³ of Aqueous $Ba(NO_3)_2$
- 7. 0.05 mol dm⁻³ of aqueous silver nitrate (AgNO₃)
- 8. Limewater