

NANYANG JUNIOR COLLEGE
JC2 PRACTICAL PRELIMINARY EXAMINATION
Higher 2

CANDIDATE
NAME

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CLASS

2	1		
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CENTRE
NUMBER

TUTOR

INDEX
NUMBER

CHEMISTRY

Paper 4 Practical

9729/04

18 August 2022

2 hour 30 minutes

Candidates answer on the Question Paper

Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

Write your name and class 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 19 and 20.

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	/ 17
2	/ 16
3	/10
4	/ 12
Total	/55

Answer **all** the questions in the spaces provided.

1 An investigation of the chemistry of some vanadium ions

FA 1 is a solution of a dilute acid.

FA 2 contains vanadate(V) ions, VO_3^- , of concentration 0.50 mol dm^{-3} .

Ammonium vanadate(V), NH_4VO_3 , is a crystalline solid that is slightly yellow in colour. It has a relatively low solubility in water at room temperature.

Vanadium, like all transition metals, is able to exhibit variable oxidation states in its compounds.

You are provided with a solution, **FA 2**, which was produced by reacting NH_4VO_3 with aqueous sodium hydroxide. In this reaction, the anion remains unreacted.

- (a) Write an equation for the reaction between ammonium vanadate(V) and sodium hydroxide to produce **FA 2**.

Describe how, using a simple chemical test, you can confirm that this reaction occurred during the preparation of **FA 2**.

DO NOT carry out this test.

equation

test

.....

.....[1]

Relevant standard electrode potential data of some species are given in Table 1.1.

Table 1.1

$\text{V}^{3+}(\text{aq}) + \text{e}^-$ green	✓	$\text{V}^{2+}(\text{aq})$ purple	$E^\ominus = -0.26 \text{ V}$
$\text{VO}^{2+}(\text{aq}) + 2\text{H}^+ + \text{e}^-$ blue	✓	$\text{V}^{3+}(\text{aq}) + \text{H}_2\text{O}(\text{l})$ green	$E^\ominus = +0.34 \text{ V}$
$\text{VO}_2^+(\text{aq}) + 2\text{H}^+ + \text{e}^-$ yellow	✓	$\text{VO}^{2+}(\text{aq}) + \text{H}_2\text{O}(\text{l})$ blue	$E^\ominus = +1.00 \text{ V}$
$\text{Zn}^{2+} + 2 \text{e}^-$	✓	Zn	$E^\ominus = -0.76 \text{ V}$
$\text{MnO}_4^-(\text{aq}) + 8\text{H}^+(\text{aq}) + 5\text{e}^-$	✓	$\text{Mn}^{2+}(\text{aq}) + 4\text{H}_2\text{O}(\text{l})$	$E^\ominus = +1.51 \text{ V}$

- (b) (i) When **FA 2** is acidified and reacted with zinc powder, VO_3^- ions are reduced stepwise.

Carry out the following tests. Carefully record your observations in Table 1.2.

Test and identify any gases evolved.

Table 1.2

tests		observations
1	Using a measuring cylinder, transfer 1 cm^3 of FA 2 into a boiling tube. To this same boiling tube, use a measuring cylinder to add 4 cm^3 of FA 1 and stir the mixture. This is solution W. Retain solution W for use in test 2.	
2	To solution W in the boiling tube, add a spatula of zinc powder using a metal spatula. Swirl the mixture gently and record your observations. Continue to add more zinc powder one spatula at a time with swirling, until about 4 spatulas of zinc powder is added. Record all colour changes observed throughout the initial 10 minutes.	
When no further changes are seen, decant the reaction mixture into a test-tube. This is solution X which contains one of the reduction product of the vanadium ion originally present in W. Retain solution X for use in test 3.		
3	Pour 1 cm^3 of X into a test-tube. Observe this solution for at least 5 minutes.	

[6]

- (ii) State the ion formed when **FA 1** is added to **FA 2** in test 1. Write an ionic equation for this reaction.

ion formed

ionic equation [1]

- (iii) Suggest which ion is responsible for the final colour observed in test 2. Explain your answer in terms of the E_{r} values given in Table 1.1.

ion.....

explanation.....

.....

.....

.....

.....

.....

.....

.....

.....[2]

- (iv) Suggest an explanation for your observations in test 3.

explanation.....

.....[1]

- (v) When aqueous sodium hydroxide was added dropwise till excess into a solution containing the complex ion $[\text{V}(\text{H}_2\text{O})_6]^{3+}$, a brown precipitate is observed.

State the type of reaction and write an equation to explain the observation.

.....

.....[2]

- (c) The identity of **FA 1** could be hydrochloric acid, nitric acid or sulfuric acid.
- (i) Devise a test that will positively identify hydrochloric acid, nitric acid, and sulfuric acid respectively. For each of the possible acids, you should indicate the expected observations in the table below. Your tests should be based on the Qualitative Analysis Notes on pages 19–20 and should use only the bench reagents provided.

	tests	expected observations
1		
2		
3		

[3]

- (ii) Perform your tests on **FA 1** to confirm its identity.

Any test requiring heating MUST be performed in a boiling tube.

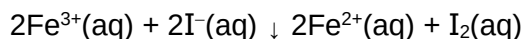
FA 1.....

[1]

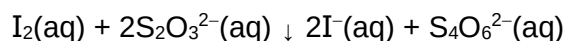
[Total: 17]

2 Investigation on how rate of reaction is affected by the concentration of iodide ions

In acidic solutions iron(III) ions are reduced by iodide ions to form iron(II) ions. The iodide ions are oxidised to iodine.



The rate of this reaction can be investigated by using starch indicator, which turns blue-black in the presence of iodine. Sodium thiosulfate is added to the reaction mixture to react with iodine as it is formed. The blue-black colour is seen when all the thiosulfate has reacted.



You will investigate how the rate of reaction is affected by changing the concentration of the iodide ions.

FA 3 is 0.0500 mol dm⁻³ potassium iodide, KI.

FA 4 is 0.0500 mol dm⁻³ acidified iron(III) chloride, FeCl₃.

FA 5 is 0.00500 mol dm⁻³ sodium thiosulfate, Na₂S₂O₃.

FA 6 is starch indicator.

Read through the whole method before starting any practical work.

(a) Method

Prepare a table on page 8 for your results. You will need to include the volume of **FA 3**, volume of water, reaction time and rate of reaction for each of five experiments.

Experiment 1

1. Fill the burette with **FA 3**. Run 20.00 cm³ of **FA 3** into the 100 cm³ beaker.
2. Using appropriate measuring cylinders, transfer to the beaker:
 - 20.0 cm³ of **FA 5**
 - 10.0 cm³ of **FA 6**.
3. Stir the contents of the beaker using a glass rod.
4. Use the 10 cm³ measuring cylinder to transfer 10.0 cm³ of **FA 4** to the beaker. Start the stopwatch during this addition.
5. Mix the contents in the beaker by **thoroughly** stirring.
6. Stop the stopwatch when the solution **first** turns blue-black. Record the time to the nearest second.
7. Carefully wash out the beaker. Stand it upside down on a paper towel to drain.

Experiment 2

8. Fill the second burette with distilled water.
9. Run 10.00 cm³ of **FA 3** into another 100 cm³ beaker.
10. Run 10.00 cm³ of distilled water into the beaker containing **FA 3**.
11. Using appropriate measuring cylinders, transfer to the beaker:
 - 20.0 cm³ of **FA 5**
 - 10.0 cm³ of **FA 6**.
12. Stir the contents of the beaker using a glass rod.
13. Use the 10 cm³ measuring cylinder to transfer 10.0 cm³ of **FA 4** to the beaker. Start the stopwatch during this addition.
14. Mix the contents in the beaker by **thoroughly** stirring.
15. Stop the stopwatch when the solution **first** turns blue-black. Record the time to the nearest second.
16. Carefully wash out the beaker. Stand it upside down on a paper towel to drain.

Experiments 3 – 5

17. Carry out three further experiments to investigate how the reaction time changes with different volumes of potassium iodide, **FA 3**.

Remember

- The combined volume of **FA 3** and distilled water must always be 20.00 cm³.
- Do **not** use a volume of **FA 3** that is less than 6.00 cm³.
- You should record all your results in a single table.

Results

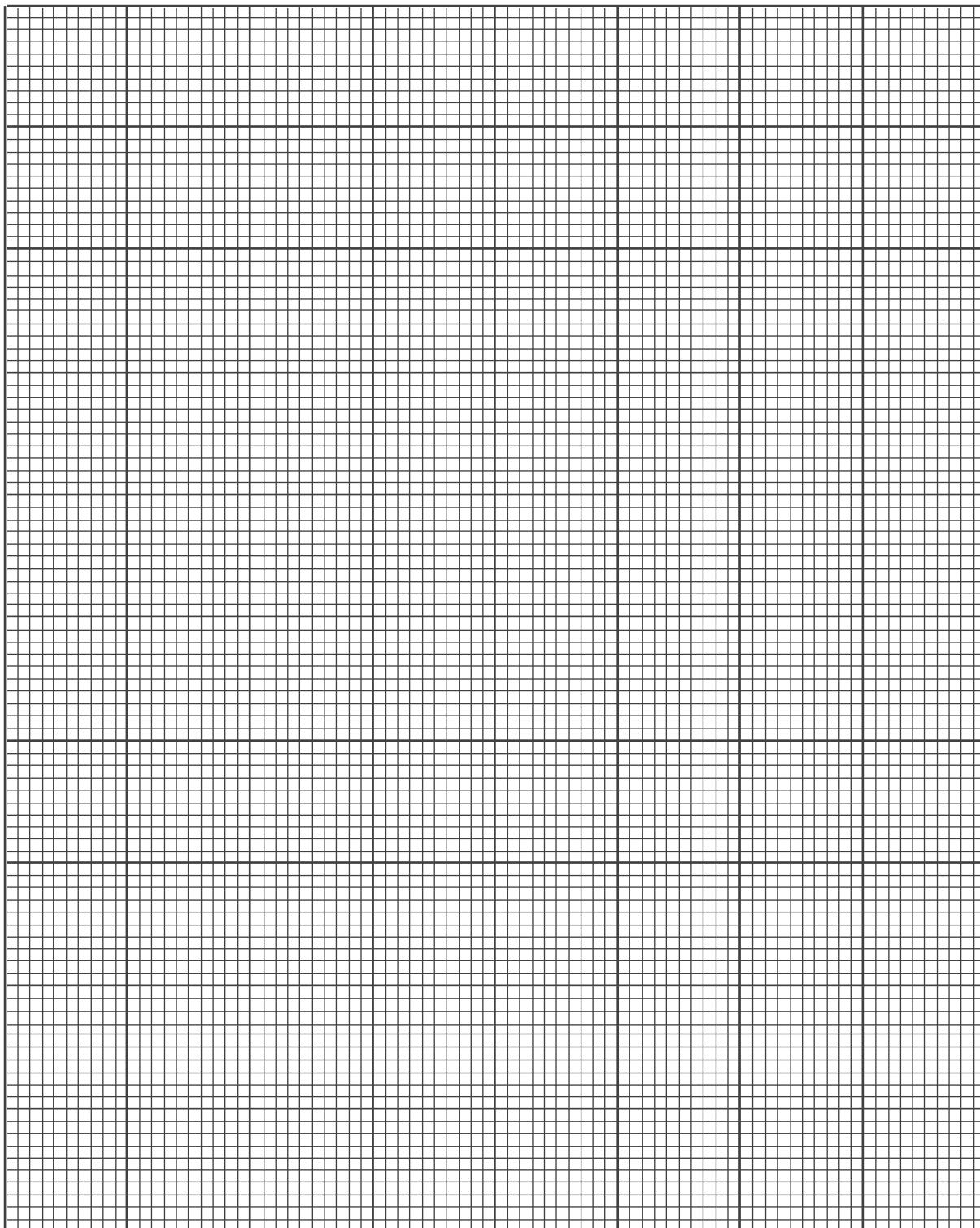
The rate of reaction can be calculated as shown:

$$\text{rate} = \frac{1000}{\text{reaction time}}$$

Candidate's ratio	
----------------------	--

[5]

- (b) Use the grid below to plot a graph of rate (y-axis) against volume of FA 3 (x-axis). Include the origin, (0,0), in your scales. Draw a line of best fit. [3]



I	
II	
III	

- (c) **Use your graph** to calculate the time to the nearest second that the reaction would have taken if 12.00 cm^3 of **FA 3** had been used. **Show on the graph** how you obtained your answer.

time = s [1]

- (d) (i) Using data from **Experiments 1** and **2**, show by calculation that the volume of aqueous potassium iodide, **FA 3**, used was directly proportional to the concentration of iodide ions.

[2]

- (ii) Explain, by referring to your graph, how the rate of reaction is affected by an increase in the concentration of aqueous potassium iodide, **FA 3**.

.....

 [2]

- (e) Thiosulfate ions can reduce iron(III) ions and also react with acid to form sulfur, sulfur dioxide and water.

Write an ionic equation for the reaction between thiosulfate ions and hydrogen ions in aqueous solution. Include state symbols.

..... [1]

- (f) Another student investigates the effect of iron(III) concentration on the rate of this reaction at a different temperature. The student carries out another experiment, **Experiment 6**, and the rate is compared to that of **Experiment 2**. In **Experiment 2**, the volumes used were:

reagent	volume / cm ³
FA 3	10.00
FA 4	10.0
FA 5	20.0
FA 6	10.0
distilled water	10.00

- (i) Suggest the volumes the student could use for **Experiment 6**.

reagent	volume / cm ³
FA 3	
FA 4	
FA 5	
FA 6	
distilled water	

[1]

- (ii) This student records a time of 178 s for **Experiment 2**

The rate of reaction is directly proportional to the concentration of iron(III) ions.

Suggest how long it would take the reaction mixture proposed for **Experiment 6** in (f)(i) to turn blue-black. Assume that **Experiment 6** is carried out at the same temperature as **Experiment 2**.

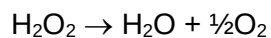
Do not carry out Experiment 6.

time = s [1]

[Total: 16]

3 Planning

Baker's yeast is a useful enzyme which can be used to catalyse the decomposition of hydrogen peroxide.



You are provided with

Apparatus:

- 1 × 100 cm³ conical flask, fitted with rubber bung and rubber tubing
- 1 × gas syringe (possible capacities of 10, 20, 50 or 100 cm³)
- stopwatch
- all other common laboratory equipment

Reagents:

- 100 cm³ of yeast suspension
- 30 cm³ of 3% (by weight) hydrogen peroxide
- distilled water

When 8.00 cm³ of the yeast suspension, 4.00 cm³ of H₂O₂ and 18.0 cm³ of distilled water are mixed in one of the experimental runs, 10 cm³ of oxygen gas was produced in 90 seconds.

Use the above information and the reagents provided to design an experiment to prove that the reaction is first order reaction with respect to yeast by a graphical method.

In your experiment, you should perform a total of five experimental runs (including the above run) to measure the volume of oxygen gas produced at regular intervals in each run.

(a) Suggest suitable volumes used for each reagent in the table below.

run	volume of yeast / cm ³	volume of H ₂ O ₂ / cm ³	volume of water / cm ³
1			
2	8.00	4.00	18.0
3			
4			
5			

[2]

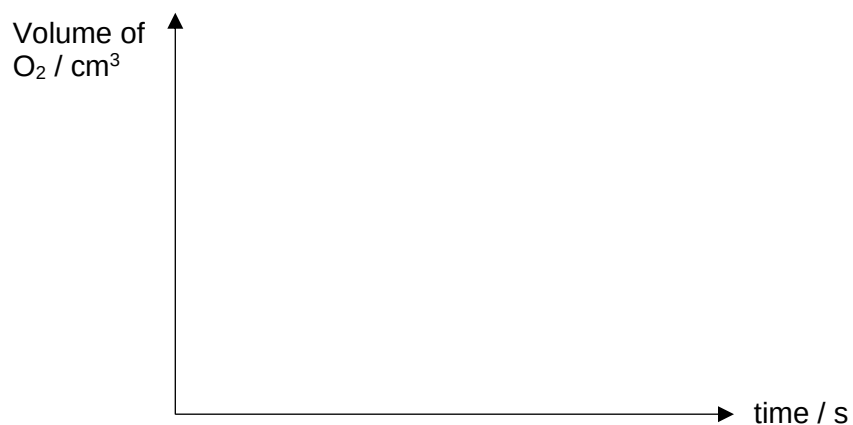
(b) In your plan, you should include brief details of:

- the calculations to determine the appropriate capacity of the gas syringe by assuming that the density of H_2O_2 is 1.00 g cm^{-3} and conditions are at r.t.p.,
- the apparatus you would use,
- the measurements you would make to determine the initial rate for each run and the order with respect to yeast.

[illegible]

[5]

- (c) (i) Sketch the graph you would expect to obtain in run 2.



[1]

- (ii) On the same graph in (c)(i), show how you would obtain the initial rate in run 2.

[1]

- (d) Hence, sketch a suitable graph to show that the reaction is first order reaction with respect to yeast.

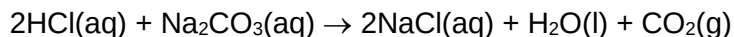


[1]

[Total: 10]

4 Determination of percentage purity of a sample of contaminated sodium carbonate

FA 7 is a solution of the contaminated sodium carbonate. You will first dilute **FA 7** and then titrate the diluted solution using hydrochloric acid.



FA 7 was prepared by dissolving 125 g of contaminated sodium carbonate, Na_2CO_3 , in distilled water and making the solution up to 1 dm^3 .

FA 8 is $0.100 \text{ mol dm}^{-3}$ hydrochloric acid, HCl .
methyl orange indicator

(a) Method

Dilution

1. Fill the burette with **FA 7**.
2. Run between 13.00 and 13.50 cm^3 of **FA 7** into the 250 cm^3 volumetric (graduated) flask.
Record the volume in the space below.

volume of **FA 7** = cm^3

3. Fill the volumetric flask to the line with distilled water. Stopper the flask and shake it to ensure thorough mixing. This flask is **FA 9**.

Titration

4. Fill the burette with **FA 8**.
5. Use the pipette to transfer 25.0 cm^3 of **FA 9** into a conical flask.
6. Add 5 – 10 drops of methyl orange indicator.
7. Titrate the mixture in the conical flask until the end-point is reached.
8. Record your titration results in the space provided on page 17.
9. Repeat steps 5 to 8 until consistent results are obtained.

Titration results

I	
II	
III	
IV	

Teacher's ratio	
Candidate's ratio	
difference	

[6]

- (b) From your accurate titration results, obtain a suitable volume of **FA 8** to be used in your calculations.
Show clearly how you obtained this value.

25.0 cm³ of **FA 9** required cm³ of **FA 8**. [1]

(c) Calculations

Show your working and appropriate significant figures in the final answer to **each** step of your calculations. [1]

- (i) Calculate the amount of hydrochloric acid present in the volume of **FA 8** calculated in (b). Hence, calculate the amount of sodium carbonate present in 25.0 cm³ of **FA 9**.

amount of HCl = mol

amount of Na₂CO₃ = mol
[1]

- (ii) Calculate the concentration, in mol dm^{-3} , of sodium carbonate in **FA 9**.

concentration of Na_2CO_3 in **FA 9** = mol dm^{-3} [1]

- (iii) Calculate the concentration, in mol dm^{-3} , of sodium carbonate in **FA 7**.

concentration of Na_2CO_3 in **FA 7** = mol dm^{-3} [1]

- (iv) Calculate the percentage purity by mass of sodium carbonate in the contaminated sample used to prepare solution **FA 7**.
(Ar: C, 12.0; O, 16.0; Na, 23.0)

percentage purity by mass = % [1]

[Total: 12]

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

<i>anion</i>	<i>reaction</i>
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, $\text{Cl}^-(\text{aq})$	gives white ppt. with $\text{Ag}^+(\text{aq})$ (soluble in $\text{NH}_3(\text{aq})$)
bromide, $\text{Br}^-(\text{aq})$	gives pale cream ppt. with $\text{Ag}^+(\text{aq})$ (partially soluble in $\text{NH}_3(\text{aq})$)
iodide, $\text{I}^-(\text{aq})$	gives yellow ppt. with $\text{Ag}^+(\text{aq})$ (insoluble in $\text{NH}_3(\text{aq})$)
nitrate, $\text{NO}_3^-(\text{aq})$	NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil
nitrite, $\text{NO}_2^-(\text{aq})$	NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil; NO liberated by dilute acids (colourless $\text{NO} \rightarrow$ (pale) brown NO_2 in air)
sulfate, $\text{SO}_4^{2-}(\text{aq})$	gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (insoluble in excess dilute strong acids)
sulfite, $\text{SO}_3^{2-}(\text{aq})$	SO_2 liberated with dilute acids; gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (soluble in dilute strong acids)

(c) Tests for gases

<i>gas</i>	<i>test and test result</i>
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

<i>halogen</i>	<i>colour of element</i>	<i>colour in aqueous solution</i>	<i>colour in hexane</i>
chlorine, Cl_2	greenish yellow gas	pale yellow	pale yellow
bromine, Br_2	reddish brown gas / liquid	orange	orange-red
iodine, I	black solid / purple gas	brown	purple