



ANDERSON SERANGOON JUNIOR COLLEGE

2026 JC2 PRELIMINARY EXAMINATION

NAME: _____ ()

CLASS: 26 / _____

CHEMISTRY

Paper 4 Practical

9476/04

18 August 2026

2 hours 30 minutes

You must answer on the question paper.

You will need: The materials and apparatus listed in the confidential instructions.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use a pencil for any diagrams or graphs.
- Write your name, class and register number on the blanks at the top of the page.
- Write down your student ID on the right. Using a dark pencil, **completely** shade the corresponding circles for the digit or letter in each column. Cleanly erase any mistakes.
- Do **not** use an erasable pen. Do **not** use correction fluid or tape.
- You may use an approved calculator.
- Quantitative Analysis Notes are printed on the question paper.
- Write the details of the shift and laboratory in the boxes provided.

INFORMATION

- The total mark for this paper is 50.
- The number of marks for each question or part question is shown in brackets [].

STUDENT ID											
0	0	0	0	0	0	A	N				
1	1	1	1	1	1	B	O				
2	2	2	2	2	2	C	P				
3	3	3	3	3	3	D	Q				
4	4	4	4	4	4	E	R				
5	5	5	5	5	5	F	S				
6	6	6	6	6	6	G	T				
7	7	7	7	7	7	H	U				
8	8	8	8	8	8	I	V				
9	9	9	9	9	9	J	W				
						K	X				
						L	Y				
						M	Z				

Shift	
Laboratory	

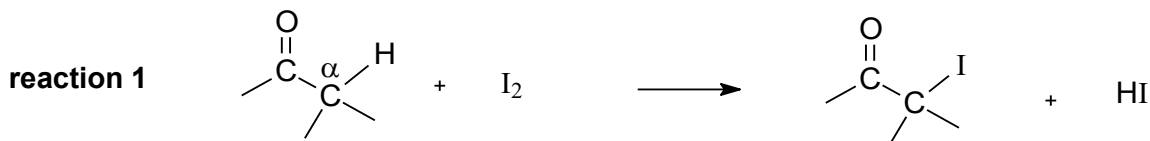
For Examiner's Use	
1	/18
2	/12
3	/10
4	/10
Total	/50

This document consists of **19** printed pages and **1** blank page.

1 (a) To determine the order of reaction with respect to iodine in an alpha halogenation reaction of a carbonyl compound

Aldehydes and ketones can be halogenated at their α positions by reaction with halogens like iodine in acidic solution.

A general equation is as shown in reaction 1.



FA 1 is 1.00 mol dm^{-3} of an unknown carbonyl compound

FA 2 is 1.00 mol dm^{-3} sulfuric acid, H_2SO_4

FA 3 is an aqueous solution of iodine, I_2

FA 4 is $0.0100 \text{ mol dm}^{-3}$ sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$

FA 5 is 0.50 mol dm^{-3} sodium hydrogencarbonate, NaHCO_3

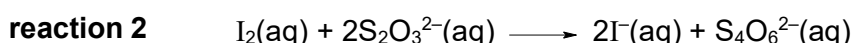
You are also provided with **Solution S**, 1% starch solution.

This reaction is first order with respect to both the carbonyl compound and H^+ ions.

You are to investigate the order of reaction with respect to I_2 .

To do this, you will prepare a reaction mixture containing the carbonyl compound, I_2 and H^+ . At timed intervals, you will remove aliquots (portions) of this reaction mixture and add an excess of NaHCO_3 to the aliquots.

The remaining amount of I_2 at different times can then be determined by titration with $\text{Na}_2\text{S}_2\text{O}_3$ using starch indicator. I_2 reacts with $\text{Na}_2\text{S}_2\text{O}_3$ as shown in the equation in reaction 2



The required order of reaction will be obtained by graphical analysis of your results.

(i) Preparation and titration of reaction mixture

Notes:

You will perform each titration **once** only. Great care must be taken that you do not overshoot the end-point.

Once you have started the stopwatch, it must continue running for the duration of the experiment. You must **not** stop it until you have collected all of your aliquots.

You should transfer your first aliquot and treat it with **FA 5** at approximately **four minutes** after the reagents were mixed. You will then remove four further aliquots, at time intervals of your choice, up to a maximum time of 25 minutes.

In an appropriate format in the space provided on **page 4**, prepare a table to record for each aliquot

- the actual time of transfer, t , in minutes and seconds,
- the decimal time, t_d , in minutes, to 0.1 min, for example if $t = 4 \text{ min } 33\text{s}$, then $t_d = 4 + 33/60 \text{ min} = 4.6 \text{ min}$,
- the burette readings and the volume of **FA 4** added.

Do not write in margin

QUESTION 1 CONTINUES ON PAGE 4

Safety notes:

- Keep the conical flask (**reaction mixture**) stoppered except when removing aliquots.
- **FA 1** is flammable. Transfer your titrated solutions into the **waste** bottle for disposal. Keep this bottle stoppered when not in use.

1. Fill a burette with **FA 4**.
2. Using a measuring cylinder, add the following to a 100 cm³ beaker.
 - 25.0 cm³ of **FA 1**
 - 25.0 cm³ of **FA 2**
3. Using another burette, transfer 50.00 cm³ of **FA 3** into the 250 cm³ conical flask, labelled **reaction mixture**.
4. Pour the contents of the 100 cm³ beaker into this 250 cm³ conical flask. Start the stopwatch, **insert the stopper** and swirl the mixture thoroughly.
5. Using a 10 cm³ pipette, transfer a 10.0 cm³ aliquot of the reaction mixture into a second 250 cm³ conical flask. Replace the stopper in the flask.
6. Using a 10 cm³ measuring cylinder, transfer about 10 cm³ of **FA 5** to the 10.0 cm³ aliquot in the second conical flask. Swirl the conical flask **thoroughly**.

Record the time of transfer, t , in minutes and seconds, to the nearest second, when **FA 5** is added to the aliquot.

7. **Immediately**, titrate the iodine in the second conical flask with **FA 4**. When the colour of the solution turns pale yellow, add about 1 cm³ of **Solution S** using a teat pipette. The solution will turn dark blue/black. Continue titration until the dark blue/black colour just disappears. Record your titration results.
8. Empty the contents of the second conical flask into the **waste** bottle. Wash this conical flask thoroughly with water.
9. Repeat steps **5** to **8** for four further aliquots, removing each at time intervals of your choice, up to a maximum time of 25 minutes. Continue until a total of five aliquots have been titrated and their results recorded.

Results

- (ii) Plot a graph of **volume of FA 4**, on the y-axis, against decimal time, t_d , on the x-axis on the grid in Fig. 1.1

Draw the most appropriate best-fit line taking into account all of your plotted points. Extrapolate (extend) this curve to $t_d = 0.0$ min.

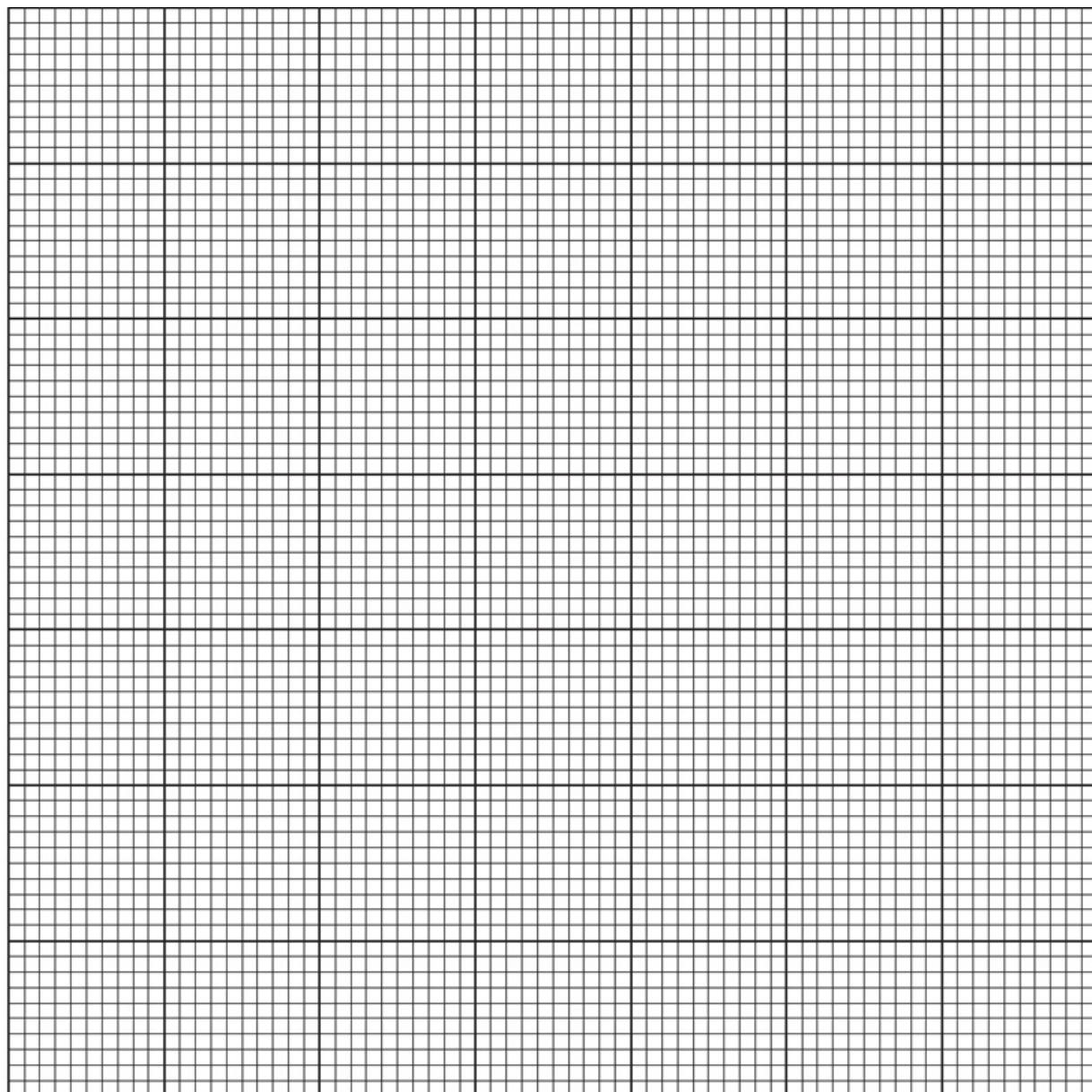


Fig. 1.1

[3]

- (iii) Deduce the order of reaction with respect to I_2 for reaction 1. Explain your answer.

Order:

Explanation:

.....[1]

- (iv) Calculate the gradient of the line, showing clearly how you did this.

gradient =[1]

- (v) The y-intercept of your line gives the volume of sodium thiosulfate required to completely react with the iodine present if an aliquot is taken at $t_d = 0.0$ min.

Read and record this volume of **FA 4**, $V_{\max}$. Use this value to calculate the concentration of iodine in **FA 3**.

$V_{\max} = \dots\dots\dots \text{cm}^3$

concentration of iodine in **FA 3** = mol dm^{-3} [4]

- (vi) Use your answer to **1(a)(iv)** together with your value for $V_{\max}$ to estimate the time, $t_{\max}$, at which all the iodine in your reaction mixture would have reacted completely.

$t_{\max} = \dots\dots\dots \text{min}$ [1]

- (vii) Explain why it is necessary to add **FA 5** in step 6, and how the titre values will be affected if this step is omitted.

.....

 [2]

(b) Organic Analysis

In this question you will deduce the identity of **FA 1**, which contains two to three carbon atoms.

- (i) Carry out the tests described in Table 1.1. Carefully record your observations in Table 1.1.

Table 1.1

tests		observations
1	To a 1 cm depth of aqueous sodium hydroxide in a test-tube, add 1 cm depth of FA 3 . Then add five drops of FA 1 .	
2	Add 2 cm depth of aqueous silver nitrate to a test-tube. Then slowly add 1 cm depth of aqueous sodium hydroxide. Add aqueous ammonia slowly, with shaking, until the precipitate just dissolves. You may use a clean glass rod to stir the mixture and dissolve the precipitate. Add 2 cm depth of FA 1 to this mixture, shake the test-tube and place it in the test-tube rack to stand.	

[1]

- (ii) From the observations in **1(b)(i)**, deduce the identity of **FA 1**. Explain your answer.

.....

 [2]

[Total: 18]

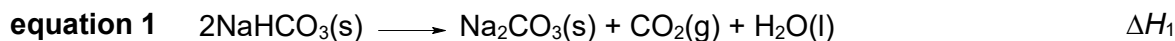
Do not write in margin

2 Determination of the molar enthalpy change of a reaction by an indirect method

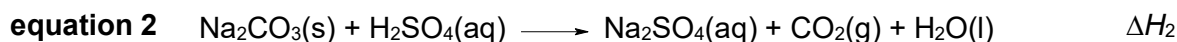
FA 2 is 1.00 mol dm⁻³ sulfuric acid, H₂SO₄

FA 6 is solid sodium carbonate, Na₂CO₃

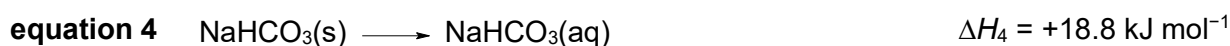
Sodium hydrogencarbonate decomposes according to equation 1.



Solid sodium carbonate and aqueous sodium hydrogencarbonate each react with sulfuric acid.



Sodium hydrogencarbonate dissolves in water according to equation 4.



(a) Determination of the molar enthalpy change of reaction, ΔH_2

You are to perform an experiment to measure the maximum temperature change (ΔT_{max}) when H₂SO₄(aq) is mixed with Na₂CO₃(s). You will use this value to calculate the heat change, q , for the experiment and hence determine a value for the molar enthalpy change of reaction, ΔH_2 .

In Table 2.1 provided on page 9, record for your experiment:

- all weighings to an appropriate level of precision,
- all values of temperature to an appropriate level of precision.

PROCEDURE

1. Weigh the capped bottle containing **FA 6**. Record this mass.
2. Place one polystyrene cup in a glass beaker.
3. Use a measuring cylinder to transfer 25 cm³ of **FA 2** into the polystyrene cup.
4. Stir the **FA 2** in the polystyrene cup with the thermometer. Read and record its initial temperature, T_i .
5. Slip the thermometer through the lid. Carefully transfer, **in small portions**, all the solid **FA 6** in the bottle to the **FA 2** in the polystyrene cup to avoid too much frothing. Secure the lid onto the cup.
6. Use the thermometer to stir the mixture. Observe the temperature until it shows the maximum change from the initial temperature. Record this temperature, T_m .
7. Reweigh the empty capped bottle. Record this mass.
8. Determine the maximum temperature change, ΔT_{max} , and the mass of **FA 6** used.

Results

Table 2.1

mass of weighing bottle and FA 6 / g	
mass of weighing bottle and residual FA 6 / g	
mass of FA 6 used / g	
$T_i / ^\circ\text{C}$	
$T_m / ^\circ\text{C}$	
$\Delta T_{max} / ^\circ\text{C}$	

[3]

- (b) In the following calculations, you should assume that the specific heat capacity of the solution is $4.18 \text{ J g}^{-1} \text{ K}^{-1}$, and the density of the solution is 1.00 g cm^{-3} .

- (i) Use your results from **2(a)** to calculate the heat change for your experiment.

heat change =[1]

- (ii) Hence, determine a value for ΔH_2 . The sulfuric acid is in excess.

Include the sign of ΔH_2 in your answer.

[A_r : H, 1.0; C, 12.0; O, 16.0; Na, 23.0]

$\Delta H_2 = \dots\dots\dots$ [1]

Do not write in margin

- (c) The results of an experiment where a solution of 1.0 mol dm^{-3} aqueous sodium hydrogencarbonate, $\text{NaHCO}_3(\text{aq})$ was reacted completely with an excess of 2.00 mol dm^{-3} dilute sulfuric acid, H_2SO_4 , are shown in Table 2.2.

Table 2.2

volume of $\text{NaHCO}_3(\text{aq})$ used / cm^3	40.0
volume of H_2SO_4 used / cm^3	15.0
initial temperature of $\text{NaHCO}_3(\text{aq})$ / $^\circ\text{C}$	29.0
initial temperature of H_2SO_4 / $^\circ\text{C}$	30.6
minimum temperature / $^\circ\text{C}$	28.6

- (i) Use the results given in Table 2.2 and the formula below to calculate the weighted average initial temperature, T_{av} , of the reaction mixture.

The formula for T_{av} is given as

$$T_{\text{av}} = \frac{(\text{vol. of } \text{H}_2\text{SO}_4 \times \text{initial T of } \text{H}_2\text{SO}_4) + (\text{vol. of } \text{NaHCO}_3 \times \text{initial T of } \text{NaHCO}_3)}{\text{total volume of reaction mixture}}$$

$$T_{\text{av}} = \dots\dots\dots [1]$$

- (ii) Hence, calculate a value for ΔH_3 .

$$\Delta H_3 = \dots\dots\dots [4]$$

- (d) Use the information given in the question and your answers from **2(b)(ii)** and **2(c)(ii)**, draw an energy cycle and use it to calculate a value for ΔH_1 for the reaction shown in equation 1.

If you are not able to determine a value for **2(b)(ii)** and/or **2(c)(ii)**, you may use x and y to represent the respective enthalpy changes and proceed with this part of the question.

Do not write in margin

$\Delta H_1 = \dots\dots\dots$ [2]

[Total: 12]

3 Identification of two cations and one anion

FA 7 contains two cations and an anion.

- (a) Carry out the following tests and identify the two cations present in **FA 7**. Carefully record your observations in Table 3.1.

The volumes given below are approximate and should be estimated rather than measured.

Test and identify any gases evolved.

If there is no observable change, write **no observable change**.

Table 3.1

tests		observations
1	Test the pH of FA 7 by placing one drop of the solution on the Universal Indicator paper.	
2	Add 1 cm depth of FA 7 solution into a clean test-tube. Add aqueous sodium hydroxide slowly, with shaking, until the aqueous sodium hydroxide is in excess.	
3	Filter the mixture into a clean boiling tube.	
4	Transfer 1 cm depth of the filtrate to a clean test-tube. Add dilute sulfuric acid drop-wise to the filtrate, until no further change is seen.	
5	To the remaining filtrate in the boiling tube, warm the boiling tube.	

[3]

Do not write in margin

- (b) (i) Identify the two cations present in **FA 7**. Quote experimental evidence to support your conclusions.

cations	evidence

[2]

- (ii) With the aid of **two** equations, explain the pH of the **FA 7** solution observed in Test 1 of Table 3.1.

.....

.....

.....

.....[2]

- (c) **FA 7** contains one of the following anions:

chloride, bromide, iodide and sulfate

With reference to the Qualitative Analysis Notes on page 19, use Table 3.2 to plan and carry out **two different tests**, using only the bench reagents provided, which will allow you to identify the anion in **FA 7** solution.

If no change is observed, you must clearly state the negative of the expected observation.

Table 3.2

tests		observations
1		
2		

identity of the anion :

[3]

[Total: 10]

4 Planning

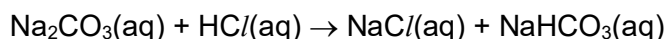
You are to plan an experiment to determine the actual mass percentage of sodium carbonate, Na_2CO_3 , and sodium hydrogencarbonate, NaHCO_3 , in a solid sample. You will first make up a solution from 5.0 g of the solid sample and then titrate this solution using hydrochloric acid.

Reactions

Hydrochloric acid reacts with sodium carbonate and sodium hydrogencarbonate in the mixture in two stages as follows.

Stage 1

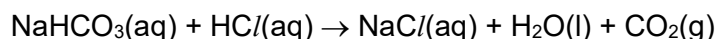
During titration, all Na_2CO_3 reacts with HCl to form NaHCO_3 in stage 1.



The equivalence point of this stage occurs at approximately pH 8.3.

Stage 2

HCl is added until all NaHCO_3 , both that formed in Stage 1 and that originally present in the mixture, has been completely reacted.



The equivalence point of this stage occurs at approximately pH 4.

The two stages have different equivalence points, so a different indicator is required for each stage. The colour changes of two available indicators are given below.

indicator	colour in acid	colour in alkali
phenolphthalein	colourless	pink
methyl orange	red	yellow

A suitable indicator is added to the mixture in the conical flask and the titration is performed until the end point of Stage 1 is reached. A second suitable indicator is then added to the same solution and the titration is continued until the end point of Stage 2 is reached. Titration results for second end point is used to determine reliability.

You may assume that you are provided with:

- **FA 8** is a solid mixture of anhydrous Na_2CO_3 , and NaHCO_3
- **FA 9** is $0.200 \text{ mol dm}^{-3}$ hydrochloric acid, HCl
- phenolphthalein indicator
- methyl orange indicator
- the apparatus and chemicals normally found in a school or college laboratory

(a) Your plan should include:

- an outline of how you would prepare a 250 cm^3 standard sample solution, **FA 10**, from the solid sample **FA 8**,
- the apparatus and quantities of chemicals you would use,
- an outline of how you would carry out the titrations, including the colour change at the respective end-points of the titrations,
- a table showing how the titration results could be recorded.

-[9]
- (b) Assuming the volume of **FA 9** used to complete stage 1 is $V_1 \text{ cm}^3$ and that to complete stages 1 and 2 is $V_2 \text{ cm}^3$, determine the following:

Volume of **FA 9** that reacted with Na_2CO_3 in **FA 10** = cm^3

Volume of **FA 9** that reacted with NaHCO_3 in **FA 10** = cm^3
[1]

[Total: 10]

Do not write in margin

Qualitative Analysis Notes

[ppt. = precipitate]

(a) Reactions of 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

Do not write in margin

(b) Reactions of anions

anion	reaction
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

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

Do not write in margin

(e) Tests for organic compounds

organic compounds	reactions
alkene	decolourises orange Br ₂ (aq)
chloroalkane	heat with NaOH(aq), white ppt. formed on adding dilute HNO ₃ , followed by Ag ⁺ (aq)
bromoalkane	heat with NaOH(aq), pale cream ppt. formed on adding dilute HNO ₃ , followed by Ag ⁺ (aq)
iodoalkane	heat with NaOH(aq), yellow ppt. formed on adding dilute HNO ₃ , followed by Ag ⁺ (aq)
alcohol	- forms white fumes with solid PCl₅ - decolourises purple acidified KMnO₄(aq) on heating (for primary and secondary alcohols) - gives pale yellow ppt. with alkaline I₂(aq) on warming (for alcohols with CH₃CH(OH)– group)
phenol	decolourises orange Br ₂ (aq) and forms a white ppt
carbonyl compounds (aldehydes and ketones)	- gives orange ppt. with 2,4-dinitrophenylhydrazine - gives pale yellow ppt. with alkaline I₂(aq) on warming (for carbonyl compounds with CH₃CO– group) - gives red-brown ppt. with Fehling's solution on warming (for aliphatic aldehydes) - gives silver mirror with Tollens' reagent on warming (for aldehydes)
carboxylic acid	- CO₂ liberated with Na₂CO₃(aq) - gives white fumes with solid PCl₅
phenylamine	decolourises orange Br ₂ (aq) and form a white ppt
primary amide	NH ₃ liberated on heating with NaOH(aq)