UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Subsidiary Level and Advanced Level

CANDIDATE NAME	

CENTRE NUMBER		CANDIDATE NUMBER	

CHEMISTRY **9701/31**

Paper 31 Advanced Practical Skills **October/November 2008**

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Give details of the practical session and laboratory where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.
You are advised to show all working in calculations.
Use of a Data Booklet is unnecessary.

Qualitative Analysis Notes are printed on pages 11 and 12.

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.

Session
Laboratory

For Examiner's Use	
1	
2	
3	
Total	

This document consists of **11** printed pages and **1** blank page.

UNIVERSITY *of* CAMBRIDGE International Examinations

[Turn over

1 **FA 1** contains the monoprotic (monobasic) acid RCO_2H. You are to determine the relative molecular mass, M_r, of the acid and deduce its molecular formula.

For Examiner's Use

You are provided with the following.

FA 1, the aqueous acid, containing 38.68 g dm^{-3} RCO_2H
FA 2, aqueous sodium hydroxide containing 3.40 g dm^{-3} NaOH
Phenolphthalein indicator.

(a) Dilution of FA 1

By using a burette measure between 38.00 cm^3 and 39.00 cm^3 of **FA 1** into the 250 cm^3 graduated (volumetric) flask labelled **FA 3**.
Record your burette readings and the volume of **FA 1** added to the flask in the space below.

Make up the contents of the flask to the 250 cm^3 mark with distilled water. Place the stopper in the flask and mix the contents thoroughly by slowly inverting the flask a number of times.

Titration

Fill a second burette with **FA 3**, the diluted solution containing RCO_2H.

Pipette 25.0 cm^3 of **FA 2** into the conical flask and add 2–3 drops of phenolphthalein indicator.

Titrate the sodium hydroxide in the flask with **FA 3** until the solution just turns colourless.

Perform a rough (trial) titration and sufficient further titrations to obtain accurate results.

Record your titration results in the space below. Make certain that your recorded results show the precision of your working.

i	
ii	
iii	
iv	
v	
vi	

[6]

(b) From your titration results obtain a volume of **FA 3** to be used in your calculations. Show clearly how you obtained this volume.

For Examiner's Use

[1]

Calculations

Show your working and appropriate significant figures in all of your calculations.

(c) Calculate how many moles of NaOH have been pipetted into the conical flask.
[A_r: H, 1.0; O, 16.0; Na, 23.0]

…………………. mol of NaOH were pipetted into the conical flask.

Use your titre volume in **(b)** and the answer above to calculate how many moles of RCO_2H are contained in 250 cm^3 of the diluted acid **FA 3**.

250 cm^3 of **FA 3** contains …………………. mol of RCO_2H.

Use this answer to calculate the concentration, in mol dm^{-3}, of the undiluted acid in **FA 1**.

The concentration of RCO_2H in **FA 1** is …………………. mol dm^{-3}.

Use this answer to calculate, correct to **3 significant figures**, the relative molecular mass, M_r, of RCO_2H.

i	
ii	
iii	
iv	
v	

The relative molecular mass, M_r, of RCO_2H is …………………… .

Use this answer to deduce the formula of the acid RCO_2H.

The formula of RCO_2H is …………………… .

[5]

[Total: 12]

For Examiner's Use

2 You are required to find the percentage by mass of water of crystallisation in **FA 4**, hydrated magnesium sulphate, $MgSO_4.\mathbf{x}H_2O$.

The water contained in the crystals can be removed by heating the crystals.

Method

(a) Follow the instructions below to determine the mass of water driven off when heating magnesium sulphate crystals.

- Weigh the empty hard glass boiling-tube.
- Tip the contents of the tube labelled **FA 4** into the boiling-tube.
- Reweigh the boiling-tube and **FA 4.**
- Hold the boiling-tube in the holder provided and heat gently at first, then strongly for several minutes.
- Leave the boiling-tube to cool on a heat-proof mat.
- **Carry on with other parts of the paper, e.g. question 3, while the boiling-tube cools.**
- When cool weigh the boiling-tube and its contents.
- Continue the heating, cooling and weighing until you are satisfied that all of the water of crystallisation has been driven from the crystals.

In an appropriate form record below

- all measurements of mass,
- the final mass of the residue and the mass of water driven off.

Results

i	
ii	
iii	
iv	
v	
vi	
vii	

[7]

Calculations

For Examiner's Use

(b) Calculate the percentage by mass of water of crystallisation in the crystals.

Hydrated magnesium sulphate crystals contain .... % of water by mass. [1]

(c) Use the relative molecular mass information provided to complete the table below.
[M_r: $MgSO_4$, 120.4; H_2O, 18.0]

possible value of **x** in $MgSO_4.\mathbf{x}H_2O$	% water by mass
1	13.0
2	23.0
3	
4	37.4
5	42.8
6	47.3
7	51.1
8	54.5
9	
10	59.9

Use your answer in **(b)** and the information in the table to find the experimental value of **x** in the formula $MgSO_4.\mathbf{x}H_2O$.

.... is the value of **x** in $MgSO_4.\mathbf{x}H_2O$. [2]

(d) A student is instructed to repeat the whole experiment to ensure **reliability** of results. Explain how repeating the experiment would lead to greater **reliability** in the experimental results.

....

....

....[1]

(e) On a balance weighing to 1 decimal place assume the maximum error is ±0.1 g. What mass would have to be weighed out on this balance to result in an error of 0.04%?

For Examiner's Use

The mass is .... g.
[1]

[Total: 12]

3 **FA 5** is a solid metal oxide. **FA 6** and **FA 7** are aqueous solutions.

You will carry out specified tests to deduce

- the chemical properties of **FA 5** and **FA 7**,
- the identities of the anion and cation present in **FA 6**.

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 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.

Marks are **not** given for chemical equations.

No additional tests for ions present should be attempted.

(a) Pour 1 cm depth of **FA 7** into a boiling-tube, stand the tube in a test-tube rack and, using a spatula, add a **very small** amount of the solid **FA 5**.
A vigorous reaction will be observed.

The gas evolved is one of carbon dioxide, hydrogen or oxygen.

By considering the density of each gas compared to that of air, you are to decide which of these three gases you should test for first. Explain your answer.
[A_r: C, 12.0; H, 1.0; O, 16.0]
[1 mol of any gas occupies approximately 24 dm^3 at room temperature and pressure.]
[24 dm^3 of air at room temperature and pressure has a mass of approximately 25.6 g.]

....

....

....

Add a further 1 cm depth of **FA 7** to the boiling-tube. Test and identify the gas given off. Record in a suitable form the test or tests performed and the observation made for any test carried out.

For Examiner's Use

i	
ii	
iii	
iv	

Deduce the identity of the gas evolved.

The gas evolved is ....

[4]

(b) Place 1 cm depth of 10% potassium iodide solution, KI, in a test-tube and add a **very small** amount of **FA 5**. Observe, then add a few drops of starch solution.

Record the tests used and all of your observations in an appropriate form below.

[2]

For Examiner's Use

(c) Conclusions about the chemical properties of FA 5

In test **(a)** **FA 5** remained unchanged at the end of the reaction.

FA 5 was acting as ………………………………… in this reaction.

In test **(b)** **FA 5** was acting as ………………………………… .

Where in the Periodic Table might you find the metallic element contained in **FA 5**?

....

[2]

(d) To 1 cm depth of **FA 6** in a boiling-tube add an equal volume of **FA 7**. Mix thoroughly by gently shaking the tube.
Using aqueous sodium hydroxide and aqueous ammonia you are to identify the cation present in **FA 6**, and the cation present in the mixture of **FA 6** and **FA 7**.

Record all of your observations in the table below.

	observations	
test	**FA 6**	mixture of **FA 6** and **FA 7**
To 1 cm depth of solution in a test-tube add, drop by drop, 1 cm depth of aqueous sodium hydroxide. Stir the mixture, then add a further 1 cm depth of aqueous sodium hydroxide.		
To 1 cm depth of solution in a test-tube add, drop by drop, 1 cm depth of aqueous ammonia. Stir the mixture, then add a further 1 cm depth of aqueous ammonia.		

Conclusions

The cation present in **FA 6** is …………………………......... .

The cation present in the mixture of **FA 6** and **FA 7** is …………………………......... .

When **FA 6** and **FA 7** reacted together, **FA 7** was acting as …………………………......... .

[5]

i	
ii	
iii	
iv	
v	

For Examiner's Use

(e) Solution **FA 6** was prepared using a bottle of solid whose label was partly missing. The solid is believed to contain the sulphate ion, SO_4^{2-}, but may contain the sulphite ion, SO_3^{2-}.

By selecting appropriate reagents from those listed on page 12 of the qualitative analysis notes show that sulphate ions, SO_4^{2-}, are present.

Record your tests, observations and conclusions in an appropriate form below.

[3]

[Total: 16]

BLANK PAGE

Qualitative Analysis Notes

Key: [ppt. = precipitate]

1 Reactions of aqueous cations

ion	*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. insoluble in excess	green ppt. insoluble in excess
iron(III), $Fe^{3+}(aq)$	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
lead(II), $Pb^{2+}(aq)$	white ppt. soluble in excess	white 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. insoluble in excess	off-white ppt. insoluble in excess
zinc, $Zn^{2+}(aq)$	white ppt. soluble in excess	white ppt. soluble in excess

[Lead(II) ions can be distinguished from aluminium ions by the insolubility of lead(II) chloride.]

2 Reactions of anions

ion	*reaction*
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chromate(VI), CrO_4^{2-} (aq)	yellow solution turns orange with H^+(aq); gives yellow ppt. with Ba^{2+}(aq); gives bright yellow ppt. with Pb^{2+}(aq)
chloride, Cl^-(aq)	gives white ppt. with Ag^+(aq) (soluble in NH_3(aq)); gives white ppt. with Pb^{2+}(aq)
bromide, Br^-(aq)	gives pale cream ppt. with Ag^+(aq) (partially soluble in NH_3(aq)); gives white ppt. with Pb^{2+}(aq)
iodide, I^- (aq)	gives yellow ppt. with Ag^+(aq) (insoluble in NH_3(aq)); gives yellow ppt. with Pb^{2+}(aq)
nitrate, NO_3^- (aq)	NH_3 liberated on heating with OH^-(aq) and A*l* foil
nitrite, NO_2^- (aq)	NH_3 liberated on heating with OH^-(aq) and A*l* foil; NO liberated by dilute acids (colourless NO → (pale) brown NO_2 in air)
sulphate, SO_4^{2-} (aq)	gives white ppt. with Ba^{2+}(aq) or with Pb^{2+}(aq) (insoluble in excess dilute strong acids)
sulphite, SO_3^{2-} (aq)	SO_2 liberated with dilute acids; gives white ppt. with Ba^{2+}(aq) (soluble in excess dilute strong acids)

3 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
sulphur dioxide, SO_2	turns aqueous potassium dichromate(VI) (aq) from orange to green