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

CANDIDATE NAME

CENTRE NUMBER | | | | | |

CANDIDATE NUMBER | | | | |

4456048604

CHEMISTRY **9701/31**

Advanced Practical Skills **May/June 2011**

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Instructions to Supervisors

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 may lose marks if you do not show your working or if you do not use appropriate units.
Use of a Data Booklet is unnecessary.

Qualitative Analysis Notes are printed on pages 10 and 11.

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.

DC (SM) 33746/4

UNIVERSITY *of* CAMBRIDGE
International Examinations

[Turn over

1 **FA 1** is sulfuric acid, H_2SO_4, of approximate concentration 0.7 mol dm^{-3}.
FA 2 is 0.150 mol dm^{-3} sodium hydroxide.
You are also provided with phenolphthalein (indicator).

You will determine the exact concentration of **FA 1** by titration.

$$H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

(a) Method

Dilution

- Pipette 25.0 cm^3 of **FA 1** into the 250 cm^3 graduated (volumetric) flask labelled **FA 3**.
- Make the solution up to the mark using distilled water.
- Shake the flask to mix the solution of **FA 3**.

Titration

- Rinse out the pipette with distilled water and then with **FA 3**.
- Pipette 25.0 cm^3 of **FA 3** into a conical flask.
- Add 5 drops of phenolphthalein indicator to the flask. The indicator should remain colourless.
- Fill the burette with **FA 2**.
- Titrate **FA 3** with **FA 2**, until a permanent pale pink colour is obtained.

You should perform a **rough titration**.
In the space below record your burette readings for this rough titration.

The rough titre is .... cm^3.

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Record in a suitable form below all of your burette readings and the volume of **FA 2** added in each accurate titration.
- Make sure that your recorded results show the precision of your practical work.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

(b) From your accurate titration results, obtain a suitable value to be used in your calculations.
Show clearly how you have obtained this value.

25.0 cm^3 of **FA 3** required .... cm^3 of **FA 2**. [1]

(c) Calculations

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

(i) Calculate how many moles of NaOH were present in the volume of **FA 2** calculated in **(b)**.

.... mol of NaOH

(ii) Calculate how many moles of H_2SO_4 were present in 25.0 cm^3 of **FA 3**.

$$H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

I	
II	
III	
IV	

.... mol of H_2SO_4

(iii) Calculate how many moles of H_2SO_4 were present in 25.0 cm^3 of the undiluted solution **FA 1**.

.... mol of H_2SO_4

(iv) Calculate the concentration, in mol dm^{-3}, of H_2SO_4 in **FA 1**.

The concentration of H_2SO_4 in **FA 1** was .... mol dm^{-3}. [4]

[Total: 12]

2 You will determine, using Hess' Law, the enthalpy change, ΔH_1, for the reaction of mag with oxygen to form magnesium oxide.

$$Mg(s) + \tfrac{1}{2}O_2(g) \rightarrow MgO(s)$$

(a) Reaction of magnesium with sulfuric acid

Method

FA 4 is 0.64 mol dm^{-3} sulfuric acid.
FA 5 is magnesium turnings. This is supplied in two containers.

You will carry out the experiment **twice**.

- Support the plastic cup in a 250 cm^3 beaker.
- Using a measuring cylinder, transfer 25 cm^3 of **FA 4** into the plastic cup.
- Tilt the beaker so that the bulb of the thermometer is covered by the solution. Measure and record the initial temperature of the solution.
- **Carefully**, add all the **FA 5** from one of the containers into the plastic cup.
- Stir the mixture constantly with the thermometer.
- Record the highest temperature obtained.
- Empty and rinse the plastic cup and dry it with a paper towel.
- Repeat the experiment using the second portion of **FA 5**.

In the space below, record all your readings in an appropriate form.
Calculate the mean temperature rise.

I	
II	
III	
IV	
V	

mean temperature rise = ... °C [5]

Calculation

Show your working and express your answers to **three** significant figures.

(i) Using the mean temperature rise above, calculate the mean heat energy produced in the reaction.
(You may assume that 4.3 J are required to raise the temperature of 1.0 cm^3 of any solution by 1.0 °C.)

heat energy produced = ...
value *unit*

(ii) Calculate the enthalpy change, ΔH_2, in $kJ\,mol^{-1}$, for the following reaction.

$$Mg(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2(g)$$

You should assume that the magnesium in your reaction is in excess.

ΔH_2 = ... $kJ\,mol^{-1}$ [2]
sign *value*

(b) Reaction of magnesium oxide with sulfuric acid

Method

FA 4 is $0.64\,mol\,dm^{-3}$ sulfuric acid.
FA 6 is magnesium oxide.

- Using a measuring cylinder, transfer $50\,cm^3$ of **FA 4** into a $250\,cm^3$ beaker.
- Place the beaker on a tripod and gauze, and heat gently until the temperature of the acid reaches 45 °C–60 °C.
- Support a plastic cup in a $250\,cm^3$ beaker.
- Transfer all the solution of hot **FA 4** into the plastic cup.
- Stir and record the temperature of hot **FA 4**.
- **Immediately** add all the **FA 6** to the **FA 4** in the plastic cup.
- Stir the mixture constantly with the thermometer.
- Record the highest temperature obtained.

In the space below, record all your readings in an appropriate form.

[3]

Calculation

Show your working and express your answers to **three** significant figures.

(i) Calculate the heat energy produced in the reaction.
(You may assume that 4.3 J are required to raise the temperature of 1.0 cm^3 of any solution by 1.0 °C.)

heat energy produced = ...
value *unit*

(ii) Calculate the enthalpy change, ΔH_3, in $kJ\,mol^{-1}$, for the following reaction.

$$MgO(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2O(l)$$

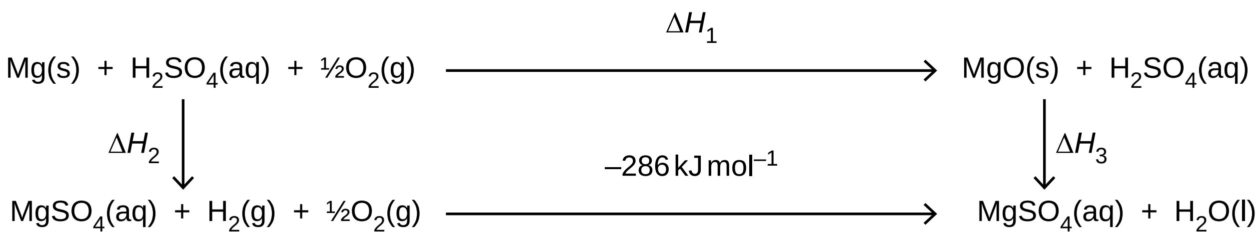
You should assume that the magnesium oxide in your reaction is in excess.

ΔH_3 = ... $kJ\,mol^{-1}$
sign *value*

(iii) The enthalpy change for the following reaction is $-286\,kJ\,mol^{-1}$.

$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(l) \qquad \Delta H = -286\,kJ\,mol^{-1}$$

Use the Hess' Law cycle given below to calculate ΔH_1, the enthalpy change for the reaction of magnesium with oxygen.



ΔH_1 = ... $kJ\,mol^{-1}$ [3]
sign *value*

(c) Suggest **one** improvement to the method by which heat losses from your apparatus could have been reduced.

....

....[1]

[Total: 14]

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

When 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 should be attempted.

If any solution is warmed, a boiling tube MUST be used.

Rinse and re-use test-tubes and boiling tubes where possible.

Where reagents are selected for use in a test, the full name or correct formula of the reagents must be given.

(a) **FA 7** contains one cation and one anion from those listed in the Qualitative Analysis Notes on pages 10 and 11.

Put two spatula measures of **FA 7** into a test-tube.
Add about two-thirds of a test-tube of distilled water and dissolve the solid.
For each test that you carry out, use 1 cm depth of the solution of **FA 7**.

(i) Carry out the following tests and complete the table below.

test	*observation(s)*
Add 5 drops of aqueous barium chloride (or barium nitrate) to your solution of **FA 7**.	
Add 5 drops of aqueous silver nitrate to your solution of **FA 7**.	

I	
II	
III	

(ii) Put a **very small** spatula measure of solid **FA 7** into a hard glass test-tube.
Hold the test-tube horizontally and heat it gently for a few seconds, then he[illegible] strongly until no further change takes place.
Leave the test-tube to cool to room temperature.
While cooling takes place, move on to ***(iv)****.*
In the space below record the observations made at each stage in an appropriate form.

(iii) State what deductions you can make about the identity of the anion in **FA 7** from the tests above.

....

....

(iv) Use the information in the Qualitative Analysis Notes on pages 10 and 11 to select a further test to confirm the identity of the anion in **FA 7**.

test ....

Carry out **this test** and, in the space below, record the observation(s) made in an appropriate form. State your conclusion.

IV	
V	
VI	
VII	
VIII	
IX	

(v) The cation in **FA 7** is aluminium ion, calcium ion or zinc ion.
Select **one reagent** to identify the cation in **FA 7**.

reagent ....

Use this reagent to carry out a test.
Record the observation(s) made and identify the cation.

....

....

....

.... [9]

(b) **FA 8** contains one cation from those listed on page 10 and 11.

Put all of the **FA 8** into a test-tube.
Half fill the test-tube with distilled water and dissolve the solid.

(i) To 1 cm depth of the solution of **FA 8** in a test-tube, add aqueous potassium iodide until the test-tube is half full. Allow the mixture to stand for two minutes.

Use a dropping pipette to transfer about 1 cm^3 of the mixture from the top of the test-tube to another test-tube. Add 5 drops of starch solution.
Record all of your observations.

I	
II	
III	
IV	
V	

(ii) State what **type** of chemical behaviour has been shown by potassium iodide in this reaction. Give an ionic equation to justify your answer.

....

....

....

(iii) To another 1 cm depth of solution of **FA 8** in a test-tube, add aqueous sodium hydroxide.
Record the observation(s) made.
Give the **ionic** equation for the reaction taking place.

....

....

....

.... [5]

[Total: 14]

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)	no ppt. 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
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. 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

[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 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 Al foil
nitrite, NO_2^- (aq)	NH_3 liberated on heating with OH^-(aq) and Al foil; NO liberated by dilute acids (colourless NO → (pale) brown NO_2 in air)
sulfate, SO_4^{2-} (aq)	gives white ppt. with Ba^{2+}(aq) or with Pb^{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 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
sulfur dioxide, SO_2	turns acidified aqueous potassium dichromate(VI) from orange to green

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