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 **May/June 2010**

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	
Total	

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[Turn over

1 Read through question 1 before starting any practical work.

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You are provided with the following reagents.

FA 1, 2.0 mol dm^{-3} sulfuric acid, H_2SO_4
FA 2, aqueous sodium hydroxide, NaOH

The reaction of sulfuric acid with sodium hydroxide is exothermic.
In separate experiments you will add increasing volumes of **FA 2** to a fixed volume of **FA 1**. In each experiment you will measure the maximum temperature rise. As the volume of **FA 2** is increased, this maximum temperature rise will increase and then decrease.

By measuring the maximum temperature rise for different mixtures of the two reagents you are to determine the following.

- the concentration of sodium hydroxide, NaOH, in **FA 2**
- the enthalpy change when 1 mol of H_2SO_4 is neutralised by NaOH

(a) Method

- Fill the burette with **FA 1**.
- Support the plastic cup in the 250 cm^3 beaker.
- Run 10.00 cm^3 of **FA 1** from the burette into the plastic cup.
- Measure 10 cm^3 of **FA 2** in a measuring cylinder.
- Place the thermometer in the **FA 2** in the measuring cylinder and record the steady temperature of the solution.
- Tip the **FA 2** in the measuring cylinder into the plastic cup, stir and record the maximum temperature obtained in the reaction.
- Empty and rinse the plastic cup. Rinse the thermometer. Shake dry the plastic cup.
- Carry out the experiment four more times. Each time use 10.00 cm^3 of **FA 1**.
  Use 20 cm^3, 30 cm^3, 40 cm^3 and 50 cm^3 of **FA 2** in these different experiments.

Carry out **two further experiments**.
Choose volumes of **FA 2** which will allow you to investigate more precisely the volume of **FA 2** that produces the highest temperature rise when added to 10.00 cm^3 of **FA 1**.

Results
Record your results in an appropriate form showing, for each experiment, the volumes of solution used, temperature measurements and the temperature rise.

i	
ii	
iii	
iv	
v	
vi	
vii	
viii	
ix	

[9]

(b) Use the grid below to plot a graph of temperature rise (*y-axis*) against the volume of **FA 2** added (*x-axis*).
Draw a line of best fit through the points where the temperature rise is increasing and another line through the points where the temperature rise is decreasing.
The intersection of these lines represents the temperature rise for the volume of **FA 2** that exactly neutralises the sulfuric acid present in 10.00 cm^3 of **FA 1**.

For Examiner's Use

i	
ii	
iii	
iv	

[4]

For Examiner's Use

(c) Read from the graph the volume of **FA 2** that gives the maximum temperature rise.

The volume of **FA 2** giving the maximum temperature rise is …………..cm^3. [1]

(d) Explain why the temperature rise is plotted on the *y-axis* rather than on the *x-axis*.

....

.... [1]

(e) Construct the balanced equation for the reaction of sulfuric acid with sodium hydroxide.

.... [1]

(f) **(i)** Calculate how many moles of sulfuric acid, H_2SO_4, are contained in 10.00 cm^3 of **FA 1**.

10.00 cm^3 of **FA 1** contain ………….. mol of H_2SO_4.

(ii) Calculate how many moles of NaOH are required to neutralise the amount of H_2SO_4 calculated in **(i)** above.

The sulfuric acid in 10.00 cm^3 of **FA 1** is neutralised by ……….. mol of NaOH. [2]

(g) Use the equation below to calculate the concentration of NaOH in **FA 2**.

$$\text{concentration of NaOH (mol dm}^{-3}\text{)} = \text{answer to } \textbf{(f)(ii)} \times \frac{1000}{\text{volume of } \textbf{FA 2} \text{ (cm}^3\text{) from } \textbf{(c)}}$$

The concentration of NaOH in **FA 2** = ……………………….mol dm^{-3}. [1]

(h) Read the maximum temperature rise from the graph and use this to calculate the enthalpy change when 1 mol H_2SO_4 is neutralised by NaOH. Give your answer in kJ mol^{-1} and include the correct sign for the reaction.
[4.3 J are absorbed or released when the temperature of 1 cm^3 of solution changes by 1 °C. Remember that separate volumes of **FA 1** and **FA 2** were mixed together.]

ΔH = ……………………… kJ mol^{-1}. [2]

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(i) A student suggested that the accuracy of the experiment would be improved if the volume of **FA 2** had been measured using a burette rather than a measuring cylinder. Suggest an advantage **and** a disadvantage of using a burette in the procedure.

advantage ....

....

disadvantage ....

....

[2]

(j) Identify **two** further significant sources of error, other than the measurement of volume, in the experiments used for measuring temperature rise.

error 1 ....

....

error 2 ....

....

[1]

(k) Complete the sections below.

(i) The maximum error in taking a temperature reading on a thermometer with

graduations at 1 °C is ……………….°C.

(ii) The temperature rise when 30 cm^3 of **FA 2** is added to 10.00 cm^3 of **FA 1**

is ……………….°C.

(iii) Calculate the maximum percentage error due to the thermometer when measuring the temperature **rise** in **(ii)** above.

The maximum percentage error = ………………. %.

[2]

[Total: 26]

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2 Solutions **FA 3**, **FA 4** and **FA 5** each contain a Group 2 halide.
Solution **FA 6** contains a potassium salt.

You will carry out tests to deduce the following.

- the anion present in **FA 6**
- the solution containing the chloride ions
- the solution containing barium ions

At each stage of any test you are to record details of the following.

- colour changes seen
- the formation of any precipitate and the colour of the precipitate

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.

If any solution is warmed directly with a Bunsen burner a boiling-tube MUST be used.
Rinse and reuse test-tubes where possible.

(a) Use information from the Qualitative Analysis Notes on page 11 to select a pair of reagents that, **used together**, identify the halide ion present.

The reagents are ……………………………..…………

followed by ……………………………..………… . [1]

(b) Use your chosen reagents to carry out tests on **FA 3**, **FA 4** and **FA 5**.
Record your results in an appropriate form in the space below.

[2]

(c) From the results of the tests in **(b)** state which solution contains the chloride ion, Cl^-.

Solution ………….. contains the chloride ion.

Explain the evidence that supports your conclusion.

....

....[1]

(d) Carry out the following tests on each of the solutions **FA 3**, **FA 4** and **FA 5**. Record your observations below.

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test	*observations*		
	FA 3	**FA 4**	**FA 5**
To 1 cm depth of solution in a test-tube, add 2 cm depth of aqueous sodium hydroxide.			
To 1 cm depth of solution in a test-tube, add 2 cm depth of aqueous ammonia.			
To 1 cm depth of solution in a test-tube, add 1 cm depth of **FA 6**.			

[3]

(e) To 1 cm depth of **FA 6** in a test-tube add 1 cm depth of dilute sulfuric acid.

observation

....

....[1]

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(f) From your observations in **(d)** and **(e)** you should be able to identify the anion in **FA 6** and which of the solutions **FA 3**, **FA 4** or **FA 5** contains barium cations.

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

Ba^{2+} ions are contained in solution ………………………. .

Explain how your observations support your conclusions for

(i) the anion present in **FA 6**, ...

....

(ii) the solution containing Ba^{2+} ions. ....

....

[1]

Read through the remainder of question 2 before starting further practical work.

Heat a half-full 250 cm^3 beaker of water for use as a hot water-bath.

(g) **FA 7**, **FA 8**, **FA 9** and **FA 10** are organic compounds. Each contains one of the following different functional groups.

- primary alcohol
- tertiary alcohol
- aldehyde
- ketone

You are to react some of these compounds with some of the following reagents.

- acidified aqueous potassium dichromate(VI)
- 2,4-dinitrophenylhydrazine (2,4-DNPH) reagent
- ammoniacal silver nitrate (Tollens' reagent)

You are provided with the first two reagents. You must prepare the last of these reagents, Tollens' reagent, immediately before use. Follow the instructions in the box below.

To 2 cm depth of aqueous silver nitrate in a boiling-tube add ½ cm depth of aqueous sodium hydroxide. This will produce a brown precipitate of silver(I) oxide. Add aqueous ammonia a little at a time, with continuous shaking, until the brown precipitate **just** dissolves. **Do not add an excess of aqueous ammonia**.

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In each of the following tests add a few drops of the reagent to 1 cm depth of **FA 7**, **FA 8**, **FA 9** and **FA 10** in separate test-tubes.

In the tests using acidified potassium dichromate(VI) and Tollens' reagent, if no initial reaction is seen, warm that tube and its contents in your hot water-bath. There is no need to heat any tube to which you have added 2,4-DNPH reagent.

Do **not** heat any tube with a naked flame.

Record your results in the table below.

Do **not** carry out tests for the shaded boxes.

reagent	*observations*			
	FA 7	**FA 8**	**FA 9**	**FA 10**
acidified potassium dichromate(VI)				
2,4-DNPH reagent				
Tollens' reagent				

[3]

(h) State which of the solutions contains a tertiary alcohol. Explain the observations leading to your conclusion.

FA …………… contains the tertiary alcohol.

explanation ....

....

State which of the solutions contains the aldehyde. Explain the observations leading to your conclusion.

FA …………… contains the aldehyde.

explanation ....

....

[2]

[Total: 14]

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.]

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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 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 $\rightarrow$ (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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