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

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

0830907008

CHEMISTRY **9701/32**

Paper 32 Advanced Practical Skills **October/November 2009**

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	
Total	

This document consists of **12** printed pages.

© UCLES 2009

UNIVERSITY of CAMBRIDGE International Examinations

[Turn over

1 This question concerns the **solubility** of **FB 1**, potassium nitrate, in water.

For Examiner's Use

The **solubility** of a substance in water is defined as:
the mass of substance that will dissolve in and just saturate 100 g of water at a particular temperature.
When a solution is saturated the dissolved solid is in equilibrium with undissolved solid.
When a solution of potassium nitrate is cooled it becomes saturated when crystals form in the solution.

You are to investigate how the **solubility** of **FB 1** in water varies with temperature.

You are provided with the following materials.
weighing bottle, labelled **FB 1**, containing potassium nitrate
distilled water

Read through the instructions before starting any practical work.

Method

- Weigh an empty boiling-tube.
- Add the contents of the weighing bottle labelled **FB 1** to the weighed boiling-tube.
- Reweigh the boiling-tube and its contents.
- Record, in an appropriate form below, your weighings and the mass of **FB 1** used.

(a) Weighings

[2]

(b) Preparing a saturated solution

- Fill the burette with distilled water.
- Add 14.00 cm^3 of distilled water from the burette to the weighed boiling-tube containing **FB 1**.
- Use the clamp as a holder for the boiling-tube. Take care not to break the tube by clamping it too tightly.
- Warm the tube carefully, while stirring the contents with a thermometer, until all the solid has dissolved. (Take care that you do not break the thermometer bulb or the tube while stirring.)
- Keeping the tube in the clamp attach the clamp to a stand.
- Let the tube cool and continue to stir gently with the thermometer.
- Watch the solution carefully. Note and record (**on the next page**) the temperature at which you **first** notice crystals forming in the solution.
- If you are uncertain about the temperature when crystals first form, warm the tube again for a few moments and repeat the cooling.
- As soon as you have recorded the temperature add a further 2.00 cm^3 of distilled water to the tube from the burette.
- Warm to redissolve the solid and cool as before.
- Note and record (**on the next page**) the temperature at which crystals now form in the solution. This will be lower than the temperature obtained with 14.00 cm^3 of water.
- Repeat the addition of 2.00 cm^3 of distilled water, the heating and the cooling, until you have four readings in total.

© UCLES 2009

[Turn over

(c) In an appropriate form in the space below, record the following.

- the total volume of distilled water in the boiling-tube
- the temperature at which crystals first appeared for each solution

Make certain that your results show the precision of your working.

For Examiner's Use

i	
ii	
iii	
iv	
v	
vi	
vii	
viii	

[8]

(d) For each solution, calculate the **solubility** (in grams of solid per 100 g of water) using the following formula.

$$\textbf{solubility} = \frac{100}{\text{volume of water}} \times \text{mass of } \textbf{FB 1} \text{ dissolved}$$

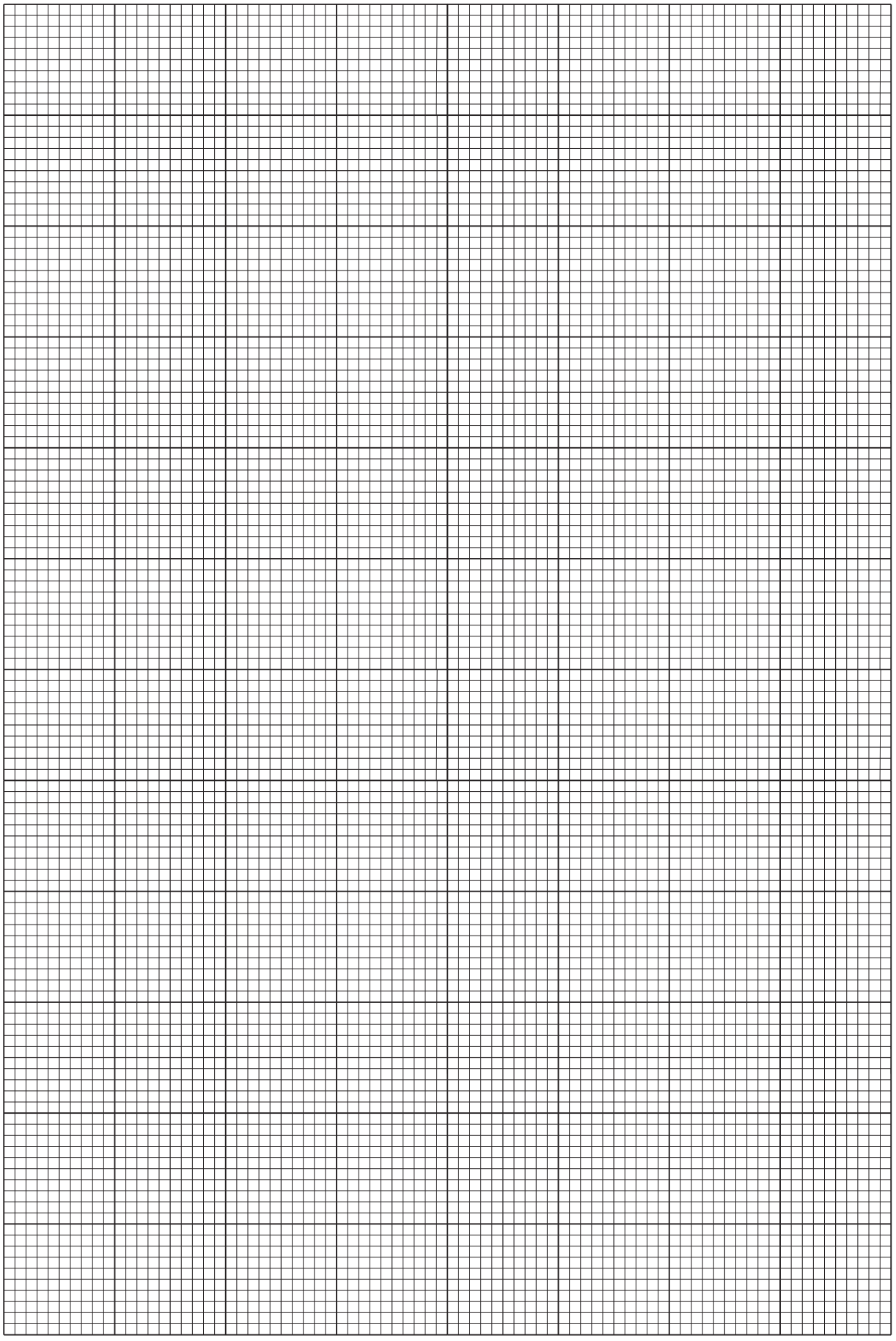
Complete the table below to show the **solubility** at different temperatures.
In all calculated values show appropriate significant figures.

solubility (in grams of solid per 100 g of water)	temperature / °C

[3]

(e) Plot **solubility** against temperature and draw an appropriate line through the points plotted. Do **not** start at zero on either axis. You will need to be able to find the solubility of **FB1** at 42.5°C.

For Examiner's Use



From the graph plotted the **solubility** of **FB 1** in water at 42.5 °C is

…….. g of solid per 100 g of water.
[6]

For Examiner's Use

(f) Describe how the **solubility** of **FB 1** changes with temperature.

.....

.....

..... [1]

(g) Use your answer to **(f)** and your understanding of equilibrium systems to explain if dissolving **FB 1**, KNO_3, under equilibrium conditions is exothermic or endothermic.

$$KNO_3(s) + aq \rightleftharpoons KNO_3(aq)$$

.....

.....

.....

..... [2]

(h) Suggest **two** possible sources of inaccuracy, other than poor experimental technique, in this experiment.

1 .....

.....

.....

2 .....

.....

.....
[2]

© UCLES 2009

(i) A solution of KNO_3, saturated at 60 °C, is prepared in a thermostatically controlled water bath.

For Examiner's Use

The **solubility** of KNO_3 at 60 °C can be calculated if the mass of the solution and the mass of solid dissolved in the solution can be determined.
Suggest steps to enable you to find these masses.
You may not need all of these numbered steps.

1 .....

2 .....

3 .....

4 .....

5 .....

6 .....

7 .....

Show how you would calculate the **solubility** of KNO_3 at 60 °C from the mass of the solution and the mass of solid dissolved in the solution.

[2]

[Total: 26]

2 You are provided with three solids, **FB 2**, **FB 3**, and **FB 4**.
Each of the solids contains one cation from those on page 11 and a sulfite or sulfate anion.

For Examiner's Use

You will carry out specified tests to identify the cations and anions present in **FB 2**, **FB 3** and **FB 4**. Use the data on pages 11 and 12.

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

(a) In separate boiling-tubes, dissolve half of each of the solids **FB 2**, **FB 3** and **FB 4** in a minimum volume of dilute hydrochloric acid.
Gently warm each of the boiling-tubes.
Add distilled water so that each boiling-tube is approximately $^2/_3$ full.
Record your observations in an appropriate form in the space below.

[2]

(b) The cations present in **FB 2**, **FB 3** and **FB 4** can be identified by reaction of each solution, with aqueous sodium hydroxide and with aqueous ammonia.
React 1 cm depth of each of the solutions prepared in **(a)** with each of these two reagents.
Record, in an appropriate form, in the space below your observations for these reactions.

i	
ii	
iii	
iv	
v	

© UCLES 2009

Conclusions

For Examiner's Use

Using your observations you should be able to identify the cation in two of the solutions. For the remaining solution you should be able to identify two possible cations.

FB 2 contains the cation(s) ……. .

FB 3 contains the cation(s) ……. .

FB 4 contains the cation(s) ……. . [5]

(c) Use the information on pages 11 and 12 to select a reagent to distinguish between the two possible cations identified as present in one of the solutions in **(b)**.

.....

Carry out the test with the selected reagent.

observation .....

conclusion .....
[1]

(d) In separate boiling-tubes shake the remaining half of each solid with 3 cm depth of distilled water.
If any solid does not readily dissolve in water filter the mixture and retain the solution formed.
You will need to keep some of the **FB 2** solution for test **(f)**.
Carry out the following tests.

test	*observations*		
	FB 2	**FB 3**	**FB 4**
To 1 cm depth of the solution in a test-tube, add 1 cm depth of aqueous barium chloride, then,			
add 2 cm depth of dilute hydrochloric acid.			

Draw appropriate conclusions as to the identity of the anion in each solution.

FB 2 contains the anion ……. .

FB 3 contains the anion ……. .

FB 4 contains the anion ……. . [3]

(e) Explain why aqueous barium chloride must be added before hydrochloric acid when distinguishing between a sulfite and a sulfate.

For Examiner's Use

.....

.....

.....

..... [1]

(f) Carry out the following test with the solution of **FB 2** prepared in **(d)**.

test	*observation*
To 1 cm depth of the solution of **FB 2** in a test-tube add 1 cm depth of aqueous potassium iodide, then	
add a few drops of starch solution.	

What is the nature of the reaction taking place between **FB 2** and potassium iodide?

.....

.....

..... [2]

[Total: 14]

© UCLES 2009

Qualitative Analysis Notes

Key: [ppt. = precipitate]

1 Reactions of aqueous cations

	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 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 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 acid)
sulfite, SO_3^{2-} (aq)	SO_2 liberated with dilute acids; gives white ppt. with Ba^{2+}(aq) (soluble in excess dilute strong acid)

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) (aq) from orange to green

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

University of Cambridge International Examinations is part of the Cambridge Assessment Group. Cambridge Assessment is the brand name of University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge.