UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME			
CENTRE NUMBER		CANDIDATE NUMBER	

7808571428

CHEMISTRY **9701/52**

Paper 5 Planning, Analysis and Evaluation **October/November 2013**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
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.
Electronic calculators may be used.
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.

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.

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1	
2	
Total	

This document consists of **9** printed pages and **3** blank pages.

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1 Ammonium nitrate, NH_4NO_3, is soluble in water (approximately 2.5 mol / 100 g at 25 °C). The molar enthalpy of solution of a solid is defined as the enthalpy change when one mole of the solid is dissolved in water.

$$NH_4NO_3(s) \rightleftharpoons NH_4^+(aq) + NO_3^-(aq) \qquad \Delta H_{soln} = +26.5\,kJ\,mol^{-1}$$

(a) **(i)** Predict how the temperature of water, initially at 25 °C, would change as ammonium nitrate is dissolved. Explain this prediction in terms of lattice energy and the enthalpy of hydration of ions.

Prediction of the temperature change ....

....

....

Explanation ....

....

....

....

(ii) In the space below, sketch a graph to show your prediction of temperature change with concentration. Use two labelled axes and include an origin.

[4]

(b) If you were to carry out an experiment to investigate how the **temperature change** of the solution varies as the **concentration changes** name,

(i) the independent variable, ...

(ii) the dependent variable. ....

[1]

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(c) You are to plan an experiment to determine as accurately as possible how the temperature change varies when different solutions are made, each with different concentrations of ammonium nitrate. You are reminded that the approximate solubility of ammonium nitrate is 2.5 mol / 100 g at 25 °C.

The following information gives some of the hazards associated with ammonium nitrate.

Ammonium nitrate NH_4NO_3. Contact with combustible material may cause fire. Explosive when mixed with combustible material. **Do not allow the salt to become contaminated with organic matter and do not grind it.** Solutions should be diluted to less than 0.5 mol dm^{-3} for disposal.

You should use only standard apparatus found in a school or college laboratory. Draw a diagram of the apparatus and experimental set up you would use showing clearly the following:

(i) the apparatus used, such as the reaction vessel, and how the thermometer will be positioned in order to measure the temperature of the solution as accurately as possible,

(ii) how the apparatus will be insulated.

Label each piece of apparatus used, indicating its size or capacity and both the temperature range and the precision of the thermometer.

[3]

(d) Using the apparatus shown in **(c)** design an experiment to test your prediction in **(a)(ii)** of how the temperature change of the solution varies with solutions of different concentration.

In addition to the apparatus normally found in a laboratory you are provided with the following materials;

a supply of solid ammonium nitrate,
distilled (deionised) water.

Give a step-by-step description of how you would carry out the experiment to include;

(i) the number of experiments you would do,

(ii) the temperature measurements you would take,

(iii) the volume of water you would use,

(iv) a calculation to show the maximum mass of ammonium nitrate you could use for your volume of water in **(iii)** and a range of masses for the other experiments.

[A_r: H, 1.0; N, 14.0; O, 16.0]

[4]

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(e) State one hazard that must be considered when planning the experiment and describe a precaution that should be taken to keep risks from this hazard to a minimum. You may use the information in **(c)** if you wish.

....

....

....

....

....

.... [1]

(f) In order to test your prediction in **(a)(ii)**, you would need to plot a graph. In the space below, draw a table with appropriate headings, in which you would record all your experimental data and calculated values necessary for the construction of the graph. The headings **must** include the appropriate units.

[2]

[Total: 15]

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2 The solubility of hydrated sodium sulfate, $Na_2SO_4.10H_2O$, in water increases with temperature. At a temperature between 25 °C and 70 °C there is a transition and the solubility becomes that of Na_2SO_4. The units of solubility are grams per one hundred grams of water, g / 100 g water.

An experiment was carried out to investigate this solubility and determine the transition temperature between the two forms of sodium sulfate.

- An empty boiling tube was weighed and the mass recorded.
- Some distilled water was added to the boiling tube and the new mass recorded.
- A small sample of hydrated sodium sulfate was added and this new mass recorded.
- The boiling tube was carefully heated with stirring until all the solid had dissolved.
- The apparatus was cooled slowly while constantly stirring and the temperature recorded when the first crystals appeared in the tube.

(a) The results of several of these experiments are recorded below.

Process the results in the table to calculate the solubility, in g / 100 g water, of the sodium sulfate for each of the temperatures listed.

Record these values to **two decimal places** in the additional columns of the table. You may use some or all of the columns.

Label the columns you use.

For each column you use include units where appropriate and an expression to show how your values are calculated.

Use the column headings **A** to **H** for these expressions (e.g. **A–B**).

A	B	C	D	E	F	G	H
experiment number	mass of boiling tube / g	mass of boiling tube + water / g	mass of boiling tube + water + solid / g	crystallising temperature °C			
1	10.20	35.20	36.45	0.0			
2	10.35	30.35	31.60	10.0			
3	10.10	35.10	40.10	20.0			
4	9.80	29.20	36.96	30.0			
5	9.95	32.95	44.06	40.0			
6	9.90	34.90	46.65	50.0			
7	9.70	30.70	40.32	60.0			
8	10.45	30.45	39.55	70.0			
9	10.05	35.05	46.30	80.0			
10	10.10	40.10	53.45	90.0			

[3]

(b) Plot a graph to show the variation of solubility (*y*-axis) with temperature (*x*-axis).
Draw **two curves** of best fit and extrapolate to locate their intersection at the transition temperature.

[4]

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(c) From your graph, state the transition temperature and the solubility at which it occurs.

[2]

(d) **(i)** In an attempt to repeat the 4th experiment using the same masses of water and solid, the temperature was mistakenly read and recorded before crystals appeared. Place a cross on your graph to represent the point that would have been obtained.

(ii) If this was a valid point, what effect would this have on your transition temperature? Explain your answer.

....

....

....
[2]

(e) It was found that all the mass recordings in columns **C** and **D** had been made with a balance that had been zeroed incorrectly and they should all have been 0.3 g smaller. The masses recorded in column **B** can be considered to be accurate. Using the corrected masses from experiment 6 calculate the new value of the solubility. By comparing this with the original solubility value for experiment 6 calculate the percentage error difference.

[2]

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(f) From the pattern of solubility demonstrated by your graph, predict and explain whether the dissolving of the two forms of sodium sulfate in water are exothermic or endothermic reactions.

prediction for $Na_2SO_4.10H_2O$ ....

....

explanation ....

....

....

....

prediction for Na_2SO_4 ....

....

explanation ....

....

....

....

[2]

[Total: 15]

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