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

CANDIDATE NAME	

CENTRE NUMBER		CANDIDATE NUMBER	

7061834157

CHEMISTRY **9701/05**

Paper 5 Planning, analysis and evaluation **May/June 2009**

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.
You are advised to show all working in calculations.
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.

For Examiner's Use	
1	
2	
Total	

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

1 You are to plan an investigation into the thermal decomposition of caesium nitrate, $CsNO_3$.

You may make use of some or all of the following data when planning your investigation.

Group I element	cation	ionic radius / nm
lithium	Li^+	0.060
sodium	Na^+	0.095
potassium	K^+	0.133
rubidium	Rb^+	0.148
caesium	Cs^+	0.176

Equations for the thermal decomposition of lithium nitrate and sodium nitrate are given below.

$$4LiNO_3(s) \longrightarrow 2Li_2O(s) + 4NO_2(g) + O_2(g)$$
$$2NaNO_3(s) \longrightarrow 2NaNO_2(s) + O_2(g)$$

nitrogen dioxide gas	oxygen gas
NO_2	O_2
brown in colour	colourless
soluble in water	almost insoluble in water
poisonous	powerful oxidant

1 mol of any gas occupies a volume of approximately 24 dm^3 at room temperature and atmospheric pressure.

A_r: Cs, 133; N, 14.0; O, 16.0

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(a) Predict which of the equations below will represent the thermal decomposition of caesium nitrate. Place a tick against the equation of your choice.

$4CsNO_3(s) \longrightarrow 2Cs_2O(s) + 4NO_2(g) + O_2(g)$	
$2CsNO_3(s) \longrightarrow 2CsNO_2(s) + O_2(g)$	

Use data provided on page 2 to explain your prediction.

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.... [2]

(b) You are to plan an experiment in which
- caesium nitrate is heated,
- gas is collected,
- the volume of gas collected is measured,
- the experimental results are used in a calculation to confirm or reject your prediction.

(i) Identify the independent variable in the experiment.

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(ii) Identify the dependent variable in the experiment.

.... [2]

(c) Draw a diagram of the apparatus you would use in this experiment.
Your apparatus should use only standard items found in a school or college laboratory.
Show clearly how the solid will be heated, the gas collected and its volume measured.
Label each piece of apparatus used, indicating its size or capacity, e.g. *250 cm^3 beaker*.

Assuming that either equation in **(a)** might be correct, which gas or gases would you expect to collect in your apparatus. Explain your answer.

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.... [3]

(d) Calculate the volume of gas you would expect to collect in your apparatus if 1 mol of caesium nitrate completely decomposed according to your predicted equation in **(a)**.

[1]

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(e) Use your answer to **(d)** and the size of the apparatus selected in **(c)** to calculate the maximum mass of $CsNO_3$ that can be used in your experiment.

[1]

(f) Outline, in a series of numbered steps, the method to be used in the experiment.
Make certain that the steps you describe are in the correct order.
You need **not** explain how the apparatus is assembled.
Indicate clearly how you will know when decomposition is complete.

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(g) What should be done when decomposition is complete to ensure that the volume of gas measured in the apparatus is the "correct" volume?

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(h) Identify a risk present in the method you have described.

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Describe how you would minimise this risk.

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[2]

[Total: 15]

2 **Solubility** is defined as the amount of a substance that will dissolve in and just saturate 100 g of solvent at a particular temperature.

$$\textbf{solubility} = \frac{\textbf{mass of solid in a saturated solution}}{\textbf{mass of water in the saturated solution}} \times 100$$

When a solution is saturated, dissolved solid is in equilibrium with undissolved solid.

To make a saturated solution add the solid to water at a particular temperature until no more dissolves. Then add more solid and leave the mixture in a thermostatically controlled water bath to establish equilibrium.

This question uses sodium iodide as the solid to be dissolved and water as the solvent.

When a solution of sodium iodide, NaI, saturated at 100 °C is cooled, crystals of NaI form and sink to the bottom of the solution.
As the solution continues to cool a temperature is reached below which crystals of $NaI.2H_2O$ are deposited.
The temperature when this change takes place is called the transition temperature. Above and below this temperature the way in which the **solubility** changes with temperature is noticeably different.

A group of students carried out an experiment to determine the transition temperature.

The instructions given for the experiment were as follows.

- Prepare a saturated solution at a temperature between 20 °C and 100 °C.
- Record the temperature of the saturated solution.
- Weigh an empty evaporating basin.
- Transfer some of the saturated solution, but no solid, into the weighed evaporating basin.
- Weigh the evaporating basin and solution.
- Evaporate the water from the solution by placing the evaporating basin on top of a beaker of boiling water.
- When all of the water in the solution has evaporated, cool and reweigh the evaporating basin.
- Repeat the heating, cooling and weighing until a constant mass is obtained.

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The results of the experiment are recorded below.

A	B	C	D	E	F	G	H
temperature at which the saturated solution was prepared / °C	mass of evaporating basin / g	mass of basin + solution / g	final constant mass of basin + solid / g				
20	23.7	145.1	101.6				
30	31.8	182.0	130.2				
40	33.4	172.5	126.9				
45	25.9	214.3	154.3				
50	31.9	229.1	166.7				
55	27.6	217.0	160.8				
60	33.3	242.9	184.2				
65	31.6	298.7	228.6				
70	28.5	225.7	175.4				
75	29.1	203.6	159.2				
80	30.0	220.4	172.2				
85	27.8	242.4	188.2				
90	36.6	226.0	178.4				
95	31.4	247.0	193.1				
100	32.9	225.9	177.9				

(a) Process the results in the table to produce values that will enable you to plot a graph to show the **solubility** of sodium iodide in water at different temperatures.

Record these values 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 the units and an expression to show how your values are calculated.
You may use the column headings **A** to **H** in the expressions e.g. **C** – **B**. [3]

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(b) Present the values calculated in **(a)** in graphical form.
Draw **two** separate lines and extrapolate them to a point of intersection. The line at higher temperatures represents the **solubility** of NaI. The line at lower temperatures represents the **solubility** of $NaI.2H_2O$.
Do **not** start either scale at zero.

[4]

(c) Read from the graph the temperature where the two lines intersect. This is the transition temperature.

The transition temperature is ……………… °C. [1]

(d) Circle, on the graph, any point(s) you consider to be anomalous.

For any point circled on the graph suggest an error in the conduct of the experiment that might have led to the anomalous result.

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(e) Suggest additional measurements that could be made to enable a more precise value of the transition temperature to be determined.

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(f) Describe the difference in the variation of **solubility** with temperature

above the transition temperature,

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below the transition temperature.

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The **solubility** curve represents equilibrium conditions between solid sodium iodide and dissolved sodium iodide.
The position of equilibrium can be influenced by temperature change and whether a change is exothermic or endothermic.
From the shape of your graph, comment on the likely enthalpy change for solid sodium iodide dissolving under equilibrium conditions. Explain your answer.

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.... [2]

[Total: 15]

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