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

CANDIDATE NAME	
CENTRE NUMBER	
CANDIDATE NUMBER	

3028591348

CHEMISTRY **9701/51**

Paper 5 Planning, Analysis and Evaluation **October/November 2011**

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 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 **8** printed pages and **4** blank pages.

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1 When potassium nitrate dissolves in water, the temperature of the solution goes down because the enthalpy of solution is endothermic.

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You are to plan an experiment to investigate how the solubility of potassium nitrate varies with temperature. The units of solubility are grams per one hundred grams of water (g / 100g water).

(a) (i) Predict how the solubility of potassium nitrate will change if the solution temperature is **increased**.

Explain your prediction using the fact that dissolving potassium nitrate is endothermic.

prediction .....

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explanation .....

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(ii) Display your prediction in the form of a sketch graph, labelling clearly the axes.



[3]

(b) In the experiment you are about to plan, identify the following.

(i) the independent variable .....

(ii) the dependent variable .....

[2]

(c) Design a laboratory experiment to test your prediction in **(a)**.

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In addition to the standard apparatus present in a laboratory you are provided with the following materials,

a boiling tube,
a looped wire stirrer,
a thermometer covering the temperature range 0 °C to 100 °C.

Describe how you would carry out the experiment. You should

- ensure a wide range of results suitable for analysis by graph,
- decide on the amounts of water and potassium nitrate to use,
- measure the amounts of the two reagents,
- heat the apparatus,
- decide at what point the temperature of the solution is to be taken.

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.....[7]

(d) State a hazard that must be considered when planning the experiment and describe precautions that should be taken to keep risks to a minimum.

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..... [1]

(e) Draw a table with appropriate headings to show the data you would record when carrying out your experiments and the values you would calculate in order to construct a graph to support or reject your prediction in **(a)**. The headings **must** include the appropriate units.

[2]

[Total: 15]

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2 Chemical reactions occur more rapidly as the temperature of the reaction mixture increases. The mathematical relationship that summarises this is

$$\log_{10}(\text{rate of reaction}) = \frac{-E_A}{19T}$$

where $\mathbf{E_A}$ is the **activation energy** of the reaction and **T** is the **absolute temperature** in Kelvin and the **rate of reaction** can be taken as the reciprocal of the time taken in seconds **(1/time)**.

An experiment was carried out to investigate this relationship using dilute hydrochloric acid and aqueous sodium thiosulfate.

- 20 cm^3 of dilute hydrochloric acid was placed in a boiling tube contained in a water bath.
- 20 cm^3 of aqueous sodium thiosulfate was added to the dilute hydrochloric acid, while stirring and a stopwatch started.
- The temperature of the water bath was recorded.
- After a period of time the liquid became cloudy (opaque) due to the formation of a precipitate of sulfur.
- As soon as this cloudiness (opacity) appeared the time was recorded.
- The temperature of the water bath was raised and the whole experiment repeated.

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

Process the results in the table to calculate **$\log_{10}$ (rate of reaction)**, the reciprocal of the absolute temperature (**1/T**) and the 'rate of reaction' (**1/time**). You should expect the values of **$\log_{10}$ (rate of reaction)** to be negative.

Record these values to **three significant figures** in the additional columns of the table.

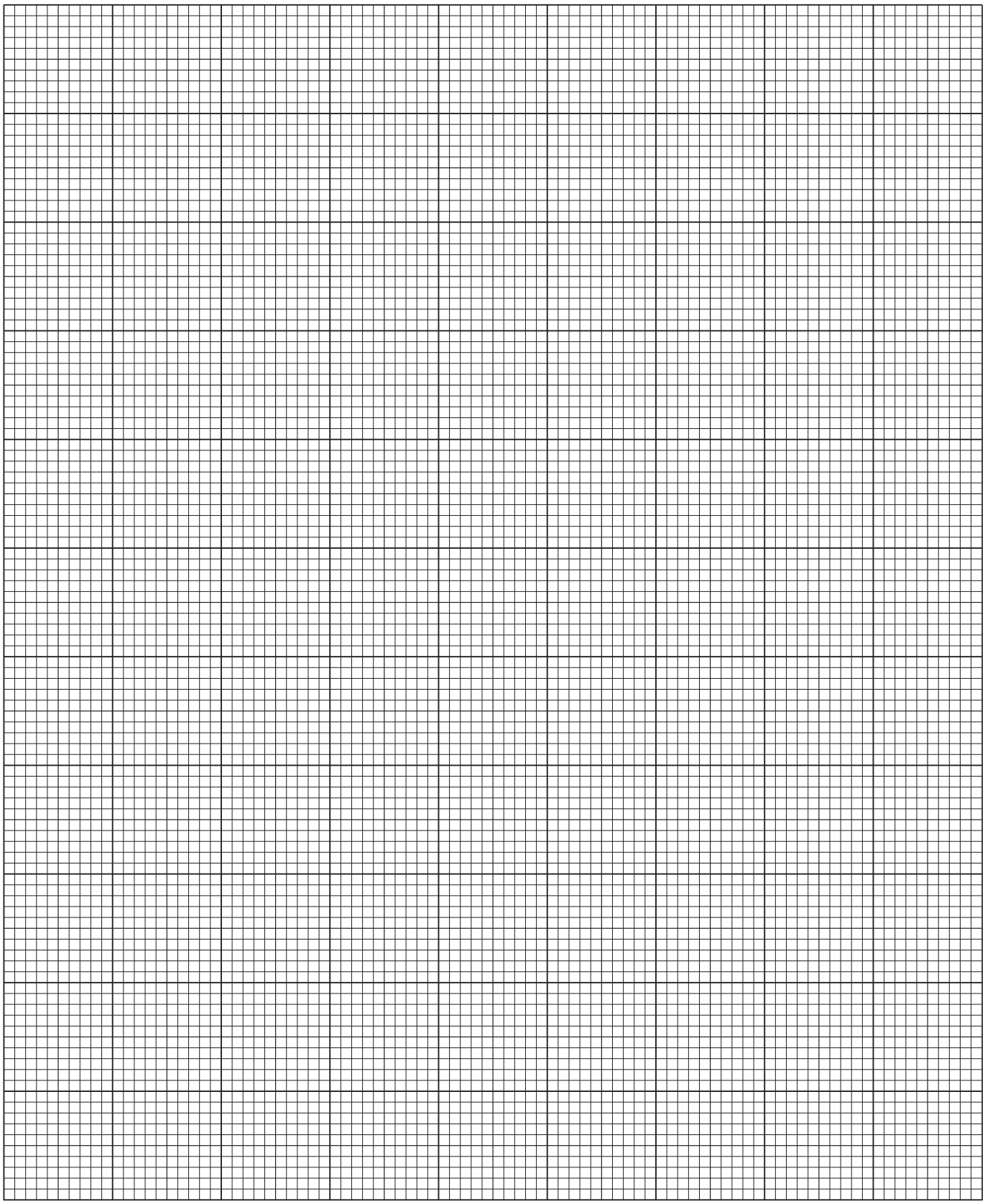
Label the columns you use. For each column you use include units where appropriate and an expression to show how your values are calculated.

You may use the column headings A to F for these expressions (e.g. A–B). [3]

A	B	C	D	E	F
temperature / °C	absolute temperature / K	time / s			
20.0	293	60.3			
30.0	303	46.8			
40.0	313	41.6			
45.0	318	31.6			
50.0	323	28.8			
55.0	328	25.1			
60.0	333	21.0			
65.0	338	20.4			
70.0	343	18.1			
80.0	353	15.1			

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(b) Plot a graph to show the relationship between **$\log_{10}$ (rate of reaction)** and the reciprocal of the absolute temperature. You are reminded that the values for **$\log_{10}$ (rate of reaction)** are negative.
Draw the line of best fit.



[3]

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(c) Circle and label on the graph any point(s) you consider to be anomalous. For each anomalous point give a different reason why it is anomalous, clearly stating which point you are describing.

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.....[3]

(d) Comment on whether the results obtained can be considered as reliable.

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.....[1]

(e) Determine the slope of the graph. Mark clearly on the graph any construction lines and show clearly in your calculation how the values from the intercepts were used in the calculation of the slope.

[2]

(f) Using the value of the slope of your graph calculated in **(f)** calculate a value for the **activation energy, E_A**. Correct use of the equation will produce an answer in $kJ\,mol^{-1}$.

[1]

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(g) By considering the movement of particles in the reaction explain why the rate of reaction increases with increasing temperature.

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[2]

[Total: 15]

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