Cambridge International A Level

Cambridge International Examinations
Cambridge International Advanced Level

CANDIDATE NAME	
CENTRE NUMBER	
CANDIDATE NUMBER	

9297643386

CHEMISTRY **9701/53**

Paper 5 Planning, Analysis and Evaluation **October/November 2015**

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 an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, 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.

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

CAMBRIDGE International Examinations

1 The halogenoalkanes can react with hydroxide ions to form an alcohol and a halide ion.

(a) The rate at which the reaction occurs depends on which of the halogenoalkanes is chosen. The reaction is a nucleophilic attack by the hydroxide ion and the rate might depend on:

- the polarity of the carbon-halogen bond,
- the bond strength of the carbon-halogen bond.

For **(i)** and **(ii)**, chlorobutane, bromobutane and iodobutane should be considered.

(i) If the rate of reaction was only controlled by the polarity of the carbon-halogen bond, the order of reactivity (most reactive to least reactive) would be

..... .

Explain the variation in the polarity of the carbon-halogen bonds.

.....

.....

.....

[2]

(ii) If the rate of reaction was only controlled by the bond strength of the carbon-halogen bond, the order of reactivity (most reactive to least reactive) would be

..... .

Explain the variation in the bond strength of the carbon-halogen bonds.

.....

.....

.....

[2]

(b) An experiment can be carried out to compare the extent of the reaction between aqueous hydroxide ions and chlorobutane, bromobutane and iodobutane. Samples of the halogenoalkanes are reacted with sodium hydroxide for 2 minutes at 50 °C. After the reaction, addition of aqueous silver nitrate causes the formation of a silver halide precipitate.

> Some hazards associated with the use of halogenoalkanes include:
> - very hazardous in case of skin and particularly eye contact,
> - very hazardous if inhaled or ingested,
> - flammable.

To carry out this experiment, the following would be supplied.

- usual laboratory apparatus
- laboratory reagents including a suitable aqueous solution of sodium hydroxide and aqueous silver nitrate
- samples of each of the three liquid halogenoalkanes

(i) Identify the independent variable and the dependent variable in this experiment.

independent variable .....

dependent variable .....
[1]

(ii) The amount of each halogenoalkane liquid to use is most practically measured by its volume. Usually equal volumes of the three halogenoalkanes are used.

Explain why this is not ideal and what change should be made to obtain a more reliable comparison between the halogenoalkanes.

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.....

.....

..... [2]

[Turn over

(iii) Answer the following questions about the experiment.

- Having measured the quantity of halogenoalkanes, what must be ensured about the amount of sodium hydroxide used?

.....

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- How would the reaction tubes be heated and the experiment be started?

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- What reagent could be added which would ensure that after 2 minutes the reaction was stopped?

.....

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- After the reaction has been stopped and aqueous silver nitrate added, the amount of precipitate formed could be determined by measuring its height.
  Why is it necessary to leave the tubes for some time before making this measurement?

.....

.....

.....

[5]

(iv) Although the amount of silver halide formed can reasonably be obtained by measuring the height of the precipitate in the reaction tube, this is not very reliable.

Explain what should be done with the precipitate to obtain a more reliable measurement of the amount of silver halide produced.

.....

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.....

..... [2]

(c) The use of halogenoalkanes is hazardous and both gloves and eye protection are necessary. State one other essential precaution which should be taken when carrying out the experiments.

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.....

.....

..... [1]

[Total: 15]

2 At 25 °C, dinitrogen tetroxide, $N_2O_4(g)$, forms an equilibrium mixture with nitrogen dioxide, $NO_2(g)$.

$$N_2O_4(g) \rightleftharpoons 2NO_2(g) \qquad \Delta H = +57.2\,kJ\,mol^{-1}$$

As $N_2O_4(g)$ is colourless and $NO_2(g)$ is brown, the composition of an equilibrium mixture can be determined by its colour.

(a) Write an expression for the equilibrium constant, K_c, for this equilibrium.

[1]

(b) In an experiment, quantities of N_2O_4 are left to reach an equilibrium which contains N_2O_4 and NO_2. These are analysed to determine the concentrations of $N_2O_4(g)$ and $NO_2(g)$ that are present. The results are listed in the first two columns of the table below.

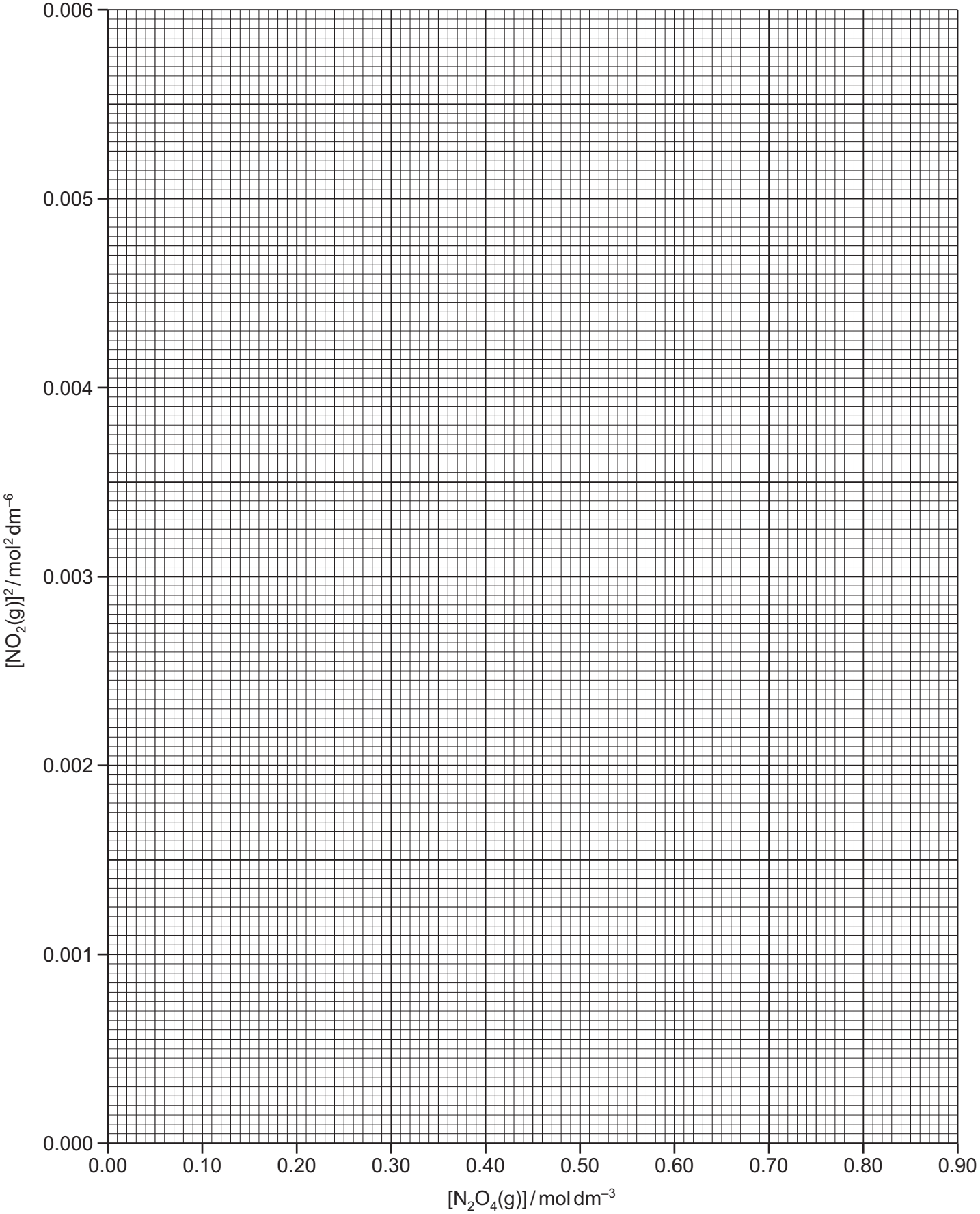
Complete the third column of the table to give the value of $[NO_2(g)]^2$ for each of the results of the experiment. Values should be given to **three significant figures**.

$[N_2O_4(g)]$ / mol dm^{-3}	$[NO_2(g)]$ / mol dm^{-3}	$[NO_2(g)]^2$ / mol^2 dm^{-6}
0.900	0.0729	
0.800	0.0687	
0.700	0.0643	
0.600	0.0595	
0.500	0.0548	
0.400	0.0486	
0.300	0.0390	
0.200	0.0344	
0.100	0.0243	

[2]

(c) (i) The value of the equilibrium constant for $N_2O_4(g) \rightleftharpoons 2NO_2(g)$ can be calculated from a graph of $[N_2O_4(g)]$ against $[NO_2(g)]^2$.

Use the grid on page 7 to plot this graph and draw a line of best fit through the plotted points.


0.006
0.005
0.004
0.003
0.002
0.001
0.000
$[NO_2(g)]^2 / mol^2 dm^{-6}$
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
$[N_2O_4(g)] / mol\ dm^{-3}$

[2]

(ii) Choose two suitable sets of values from your graph and use them to calculate a value for the equilibrium constant, K_c. Give your answer to **three significant figures** and give its units.

co-ordinates of two points used ....

K_c = ... units .....
[3]

(d) Identify the result which is most anomalous and suggest a reason, other than a calculation error, why this may have occurred.

.....

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.....

.....

..... [2]

(e) **(i)** On your graph, draw a line that would be obtained if the temperature of the equilibrium mixture was raised. [1]

(ii) Explain the position of the line drawn in **(i)**.

.....

..... [1]

(iii) What effect, if any, would the higher temperature have on the value of K_c?

.....

..... [1]

(iv) How would your value for the equilibrium constant change if the pressure applied to the equilibrium mixture was increased?

..... [1]

(f) In the experiments, the results have been obtained by starting with pure $N_2O_4(g)$ and then letting the equilibrium with $NO_2(g)$ form.

Calculate the starting concentration of pure $N_2O_4(g)$ that would be required to produce the mixture of $0.900\,mol\,dm^{-3}$ of $N_2O_4(g)$ and $0.0729\,mol\,dm^{-3}$ of $NO_2(g)$ once equilibrium had been established.

[1]

[Total: 15]

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