UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

*9037415928*

**CHEMISTRY** **9701/52**

Paper 5 Planning, Analysis and Evaluation **May/June 2012**

**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 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.

| For Examiner's Use | |
|---|---|
| 1 | |
| 2 | |
| Total | |

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


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**1** When ammonium nitrate(V), $NH_4NO_3$, is heated it decomposes completely into nitrogen(I) oxide, $N_2O$, and water vapour, $H_2O$, which if allowed to cool will condense to liquid water.

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The stoichiometric equation for this decomposition is

$$NH_4NO_3(s) \rightarrow N_2O(g) + 2H_2O(l).$$

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

**Ammonium nitrate(V)** $NH_4NO_3$
**Oxidising:** 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.**

You are to plan an experiment to investigate the molar ratio of nitrogen(I) oxide and ammonium nitrate(V) at 25 °C, and confirm that it remains unchanged as the mass of ammonium nitrate(V) changes.

**(a) (i)** Predict quantitatively how the number of moles of nitrogen(I) oxide varies as the number of moles of ammonium nitrate(V) increases, if the products are measured at room temperature 25 °C.

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**(ii)** Predict quantitatively how the sum of the number of moles of water vapour and nitrogen(I) oxide varies as the number of moles of ammonium nitrate(V) increases, if the products are measured at 110 °C.

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**(iii)** Display both your predictions in the form of sketch graphs on the axes below. Label clearly each axis and each graph line.

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[3]

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**(b)** In the experiment you are about to plan to test your prediction in **(a)(i)** at 25 °C, identify the following.

**(i)** the independent variable .....

**(ii)** the dependent variable .....

[2]

**(c)** Draw a diagram of the apparatus and the experimental set up you would use to carry out this experiment. Your apparatus should use only standard items found in a school or college laboratory and show clearly

**(i)** how the solid will be heated,

**(ii)** how the water vapour will be condensed into a liquid and collected. Ice is available,

**(iii)** how the nitrogen(I) oxide will be collected.

Label each piece of apparatus used, indicating its size or capacity.

[3]

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**(d)** Using the apparatus shown in **(c)** design a laboratory experiment to test your prediction in **(a)(i)** for an experiment at 25 °C.

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

a sample of solid ammonium nitrate(V)
crushed ice

Give a step-by-step description of how you would carry out the experiment,

**(i)** to produce enough results to give sufficient data to plot a graph as in **(a)(iii)**,
**(ii)** by stating the volumes of nitrogen(I) oxide you would collect,
**(iii)** by calculating the mass of ammonium nitrate(V) needed to produce one of the volumes of nitrogen(I) oxide suggested in **(ii)**,
**(iv)** by stating how you would ensure that decomposition was complete.
[$A_r$ : H, 1.0; N, 14.0; O, 16.0; the molar volume of a gas at 25 °C, 24.0 $dm^3$]

[4]

**(e)** State one hazard that must be considered when planning the experiment and describe a precaution that should be taken to minimise the risk from this hazard.

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.....[1]

**(f)** 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)(i)**. The headings should include the appropriate units.

[2]

[Total: 15]

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**2** The variation of the volume with pressure of a fixed mass of any ideal gas at constant temperature may be represented by a relationship known as Boyle's law,

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$$PV = \text{constant}$$

where P is the pressure of the gas, V is the volume of the gas.

A gas such as carbon dioxide, under certain conditions of temperature and pressure, does not always behave as an ideal gas.

An experiment was carried out on carbon dioxide to investigate its behaviour.

- A calibrated glass tube was filled with a sample of carbon dioxide.
- The tube was attached to a calibrated pressure pump.
- The pressure and the volume of the gas sample were recorded.
- The measured pressure on the gas was increased and the new volume recorded.

**(a)** The results of the experiment are recorded in the table below.

A graph of V against P has been plotted for you.

Process the results in the table to enable you to plot two further graphs:

- PV against P
- 1/V against P

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 D for these expressions (e.g. A–B).

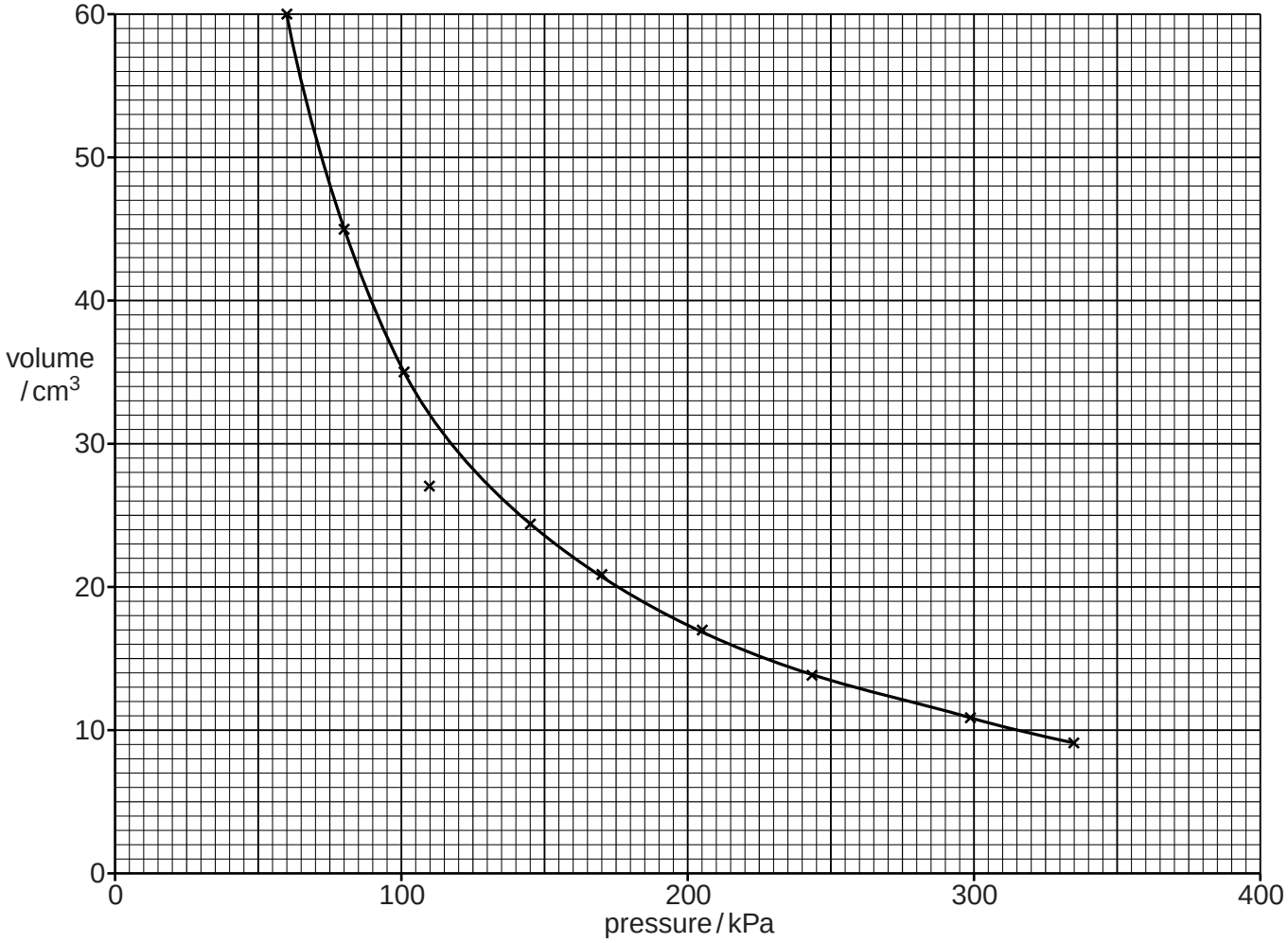
| A | B | C | D |
|---|---|---|---|
| pressure of the gas / kPa | volume of the gas / $cm^3$ | | |
| 335 | 9.09 | | |
| 298 | 10.9 | | |
| 243 | 13.9 | | |
| 205 | 17.0 | | |
| 170 | 20.8 | | |
| 145 | 24.4 | | |
| 110 | 27.0 | | |
| 101 | 35.0 | | |
| 80.0 | 45.5 | | |
| 60.0 | 60.0 | | |

[2]

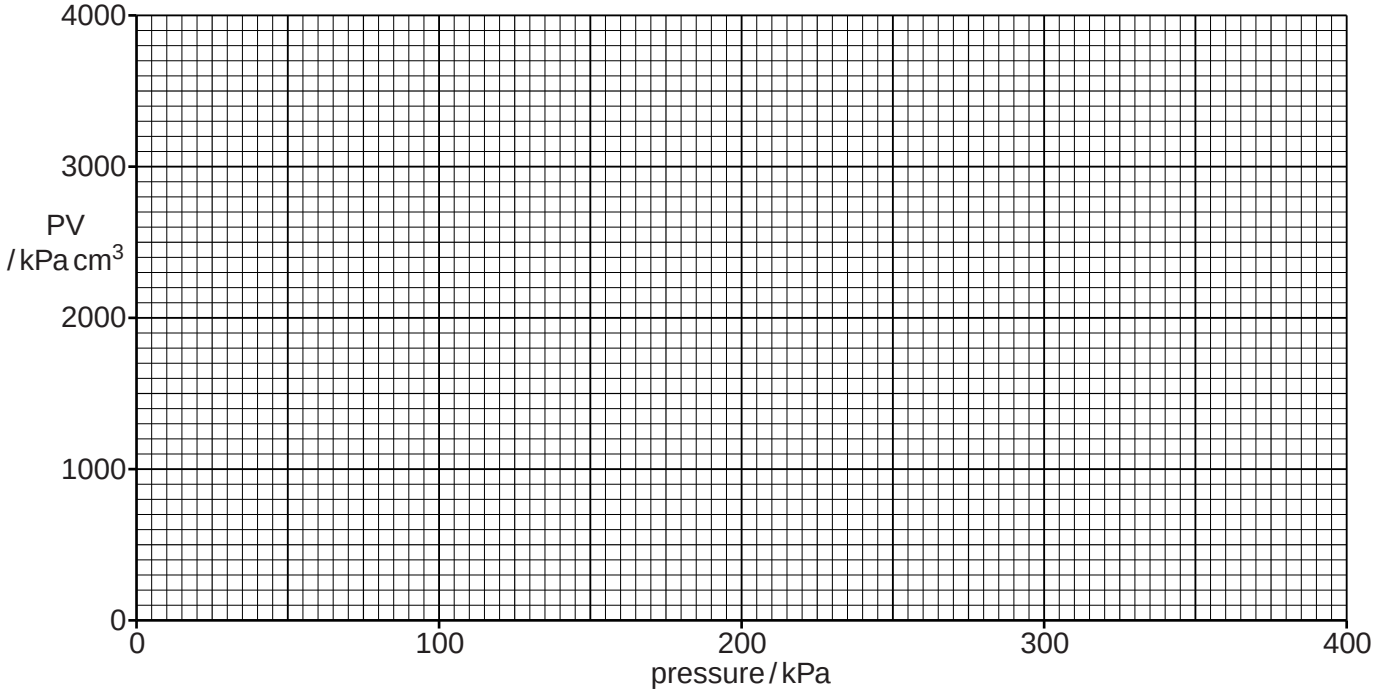
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**[Turn over**

This graph shows the relationship between the volume of the gas and the pressure of the gas.



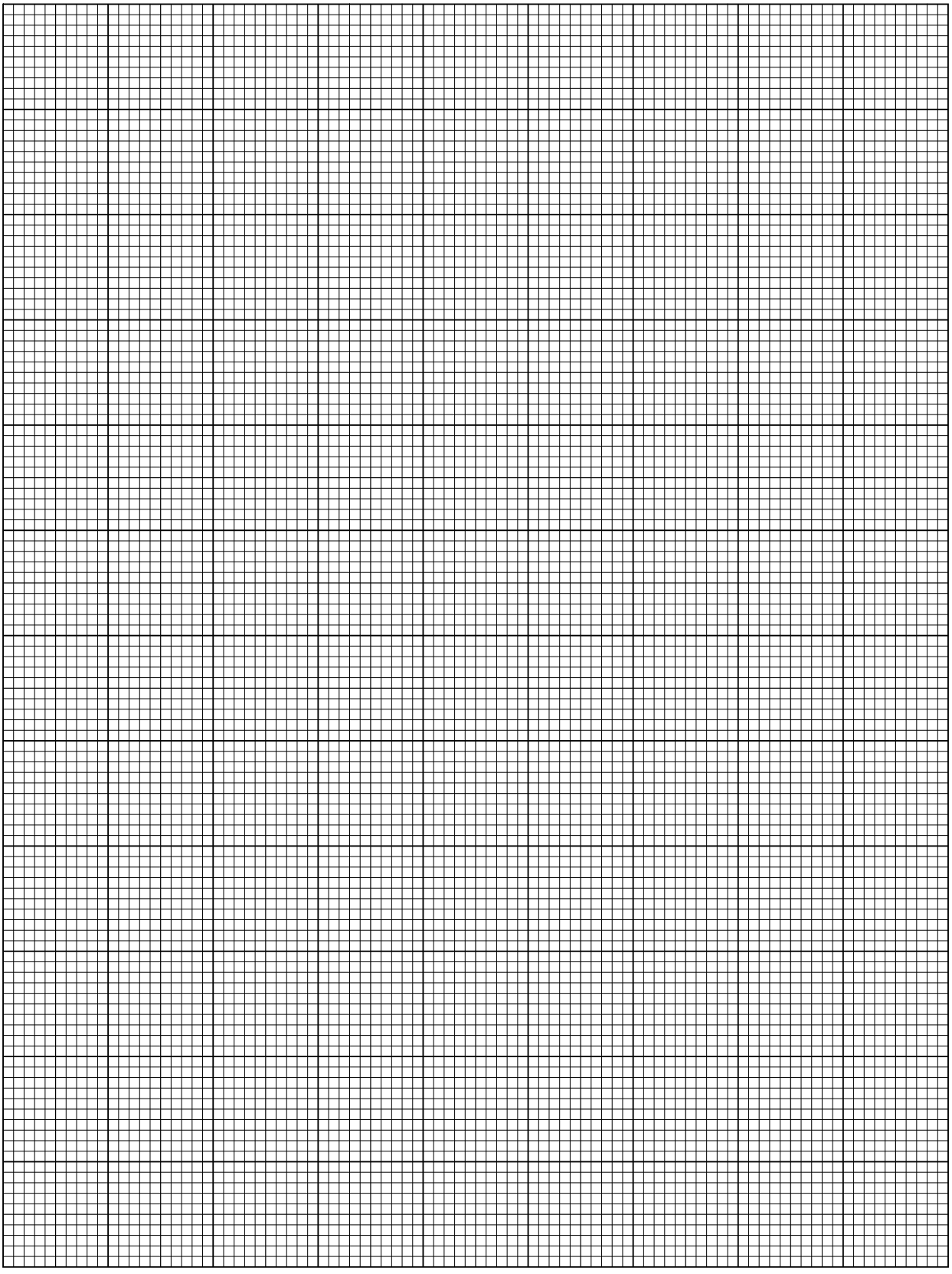

**(b)** Plot a graph to show the relationship between the product of the pressure and volume, PV, of the gas and the pressure, P, of the gas. Draw the line of best fit.




[1]

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**(c)** Plot a graph to show the relationship between the reciprocal of the volume of the gas and the pressure (1/V against P) of the gas. Begin the scales on both axes at 0. Draw the line or curve of best fit.



[3]

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

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.....[2]

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

[2]

**(f)** **(i)** Does the initial shape of your graph in **(c)** confirm the equation PV = constant?

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**(ii)** Explain your answer in **(i)** above.

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**(iii)** Why is the graph of volume against pressure provided inappropriate for the verification of Boyle's law?

[3]

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**(g)** **(i)** Explain why it was important to measure the initial slope of the graph in **(e)**.

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**(ii)** What is the significance of the value of the initial slope?

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.....[2]

[Total: 15]

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