Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

7324969073

CHEMISTRY **9701/51**

Paper 5 Planning, Analysis and Evaluation **May/June 2020**

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working, use appropriate units and use an appropriate number of significant figures.

INFORMATION

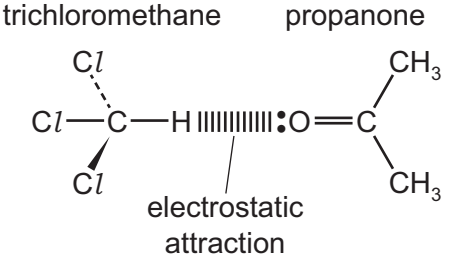
- The total mark for this paper is 30.
- The number of marks for each question or part question is shown in brackets [ ].

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1 Trichloromethane and propanone are both organic liquids. The molecules within each liquid are attracted to each other by relatively weak permanent dipole-dipole interactions.

When trichloromethane is mixed with propanone a strong electrostatic attraction forms between the two different molecules.



A student plans to perform an experiment to investigate the strength of this electrostatic attraction by finding the temperature change when equal volumes of trichloromethane and propanone are mixed together.

(a) (i) State and explain your prediction for the temperature change for this experiment.

.....

.....

..... [1]

(ii) The student is given **only** the following equipment and chemicals for the experiment.

$1 \times 25\,cm^3$ beaker
$2 \times$ thermometers
$2 \times 25\,cm^3$ measuring cylinders
$50\,cm^3$ trichloromethane
$50\,cm^3$ propanone

Outline the method the student should use in this one experiment to find the temperature change when trichloromethane is mixed with propanone. Give details of the volumes of liquids used and any readings taken.

volumes used .....

.....

readings taken .....

.....

.....

method used .....

.....

.....

.....

[3]

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(b) The apparatus used leads to significant heat loss.

State **one** improvement the student could make to the apparatus to reduce heat loss.

.....

..... [1]

(c) Trichloromethane and propanone are both volatile and flammable.

State **one** relevant precaution that should be taken when carrying out this experiment.

.....

..... [1]

(d) State **one** change, apart from reducing heat loss, that could be made to improve the accuracy of this experiment.

.....

..... [1]

(e) In another experiment, a student uses 37.50 g of trichloromethane and 19.75 g of propanone and determines that the energy released is 1.67 kJ.

(i) Calculate the number of moles of each compound in this mixture.

M_r trichloromethane = 119.5
M_r propanone = 58.0

moles of trichloromethane = ... mol

moles of propanone = ... mol
[1]

(ii) Calculate the enthalpy change, ΔH, of the electrostatic attraction formed between trichloromethane and propanone. You must include a sign in your answer.

ΔH = ... kJ mol^{-1} [2]

(f) Suggest an experiment the student could carry out to test whether the number of moles of trichloromethane affects the temperature change.

.....

.....

..... [1]

[Total: 11]

2 Nitrogen dioxide can be prepared by strongly heating anhydrous lead nitrate, $Pb(NO_3)_2(s)$. The thermal decomposition occurs according to the equation shown.

$$2Pb(NO_3)_2(s) \rightarrow 2PbO(s) + 4NO_2(g) + O_2(g)$$

The nitrogen dioxide, NO_2, can be separated from the oxygen by cooling the gas mixture produced until the NO_2 condenses and the oxygen does not.

	melting point / K	boiling point / K
nitrogen dioxide	262	294
oxygen	54	90

(a) Draw a labelled diagram of the laboratory apparatus (assembled) that could be used to prepare **liquid** nitrogen dioxide from the thermal decomposition of anhydrous lead nitrate.

[2]

(b) At room temperature, nitrogen dioxide exists in equilibrium with dinitrogen tetroxide according to the equation shown.

$$2NO_2(g) \rightleftharpoons N_2O_4(g)$$
brown colourless

For this equilibrium, $K_p = p_{N_2O_4} / p^2_{NO_2}$.

$p_{N_2O_4}$ and p_{NO_2} are measured in kPa.

State the units of K_p.

..... [1]

A student plans to investigate the variation of K_p with temperature.

(c) (i) A sample of the mixture of nitrogen oxides is introduced into a gas syringe at 295 K and the gas syringe is sealed so that it is both airtight and watertight. The volume occupied by the mixture is measured at different temperatures. The K_p value is calculated at each temperature.

Name the apparatus you would use to heat the gas syringe at different temperatures between 295 K and 370 K so that a volume reading of the gas syringe could be easily taken.

..... [1]

(ii) The results obtained are shown in the table.

Complete the table by calculating values for $\frac{1}{T}$ and log K_p.

Record the value of $\frac{1}{T}$ to **three significant figures**.

Record the value of log K_p to **two decimal places**.

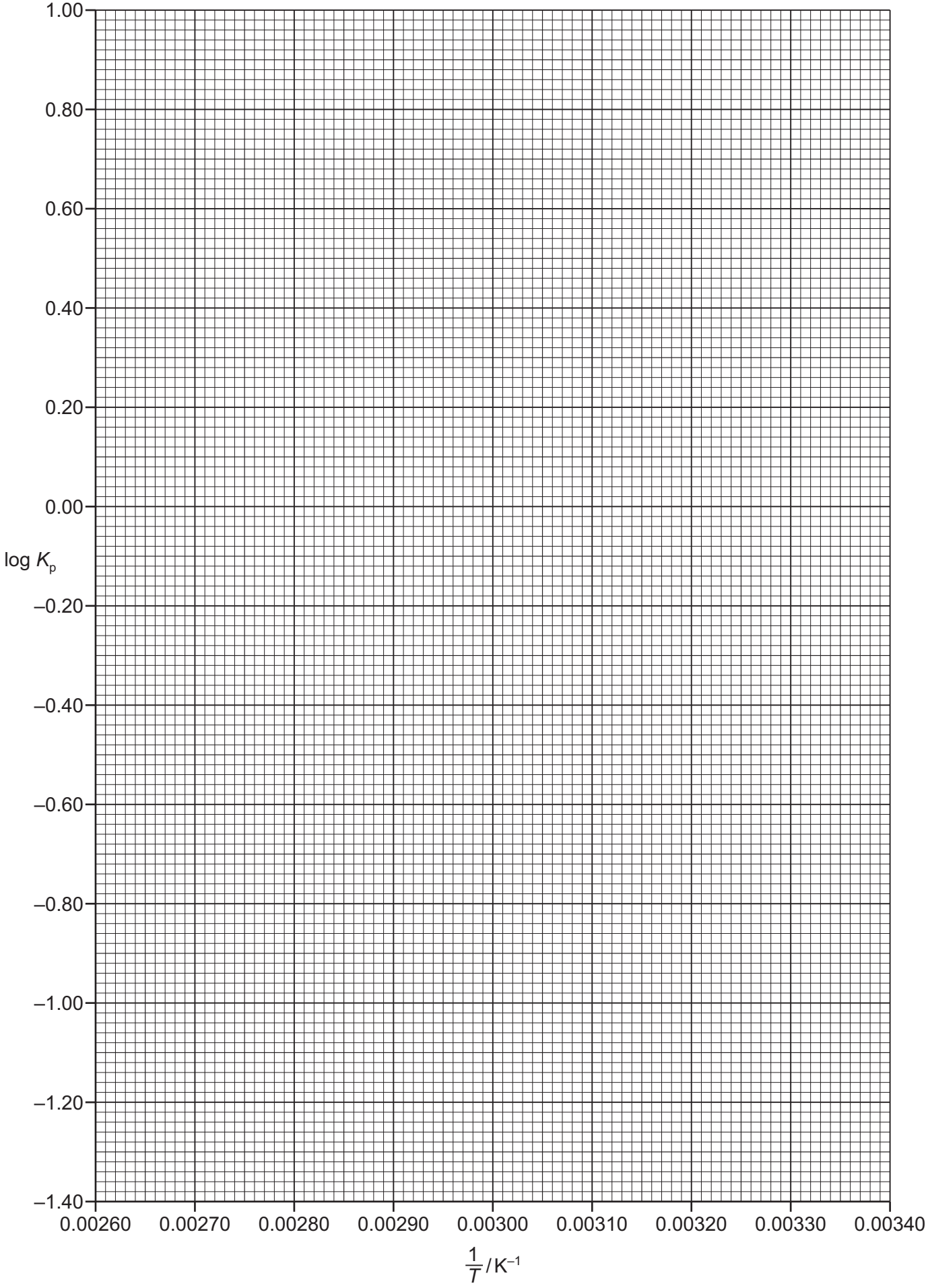
T / K	$\frac{1}{T}$ / K^{-1}	K_p	log K_p
377		0.076	
361		0.122	
344		0.257	
330		0.741	
315		1.506	
312		3.490	
295		9.025	

[2]

(iii) Plot a graph on the grid of log K_p against $\frac{1}{T}$.

Draw a line of best fit through the plotted points. [2]

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[Turn over

(d) (i) State and explain what your graph shows about the accuracy of the experimental results.

.....

.....

..... [1]

(ii) Suggest a reason for your answer in **(d)(i)**.

.....

..... [1]

(iii) Suggest what the student could do to improve the accuracy of the experiment.

.....

..... [1]

(e) (i) Use the graph to determine the gradient of the line of best fit.

State the coordinates of both points you used in your calculation. These must be on your line of best fit.

Give your answer to **three significant figures**.

coordinates 1 ..... coordinates 2 .....

gradient = ... K
[2]

(ii) The relationship between log K_p and $\frac{1}{T}$ is given by the equation shown.

$$\log K_p = (-\Delta H / 2.303 RT) + \text{constant}$$

$R = 8.31\,\text{J K}^{-1}\,\text{mol}^{-1}$

Use the gradient determined to calculate a value for ΔH.

If you were unable to determine a value for the gradient, use the value 2800 K. This is **not** the correct value.

ΔH = ... kJ mol^{-1}
[2]

(f) (i) With reference to the results obtained in this experiment, state and explain how K_p varies with temperature.

.....

..... [2]

(ii) With reference to **(b)** and the data for K_p in the table in **(c)(ii)** suggest how the colour of the equilibrium mixture at 370 K will differ, if at all, from the colour at room temperature. Explain your answer.

difference in colour of mixture .....

explanation .....

.....

.....
[2]

[Total: 19]

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