Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

2599261796

CHEMISTRY **9701/52**

Paper 5 Planning, Analysis and Evaluation **February/March 2021**

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 [ ].

This document has **8** pages.

IB21 03_9701_52/3RP

1 Zinc metal reacts with aqueous copper(II) sulfate.

$$Zn(s) + CuSO_4(aq) \rightarrow Cu(s) + ZnSO_4(aq)$$

The enthalpy change of this reaction, ΔH, can be determined by adding excess zinc powder to a measured volume of 0.500 mol dm^{-3} aqueous copper(II) sulfate.

The temperature of 25.0 cm^3 of 0.500 mol dm^{-3} aqueous copper(II) sulfate is recorded for three minutes. At four minutes 3 g, an excess, of zinc powder is added and the mixture is continuously stirred. The temperature is recorded at times shown in the table.

time / min	0	1	2	3		$4\frac{1}{2}$	5	$5\frac{1}{2}$	6	$6\frac{1}{2}$	7	8	9	10
temperature / °C	18	19.5	19.5	19.5		32.5	38	36	34	33	32.5	31.5	31	31

(a) Use the results table to deduce the graduations on the thermometer that is used to record these temperature readings.

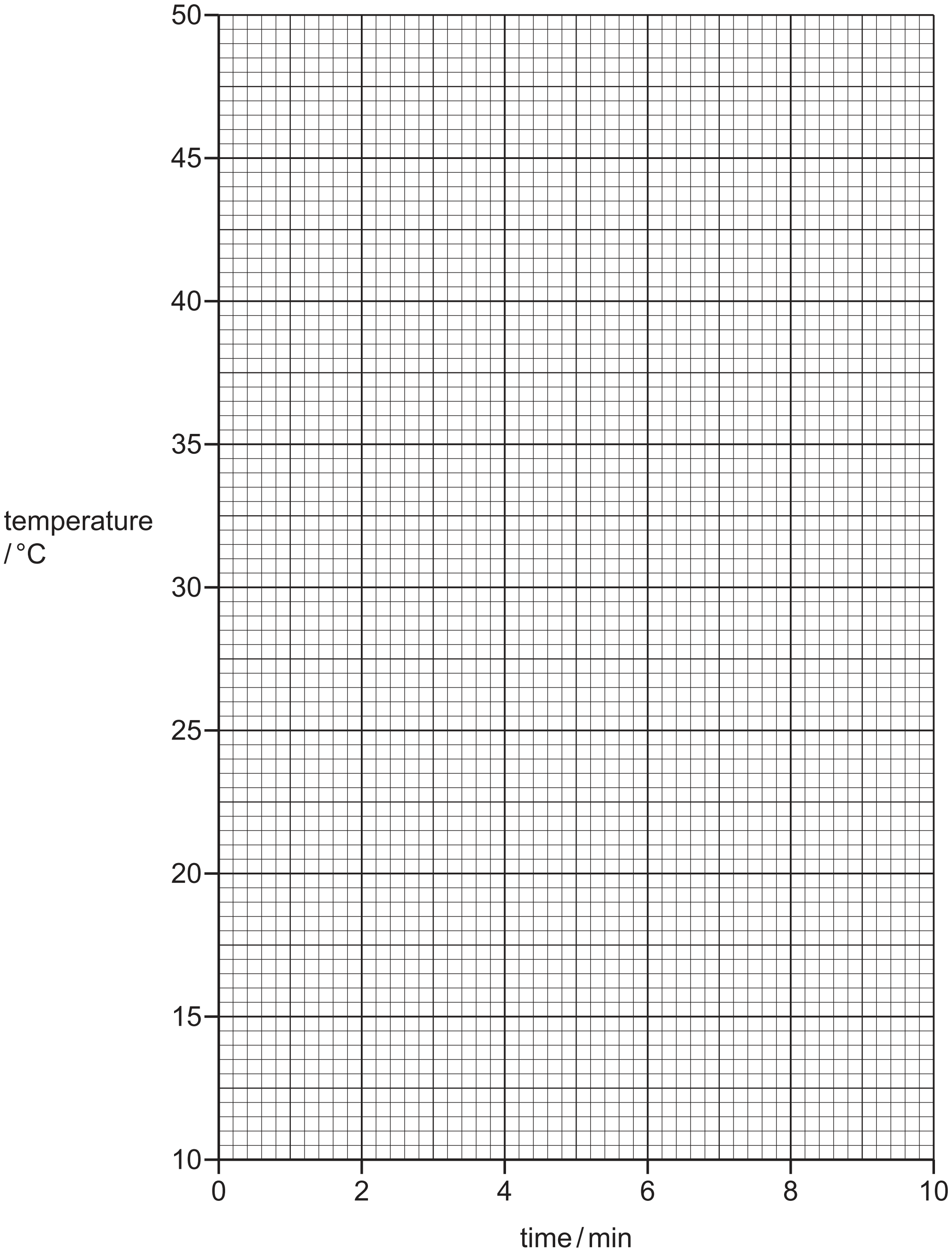
.... [1]

(b) Draw a labelled diagram of the apparatus set up at one minute.

[2]

(c) Plot a graph of temperature (y-axis) against time (x-axis). Use a cross (×) to plot each data point. Draw a line of best fit during cooling.

Extrapolate the cooling curve back to four minutes and determine the temperature change during the reaction.



temperature change = ... °C [2]

(d) Use the formula $\Delta H = -mc\Delta T$ to determine the enthalpy change of reaction, ΔH, in $kJ\,mol^{-1}$.

Assume:
- mass of $1.00\,cm^3$ of solution = $1.00\,g$
- $c = 4.18\,J\,g^{-1}\,K^{-1}$.

ΔH = ... $kJ\,mol^{-1}$ [2]

(e) Heat loss is a major source of error in the results of this experiment.

Suggest how the following changes would affect the amount of heat loss, if at all.

Explain your answer in each case.

(i) The mass of zinc is doubled.

effect on heat loss ....

explanation ....

.... [1]

(ii) The concentration of $25.0\,cm^3$ of aqueous copper(II) sulfate is doubled. The amount of zinc used is still an excess.

effect on heat loss ....

explanation ....

.... [1]

(iii) The volume of $0.500\,mol\,dm^{-3}$ aqueous copper(II) sulfate is doubled. The amount of zinc used is still an excess.

effect on heat loss ....

explanation ....

.... [1]

[Total: 10]

2 Ethanedioic acid is a white crystalline solid.

If excess aqueous potassium hydroxide, KOH(aq), is added to dilute ethanedioic acid, $H_2C_2O_4$(aq), full neutralisation occurs and potassium ethanedioate, $K_2C_2O_4$(aq), forms.

$$H_2C_2O_4(aq) + 2KOH(aq) \rightarrow K_2C_2O_4(aq) + 2H_2O(l)$$

If a small amount of potassium hydroxide is added, **partial** neutralisation takes place and not all H^+ ions in the acid are replaced by K^+ ions.

Instead an acid salt forms, which crystallises to form a solid with the formula $K_aH_b(C_2O_4)_c{\bullet}dH_2O$.

The letters *a*, *b* and *c* represent a ratio of the numbers of species present in the compound and may not necessarily be whole numbers. The relative number of water molecules associated with one formula of the compound is represented by *d*.

A student attempted to determine the values of *a*, *b*, *c* and *d* in a sample of an acid salt, $K_aH_b(C_2O_4)_c{\bullet}dH_2O$.

(a) The student wants to make a 250.0 cm^3 aqueous solution of $K_aH_b(C_2O_4)_c{\bullet}dH_2O$, solution **A**.

The student adds 1.89 g of $K_aH_b(C_2O_4)_c{\bullet}dH_2O$ into a 100 cm^3 beaker.

Describe the next steps the student should take to make solution **A**, containing exactly 1.89 g of $K_aH_b(C_2O_4)_c{\bullet}dH_2O$.

Give the name and capacity of the apparatus which should be used and describe how the student should ensure the volume is exactly 250.0 cm^3.

Write your answer using a series of numbered steps.

....

....

....

....

....

....

....

.... [4]

(b) Determining the number of moles of $C_2O_4^{2-}$ present

Ethanedioate ions, $C_2O_4^{2-}$(aq), react with manganate(VII) ions, MnO_4^-(aq), in acidified conditions, as shown.

$$5C_2O_4^{2-}(aq) + 16H^+(aq) + 2MnO_4^-(aq) \rightarrow 2Mn^{2+}(aq) + 8H_2O(l) + 10CO_2(g)$$

MnO_4^-(aq) ions are a very deep purple in colour. All other species appear colourless.

The reaction takes place above a temperature of 70 °C.

The student carries out a redox titration using the following steps.

step 1 The student rinses and fills a burette with 0.0200 mol dm^{-3} MnO_4^-(aq).

step 2 The student uses a pipette to transfer 25.0 cm^3 of solution **A** into a conical flask.

step 3 The student adds 20 cm^3, an excess, of 0.5 mol dm^{-3} H_2SO_4(aq) to the conical flask.

step 4 The conical flask is heated until a temperature of about 80 °C is reached.

step 5 The student adds MnO_4^-(aq) from the burette until an end-point is reached.

The student repeats the titration until concordant readings are achieved.

	rough	titration 1	titration 2	titration 3
final burette reading / cm^3	25.05	24.50	26.60	24.50
initial burette reading / cm^3	0.10	0.10	0.10	0.10
titre / cm^3	25.05	24.40	26.50	24.40

The student determines the average titre to be 24.40 cm^3.

(i) When emptying the pipette in **step 2**, the student touches the surface of the solution in the flask with the tip of the pipette.

Suggest why the student does this.

....

.... [1]

(ii) Suggest the most appropriate piece of apparatus to measure H_2SO_4(aq) in **step 3**.

.... [1]

(iii) Suggest why the student starts each titration with an initial burette reading of 0.10 cm^3 rather than the usual 0.00 cm^3.

.... [1]

(iv) What is meant by the term *concordant readings*?

.... [1]

(v) State the change of colour seen in the mixture in the conical flask at the end-point.

from .... to .... [1]

(vi) Determine the number of moles of $C_2O_4^{2-}$ ions in the 250.0 cm^3 of solution **A**, $K_aH_b(C_2O_4)_c{\bullet}dH_2O$.

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

moles of $C_2O_4^{2-}$ ions in 250.0 cm^3 of solution **A** = ... mol [3]

If you were unable to calculate an answer to **(b)(vi)**, then you may use the value 1.18×10^{-2} mol for your calculations in **(c)**. This is **not** the correct value.

(c) The student then does an acid–base titration of solution **A** to determine the values of *a* and *b* in $K_aH_b(C_2O_4)_c{\bullet}dH_2O$.

(i) Suggest the name of a suitable reagent to use in this titration.

.... [1]

(ii) The student finds the concentration of $H^+(aq)$ in solution **A** is 6.10×10^{-2} mol dm^{-3}.

Use this value and your answer to **(b)(vi)** to determine the ratio of *c* to *b* to **two** decimal places.

Then deduce the value of *a* in $K_aH_b(C_2O_4)_c{\bullet}dH_2O$ to **two** decimal places.

ratio *c* : *b* = 1 : ....

value of *a* = ...

[3]

(iii) Use your answer to **(b)(vi)**, **(c)(ii)** and other information given in the question to determine the mass of 1 mol of $K_aH_b(C_2O_4)_c{\bullet}dH_2O$ and hence determine the value of d to the nearest whole number.
[A_r: K, 39.1; H, 1.0; C, 12.0; O, 16.0]

If you were unable to calculate an answer to **(c)(ii)**, then you may use a = 0.30 and ratio $c:b$ = 1 : 1.60. These are **not** the correct values.

mass of 1 mol of $K_aH_b(C_2O_4)_c{\bullet}dH_2O$ = ... g

value of d = ...

[2]

(d) A second student uses another method to determine d. Crystals of the sample, with known values of a, b and c, are heated in a crucible to remove the water molecules.

Construct a results table to show the readings that would need to be taken during this experiment.

[2]

[Total: 20]