Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

9835132678

CHEMISTRY **9701/52**

Paper 5 Planning, Analysis and Evaluation **February/March 2022**

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 and use appropriate units.

INFORMATION
- The total mark for this paper is 30.
- The number of marks for each question or part question is shown in brackets [ ].
- The Periodic Table is printed in the question paper.
- Important values, constants and standards are printed in the question paper.

This document has **12** pages. Any blank pages are indicated.

1 A student has a sample of copper(II) sulfate crystals, $CuSO_4{\bullet}xH_2O$. The student wants to show that the value of x is 5.

The student uses the following method.

step 1 Weigh a clean crucible on a balance reading to two decimal places. Record the mass.

step 2 Place the sample of $CuSO_4{\bullet}xH_2O$ into the crucible. Record the mass.

step 3 Heat the crucible gently for about 1 minute then strongly for about 4 minutes.

step 4 Weigh the crucible and contents. Record the mass.

(a) Identify the instruction that is missing between **step 3** and **step 4**.

.... [1]

(b) Explain why gentle heating takes place in **step 3**.

.... [1]

(c) Name the apparatus that should be used to hold the crucible during heating.

.... [1]

(d) The method is incomplete.

State the step(s) that should be carried out to complete the method.

....

....

.... [1]

(e) The student records their results in Table 1.1.

Table 1.1

	mass / g
mass of crucible	13.60
mass of crucible + contents before heating	21.09
mass of crucible + contents at the end of experiment	17.94

(i) Calculate the experimental value of x from these results.

experimental value of x = ... [3]

(ii) Suggest why the experimental value of x varies from the expected value of 5.

If you were unable to obtain an answer to **(e)(i)**, use the experimental value x = 6.9. This is **not** the correct answer.

....

.... [1]

(f) The empty crucible weighs 13.60 g.

Calculate the percentage error in this measurement.

Show your working.

percentage error = ... [1]

[Total: 9]

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2 The conductivity of an ionic solution can be determined by passing an electric current through the solution and measuring the conductivity using a conductivity meter.

(a) A student carries out an experiment to measure the conductivity of different solutions of ethanoic acid, CH_3COOH, which is a weak acid.

The acid dissociation constant, K_a, can be determined from this experiment.

The student makes standard solution **A**, 250.0 cm^3 of 2.00 mol dm^{-3} $CH_3COOH(aq)$.

(i) State what is meant by a standard solution.

....

.... [1]

(ii) Describe how the student should make standard solution **A** from pure ethanoic acid.

The concentration of standard solution **A** should be 2.00 mol dm^{-3} to the nearest **three** significant figures.

Your answer should state the name and capacity of any apparatus that the student should use. A balance is not available.

Pure ethanoic acid is a liquid with a density of 1.05 g cm^{-3} at room temperature.

You may wish to write your answer using a series of numbered steps.

[M_r: CH_3COOH, 60.0]

....

....

....

....

....

....

....

....

.... [4]

(b) The student wears chemically resistant gloves throughout this procedure.

Suggest why.

.... [1]

(c) The student dilutes standard solution **A** with distilled water to make solutions of different concentrations. The conductivity of these solutions is measured.

Table 2.1 shows the results.

Table 2.1

1	2	3	4
$[CH_3COOH]$ / mol dm^{-3}	conductivity / S dm^{-1}	$\frac{1}{\sqrt{[CH_3COOH]}}$ / dm$^{1.5}$ mol$^{-0.5}$	molar conductivity, Λ_M / dm^2 S mol^{-1}
0.0500	3.76×10^{-3}		
0.0250	2.74×10^{-3}		
0.0125	1.92×10^{-3}		
0.00625	1.33×10^{-3}		
0.003125	1.15×10^{-3}		
0.0015625	6.68×10^{-4}		

In order to determine K_a the results must be used to obtain two sets of data.

Column 3 is the reciprocal of the square root of the concentration (column 1).

Column 4 is the molar conductivity, Λ_M, which is found by dividing the conductivity (column 2) by the concentration (column 1).

(i) Complete columns 3 and 4 in Table 2.1. Give all values to **three** significant figures. [2]

(ii) Identify the dependent variable in this experiment.

.... [1]

(iii) The student decided to measure the conductivity of distilled water at the start of the experiment.

Suggest why.

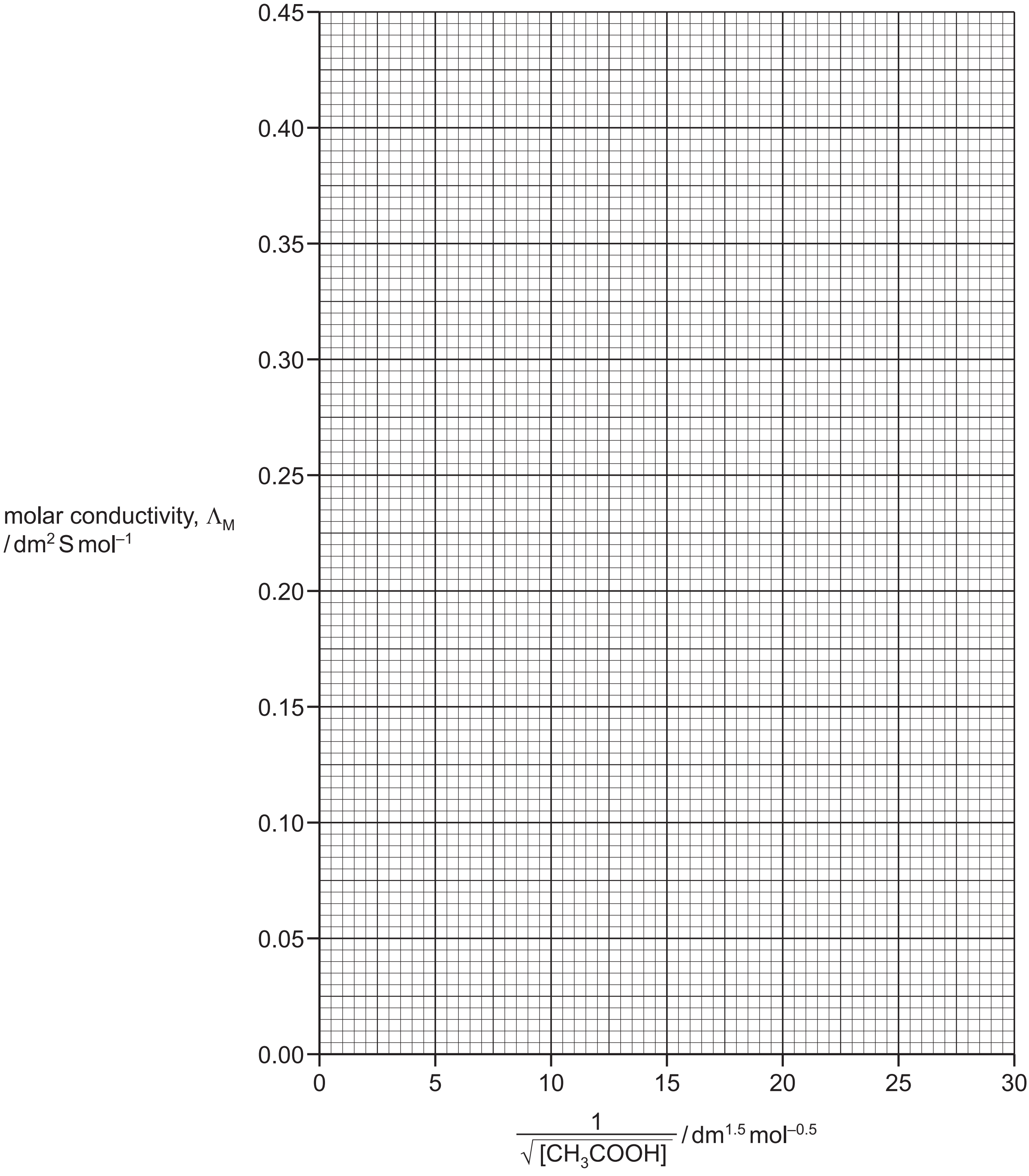
....

.... [1]

(iv) State **one** variable that should be controlled.

.... [1]

(d) Plot a graph on the grid to show the relationship between molar conductivity, Λ_M, and $\frac{1}{\sqrt{[CH_3COOH]}}$. Use a cross (×) to plot each data point. Draw a line of best fit that includes the origin.



[2]

(e) Circle **one** point on the graph that you consider to be most anomalous.

The conductivity meter was correctly functioning.

Suggest **one** reason why this anomaly may have occurred during this experimental procedure.

.... [2]

(f) The equation for the line of best fit is shown.

$$\Lambda_M = \frac{\Lambda_\infty \sqrt{K_a}}{\sqrt{[CH_3COOH]}}$$

$\Lambda_\infty = 3.91\,dm^2\,S\,mol^{-1}$

(i) Use your 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 selected from your line of best fit.

Give the gradient to **three** significant figures.

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

gradient = ... $dm^{0.5}\,S\,mol^{-0.5}$
[2]

(ii) Determine the acid dissociation constant, K_a, of ethanoic acid. Include units in your answer.

K_a = ...

units = ...
[2]

(g) The student repeats the experiment with propanoic acid. The numerical value of the K_a of propanoic acid is experimentally determined as 1.28×10^{-5}.

The theoretical numerical value is 1.34×10^{-5}.

Comment on the validity of the experimental result. Assume the maximum total percentage error from the measurements made is 6.5%.

....

....

.... [2]

[Total: 21]

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Important values, constants and standards

molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
Faraday constant	$F = 9.65 \times 10^{4}\,\mathrm{C\,mol^{-1}}$
Avogadro constant	$L = 6.022 \times 10^{23}\,\mathrm{mol^{-1}}$
electronic charge	$e = -1.60 \times 10^{-19}\,\mathrm{C}$
molar volume of gas	$V_m = 22.4\,\mathrm{dm^3\,mol^{-1}}$ at s.t.p. (101 kPa and 273 K) $V_m = 24.0\,\mathrm{dm^3\,mol^{-1}}$ at room conditions
ionic product of water	$K_w = 1.00 \times 10^{-14}\,\mathrm{mol^2\,dm^{-6}}$ (at 298 K (25 °C))
specific heat capacity of water	$c = 4.18\,\mathrm{kJ\,kg^{-1}\,K^{-1}}$ ($4.18\,\mathrm{J\,g^{-1}\,K^{-1}}$)

The Periodic Table of Elements

Key

atomic number
atomic symbol
name
relative atomic mass

Group 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
							1 H hydrogen 1.0										2 He helium 4.0
3 Li lithium 6.9	4 Be beryllium 9.0											5 B boron 10.8	6 C carbon 12.0	7 N nitrogen 14.0	8 O oxygen 16.0	9 F fluorine 19.0	10 Ne neon 20.2
11 Na sodium 23.0	12 Mg magnesium 24.3											13 Al aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 Cl chlorine 35.5	18 Ar argon 39.9
19 K potassium 39.1	20 Ca calcium 40.1	21 Sc scandium 45.0	22 Ti titanium 47.9	23 V vanadium 50.9	24 Cr chromium 52.0	25 Mn manganese 54.9	26 Fe iron 55.8	27 Co cobalt 58.9	28 Ni nickel 58.7	29 Cu copper 63.5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9	36 Kr krypton 83.8
37 Rb rubidium 85.5	38 Sr strontium 87.6	39 Y yttrium 88.9	40 Zr zirconium 91.2	41 Nb niobium 92.9	42 Mo molybdenum 95.9	43 Tc technetium –	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3
55 Cs caesium 132.9	56 Ba barium 137.3	57–71 lanthanoids	72 Hf hafnium 178.5	73 Ta tantalum 180.9	74 W tungsten 183.8	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 197.0	80 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

lanthanoids	57 La lanthanum 138.9	58 Ce cerium 140.1	59 Pr praseodymium 140.9	60 Nd neodymium 144.4	61 Pm promethium –	62 Sm samarium 150.4	63 Eu europium 152.0	64 Gd gadolinium 157.3	65 Tb terbium 158.9	66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbium 173.1	71 Lu lutetium 175.0
actinoids	89 Ac actinium –	90 Th thorium 232.0	91 Pa protactinium 231.0	92 U uranium 238.0	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –