Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

5049102829

CHEMISTRY **9701/52**

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

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1 Eggshells contain a high percentage by mass of calcium carbonate, $CaCO_3$. A student wants to find out what percentage of an eggshell is calcium carbonate and uses the following method.

This method uses a known excess of acid to dissolve the eggshell. The amount of unreacted acid is then determined by titration with an alkali. Assume the acid only reacts with the $CaCO_3$ in the eggshell.

step 1 Wash an empty eggshell with distilled water.

step 2 Warm the eggshell in an oven for a few minutes until dry.

step 3 Grind the eggshell into a powder.

step 4 Weigh approximately 2 g of the eggshell powder into a conical flask using a balance which measures to three decimal places.

step 5 Add 100 cm^3 of 2.00 mol dm^{-3} hydrochloric acid to the conical flask.

step 6 Loosely cover the conical flask and leave for two days.

step 7 Filter the contents of the conical flask, with any rinsings, into a 250.0 cm^3 volumetric flask and top-up to the mark using distilled water.

step 8 Transfer 25.00 cm^3 of the solution prepared in **step 7** into a conical flask, add a few drops of thymol blue indicator and titrate against 1.00 mol dm^{-3} sodium hydroxide using a 50 cm^3 burette.

The calcium carbonate in the eggshell reacts with the excess hydrochloric acid as follows.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

The excess acid reacts with the sodium hydroxide solution as follows.

$$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$$

(a) **(i)** Suggest how the student could confirm the eggshell is completely dry in **step 2**.

....

.... [1]

(ii) State why the eggshell is made into a powder in **step 3** before making up the solution. Explain your answer.

....

.... [1]

(iii) Suggest why the solution is left for two days in **step 6** before being used.

....

.... [1]

(b) The student uses exactly 2.136 g of powdered eggshell and obtains the results shown in Table 1.1.

Table 1.1

titration number	rough	1	2	3
final burette reading / cm^3	16.55	32.85	16.10	32.30
initial burette reading / cm^3	0.00	16.55	0.10	16.10
titre / cm^3				

(i) Complete Table 1.1. Calculate the mean titre.

mean titre = ... cm^3 [2]

(ii) Calculate the amount, in mol, of unreacted $HCl(aq)$ in the solution prepared in **step 7**. Show your working.

hydrochloric acid = ... mol [2]

(iii) Calculate the amount, in mol, of $CaCO_3$ that reacts with the excess of acid. Use your answer to calculate the percentage by mass of $CaCO_3$ in the eggshell. Show your working.

percentage by mass of $CaCO_3$ = ... % [3]

(c) Name a suitable piece of apparatus which could be used to transfer 25.00 cm^3 of solution in **step 8**.

.... [1]

(d) In **step 4**, a conical flask is weighed using a balance accurate to three decimal places and the mass recorded. The eggshell is placed in the conical flask and the mass increases by 2.136 g.

Calculate the percentage error in measuring the mass of this eggshell.
Show your working.

percentage error = ... %
[1]

(e) State the effect on the percentage by mass if the eggshell is **not** completely dried in **step 2**. Explain your answer.

....

....

.... [1]

(f) The student repeats the method using the same apparatus, but decides to use 0.100 mol dm^{-3} NaOH(aq) to reduce the risk of corrosion or damage to eyes.

Explain how this introduces a weakness to the experimental procedure.

....

....

....

.... [1]

[Total: 14]

Question 2 starts on the next page.

2 It is possible to measure the rate at which potassium manganate(VII), $KMnO_4$(aq), M_r = 158, diffuses through a permeable gel using the following method.

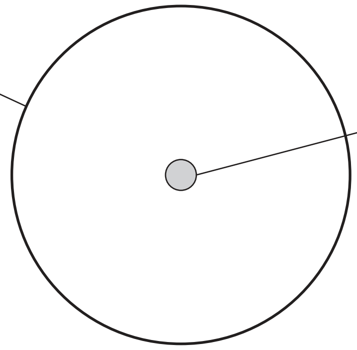


Fig. 2.1

step 1 A petri dish is prepared with a permeable gel.

step 2 A hole of diameter 0.5 cm is cut in the centre of the permeable gel.

step 3 A sample of $KMnO_4$(aq) is placed into the hole and at the same time a stopwatch is started.

step 4 After 3 minutes the diameter of the coloured spot is measured and recorded.

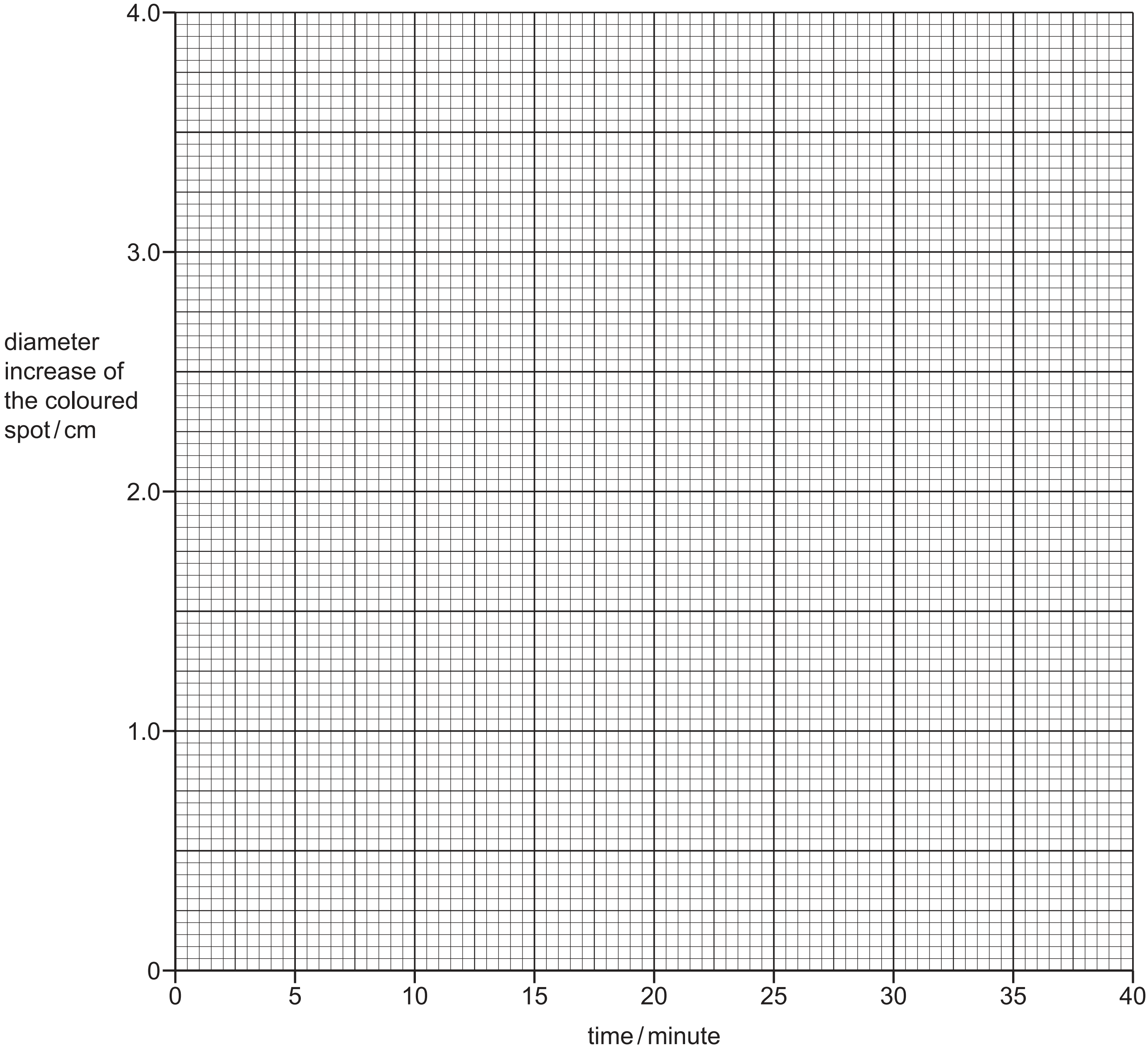
step 5 The diameter is measured every 3 minutes until there are three successive equal measurements.

A student obtained the results shown in Table 2.1.

Table 2.1

time / minute	diameter of the coloured spot / cm	diameter increase of the coloured spot / cm
0	0.5	0.0
3	1.1	0.6
6	1.7	1.2
9	2.3	1.8
12	2.7	2.2
15	3.1	2.6
18	3.2	2.7
21	3.7	3.2
24	3.9	3.4
27	4.0	3.5
30	4.1	3.6
33	4.1	3.6
36	4.1	3.6

(a) Plot a graph on the grid to show the relationship between diameter increase of the coloured spot and time. Use a cross (×) to plot each data point. Draw a line of best fit.



[2]

(b) **(i)** On the graph, circle the point which you believe to be the most anomalous. [1]

(ii) Suggest a possible explanation for this anomaly.

....

....

.... [1]

  [Turn over

(c) Draw a suitable tangent to the line at time = 15 minutes. Calculate the gradient of your tangent. State both sets of coordinates used in your calculation. The stated coordinates must be from your tangent. Give the gradient to three significant figures.

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

gradient = ... cm $minute^{-1}$

[3]

(d) Select appropriate data from Table 2.1 and calculate the average rate of diffusion of $KMnO_4(aq)$ in cm $minute^{-1}$.

average rate of diffusion of $KMnO_4$ = ... cm $minute^{-1}$ [1]

(e) Identify the independent variable in this experiment.

....

.... [1]

(f) Suggest how the experiment could be made to be more reliable.

....

.... [1]

(g) Another compound of potassium which is coloured is potassium dichromate(VI), $K_2Cr_2O_7$, M_r = 294. This compound is corrosive when aqueous. It is possible to use the method described earlier to determine the rate of diffusion of $K_2Cr_2O_7(aq)$.

(i) Predict how the graph obtained for $K_2Cr_2O_7(aq)$ would differ from that obtained for $KMnO_4(aq)$. Explain your answer.

....

....

.... [2]

(ii) Apart from temperature, state **one** variable which must be controlled when comparing the rate of diffusion of $K_2Cr_2O_7(aq)$ and $KMnO_4(aq)$.

....

.... [1]

(h) (i) Other than wearing eye protection, state **one** safety precaution the student should take if they were to use potassium dichromate(VI).

....

.... [1]

(ii) Another student suggests that to compare the rates of diffusion between $K_2Cr_2O_7$ and $KMnO_4$ it would be easier to place solid crystals of each of these compounds into the holes in two petri dishes of permeable gel.

Suggest **two** practical problems that this would cause.

1 ....

....

2 ....

....

[2]

[Total: 16]

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Important values, constants and standards

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

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 –