Candidate Name	Centre Number					Candidate Number				

A LEVEL CHEMISTRY

COMPONENT 3

Chemistry in Practice

SPECIMEN PAPER

1 hour 15 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**13**	
2.	**10**	
3.	**10**	
4.	**8**	
5.	**10**	
6.	**9**	
Total	**60**	

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a data sheet and a calculator.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen. Do not use correction fluid.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

You are reminded of the need for good English and orderly, clear presentation in your answers.

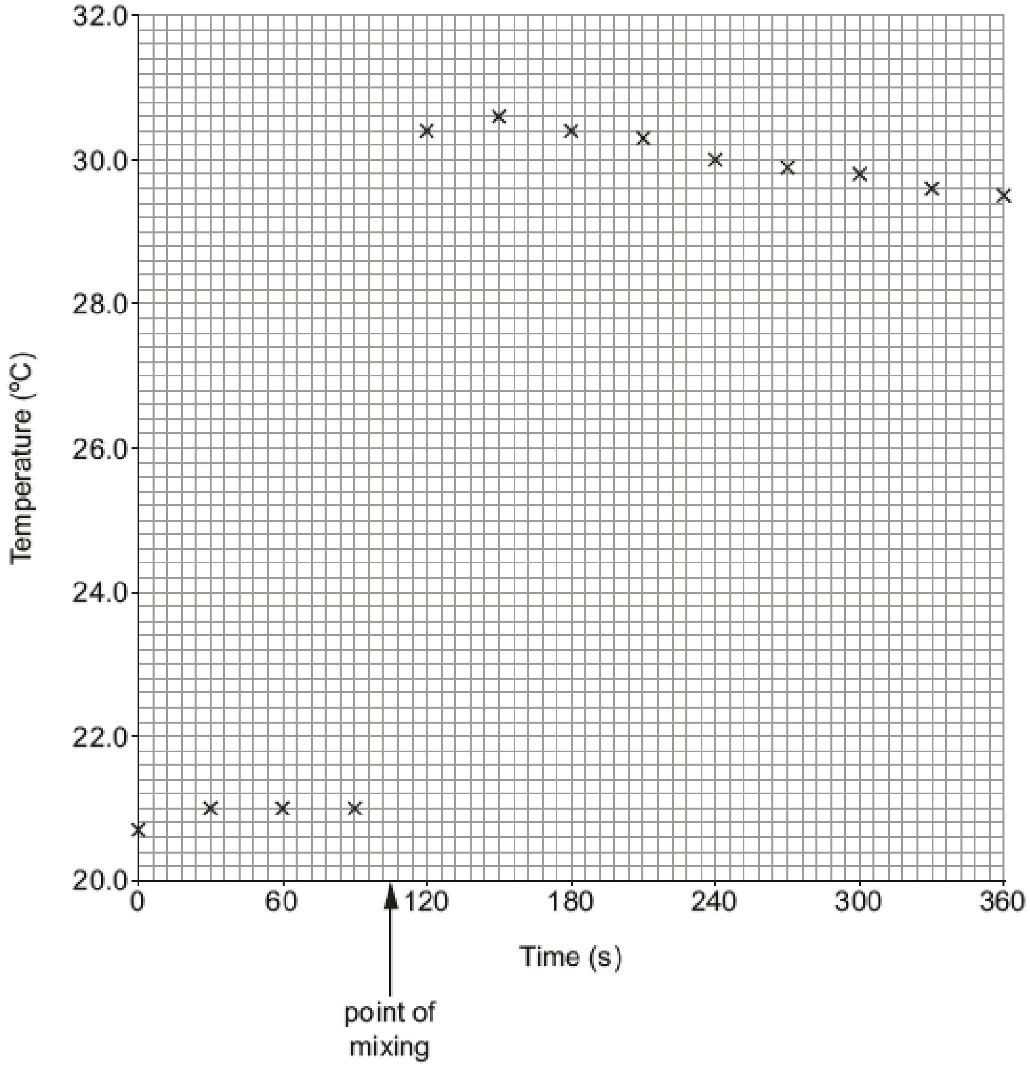
No certificate will be awarded to a candidate detected in any unfair practice during the examination.

Answer **all** *questions in the spaces provided.*

1. *(a)* Draw and label a diagram of a simple apparatus that could be used in an experiment to determine the enthalpy change of the reaction of zinc with aqueous copper(II) sulfate. The equation for the reaction is given.

$$Zn(s) + CuSO_4(aq) \rightarrow Cu(s) + ZnSO_4(aq)$$ [3]

(b) The results obtained in such an experiment have been plotted on the graph below.



(i) Determine the maximum temperature **change** by drawing lines to complete the graph. [3]

Maximum temperature change (ΔT) = ... °C

(ii) The experiment used 0.60 g of zinc (A_r = 65) and 50 cm^3 of aqueous copper(II) sulfate (an excess). Calculate the enthalpy change for this reaction in kJ mol^{-1}. Use your value for ΔT from part (i). You must show your working.

The specific heat capacity of an aqueous solution is 4.2 J g^{-1} °C^{-1}. Assume that 1.0 cm^3 of an aqueous solution has a mass of 1.0 g. [4]

Enthalpy change of reaction = ... kJ mol^{-1}

(c) (i) Explain what would be the effect on the reaction of using the same mass of zinc but as large lumps rather than zinc powder in this experiment. You should assume that all other conditions remain the same. [2]

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(ii) What effect would using larger lumps have on the graph in (*b*)? [1]

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2. A student wanted to determine the concentration of aqueous sulfuric acid by titrating it against a standard solution of sodium carbonate. The student used the following instructions.

- Dissolve approximately 2.5 g of anhydrous sodium carbonate in distilled water to give 250 cm^3 of solution.
- Rinse the burette with small volumes of acid and fill to just past the zero mark using a small funnel.
- Remove the funnel and adjust the acid in the burette so that it is exactly on the 0.00 cm^3 mark.
- Pipette 25.0 cm^3 of the sodium carbonate solution into a conical flask and add an indicator.
- Add the acid from the burette and, when the indicator shows signs of changing colour, wash the flask walls with water and continue the titration to the end-point.

(a) The student carried out a rough titration and three further accurate titrations.

Construct a results table which would be suitable to record his burette readings and titres. [2]

(b) State why the burette was rinsed with acid before filling and explain the possible effect on the titre if this was not done. [2]

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(c) The student used 2.52 g of Na_2CO_3 to make 250 cm^3 of solution. The mean titre of his three concordant results was 20.10 cm^3.

The equation for the reaction between sulfuric acid and sodium carbonate is as follows.

$$H_2SO_4(aq) + Na_2CO_3(aq) \rightarrow Na_2SO_4(aq) + CO_2(g) + H_2O(l)$$

(i) Use this information to calculate the concentration, in mol dm^{-3}, of the sulfuric acid. Record this value to the appropriate number of significant figures. [3]

Concentration = ... mol dm^{-3}

(ii) Calculate the maximum percentage error in the mean titre value and use this to justify the number of significant figures recorded in part (i). [3]

Maximum percentage error = ... %

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3. A student obtained the following results when measuring the initial rate of decomposition of aqueous hydrogen peroxide, as in the following equation.

$$H_2O_2(aq) \rightarrow H_2O(l) + \frac{1}{2}O_2(g)$$

Concentration of H_2O_2 (mol dm^{-3})	0.100	0.200	0.300	0.400	0.500
Rate (mol dm^{-3} s^{-1})	0.0511	0.0982	0.148	0.220	0.252

(a) (i) Briefly describe a method that could be used to study the rate of decomposition of hydrogen peroxide. [2]

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(ii) State the main factor that needs to remain constant in order to obtain valid results in this experiment. [1]

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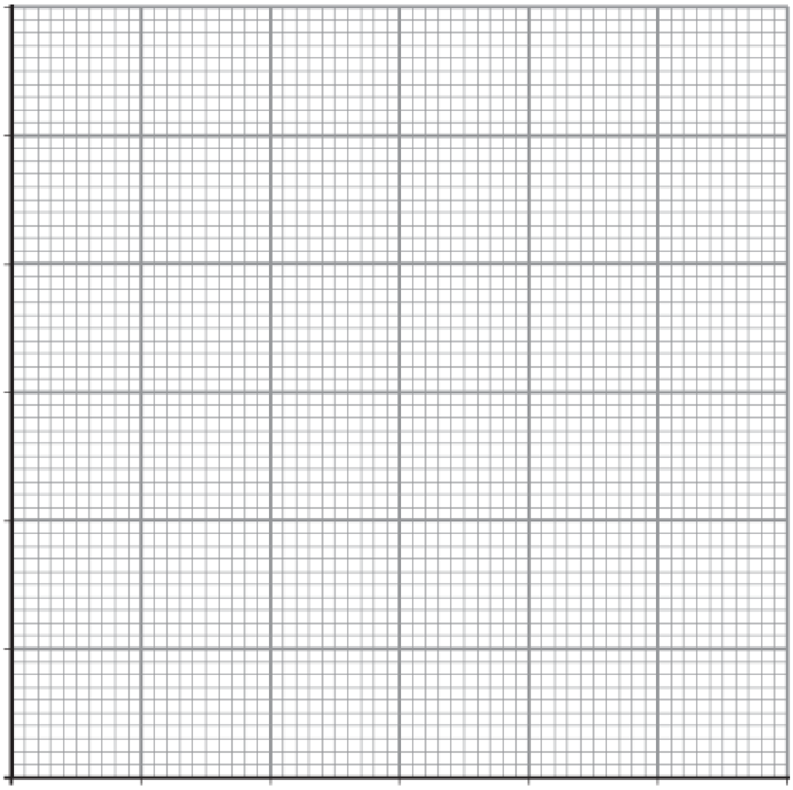
(b) Label the axes on the grid and plot the results from the table above. Draw the line of best fit.

[3]



(*c*) The reaction was catalysed by the iodide ions in a 0.103 mol dm^{-3} solution of potassium iodide. The rate equation for the reaction is as follows.

$$rate = k[H_2O_2]^x [I^-]$$

Use the graph to deduce the order with respect to hydrogen peroxide, *x*, and calculate the value of the rate constant, *k*, under these conditions. Give your answer to the appropriate number of significant figures and state the units.

[4]

k = ...

Units ....

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4. You are given the following five organic compounds in unlabelled bottles.

- 1-bromobutane
- butanone
- 1-chlorobutane
- pentan-3-one
- propanal

Plan a method to identify each compound using the fewest possible tests. All tests must be based on chemical reactions and not the physical properties of the compounds or any characteristic odours.

Your plan must include your tests, observations and conclusions. [8]

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5. Benzoic acid (C_6H_5COOH) is a solid that can be prepared from methylbenzene ($C_6H_5CH_3$) using an alkaline solution of potassium manganate(VII). In order to carry out this oxidation reaction the aqueous mixture needs to be heated for a prolonged period. After this oxidation reaction is complete, hydrochloric acid is added to the mixture to form the benzoic acid as an impure solid product.

(a) What practical technique would you use in the oxidation stage of this preparation? [1]

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(b) Complete the equations to show the reactions that occur in this preparation. You should use [O] to represent the oxidising agent. [2]

$C_6H_5CH_3$ + OH^- + ... → $C_6H_5COO^-$ + ...

$C_6H_5COO^-$ + ... → ....

(c) The solid benzoic acid can be purified by recrystallisation.
The solubility of benzoic acid in three solvents is given in the table.

Solubility of benzoic acid	Solvent **A**	Solvent **B**	Solvent **C**
in cold solvent	high	low	low
In hot solvent	high	high	low

(i) Select the appropriate solvent from the table and describe how you would carry out the recrystallisation to obtain a pure sample of benzoic acid. [6]

(Your ability to construct an extended response will be assessed in this question.)

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(ii) Describe what you would do to assess the purity of your recrystallised sample of benzoic acid. [1]

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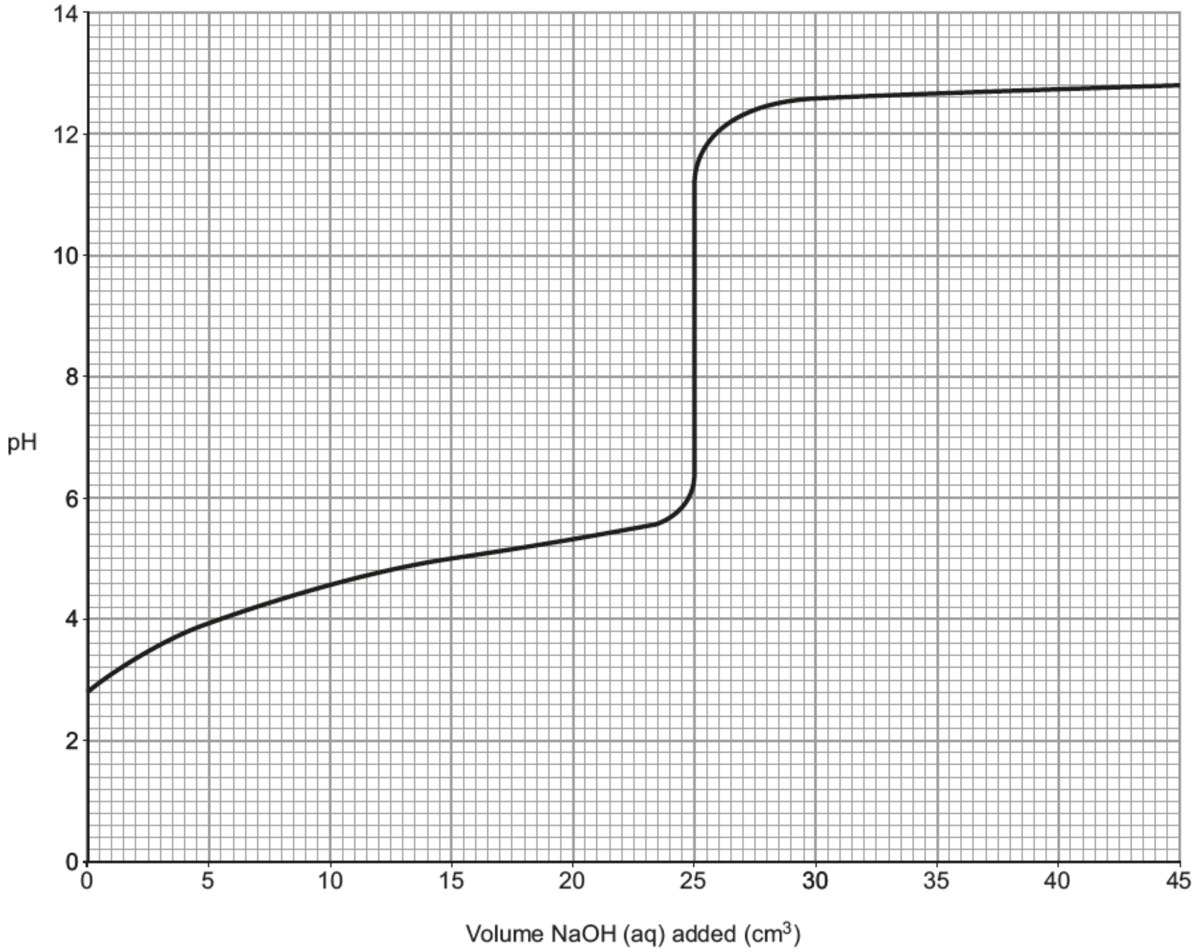
6. *(a)* The graph below shows the change in pH during a reaction between 0.10 mol dm^{-3} sodium hydroxide and 0.10 mol dm^{-3} ethanoic acid at room temperature.



Using the details included in the description and graph, describe the experiment that was carried out in order to plot the graph. [4]

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(b) A student wanted to carry out a titration to find the concentration of a sample of aqueous sodium hydroxide. He used a known volume of 0.1 mol dm^{-3} ethanoic acid and added the sodium hydroxide. The table shows the pH ranges and the colour changes of some indicators.

Indicator	pH range	Colour in acid	Colour in alkali
thymol blue	1.2 - 2.8	red	yellow
bromophenol blue	3.0 - 4.6	yellow	blue
bromocresol green	4.0 - 5.6	yellow	blue
cresol red	7.2 - 8.8	yellow	red

State which indicator the student should choose to obtain an accurate end-point in this titration. Explain your choice. [1]

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(c) Use data from the graph in part (*a*) to calculate the acid dissociation constant, K_a, of ethanoic acid at room temperature. [4]

K_a = ... mol dm^{-3}

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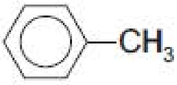
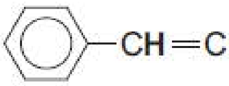
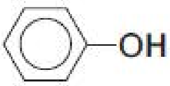
Data Booklet

Infrared absorption values

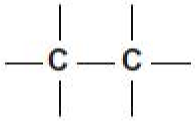
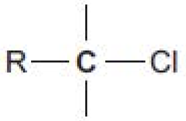
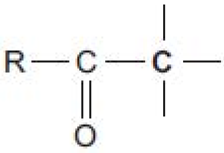
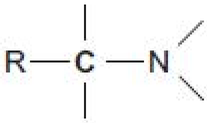
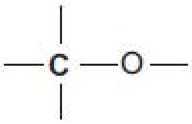
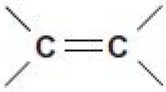
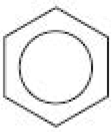
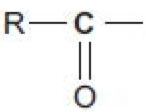
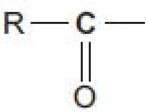
Bond	Wavenumber (cm^{-1})
C—Br	500 to 600
C—Cl	650 to 800
C—O	1000 to 1300
C=C	1620 to 1670
C=O	1650 to 1750
C≡N	2100 to 2250
C—H	2800 to 3100
O—H (carboxylic acid)	2500 to 3200 (very broad)
O—H (alcohol/ phenol)	3200 to 3550 (broad)
N—H	3300 to 3500

^1H NMR chemical shifts relative to TMS = 0

Type of proton	Chemical shift, δ (ppm)
$-CH_3$	0.1 to 2.0
$R-CH_3$	0.9
$R-CH_2-R$	1.3
$CH_3-C\equiv N$	2.0
$CH_3-C(=O)-$	2.0 to 2.5
$-CH_2-C(=O)-$	2.0 to 3.0
	2.2 to 2.3
$R-CH_2Cl$	3.3 to 4.3
$R-OH$	4.5 *
$-C=CH-CO$	5.8 to 6.5
	6.5 to 7.5
	7.0 *
$R-C(=O)H$	9.8 *
$R-C(=O)OH$	11.0 *

*variable figure dependent on concentration and solvent

^{13}C NMR chemical shifts relative to TMS = 0

Type of carbon	**Chemical shift, δ (ppm)**
	5 to 40
	10 to 70
	20 to 50
	25 to 60
	50 to 90
	90 to 150
	110 to 125
	110 to 160
 (carboxylic acid / ester)	160 to 185
 (aldehyde / ketone)	190 to 220

THE PERIODIC TABLE

Key

A_r — relative atomic mass
Symbol
Name
Z — atomic number

s Block: Groups 1–2; d Block: Sc–Zn; p Block: Groups 3–0; f Block: Lanthanoid and Actinoid elements

Period	Group 1	Group 2											Group 3	Group 4	Group 5	Group 6	Group 7	Group 0
1	1.01 H Hydrogen 1																	4.00 He Helium 2
2	6.94 Li Lithium 3	9.01 Be Beryllium 4											10.8 B Boron 5	12.0 C Carbon 6	14.0 N Nitrogen 7	16.0 O Oxygen 8	19.0 F Fluorine 9	20.2 Ne Neon 10
3	23.0 Na Sodium 11	24.3 Mg Magnesium 12											27.0 Al Aluminium 13	28.1 Si Silicon 14	31.0 P Phosphorus 15	32.1 S Sulfur 16	35.5 Cl Chlorine 17	40.0 Ar Argon 18
4	39.1 K Potassium 19	40.1 Ca Calcium 20	45.0 Sc Scandium 21	47.9 Ti Titanium 22	50.9 V Vanadium 23	52.0 Cr Chromium 24	54.9 Mn Manganese 25	55.8 Fe Iron 26	58.9 Co Cobalt 27	58.7 Ni Nickel 28	63.5 Cu Copper 29	65.4 Zn Zinc 30	69.7 Ga Gallium 31	72.6 Ge Germanium 32	74.9 As Arsenic 33	79.0 Se Selenium 34	79.9 Br Bromine 35	83.8 Kr Krypton 36
5	85.5 Rb Rubidium 37	87.6 Sr Strontium 38	88.9 Y Yttrium 39	91.2 Zr Zirconium 40	92.9 Nb Niobium 41	95.9 Mo Molybdenum 42	98.9 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
6	133 Cs Caesium 55	137 Ba Barium 56	139 La ▸ Lanthanum 57	179 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	(210) Po Polonium 84	(210) At Astatine 85	(222) Rn Radon 86
7	(223) Fr Francium 87	(226) Ra Radium 88	(227) Ac ▸▸ Actinium 89															

f Block														
▸ Lanthanoid elements	140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	(147) Pm Promethium 61	150 Sm Samarium 62	(153) Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	163 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
▸▸ Actinoid elements	232 Th Thorium 90	(231) Pa Protactinium 91	238 U Uranium 92	(237) Np Neptunium 93	(242) Pu Plutonium 94	(243) Am Americium 95	(247) Cm Curium 96	(245) Bk Berkelium 97	(251) Cf Californium 98	(254) Es Einsteinium 99	(253) Fm Fermium 100	(256) Md Mendelevium 101	(254) No Nobelium 102	(257) Lr Lawrencium 103