Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME			
CENTRE NUMBER		CANDIDATE NUMBER	

CHEMISTRY **9701/03**

Paper 3 Advanced Practical Skills **For Examination from 2016**

SPECIMEN PAPER

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Give details of the practical session and laboratory where appropriate in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.
Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.
Use of a Data Booklet is unnecessary.

Qualitative Analysis Notes are printed on pages 10 and 11.
A Periodic Table is printed on page 12.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Session
Laboratory

For Examiner's Use	
1	
2	
3	
Total	

This document consists of **12** printed pages.

CAMBRIDGE International Examinations

1 Rates of reaction can be investigated by observing the volume of gas evolved in a reaction over time. In this experiment the reaction will be between calcium carbonate, $CaCO_3$, in the form of small marble chips, and dilute hydrochloric acid, HC*l*. The equation for the reaction is given below.

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

FA 1 is approximately 1.0 g calcium carbonate, $CaCO_3$.
FA 2 is approximately 2 mol dm^{-3} hydrochloric acid, HC*l*.

(a) Method

Read through the whole method before starting any practical work.

- Fill the trough with water to a depth of about 8 cm.
- Fill the 250 cm^3 measuring cylinder **completely** with water. Hold a piece of paper towel firmly over the top, invert the measuring cylinder and place it under the water in the trough.
- Remove the paper towel and clamp the inverted measuring cylinder so the open end is just above the base of the trough.
- Use the 25 cm^3 measuring cylinder to transfer 15 cm^3 of **FA 2** into the conical flask.
- Check that the bung with delivery tube fits tightly in the neck of the conical flask and place the other end of the delivery tube under and in to the inverted large measuring cylinder. Remove the bung from the neck of the flask.
- Weigh the container with **FA 1** and record the mass in the space below.
- Tip all of **FA 1** into the conical flask, replace the bung immediately and start the stop clock as soon as possible. Swirl the flask to mix the contents.
- Record the volume of gas in the measuring cylinder every minute for 10 minutes in the table below. **Do not remove the bung.**
- Reweigh the empty container and record the mass and the mass of **FA 1** used in the space below.

Results

Mass

Gas volumes

time / minutes	gas volume / cm^3
1	
2	
3	
4	
5	

time / minutes	gas volume / cm^3
6	
7	
8	
9	
10	

[3]

(b) **(i)** Plot a graph of volume of gas against time.

[2]

(ii) Draw a line of best fit through the points. Circle or label any points you consider anomalous. [1]

(iii) The rate of reaction at any point may be determined by calculating the gradient of the tangent to the curve at that point. Select a point on your graph, draw the tangent and calculate its gradient. Show your working.

rate of reaction at the point selected = ... cm^3 $minute^{-1}$ [2]

(iv) What can be deduced about changes in the rate of reaction as the reaction progresses from the shape of the line of best fit? Explain fully how **one** factor causes this change in the rate.

....

....

.... [3]

(c) A student carrying out this experiment stated there were too many inaccuracies in the experimental procedure for numerical values of the rate of reaction to be valid.

Suggest and explain the effect of **one** inaccuracy which occurred in the method you were instructed to carry out in **(a)**. Suggest how to improve the method to eliminate or reduce this inaccuracy.

inaccuracy ....

....

....

improvement ....

....

.... [2]

[Total: 13]

Question 2 begins on the next page.

2 The exact concentration of the hydrochloric acid used in **Question 1** may be found by titration using a solution of an alkali such as sodium hydroxide. You will dilute the acid and then titrate the diluted solution against sodium hydroxide of known concentration.

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

FA 2 is approximately 2 mol dm^{-3} hydrochloric acid, HCl
FA 3 is 0.100 mol dm^{-3} sodium hydroxide, NaOH
methyl orange indicator

(a) Method

(i) Dilution of the acid

- Fill the burette with undiluted hydrochloric acid, **FA 2**.
- Run between 9 and 12 cm^3 of **FA 2** into the 250 cm^3 volumetric (graduated) flask. Record your burette readings and the exact volume of **FA 2** used in the space below.

The volume of **FA 2** used is .... cm^3. [1]

- Add distilled water to the volumetric flask to make the total volume 250 cm^3.
- Stopper the flask and mix the contents thoroughly.
- This diluted hydrochloric acid is **FA 4**.

(ii) Titration

- Rinse the burette then fill it with **FA 4**.
- Pipette 25.0 cm^3 of **FA 3** into a conical flask.
- Add about 3 drops of methyl orange indicator.
- Perform a rough titration and record your burette readings in the space below.

The rough titre is .... cm^3.

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Make certain any recorded results show the precision of your practical work.
- Record, in a suitable form below, all of your burette readings and the volume of **FA 4** added in each accurate titration.

[8]

(b) From your accurate titration results, obtain a suitable value to be used in your calculations. Show clearly how you obtained this result.

25.0 cm^3 of FA 3 required .... cm^3 of FA 4. [1]

(c) Calculation

Show your working and appropriate significant figures in the final answer to **each** step of your calculations.

(i) Calculate the number of moles of sodium hydroxide in 25.0 cm^3 of **FA 3**.

moles of NaOH = ... mol

Hence calculate the number of moles of hydrochloric acid present in the volume of **FA 4** in **(b)**.

moles of HCl in **(b)** = ... mol [1]

(ii) Use your answer to **(i)** to calculate the number of moles of hydrochloric acid present in the 250 cm^3 volumetric flask.

moles of HCl in the 250 cm^3 volumetric flask = ... mol [1]

(iii) Use your answer to **(ii)** and the volume of **FA 2** diluted in **(a)** to calculate the concentration, in mol dm^{-3}, of hydrochloric acid in **FA 2**.

concentration of hydrochloric acid in **FA 2** = ... mol dm^{-3} [1]

(iv) Make sure your answers to **(c)(i)** to **(c)(iii)** are given to an appropriate number of significant figures. [1]

[Total: 14]

3 Qualitative analysis

At each stage of any test you are to record details of the following.

- colour changes seen
- the formation of any precipitate
- the solubility of such precipitates in an excess of the reagent added

Where gases are released they should be identified by a test, **described in the appropriate place in your observations**.

You should indicate clearly at what stage in a test a change occurs.
Marks are **not** given for chemical equations.
No additional tests for ions present should be attempted.

If any solution is warmed, a boiling tube MUST be used.

Rinse and reuse test-tubes and boiling tubes where possible.

Where reagents are selected for use in a test the full name or correct formula of the reagent must be given.

(a) You are provided with solution **FA 5**. **FA 5** is an aqueous mixture of two salts and contains two cations and two anions. Carry out the following tests and complete the table below.

test	*observations*
To a 1 cm depth of **FA 5** in a test-tube, add aqueous sodium hydroxide.	
To a 1 cm depth of **FA 5** in a test-tube, add aqueous ammonia.	
To a 1 cm depth of **FA 5** in a test-tube, add a 2 cm depth of dilute sulfuric acid, shake, and leave for about 1 minute,	
then add aqueous potassium manganate(VII) drop by drop.	
To a 1 cm depth of **FA 5** in a test-tube, add a 1 cm depth of aqueous potassium iodide,	
followed by a few drops of starch indicator.	

[5]

(b) **FA 5** contains either or both a sulfate and/or a chloride. Select reagents and use them to carry out further tests on **FA 5** to positively identify which of these anions is present.

reagents .... and ....

Record your tests and all your observations in a suitable form in the space below.

[4]

(c) Use your observations in **(a)** and **(b)** to suggest the identities of as many ions present in **FA 5** as possible. Give reasons for your deductions for one cation and one anion.

possible cation(s) ....

reasons(s) ....

....

possible anion(s) ....

reasons(s) ....

.... [4]

[Total: 13]

Qualitative Analysis Notes

Key: [ppt. = precipitate]

1 Reactions of aqueous cations

ion	*reaction with*	
	NaOH(aq)	NH_3(aq)
aluminium, Al^{3+}(aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH_4^+(aq)	no ppt. ammonia produced on heating	–
barium, Ba^{2+}(aq)	no ppt. (if reagents are pure)	no ppt.
calcium, Ca^{2+}(aq)	white ppt. with high [Ca^{2+}(aq)]	no ppt.
chromium(III), Cr^{3+}(aq)	grey-green ppt. soluble in excess giving dark green solution	grey-green ppt. insoluble in excess
copper(II), Cu^{2+}(aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe^{2+}(aq)	green ppt. turning brown on contact with air insoluble in excess	green ppt. turning brown on contact with air insoluble in excess
iron(III), Fe^{3+}(aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
magnesium, Mg^{2+}(aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn^{2+}(aq)	off-white ppt. rapidly turning brown on contact with air insoluble in excess	off-white ppt. rapidly turning brown on contact with air insoluble in excess
zinc, Zn^{2+}(aq)	white ppt. soluble in excess	white ppt. soluble in excess

2 Reactions of anions

ion	*reaction*
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, $Cl^-(aq)$	gives white ppt. with $Ag^+(aq)$ (soluble in $NH_3(aq)$)
bromide, $Br^-(aq)$	gives cream ppt. with $Ag^+(aq)$ (partially soluble in $NH_3(aq)$)
iodide, $I^-(aq)$	gives yellow ppt. with $Ag^+(aq)$ (insoluble in $NH_3(aq)$)
nitrate, $NO_3^-(aq)$	NH_3 liberated on heating with $OH^-(aq)$ and Al foil
nitrite, $NO_2^-(aq)$	NH_3 liberated on heating with $OH^-(aq)$ and Al foil; NO liberated by dilute acids (colourless NO $\rightarrow$ (pale) brown NO_2 in air)
sulfate, $SO_4^{2-}(aq)$	gives white ppt. with $Ba^{2+}(aq)$ (insoluble in excess dilute strong acids)
sulfite, $SO_3^{2-}(aq)$	SO_2 liberated on warming with dilute acids; gives white ppt. with $Ba^{2+}(aq)$ (soluble in excess dilute strong acids)

3 Tests for gases

gas	*test and test result*
ammonia, NH_3	turns damp red litmus paper blue
carbon dioxide, CO_2	gives a white ppt. with limewater (ppt. dissolves with excess CO_2)
chlorine, Cl_2	bleaches damp litmus paper
hydrogen, H_2	“pops” with a lighted splint
oxygen, O_2	relights a glowing splint
sulfur dioxide, SO_2	turns acidified aqueous potassium manganate(VII) from purple to colourless

The Periodic Table of the Elements

Key

atomic number
atomic symbol
name
relative atomic mass

Group

1	2											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	3	4	5	6	7	8	9	10	11	12	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 –		114 Fl flerovium –		116 Lv livermorium –		

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 –