Surname		Other Names	
Centre Number		Candidate Number	
Candidate Signature			

For Examiner's Use

General Certificate of Education
June 2008
Advanced Subsidiary Examination

CHEMISTRY **CHM3/P**
Unit 3(b) Practical Examination

Monday 12 May 2008 1.00 pm to 3.00 pm

For this paper you must have
- a calculator.

Time allowed: 2 hours

For Examiner's Use			
Number	Mark	Number	Mark
Skill 1			
Skill 2			
Skill 3			
Skill 4			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

Instructions

- Use blue or black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Carry out **all three** exercises.
- Answer **all** questions.
- Answer questions in the spaces provided. All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Take careful note of all the instructions given in each exercise.
- The Periodic Table/Data Sheet is provided on pages 3 and 4. Detach this perforated sheet at the start of the examination.

Information

- You must **not** use note books and laboratory books.
- The maximum mark for this paper is 30.
- The skills which are being assessed are
  Skill 1 Planning (8 marks)
  Skill 2 Implementing (8 marks)
  Skill 3 Analysing (8 marks)
  Skill 4 Evaluating (6 marks)
- You will be assessed on your ability to use an appropriate form and style of writing, to organise relevant information clearly and coherently, and to use specialist vocabulary, where appropriate.

Advice

- You are advised to spend about 40 minutes on each of the three exercises.
- You are advised to carry out Exercise 1 first.

This paper consists of the following.

Exercise 1	**Implementing and Analysing**	Titration of a sample of hydrochloric acid
Exercise 2	**Analysing and Evaluating**	Determination of the identity of a sample of sodium carbonate
Exercise 3	**Planning**	Determination of an enthalpy change for a metal displacement reaction.

An essential part of any practical work is to plan for the most efficient use of the time available. There is enough time to complete the exercises set provided that a sensible approach is used.

You are advised to spend approximately

40 minutes on Exercise 1
40 minutes on Exercise 2
40 minutes on Exercise 3

The Periodic Table of the Elements

■ The atomic numbers and approximate relative atomic masses shown in the table are for use in the examination unless stated otherwise in an individual question.

Key

relative atomic mass —— 6.9 **Li** Lithium
atomic number —— 3

I	II											III	IV	V	VI	VII	0
1.0 **H** Hydrogen 1																	4.0 **He** Helium 2
6.9 **Li** Lithium 3	9.0 **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
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** Sulphur 16	35.5 **Cl** Chlorine 17	39.9 **Ar** Argon 18
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
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	101.1 **Ru** Ruthenium 44	102.9 **Rh** Rhodium 45	106.4 **Pd** Palladium 46	107.9 **Ag** Silver 47	112.4 **Cd** Cadmium 48	114.8 **In** Indium 49	118.7 **Sn** Tin 50	121.8 **Sb** Antimony 51	127.6 **Te** Tellurium 52	126.9 **I** Iodine 53	131.3 **Xe** Xenon 54
132.9 **Cs** Caesium 55	137.3 **Ba** Barium 56	138.9 **La** Lanthanum 57 *	178.5 **Hf** Hafnium 72	180.9 **Ta** Tantalum 73	183.9 **W** Tungsten 74	186.2 **Re** Rhenium 75	190.2 **Os** Osmium 76	192.2 **Ir** Iridium 77	195.1 **Pt** Platinum 78	197.0 **Au** Gold 79	200.6 **Hg** Mercury 80	204.4 **Tl** Thallium 81	207.2 **Pb** Lead 82	209.0 **Bi** Bismuth 83	210.0 **Po** Polonium 84	210.0 **At** Astatine 85	222.0 **Rn** Radon 86
223.0 **Fr** Francium 87	226.0 **Ra** Radium 88	227 **Ac** Actinium 89 †															

* **58 – 71** Lanthanides	140.1 **Ce** Cerium 58	140.9 **Pr** Praseodymium 59	144.2 **Nd** Neodymium 60	144.9 **Pm** Promethium 61	150.4 **Sm** Samarium 62	152.0 **Eu** Europium 63	157.3 **Gd** Gadolinium 64	158.9 **Tb** Terbium 65	162.5 **Dy** Dysprosium 66	164.9 **Ho** Holmium 67	167.3 **Er** Erbium 68	168.9 **Tm** Thulium 69	173.0 **Yb** Ytterbium 70	175.0 **Lu** Lutetium 71
† **90 – 103** Actinides	232.0 **Th** Thorium 90	231.0 **Pa** Protactinium 91	238.0 **U** Uranium 92	237.0 **Np** Neptunium 93	239.1 **Pu** Plutonium 94	243.1 **Am** Americium 95	247.1 **Cm** Curium 96	247.1 **Bk** Berkelium 97	252.1 **Cf** Californium 98	(252) **Es** Einsteinium 99	(257) **Fm** Fermium 100	(258) **Md** Mendelevium 101	(259) **No** Nobelium 102	(260) **Lr** Lawrencium 103

Gas constant $R = 8.31\ J\ K^{-1}\ mol^{-1}$

Table 1
Proton n.m.r chemical shift data

Type of proton	**δ/ppm**
RCH_3	0.7–1.2
R_2CH_2	1.2–1.4
R_3CH	1.4–1.6
$RCOCH_3$	2.1–2.6
$ROCH_3$	3.1–3.9
$RCOOCH_3$	3.7–4.1
ROH	0.5–5.0

Table 2
Infra-red absorption data

Bond	**Wavenumber/cm^{-1}**
C—H	2850–3300
C—C	750–1100
C=C	1620–1680
C=O	1680–1750
C—O	1000–1300
O—H (alcohols)	3230–3550
O—H (acids)	2500–3000

Exercise 1 Titration of a sample of hydrochloric acid

Skill assessed **Implementing** (8 marks)

Introduction

You are provided with a sample of hydrochloric acid of concentration approximately 1 mol dm^{-3}. You will prepare a diluted solution of the hydrochloric acid and then titrate this diluted acid with the 0.100 mol dm^{-3} solution of sodium hydroxide provided.

Wear eye protection at all times.
Assume that all solutions are toxic and corrosive.

Procedure

1 Rinse a pipette with the hydrochloric acid provided. Using this pipette and a pipette filler, transfer 25.0 cm^3 of the hydrochloric acid provided to a 250 cm^3 graduated volumetric flask and make the liquid level up to the mark with distilled or de-ionised water.
Have your solution in the volumetric flask checked by the supervisor before mixing.
Mix the contents of the flask thoroughly.

2 Rinse the burette with the **diluted** hydrochloric acid solution. Set up the burette and, using a funnel, fill it with the **diluted** hydrochloric acid solution. Record the initial burette reading in the table below.

3 Rinse a pipette with the sodium hydroxide solution provided. Using this pipette and a pipette filler, transfer 25.0 cm^3 of the sodium hydroxide solution to a clean 250 cm^3 conical flask.

4 Add 3 or 4 drops of phenolphthalein indicator to the conical flask.

5 Add the acid from the burette until the mixture in the conical flask just turns colourless. Record your final burette reading in the table below.

6 Rinse the conical flask with water and repeat the titration until you obtain **two** titres which are within 0.10 cm^3 of each other. (You should do no more than five titrations.)
Have one of your final burette readings checked by the supervisor.

7 Calculate and record the average titre.

Results

Final burette reading/cm^3					
Initial burette reading/cm^3					
Volume of hydrochloric acid used/cm^3					
Tick the titres to be used in calculating the average titre					

Average titre = ………………… cm^3

For Examiner's use only					
M		C		P	
T		A			

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Turn over ►

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Exercise 2 Determination of the identity of a sample of sodium carbonate

Skills assessed **Analysing** (8 marks) **and Evaluating** (6 marks)

Introduction

A sample of sodium carbonate was thought to be the monohydrate, $Na_2CO_3.H_2O$
A student was asked to confirm the identity of the sample by titration against hydrochloric acid.

The method chosen by the student involved rinsing a weighing bottle with pure water and then weighing 0.15 g of the carbonate into the bottle. The contents of the weighing bottle were then transferred to a conical flask by inverting the bottle over the flask and shaking the bottle. About $20\,cm^3$ of pure water were added to the conical flask.

The student filled a burette with $0.100\,mol\,dm^{-3}$ hydrochloric acid. The sample was titrated with the acid solution, using methyl orange indicator. The student then repeated the titration using further 0.15 g samples of the carbonate. The following results were obtained.

Titration number	1	2	3	4	5
Final burette reading / cm^3	23.20	22.80	45.70	22.75	29.50
Initial burette reading / cm^3	0.05	0.05	22.80	0.10	6.80

Analysis **Full marks can only be scored in calculations if you show all of your working**.

1 Use all of the concordant results in the table above to determine an average titre.

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2 The equation for the reaction is shown below.

$$Na_2CO_3 + 2HCl \longrightarrow 2NaCl + CO_2 + H_2O$$

Use the average titre to calculate the number of moles of sodium carbonate present in 0.15 g of the sample.

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3 Use your result from part 2 to determine the relative formula mass, M_r, of the sodium carbonate in the sample.

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4 Use your result from part 3 to determine the number of moles of water of crystallisation combined with one mole of sodium carbonate.

(If you could not complete the calculation in part 3 of the Analysis section, you should assume that the experimental M_r value is 130.0. This is not the correct answer.)

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5 For the balance and the burette, the maximum total errors are shown below. These errors take into account multiple measurements.

balance total error	± 0.01 g
burette total error	± 0.15 cm^3

Estimate the maximum percentage error in using these pieces of apparatus, and hence estimate their combined error.
You should use the average titre to estimate the percentage error in using the burette.

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Evaluation **Full marks can only be scored in calculations if you show all of your working**.

1 Comment on the consistency of the titres. Suggest one possible reason for an anomalous result.

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2 Calculate the difference between the experimental M_r value determined by the student and the actual M_r value of $Na_2CO_3.H_2O$
Express this difference as a percentage of the actual M_r value of $Na_2CO_3.H_2O$ and comment on the significance of this percentage. You should assume that the difference is not due to impurities.

(If you could not complete the calculation in part 3 of the Analysis section, you should assume that the experimental M_r value is 130.0. This is not the correct answer.)

Difference ....

Percentage ....

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Comment ....

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3 State **two** ways of improving the student's method of weighing the sodium carbonate. In each case explain why the accuracy of the experiment would be improved.

Improvement 1 ....

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Explanation ....

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Improvement 2 ....

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Explanation ....

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Exercise 3 Determination of an enthalpy change for a metal displacement reaction

Skill assessed **Planning** (8 marks)

Zinc reacts with aqueous copper(II) sulphate as shown by the following equation

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

The reaction is exothermic. Using an excess of powdered zinc the reaction takes a few minutes to go to completion.

Assume that zinc, copper and all of their compounds are toxic.

Question

Using the information above, describe how you would determine the enthalpy change of the reaction between zinc and copper(II) sulphate. Assume that you have access to a 0.200 $mol\,dm^{-3}$ solution of copper(II) sulphate.

Your answer must include

1 The volume of copper(II) sulphate solution to be used.

2 A suitable mass of zinc to be used, and your reasons for choosing this mass.

3 A description of the experiment you would perform. Include details of the apparatus you would use and the precautions you would take to minimise heat loss. A diagram is not essential but may help your answer.

4 An explanation, including a sketch graph of temperature against time, showing how you would use your results to determine an accurate temperature rise.

5 An explanation showing how you would use the results of your experiment to calculate the enthalpy change, in $kJ\,mol^{-1}$, of the reaction between zinc and copper(II) sulphate.

6 Details of the potential hazards, and the relevant safety precautions you would take.

END OF QUESTIONS

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