Surname		Other Names	
Centre Number			Candidate Number									
Candidate Signature												

For Examiner's Use

General Certificate of Education
June 2007
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

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

Tuesday 15 May 2007 1.30 pm to 3.30 pm

For this paper you must have
- a calculator.

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			

Time allowed: 2 hours

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 molar enthalpy change for the reaction between an acid, HA, and potassium hydroxide solution
Exercise 3	**Planning**	Determination of the number of molecules of water of crystallisation in hydrated barium chloride.

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.

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 †															

Key

relative atomic mass — 6.9 **Li** Lithium

atomic number — 3

*	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
†	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

* **58 – 71** Lanthanides

† **90 – 103** Actinides

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 0.1 mol dm^{-3}. Titrate the hydrochloric 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 the burette with the sodium hydroxide solution provided. Set up the burette and, using a funnel, fill it with the sodium hydroxide. Record the initial burette reading in the table below.

2 Rinse a pipette with the hydrochloric acid provided. Using this pipette and a pipette filler, transfer 25.0 cm^3 of the hydrochloric acid to a 250 cm^3 conical flask.

3 Add 3 or 4 drops of **phenolphthalein** indicator to the conical flask. During this titration, the indicator changes from **colourless** in acid solution to **pink** in alkaline solution. The end-point has been reached when the solution just turns pink.

4 Add the sodium hydroxide from the burette until the mixture in the conical flask just changes colour. Record your final burette reading in the table below.

5 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 your supervisor.

6 Calculate and record the average titre.

Results

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

Average titre = ... cm^3

8

For Examiner's use only					
M		C		P	
T		A			

Exercise 2 Determination of the molar enthalpy change for the reaction between an acid, HA, and potassium hydroxide solution

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

Introduction

An acid, HA, reacts with potassium hydroxide as shown by the following equation.

$$HA(aq) + KOH(aq) \longrightarrow KA(aq) + H_2O(l)$$

Using a measuring cylinder, a student measured out 50 cm^3 of a 0.950 mol dm^{-3} solution of the acid. This solution was set aside for later use.

Using a second measuring cylinder, the student measured out 50 cm^3 of a 1.00 mol dm^{-3} solution of potassium hydroxide and transferred it to a plastic cup. This cup was placed in a beaker to provide insulation and support.

A thermometer was mounted in the cup using a clamp and stand. The bulb of the thermometer was fully immersed in the liquid.

The student recorded the temperature of the liquid in the cup every minute, stirring the liquid before reading the temperature.

At the fourth minute the student added the 50 cm^3 of acid, but did not record the temperature. The student stirred the mixture thoroughly, then recorded the temperature at the fifth minute.

The student continued stirring and recording the temperature every minute for five more minutes.

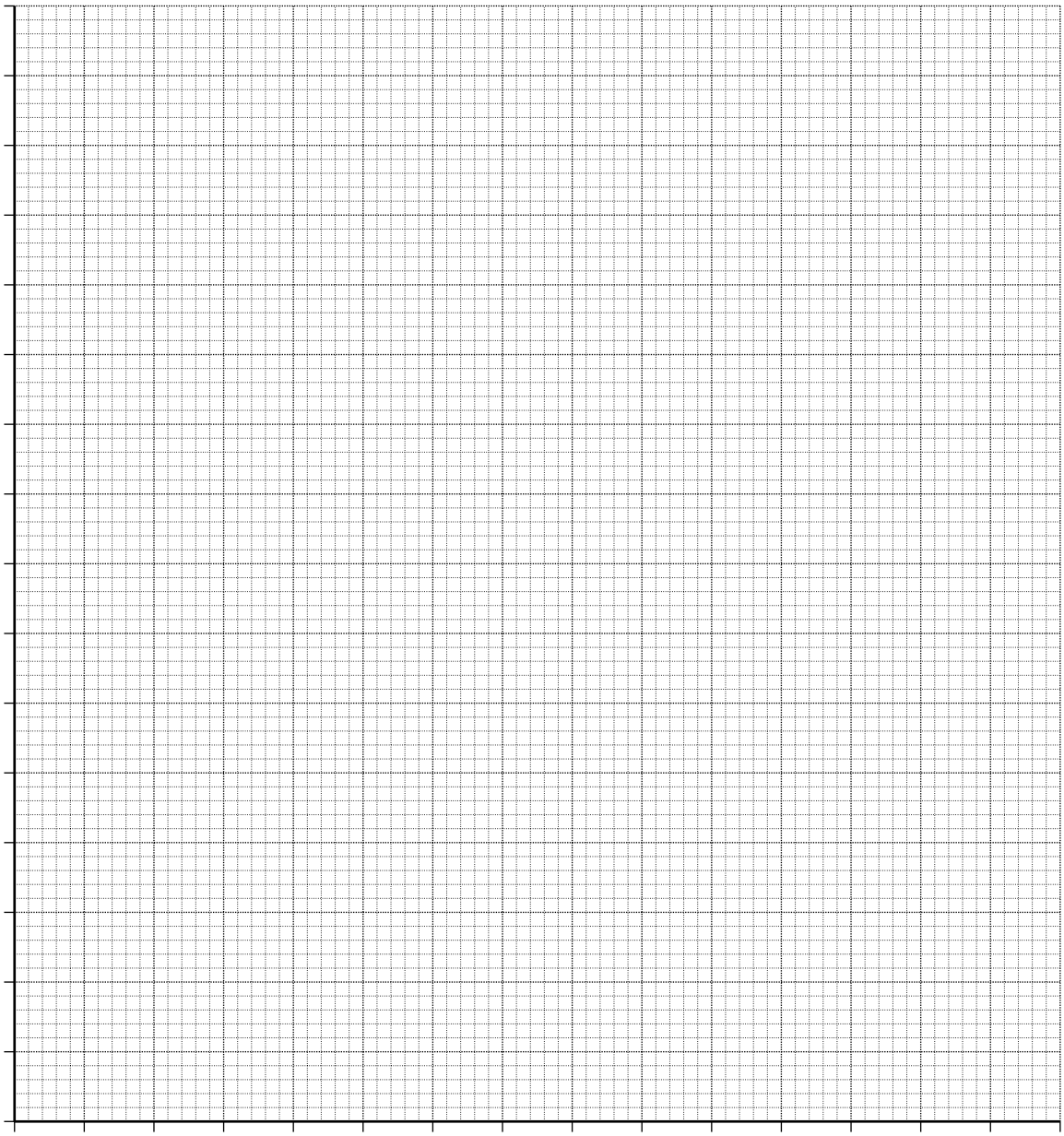
The student's results are shown below.

Time / minutes	1	2	3	4	5	6	7	8	9	10
Temperature / °C	18.9	18.9	18.9	-	24.5	24.2	24.3	23.6	23.3	23.0

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

1 Plot a graph of temperature (*y*-axis) against time on the grid below. Draw a line of best fit for the points before the fourth minute. Draw a second line of best fit for the points after the fourth minute. Extrapolate both lines to the fourth minute. Use the lines to determine the temperature rise at the fourth minute.

Temperature rise at the fourth minute ..... °C



2 Use this temperature rise to calculate the heat given out during this experiment. Assume that the solution has a density of $1.00\,g\,cm^{-3}$ and a specific heat capacity of $4.18\,J\,K^{-1}\,g^{-1}$.

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3 Calculate the number of moles of HA present in the $50\,cm^3$ of $0.950\,mol\,dm^{-3}$ solution. Hence, calculate the molar enthalpy change of neutralisation for the acid.

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4 For the measuring cylinder and the thermometer, the maximum total errors are shown below. These errors take into account multiple measurements.

$50\,cm^3$ measuring cylinder	$\pm\ 1.0\,cm^3$
thermometer	$\pm\ 0.1\,°C$

Estimate the maximum percentage error in using these pieces of apparatus and, hence, estimate their combined error.
You should use the temperature rise from your graph to estimate the percentage error in using the thermometer.

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

1 Consider your graph and comment on the results obtained by the student. Explain why your lines of best fit are good enough for you to extrapolate with confidence. Identify any anomalous results.

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2 A data book value for the molar enthalpy change for this reaction is $-55.0\,kJ\,mol^{-1}$. Calculate the difference between your answer in part 3 of the Analysis and this data book value. Express this difference as a percentage of the data book value.

(If you could not complete the calculation in part 3 of the Analysis section, you should assume that the student's enthalpy change is $-48.5\,kJ\,mol^{-1}$. This is not the correct value.)

Difference .....

Percentage .....

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3 Identify the main source of error in this experiment. Suggest **one** improvement to minimise this main source of error.

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4 Identify **one** other source of error in this experiment. Do not include apparatus errors. Suggest **one** improvement to minimise this other source of error.

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Exercise 3 Determination of the number of molecules of water of crystallisation in hydrated barium chloride

Skill assessed **Planning** (8 marks)

Hydrated barium chloride crystals contain water of crystallisation. Heating removes all of the water from the crystals.

$$BaCl_2.2H_2O(s) \longrightarrow BaCl_2(s) + 2H_2O(g)$$

Barium compounds are toxic.

You are provided with a sample of hydrated barium chloride. Assume that you have access to a balance which can be read to two decimal places. Use the information above to complete the following tasks.

1 Calculate the relative formula mass, M_r, of $BaCl_2.2H_2O$ and of $BaCl_2$

2 Suggest a suitable mass of hydrated barium chloride to be used. State your reasons for choosing this mass. Explain why using either a very large or a very small mass of hydrated barium chloride could lead to an inaccurate result.

3 Describe the apparatus you would use, and give a detailed description of the measurements you would make. You may draw a diagram, if you wish, to help to illustrate your description.

4 Show how you would use the measurements to confirm that the formula of hydrated barium chloride is $BaCl_2.2H_2O$

5 Describe briefly the potential hazards of this experiment. State the relevant safety precautions you would take.

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END OF QUESTIONS

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