Centre Number						Candidate Number				
Surname						Other Names				

Notice to Candidate. The work you submit for assessment must be your own. If you copy from someone else or allow another candidate to copy from you or if you cheat in any other way, you may be disqualified.

Candidate Declaration. I have read and understood the Notice to Candidate and can confirm that I have produced the attached work without assistance other than that which is acceptable under the scheme of assessment.

Candidate Signature		Date	

For Teacher's Use	
Section	Mark
PSA	
Task	
Section A	
Section B	
TOTAL ISA MARK (max 50)	

General Certificate of Education
Advanced Subsidiary Examination
June 2011

Chemistry CHM3T/P11/test

Unit 3T AS Investigative Skills Assignment

For submission by 15 May 2011

For this paper you must have:
- the Periodic Table/Data Sheet provided at the end of this paper
- your Task Sheet and your Candidate Results Sheet
- a ruler with millimetre measurements
- a calculator.

Time allowed
- 1 hour

Instructions:
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the space provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 30.
- You will be marked on your ability to:
  – organise information clearly
  – use scientific terminology accurately.

Details of additional assistance (if any). Did the candidate receive any help or information in the production of this work? If you answer yes give the details below or on a separate page.

Yes ☐ No ☐

Teacher Declaration:
I confirm that the candidate's work was conducted under the conditions laid out by the specification. I have authenticated the candidate's work and am satisfied that to the best of my knowledge the work produced is solely that of the candidate.

Signature of teacher .... Date ....

Section A

These questions are about the task, the determination of the concentration of sulfuric(IV) acid (H_2SO_3) in a crater-lake solution.

You should use your Task Sheet and your Candidate Results Sheet to answer them.

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

1 Record the average titre from your Candidate Results Sheet.

Average titre ....

(1 mark)

2 The concentration of the sodium hydroxide solution used was 0.100 mol dm^{-3}. Calculate the amount, in moles, of NaOH in 25.0 cm^3 of this sodium hydroxide solution.

....

(1 mark)

3 The equation for the reaction between sulfuric(IV) acid and sodium hydroxide is shown below.

$$H_2SO_3 + 2NaOH \longrightarrow Na_2SO_3 + 2H_2O$$

Use your answers from Questions **1** and **2** and the equation above to calculate the concentration, in mol dm^{-3}, of sulfuric(IV) acid in solution **A**.
Give your answer to the appropriate precision.

....

....

....

....

....

(3 marks)

4 Solution **A** was a **diluted** sample of crater-lake solution. Solution **A** was prepared by transferring 50.0 cm^3 of the **original** crater-lake solution into a 250 cm^3 volumetric (graduated) flask. The flask was made up to the mark with distilled water.

Use your answer from Question **3** to calculate the concentration, in mol dm^{-3}, of sulfuric(IV) acid in the **original** crater-lake solution.

....

....

(1 mark)

5 Use data from the Periodic Table to calculate the M_r of sulfuric(IV) acid (H_2SO_3).
Give your answer to one decimal place.

....

(1 mark)

6 Use your answers from Questions **4** and **5** to calculate the concentration, in g dm^{-3}, of sulfuric(IV) acid in the **original** crater-lake solution.

....

....

(1 mark)

7 In the preparation of solution **A**, a 100 cm^3 measuring cylinder was used to transfer 50.0 cm^3 of the original crater-lake solution into the 250 cm^3 volumetric (graduated) flask. The maximum total errors are shown below.

Measuring cylinder	± 1.0 cm^3
Volumetric (graduated) flask	± 0.50 cm^3

7 (a) Estimate the maximum percentage error in using each of these pieces of apparatus.
Show your working.

Measuring cylinder ....

....

Volumetric (graduated) flask ....

....

(2 marks)

7 (b) Give **one** change you could make to reduce the percentage error in the preparation of solution **A**.

....

....

(1 mark)

8 When the **original** sample of crater-lake solution was collected it was immediately placed in a **sealed** container. Suggest why this method of storage is needed in order to determine an accurate concentration of sulfuric(IV) acid in the sample.

....

....

(1 mark)

Turn over ▶

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9 Suggest **one** reason why the concentration of acid in the crater-lake solution may be higher than the actual concentration of sulfuric(IV) acid in the crater-lake.

....

....

(1 mark)

13

Section B starts on page 6

Turn over for the next question

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Turn over ▶

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Section B

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

Introduction

A student investigated the acid content of a different crater-lake solution. The student used a 50.0 cm^3 burette to measure out different volumes of this crater-lake solution. Each volume of crater-lake solution was titrated with a 0.100 mol dm^{-3} sodium hydroxide solution. Each titration was repeated. The results are shown below.

Volume of crater-lake solution / cm^3		10.0	20.0	30.0	40.0	50.0
Volume of sodium hydroxide solution / cm^3	Experiment 1	5.85	17.00	20.00	26.50	32.45
	Experiment 2	6.15	13.00	19.90	26.50	32.55
Average titre / cm^3		6.00	15.00	19.95	26.50	32.50

10 (a) On the graph paper opposite, plot a graph of average titre (*y*-axis) against volume of crater-lake solution. Both axes must start at zero. *(3 marks)*

10 (b) Draw a line of best fit on the graph. *(1 mark)*

10 (c) Use the graph to determine the titre that the student would have obtained using a 25.0 cm^3 sample of crater-lake solution.

....
(1 mark)

10 (d) Excluding any anomalous points, which average titre value would you expect to be the least accurate value? Give **one** reason for your choice.

Least accurate average titre ....

Reason ....

....
(2 marks)

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Do not write outside the box

11 Another 100 cm^3 sample of crater-lake solution was reacted with an excess of powdered limestone. The gas produced was collected in a gas syringe. The equation for the reaction between the sulfuric(IV) acid in the crater-lake solution and the calcium carbonate in the powdered limestone is shown below.

$$H_2SO_3 + CaCO_3 \longrightarrow CaSO_3 + H_2O + CO_2$$

The volume of gas collected from the reaction of the sulfuric(IV) acid in 100 cm^3 of crater-lake solution with an excess of powdered limestone was 81.0 cm^3 at 298 K and 1.00×10^5 Pa.

11 (a) State the ideal gas equation.

....

(1 mark)

11 (b) Use the ideal gas equation to calculate the amount, in moles, of carbon dioxide formed.
Show your working.
(The gas constant R = 8.31 J K^{-1} mol^{-1})

....

....

....

....

(3 marks)

11 (c) Use the equation for the reaction and your answer from Question **11 (b)** to calculate the minimum mass of calcium carbonate needed to neutralise the sulfuric(IV) acid in 1.00 dm^3 of crater-lake solution.
Show your working.

(If you could not complete the calculation in Question **11 (b)** assume that the amount of carbon dioxide is 1.25×10^{-2} mol. This is **not** the correct value.)

....

....

....

....

(3 marks)

Do not write outside the box

11 (d) The percentage by mass of calcium carbonate in the powdered limestone was 95.0%. Calculate the minimum mass of this powdered limestone needed to neutralise the sulfuric(IV) acid in 1.00 dm^3 of this crater-lake solution.

....

....

(2 marks)

11 (e) Give **one** reason, other than cost, why limestone rather than solid sodium hydroxide is often used to neutralise acidity in lakes.

....

....

(1 mark)

17

END OF QUESTIONS

GCE Chemistry Data Sheet

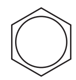
Table 1
Infrared absorption data

Bond	Wavenumber /cm^{-1}
N—H (amines)	3300–3500
O—H (alcohols)	3230–3550
C—H	2850–3300
O—H (acids)	2500–3000
C≡N	2220–2260
C=O	1680–1750
C=C	1620–1680
C—O	1000–1300
C—C	750–1100

Table 2
^{1}H n.m.r. chemical shift data

Type of proton	δ/ppm
RO**H**	0.5–5.0
RC**H**$_3$	0.7–1.2
RN**H**$_2$	1.0–4.5
R$_2$C**H**$_2$	1.2–1.4
R$_3$C**H**	1.4–1.6
R—C(=O)—C(—)(—)**H**	2.1–2.6
R—O—C(—)(—)**H**	3.1–3.9
RC**H**$_2$Cl or Br	3.1–4.2
R—C(=O)—O—C(—)(—)**H**	3.7–4.1
R(—)C=C(—)**H**	4.5–6.0
R—C(=O)—**H**	9.0–10.0
R—C(=O)—O—**H**	10.0–12.0

Table 3
^{13}C n.m.r. chemical shift data

Type of carbon	δ/ppm
—**C**—**C**—	5–40
R—**C**—Cl or Br	10–70
R—C(=O)—**C**—	20–50
R—**C**—N<	25–60
—**C**—O— alcohols, ethers or esters	50–90
>**C**=**C**<	90–150
R—**C**≡N	110–125
	110–160
R—**C**(=O)— esters or acids	160–185
R—**C**(=O)— aldehydes or ketones	190–220

The Periodic Table of the Elements

Key

relative atomic mass
symbol
name
atomic (proton) number

1	2											3	4	5	6	7	0
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*	*(13)*	*(14)*	*(15)*	*(16)*	*(17)*	*(18)*
							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** sulfur 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	96.0 **Mo** molybdenum 42	[98] **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	183.8 **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	[209] **Po** polonium 84	[210] **At** astatine 85	[222] **Rn** radon 86
[223] **Fr** francium 87	[226] **Ra** radium 88	[227] **Ac** † actinium 89	[267] **Rf** rutherfordium 104	[268] **Db** dubnium 105	[271] **Sg** seaborgium 106	[272] **Bh** bohrium 107	[270] **Hs** hassium 108	[276] **Mt** meitnerium 109	[281] **Ds** darmstadtium 110	[280] **Rg** roentgenium 111	Elements with atomic numbers 112-116 have been reported but not fully authenticated						

* **58 – 71** Lanthanides	140.1 **Ce** cerium 58	140.9 **Pr** praseodymium 59	144.2 **Nd** neodymium 60	[145] **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	173.1 **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] **Np** neptunium 93	[244] **Pu** plutonium 94	[243] **Am** americium 95	[247] **Cm** curium 96	[247] **Bk** berkelium 97	[251] **Cf** californium 98	[252] **Es** einsteinium 99	[257] **Fm** fermium 100	[258] **Md** mendelevium 101	[259] **No** nobelium 102	[262] **Lr** lawrencium 103