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 2013

Chemistry CHM3T/P13/test

Unit 3T AS Investigative Skills Assignment

Written Test

For submission by 15 May 2013

For this paper you must have:	**Time allowed**
• 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.	• 1 hour
Instructions	**Information**
• 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 spaces 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.	• The marks for questions are shown in brackets. • The maximum mark for this paper is 30. • You are expected to use a calculator, where appropriate. • 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 .....

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Do not write outside the box

Section A

These questions are about the task, an investigation of the water of crystallisation in washing soda.

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

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

1 Record the average titre from your Candidate Results Sheet.

.....

(1 mark)

2 The concentration of the hydrochloric acid used in the titration was 0.100 mol dm^{-3}.

Use your result from Question **1** to determine the amount, in moles, of hydrochloric acid in the average titre.

.....

.....

(1 mark)

3 The equation for the reaction in the titration is

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

Use this equation and your answer to Question **2** to calculate the amount, in moles, of sodium carbonate used in each titration.

.....

.....

(1 mark)

4 Use your answer to Question **3** to calculate the concentration, in mol dm^{-3}, of sodium carbonate in solution **Y**.
Give your answer to the appropriate precision. Show your working.

.....

.....

.....

.....

(3 marks)

Turn over ▶

Do not write outside the box

5 Solution **Y** was made by dissolving 71.50 g of a sample of hydrated sodium carbonate in deionised water and making up to 5.00 dm^3 of solution.

5 (a) Use your answer to Question **4** to calculate the relative formula mass (M_r) of this hydrated sodium carbonate.
Show your working.
(If you were unable to complete the calculation in Question **4**, you may assume that the concentration of the sodium carbonate solution was 0.0487 mol dm^{-3}. This is **not** the correct value.)

.....

.....

.....

.....

.....

(2 marks)

5 (b) The formula of the hydrated sodium carbonate can be represented as $Na_2CO_3.xH_2O$

5 (b) (i) Use your value of M_r from Question **5 (a)** to calculate a value for x
Give your answer to one decimal place.

.....

.....

.....

(1 mark)

5 (b) (ii) The M_r of $Na_2CO_3.10H_2O$ is 286.0
The maximum percentage error in the experiment that can be due to the apparatus is ±1.0%. If the only error is apparatus error, calculate the minimum value of the M_r of $Na_2CO_3.10H_2O$ that could be obtained from an experiment.

Use this minimum value of the M_r to calculate a minimum experimental value for x
Give your answer to one decimal place.

Minimum value of M_r .....

.....

Minimum value of x .....

.....

(2 marks)

Do not write outside the box

5 (c) A similar titration was carried out with a different sample of pure washing soda that had been stored for some time. A student obtained a value of 8.6 for the value of *x*. The container from which the hydrated sodium carbonate was taken was labelled $Na_2CO_3.10H_2O$

Assume that the student carried out the titration and the calculation accurately. State **one** reason why the number of moles of water of crystallisation is less than 10.

.....

.....

(1 mark)

6 Another student carried out the Task and obtained a set of concordant results even though the procedure was not followed correctly. The student observed an immediate red colour when the indicator was added in step 3 of the procedure. At the end of the titration the correct orange solution was formed.

6 (a) Give **one** possible reason for these observations.

.....

.....

(1 mark)

6 (b) State how the results from this student's experiment could be used to calculate the relative formula mass of the hydrated sodium carbonate.

.....

.....

.....

(1 mark)

7 Dilute solutions of sodium carbonate and hydrochloric acid are both classified as irritants. State the **essential** safety precaution to be taken when using these irritants.

.....

.....

(1 mark)

15

Do not write outside the box

Section B

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

There is another experimental method for determining the number of water molecules in the formula of hydrated sodium carbonate. This method involves heating a sample to a temperature higher than 300 °C and recording the change in mass of the sample. The equation for the reaction taking place is

$$Na_2CO_3.10H_2O(s) \longrightarrow Na_2CO_3(s) + 10H_2O(g)$$

8 A group of six students carried out this experiment. They each weighed out a sample of hydrated sodium carbonate. They then heated their sample to a temperature higher than 300 °C in a crucible for ten minutes and recorded the final mass after the crucible had cooled. Their results are summarised in the table.

Student	1	2	3	4	5	6
Initial mass / g	2.43	1.65	3.58	1.09	2.82	1.95
Final mass / g	0.90	0.61	1.53	0.40	1.15	0.72

8 (a) Plot the values of **Initial mass** (*y*-axis) against **Final mass** on the grid opposite.

A graph of these results should include an additional point.
Draw a circle on the grid around the additional point that you should include. *(4 marks)*

8 (b) Draw a best-fit straight line for these results that includes your additional point. *(1 mark)*

8 (c) Identify each student whose experiment gave an anomalous result.

.....

.....

(1 mark)

8 (d) All the students carried out the experiment exactly according to this method.
Explain why a student that you identified in Question **8 (c)** obtained an anomalous result.

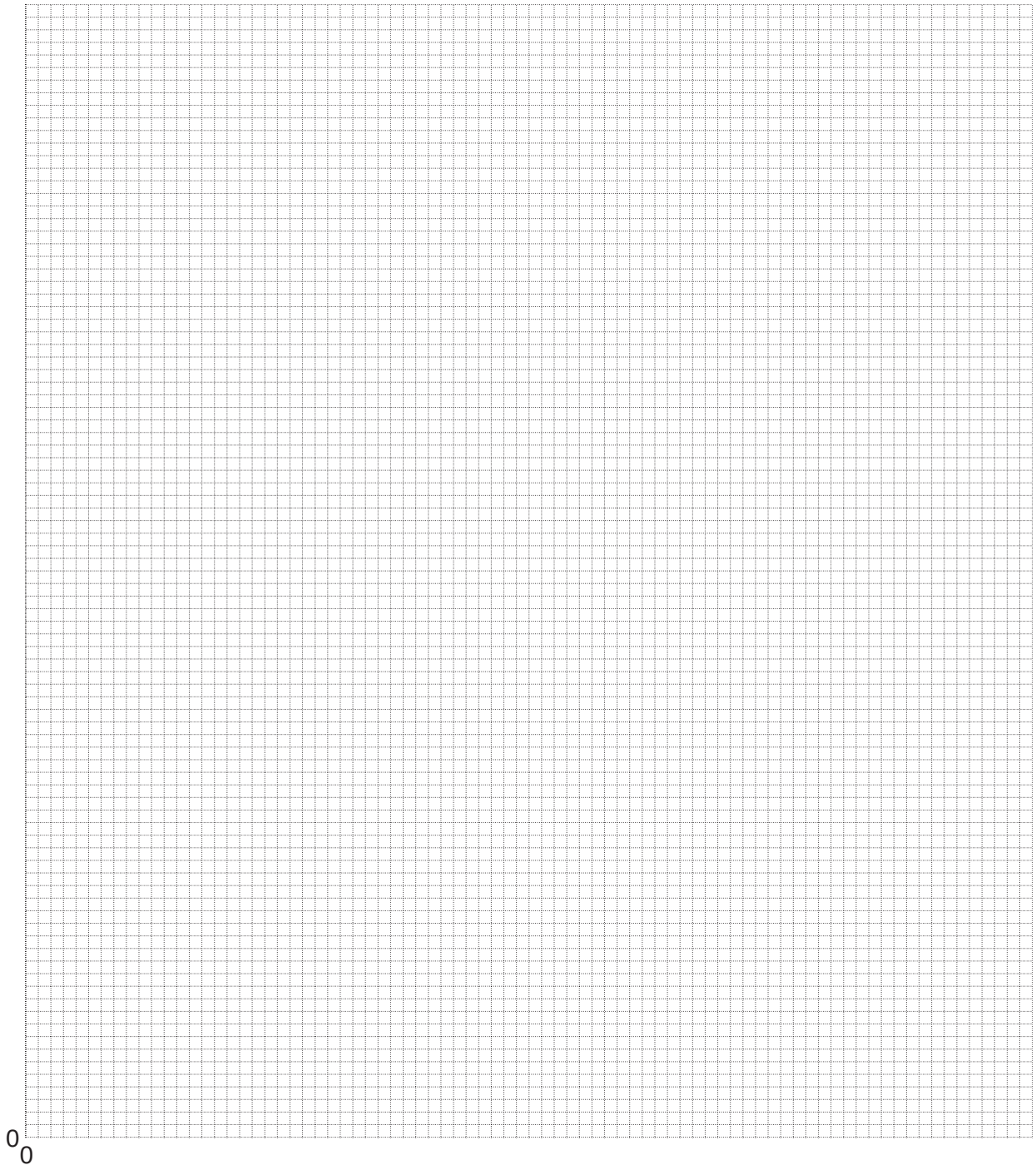
.....

.....

.....

.....

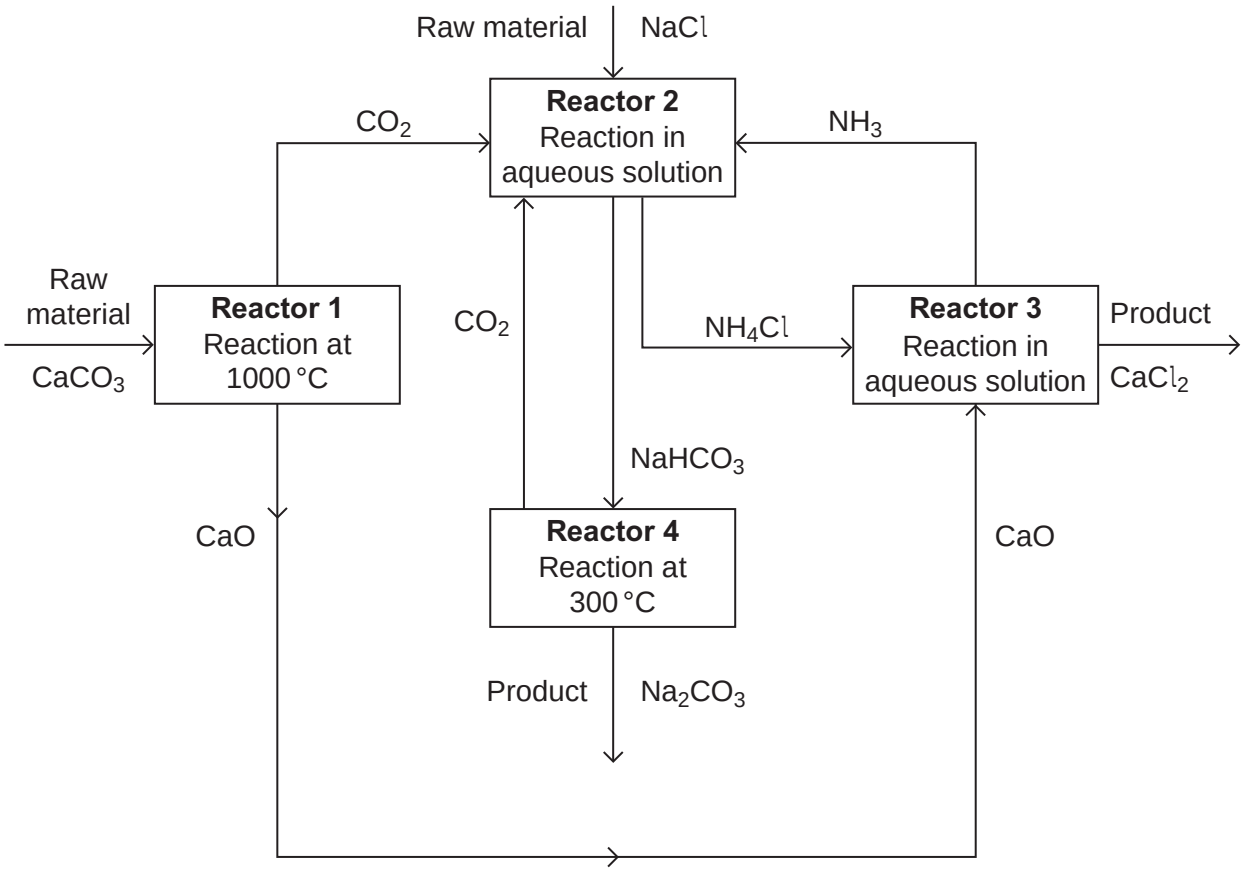
(2 marks)



Turn over for the next question

9 Sodium carbonate is manufactured by the Solvay Process.

The separate stages involved in this process are shown in this diagram.



9 (a) In **Reactor 1**, calcium carbonate is decomposed into calcium oxide and carbon dioxide. Despite no significant leakage of carbon dioxide from this decomposition, this part of the process results in an increase in carbon dioxide in the atmosphere.

State why this increase in carbon dioxide occurs.

.....

.....

(1 mark)

9 (b) In **Reactor 2**, sodium chloride solution, carbon dioxide and ammonia react to form sodium hydrogencarbonate and ammonium chloride.

Write an equation for this reaction.

.....

(1 mark)

Do not write outside the box

9 (c) Use information from the diagram to deduce an equation for the reaction taking place in **Reactor 3**.

.....

.....

(1 mark)

9 (d) An equation for the overall reaction in the Solvay Process is

$$2NaCl(aq) + CaCO_3(s) \longrightarrow Na_2CO_3(s) + CaCl_2(aq)$$

9 (d) (i) Calculate the percentage atom economy of this reaction to produce sodium carbonate. Show your working.

.....

.....

.....

(2 marks)

9 (d) (ii) State what could be done to improve the percentage atom economy of the Solvay Process.

.....

.....

(1 mark)

9 (e) Use information from the diagram to suggest why ammonia is **not** regarded as a raw material in the Solvay Process.

.....

.....

(1 mark)

15

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

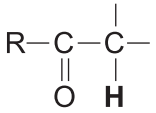
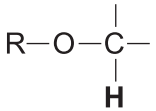
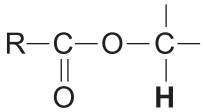
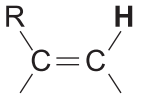
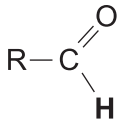
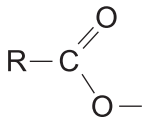
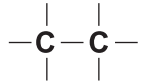
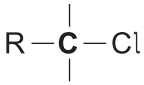
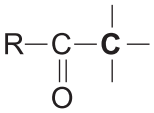
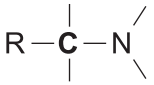
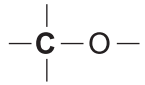
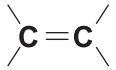
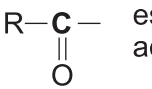
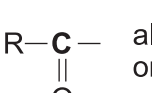
Type of proton	δ/ppm
ROH	0.5 – 5.0
RCH_3	0.7 – 1.2
RNH_2	1.0 – 4.5
R_2CH_2	1.2 – 1.4
R_3CH	1.4 – 1.6
	2.1 – 2.6
	3.1 – 3.9
RCH_2Cl or Br	3.1 – 4.2
	3.7 – 4.1
	4.5 – 6.0
	9.0 – 10.0
	10.0 – 12.0

Table 3

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

Type of carbon	δ/ppm
	5 – 40
	10 – 70
	20 – 50
	25 – 60
 alcohols, ethers or esters	50 – 90
	90 – 150
	110 – 125
	110 – 160
 esters or acids	160 – 185
 aldehydes or ketones	190 – 220

The Periodic Table of the Elements

1	2											3	4	5	6	7	0
																	(18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass **symbol** name atomic (proton) number									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	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(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						

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
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

* **58 – 71** Lanthanides

† **90 – 103** Actinides