

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: <ul style="list-style-type: none"> 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 <ul style="list-style-type: none"> 1 hour
Instructions <ul style="list-style-type: none"> 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. 	Information <ul style="list-style-type: none"> 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: <ul style="list-style-type: none"> 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

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There are no questions printed on this page

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**

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.

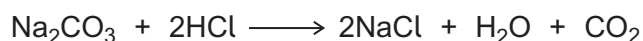
.....
(1 mark)

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

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



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 ►

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 dm³ 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 Na₂CO₃.xH₂O

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 Na₂CO₃.10H₂O 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 Na₂CO₃.10H₂O 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)

- 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 $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$

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)

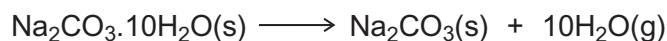
- 7 Dilute solutions of sodium carbonate and hydrochloric acid are both classified as irritants. State the **essential** safety precaution to be taken when using these irritants.

.....
.....
(1 mark)

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



- 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.

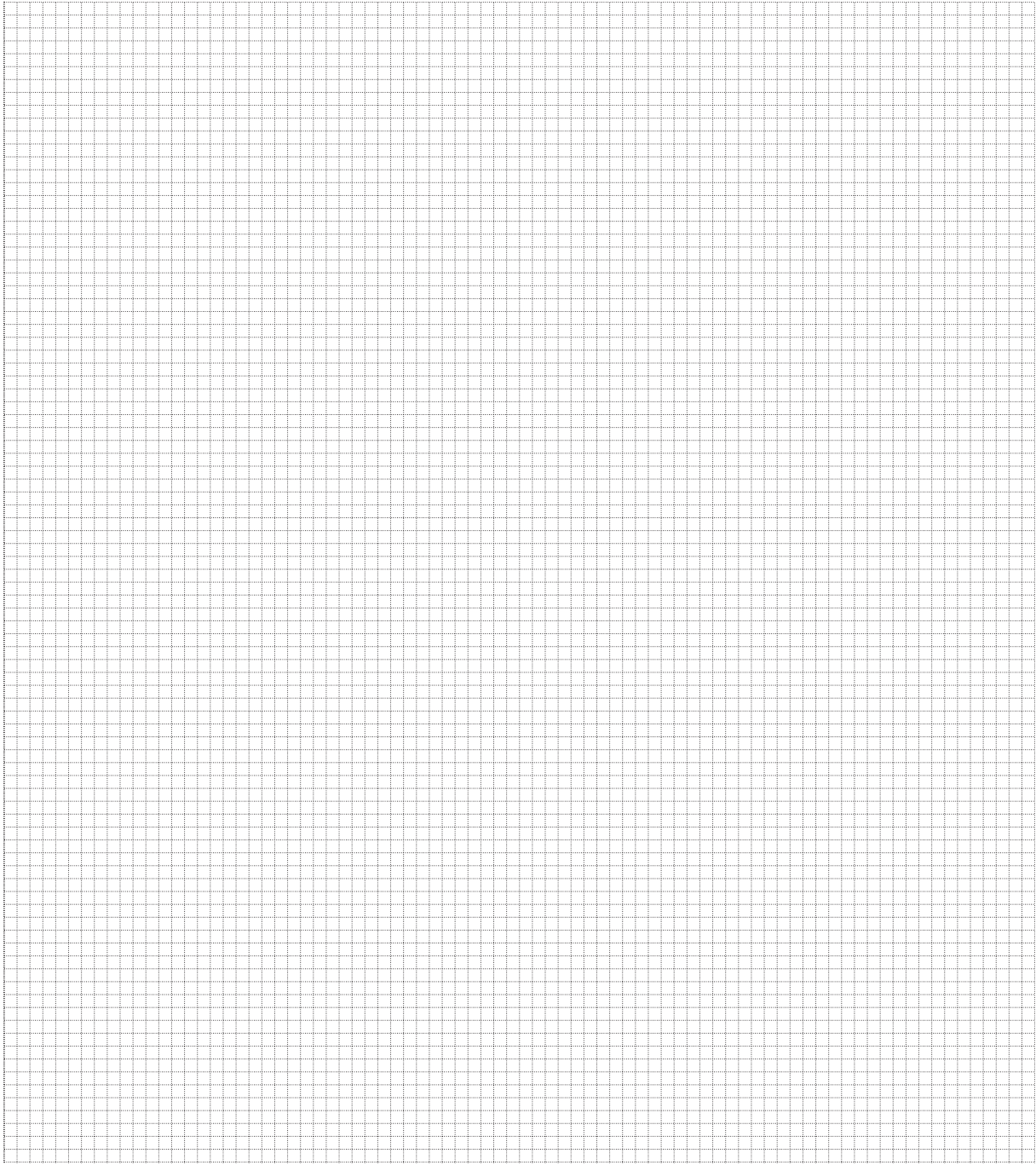
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 (1 mark)

- 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)



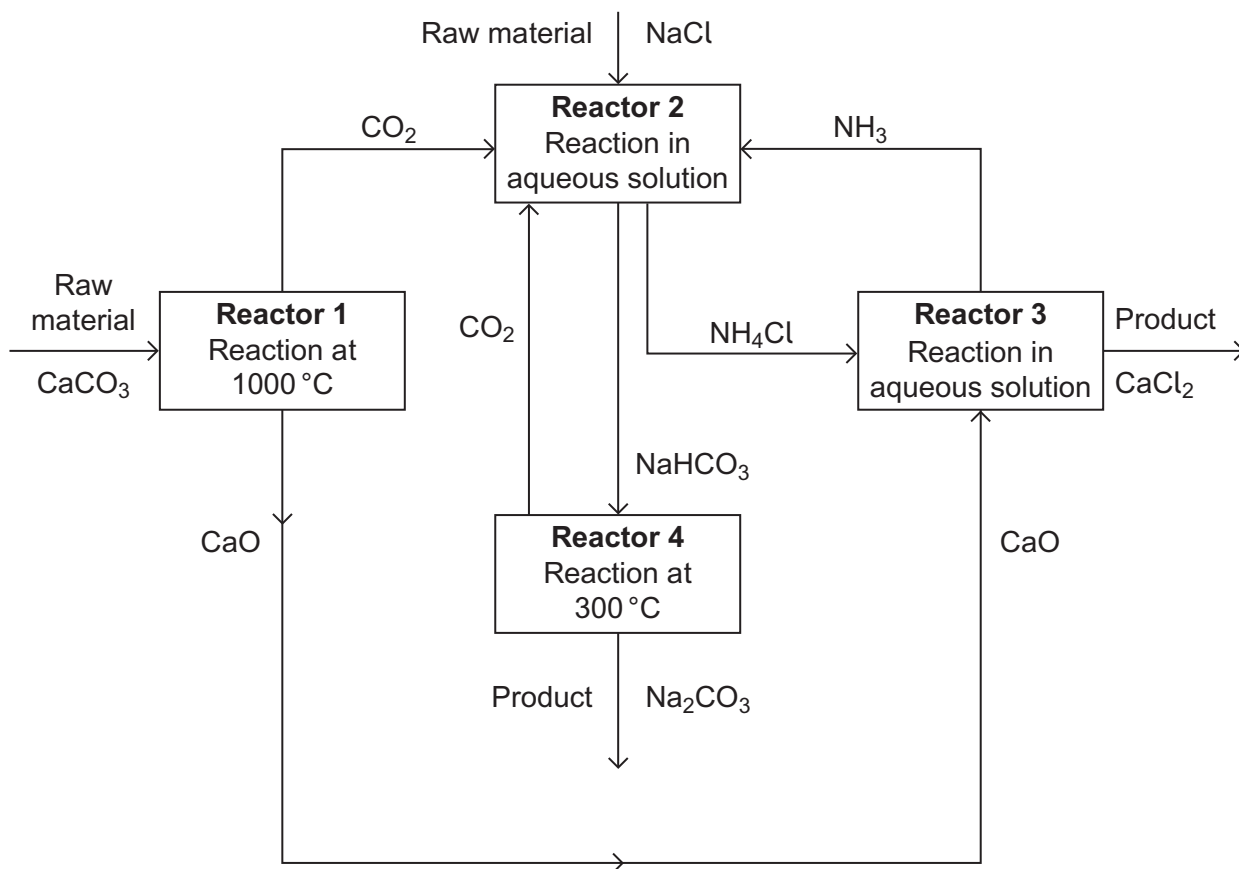
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Turn over for the next question

Turn over ►

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)

- 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



- 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)

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

¹H 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 ₂ CH ₂	1.2 – 1.4
R ₃ CH	1.4 – 1.6
$\begin{array}{c} \\ \text{R}-\text{C}-\text{C}- \\ \quad \\ \text{O} \quad \text{H} \end{array}$	2.1 – 2.6
$\begin{array}{c} \\ \text{R}-\text{O}-\text{C}- \\ \\ \text{H} \end{array}$	3.1 – 3.9
RCH ₂ Cl or Br	3.1 – 4.2
$\begin{array}{c} \\ \text{R}-\text{C}-\text{O}-\text{C}- \\ \quad \\ \text{O} \quad \text{H} \end{array}$	3.7 – 4.1
$\begin{array}{c} \text{H} \\ \\ \text{R}-\text{C}=\text{C}- \\ \\ \text{H} \end{array}$	4.5 – 6.0
$\begin{array}{c} \text{O} \\ \\ \text{R}-\text{C}-\text{H} \end{array}$	9.0 – 10.0
$\begin{array}{c} \text{O} \\ \\ \text{R}-\text{C}-\text{O}-\text{H} \end{array}$	10.0 – 12.0

Table 3

¹³C n.m.r. chemical shift data

Type of carbon	δ/ppm
$\begin{array}{c} \\ -\text{C}-\text{C}- \\ \end{array}$	5 – 40
$\begin{array}{c} \\ \text{R}-\text{C}-\text{Cl or Br} \\ \end{array}$	10 – 70
$\begin{array}{c} \\ \text{R}-\text{C}-\text{C}- \\ \quad \\ \text{O} \end{array}$	20 – 50
$\begin{array}{c} \\ \text{R}-\text{C}-\text{N}- \\ \end{array}$	25 – 60
$\begin{array}{c} \\ -\text{C}-\text{O}- \\ \end{array}$ alcohols, ethers or esters	50 – 90
$\begin{array}{c} \diagup \\ \text{C}=\text{C} \\ \diagdown \end{array}$	90 – 150
R-C≡N	110 – 125
	110 – 160
$\begin{array}{c} \text{O} \\ \\ \text{R}-\text{C}- \end{array}$ esters or acids	160 – 185
$\begin{array}{c} \text{O} \\ \\ \text{R}-\text{C}- \end{array}$ aldehydes or ketones	190 – 220

ACQA

The Periodic Table of the Elements

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)													
6.9 Li lithium 3	9.0 Be beryllium 4	23.0 Na sodium 11	24.3 Mg magnesium 12	39.1 K potassium 19	40.1 Ca calcium 20	87.6 Sr strontium 38	132.9 Cs caesium 55	[223] Fr francium 87	1.0 H hydrogen 1	10.8 B boron 5	12.0 C carbon 6	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													
55 Rb rubidium 37	85.5 K potassium 19	87.6 Sr strontium 38	132.9 Cs caesium 55	178.5 Hf hafnium 72	178.5 Hf hafnium 72	180.9 Ta tantalum 73	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	210 At astatine 85	222 Rn radon 86											
88 Ra radium	89 Ac actinium	90 Th thorium	91 Pa protactinium	92 U uranium	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	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	113 Nh nihonium	114 Fl flerovium	115 Mc moscovium	116 Lv livermorium	117 Ts tennessine	118 Og oganesson

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* 58 – 71 Lanthanides

† 90 – 103 Actinides