OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

CHEMISTRY 2815/01

Trends and Patterns

Wednesday **29 JANUARY 2003** Afternoon 1 hour

Candidates answer on the question paper.
Additional materials:
Data Sheet for Chemistry
Scientific calculator

Candidate Name	Centre Number	Candidate Number

TIME 1 hour

INSTRUCTIONS TO CANDIDATES

- Write your name in the space above.
- Write your Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers in the spaces on the question paper.
- Read each question carefully and make sure you know what you have to do before starting your answer.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [ ] at the end of each question or part question.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use a scientific calculator.
- You may use the *Data Sheet for Chemistry*.
- You are advised to show all the steps in any calculations.

FOR EXAMINER'S USE		
Qu.	**Max.**	**Mark**
1	**15**	
2	**8**	
3	**10**	
4	**12**	
TOTAL	**45**	

This question paper consists of 10 printed pages and 2 blank pages.

Answer **all** the questions.

1 The question below relates to chlorides of some of the elements in Period 3 of the Periodic Table.

(a) Explain the trend in the **formulae** of the chlorides.

$NaCl$ $MgCl_2$ $AlCl_3$ $SiCl_4$ PCl_5

....

....

.... [1]

(b) Complete the table below using the following guidelines.

Complete the **'bonding'** row using **only** the words: *covalent*, *ionic* or *metallic*.

Complete the **'structure'** row using **only** the words: *giant* or *simple*.

formula of chloride	$NaCl$	$MgCl_2$	$AlCl_3$	$SiCl_4$	PCl_5
bonding					covalent
structure					simple

[4]

(c) Describe and explain, in terms of bonding and structure, the difference between the melting points of $NaCl$ and $SiCl_4$.

....

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.... [4]

(d) Describe the difference in behaviour when $NaCl$ and $SiCl_4$ are added separately to cold water.

You may include in your answer

- the pH of any resulting solution
- relevant chemical equations
- experimental observations
- the name of the process taking place.

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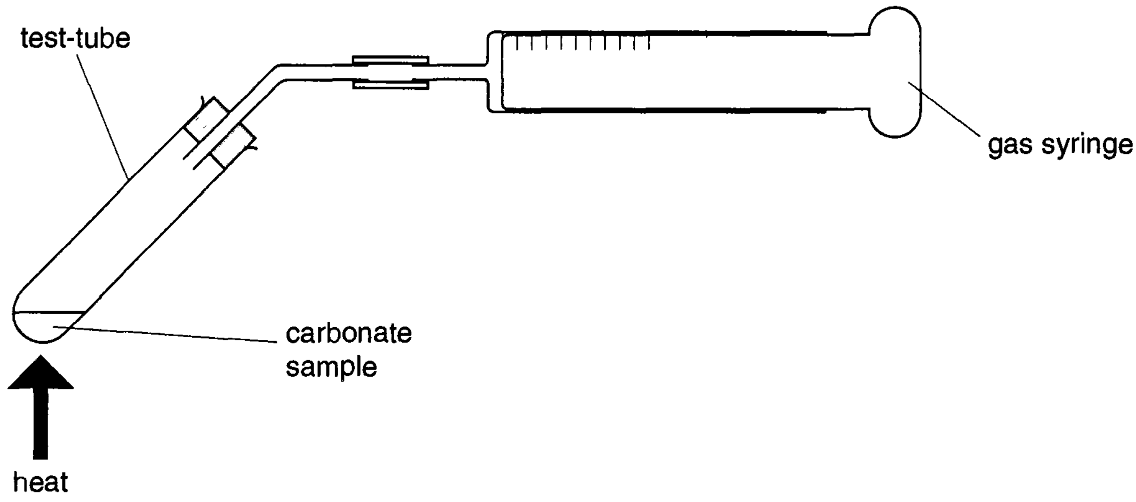
.... [6]

[Total: 15]

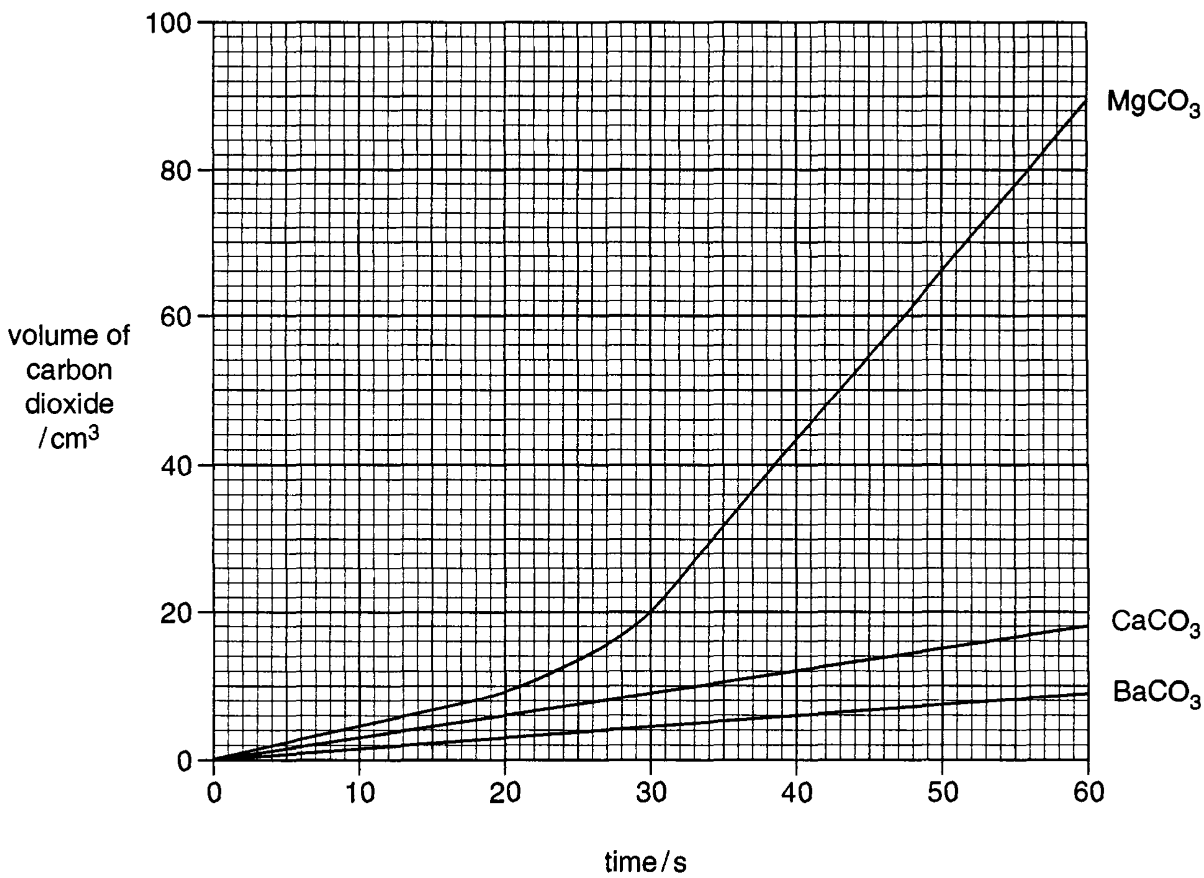
2 A student investigates the thermal decomposition of some of the carbonates of the elements in Group 2.

He separately heats the carbonates of magnesium, calcium and barium. Each time he uses the hottest flame of a Bunsen burner. In each experiment he uses the same amount, in moles, of carbonate.

The diagram shows the apparatus he uses.



The student records the total volume of carbon dioxide collected in the gas syringe every 10 seconds. The graph of his results is given below.



For Examiner's Use

(a) Write the equation to show the thermal decomposition of magnesium carbonate.

.... [1]

(b) The student uses 0.42 g of $MgCO_3$. Calculate the mass of $BaCO_3$ he should use to make the test fair.

answer .... g [2]

(c) The ionic radius of Ba^{2+} is larger than that of Mg^{2+}.

Explain why.

....

.... [1]

(d) Use the evidence from the experiments to show that the thermal stability of the carbonates is related to the charge density of the cation.

....

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.... [2]

(e) Explain the trend in thermal stability of the carbonates.

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.... [2]

[Total: 8]

3 Iron is a typical transition element.

- Iron shows more than one oxidation state in its compounds.
- Iron and its compounds are used as catalysts.

(a) Complete the electronic configuration for an **iron(III) ion, Fe^{3+}**, and use it to explain why iron is a transition element.

Fe^{3+}: $1s^2 2s^2 2p^6$ ....

explanation ....

.... [2]

(b) State **one** use of iron or one of its compounds as a catalyst. State the name of the catalyst and the reaction catalysed.

name of catalyst ....

reaction catalysed .... [1]

(c) Under certain conditions iron can be oxidised to form sodium ferrate, Na_2FeO_4. This is a red-purple coloured substance that has properties very similar to that of potassium manganate(VII).

(i) Analysis of a sample of sodium ferrate showed that it contains the following percentage composition by mass,

Na, 27.74%, Fe, 33.66% and O, 38.60%.

Show that these data are consistent with the formula Na_2FeO_4.

[2]

(ii) Deduce the oxidation state of iron in sodium ferrate, Na_2FeO_4.

.... [1]

(d) The half-equation for the reduction of ferrate ions, FeO_4^{2-}, in acidic conditions is shown below.

$$FeO_4^{2-} + 8H^+ + 4e^- \longrightarrow Fe^{2+} + 4H_2O$$

Acidified FeO_4^{2-}(aq) ions oxidise aqueous iodide ions, I^-, to form aqueous iodine, I_2.

(i) Construct the half-equation for the oxidation of iodide ions to form iodine.

.... [1]

(ii) Construct the ionic equation for the redox reaction that occurs between aqueous FeO_4^{2-} and aqueous I^- in the presence of H^+.

....

....

.... [2]

(iii) Predict the colour change you would see when aqueous FeO_4^{2-} is added to an excess of aqueous I^- in the presence of H^+.

from .... to .... [1]

[Total: 10]

4 In this question, one mark is available for the quality of written communication.

Iron forms complex ions such as $[Fe(H_2O)_6]^{2+}$ and $[Fe(H_2O)_6]^{3+}$.

- Describe and explain the bonding in, and the shape of, **one** of these complex ions.
- Explain why the H—O—H bond angle in water in an isolated gaseous molecule is different from that in the complex $[Fe(H_2O)_6]^{2+}$.
- Describe, with the aid of suitable equations, how the two complex ions can be distinguished by means of a chemical test.

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OCR

RECOGNISING ACHIEVEMENT

2815/01 Trends and Patterns (Written Paper)

January 2003

Mark Scheme

Abbreviations, annotations and conventions used in the Mark Scheme	/ = alternative and acceptable answers for the same marking point , = separates marking points NOT = answers which are not worthy of credit ( ) = words which are not essential to gain credit ___ = (underlining) key words which **must** be used to gain credit ecf = error carried forward AW = alternative wording ora = or reverse argument

Question	Expected answers	Marks	Additional guidance
1 (a)	Number of outer shell electrons increases (by one) / uses (one) more outer electron in bonding / (maximum) oxidation number increases (by one) (1)	1	**Allow** elements are in group number order
(b)	Bonding NaCl and $MgCl_2$ – ionic $AlCl_3$ and $SiCl_4$ – covalent Structure NaCl and $MgCl_2$ – giant $AlCl_3$ and $SiCl_4$ – simple	4	All 8 correct (4) 6 or 7 correct (3) 4 or 5 correct (2) 3 correct (1) **No** half marks
(c)	Sodium chloride has a **higher** melting point than silicon(IV) chloride / sodium chloride has a high melting point and silicon(IV) chloride a low melting point (1), **And** **Any three from** Silicon(IV) chloride has intermolecular forces / van der Waals forces of attraction / induced dipole-induced dipole attractions (1), these forces are weak (1); NaCl has attraction between positive ion and negative ion / NaCl has electrostatic attraction between ions (1), these attractions are strong (1)	4	**Do not allow** marks for just strong or weak bonds – the nature of the bonding must be clearly stated **Allow** strong ionic bonds for one mark
(d)	**Any six from** Sodium chloride dissolves in water / NaCl(s) → Na^+(aq) + Cl^-(aq) / NaCl dissociates in water (1), Gives a colourless solution (1); With a pH of 7 (1); Silicon(IV) chloride is hydrolysed / vigorous reaction (1), Gives a mixture with a pH of between 0 and 6 (1), White precipitate formed / steamy fumes (1), $SiCl_4 + 2H_2O \rightarrow SiO_2 + 4HCl$ / $SiCl_4 + 4H_2O \rightarrow Si(OH)_4 + 4HCl$ (1)	6	**Con** for pH is 7 and equation to give NaOH and HCl **Not** neutral **Not** acidic **Not** white fumes State symbols **not** needed for the $SiCl_4$ equation **Allow** any balanced equation with OH swapped with Cl
		Total = 15	

Question	Expected answers	Marks	Additional guidance
2 (a)	$MgCO_3 \rightarrow MgO + CO_2$ (1)	1	State symbols **not needed**
(b)	Moles of $MgCO_3$ = 0.0050 / 0.00498 (1); So mass of $BaCO_3$ = 0.98 / 0.99 (1)	2	**Allow** one mark for an appreciation that it must be the same number of moles that is used not the same mass
(c)	More (inner) shielding (shells) / more shells (1)	1	**Not** more electrons
(d)	Charge density decreases from Mg^{2+} to Ba^{2+} (1); As the rate of decomposition (as shown from the slope of graph) decreases from $MgCO_3$ to $BaCO_3$ / $MgCO_3$ produces more carbon dioxide (1)	2	**Not** reference to charge density of Mg or of magnesium Charge density must clearly refer to the ion
(e)	Anion is polarised by the positive ion / carbonate is polarised by the cation / electron cloud around carbonate ion is distorted by cation / covalent bonds within the carbonate ion are weakened (1); Polarising ability of cation decreases from Mg^{2+} to Ba^{2+} / ora (1);	2	**Not** carbonate molecule **Not** Mg / Ba or magnesium / barium must clearly refer to the ion
		Total = 8	

Question			Expected answers	Marks	Additional guidance
3	(a)		$1s^22s^22p^63s^23p^63d^5$ (1), (Iron is a transition element since this ion has an) incomplete set of 3d electrons / aw (1)	2	**Allow** second mark even if first marking point is incorrect providing it has an incomplete set of 3d electrons **Allow** partially filled d orbital
	(b)		Iron in the Haber process / Iron to catalyse reaction of nitrogen and hydrogen / iron in the synthesis of ammonia (1)	1	**Allow** $FeCl_3$ for Friedel-Crafts alkylation or acylation of benzene
	(c)	(i)	Calculation of moles / mole ratio (1) Na = 1.21, Fe = 0 603 and O = 2.41; Divide by smallest to give correct molar ratio (1) **OR** Calculation of relative formula mass (1); Working out to get the same percentage compositions (1)	2	Be careful not to award marks for the empirical formula – marks are for the working out
		(ii)	+6 (1)	1	**Allow** 6 / 6+ / VI / Fe^{6+}
	(d)	(i)	$2I^- \rightarrow I_2 + 2e^-$ (1)	1	**Allow** $2I^- - 2e^- \rightarrow I_2$ **Allow** multiples of this equation
		(ii)	$FeO_4^{2-} + 8H^+ + 4I^- \rightarrow Fe^{2+} + 4H_2O + 2I_2$ Correct reactants and products (1); Balancing (1)	2	**Ignore** state symbols **Allow** multiples of this equation **Allow** $4e^-$ on both sides of equation **No** ecf from (i)
		(iii)	Colour after is orange / yellow / brown (solution) (1)	1	**Ignore** the colour to start with
				Total = 10	

Question	Expected answers	Marks	Additional guidance
4	**Any eleven from** **Bonding and shape** Dative / coordinate bonding – this must be stated in words (1); Water is an electron pair donor / ligand is an electron pair donor / lone pair on oxygen (1); Metal ion accepts electron pair (1), Octahedral / drawing of octahedral complex (1) **Water** In both cases central oxygen is surrounded by four electron pairs (1), In gaseous water (2 bond pairs and) 2 lone-pairs (1); In gaseous water lone pair-lone pair repulsion is greater than other electron pair repulsions (1); Bond angle is 104° – 105° (1), In complex one dative bond is more like a bond pair / water has only one lone pair (1), So less repulsion from the lone pairs (1); bond angle in complex is 106° – 108° / bond angle is slightly bigger than 104° (1)	12	**Allow** by a diagram that clearly shows the oxygen lone pairs being donated to the central metal ion **Allow** shape by a diagram that clearly shows 3D shape either by wedges, construction lines or bond angles **Allow** marks by a diagram .
		Total = 12	

Question	Expected answers	Marks	Additional guidance
4	**Distinguishing** Reagent (1) e g aqueous sodium hydroxide / add aqueous ammonium thiocyanate / aqueous ammonia, Result of test with Fe^{2+} (1) e.g. green ppt with Fe^{2+} and NH_3 or NaOH and no reaction with SCN^-, Result with Fe^{3+} (1) e.g orange ppt with Fe^{3+} and NH_3 or NaOH and blood red with SCN-; Suitable equations (2) e.g. $Fe^{2+}(aq) + 2OH^-(aq) \rightarrow Fe(OH)_2(s)$ or $[Fe(H_2O)_6]^{3+} + SCN^- \rightarrow [Fe(SCN)(H_2O)_5]^{2+} + H_2O$ **And** QWC – award one mark for answers using the correct scientific terminology (1)	12	**Allow** OH^- / $NH_3(aq)$ / SCN^- **Allow** acidified MnO_4^- **Allow** other suitable reagents if they are simple chemical tests **Not** colorimetry State symbols **not** needed but may be used to indicate a ppt QWC – candidates must attempt all three parts of the question and must use at least three of the following terms (spelt correctly) octahedral, ligand, dative, coordinate / coordination, lone pair, substitution or precipitate
		Total = 12	