

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

CHEMISTRY

Trends and Patterns

2815/01

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										
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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.

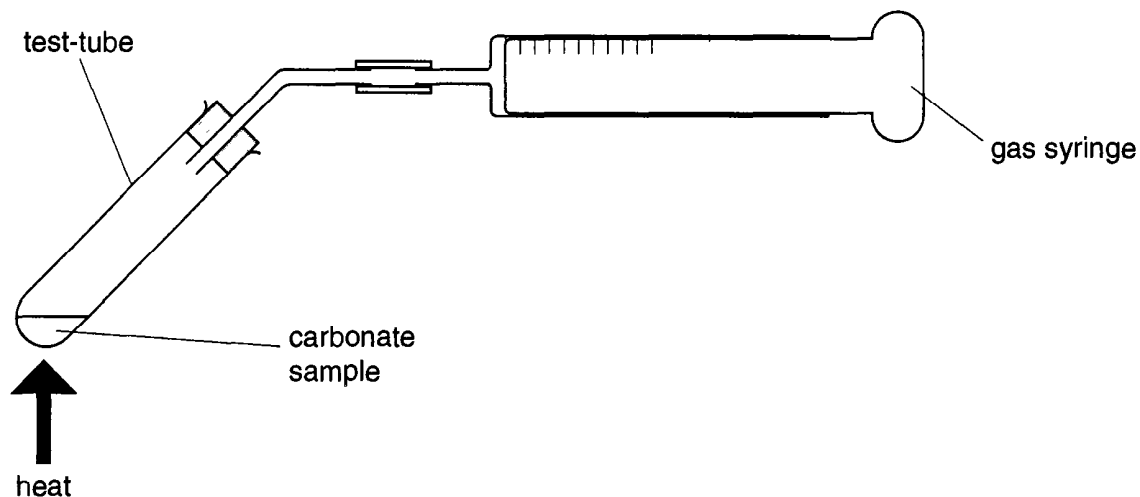
FOR EXAMINER'S USE		
Qu.	Max.	Mark
1	15	
2	8	
3	10	
4	12	
TOTAL	45	

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

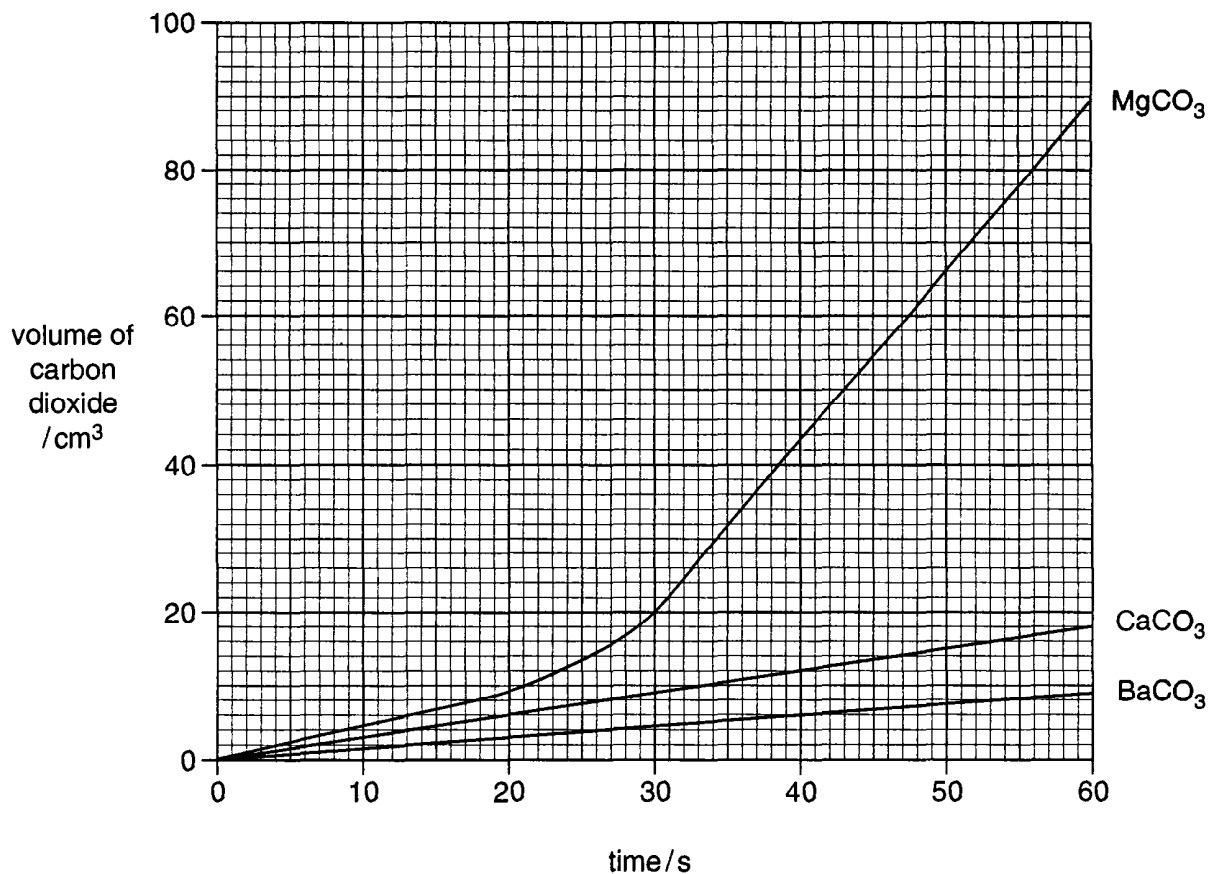
- 2 A student investigates the thermal decomposition of some of the carbonates of the elements in Group 2.

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.



(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.

.....
.....
.....
..... [2]

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

.....
.....
.....
..... [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+} : $1s^22s^22p^6$

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%.

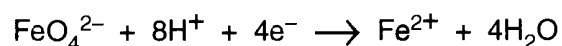
Show that these data are consistent with the formula Na_2FeO_4 .

[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.



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]



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
1 (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
1 (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
1 (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 ₂ O → SiO ₂ + 4HCl / SiCl ₄ + 4H ₂ O → 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)	$\text{MgCO}_3 \rightarrow \text{MgO} + \text{CO}_2$ (1)	1	State symbols not needed
(b)	Moles of $\text{MgCO}_3 = 0.0050 / 0.00498$ (1); So mass of $\text{BaCO}_3 = 0.98 / 0.99$ (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)	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$ (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	<p>Any eleven from</p> <p>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)</p> <p>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 $104^\circ - 105^\circ$ (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 $106^\circ - 108^\circ$ / bond angle is slightly bigger than 104° (1)</p>	12	<p>Allow by a diagram that clearly shows the oxygen lone pairs being donated to the central metal ion</p> <p>Allow shape by a diagram that clearly shows 3D shape either by wedges, construction lines or bond angles</p> <p>Allow marks by a diagram</p>
		Total = 12	

Question	Expected answers	Marks	Additional guidance
4	<p style="text-align: center;">Distinguishing</p> <p>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. $\text{Fe}^{2+}(\text{aq}) + 2\text{OH}^-(\text{aq}) \rightarrow \text{Fe}(\text{OH})_2(\text{s})$ or $[\text{Fe}(\text{H}_2\text{O})_6]^{3+} + \text{SCN}^- \rightarrow [\text{Fe}(\text{SCN})(\text{H}_2\text{O})_5]^{2+} + \text{H}_2\text{O}$</p> <p>And</p> <p>QWC – award one mark for answers using the correct scientific terminology (1)</p>	12	<p>Allow OH^- / $\text{NH}_3(\text{aq})$ / SCN^- Allow acidified MnO_4^- Allow other suitable reagents if they are simple chemical tests Not colorimetry</p> <p>State symbols not needed but may be used to indicate a ppt</p> <p>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</p>
		Total = 12	