OCR

RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

CHEMISTRY 2815/01

Trends and Patterns

Tuesday **29 JUNE 2004** Morning 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 provided 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	11	
2	14	
3	7	
4	13	
TOTAL	45	

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

Registered Charity Number: 1066969
[Turn over

Answer **all** the questions.

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

(a) Draw a '*dot-and-cross*' diagram to show the bonding in magnesium oxide. Only draw the outer shell electrons.

[2]

(b) **(i)** Draw a '*dot-and-cross*' diagram to show the bonding in a sulphur dioxide molecule. Only draw the outer shell electrons.

[1]

(ii) Predict the shape of, and bond angles in, a sulphur dioxide molecule. Explain your answer.

[3]

(c) The melting point of magnesium oxide is much higher than that of sulphur dioxide. Explain this difference in terms of structure and bonding.

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.....[2]

(d) Magnesium oxide and sulphur dioxide react differently when added to water.

- Magnesium oxide reacts with water to give compound **X**.
- Sulphur dioxide reacts with water to give an aqueous solution of compound **Y**.

(i) Identify compound **X**.

.....[1]

(ii) Write an equation to show the formation of **Y**.

.....[1]

(iii) Compound **X** reacts with an aqueous solution of compound **Y**.
Suggest why.

.....

.....[1]

[Total: 11]

2 Aqueous iron(III) chloride contains the complex ion, $[Fe(H_2O)_6]^{3+}$.

(a) Draw the shape of the complex ion $[Fe(H_2O)_6]^{3+}$. Label the bond angles on your diagram.

[2]

(b) Explain how the water molecules are bonded to the metal ion in $[Fe(H_2O)_6]^{3+}$.

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.....[2]

(c) Aqueous iron(III) chloride, $FeCl_3$, reacts with aqueous ammonium thiocyanate, NH_4SCN, to give a blood-red solution.
A ligand substitution reaction occurs to form a complex with the formula $[Fe(SCN)_x(H_2O)_y]^{2+}$.

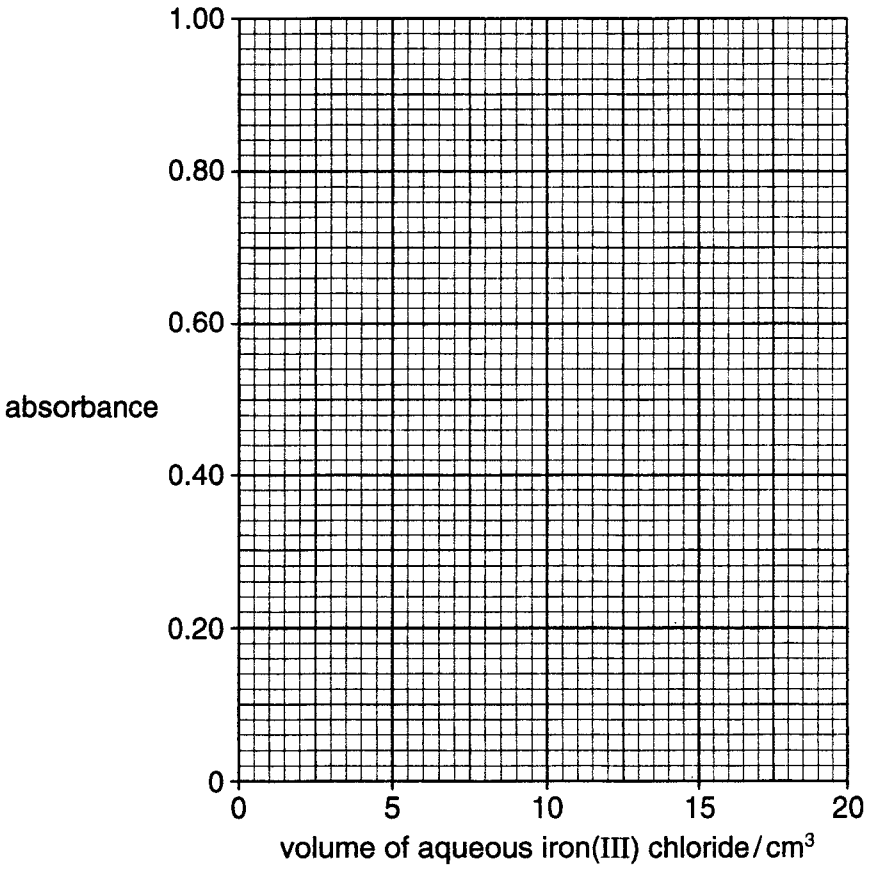
The formula of this complex ion can be determined using colorimetry.

- A student makes up six different mixtures of 0.0500 mol dm^{-3} $FeCl_3$(aq) and 0.100 mol dm^{-3} NH_4SCN(aq).
- The student places each mixture into a colorimeter and measures the absorbance of each mixture.

The table below shows the absorbance of each mixture.

mixture	one	two	three	four	five	six
volume of 0.0500 mol dm^{-3} $FeCl_3$(aq) / cm^3	4.0	8.0	12.0	16.0	18.0	19.0
volume of 0.100 mol dm^{-3} NH_4SCN(aq) / cm^3	16.0	12.0	8.0	4.0	2.0	1.0
absorbance	0.23	0.46	0.68	0.46	0.23	0.11

(i) Draw a graph of the absorbance against the volume of aqueous iron(III) chloride using the grid below.



[2]

(ii) Use the graph to estimate the volume of 0.0500 mol dm^{-3} aqueous iron(III) chloride that gives the maximum absorbance.

answer .....cm^3 [1]

(iii) How many moles of $Fe^{3+}(aq)$ are there in the volume in part **(ii)**?

answer .....mol [1]

(iv) Deduce the volume of 0.100 mol dm^{-3} aqueous ammonium thiocyanate that gives the maximum absorbance.

answer .....cm^3 [1]

(v) How many moles of $SCN^-(aq)$ are there in the volume in part **(iv)**?

answer .....mol [1]

(vi) Deduce the values **x** and **y** in the formula of the complex $[Fe(SCN)_x(H_2O)_y]^{2+}$.

x = ... and **y** = ... [1]

(d) Another complex of iron is used as an anti-caking agent in table salt. Analysis of a sample of this complex shows that it contains 547 mg of potassium, 195 mg of iron, 252 mg of carbon and 294 mg of nitrogen.

(i) Calculate the empirical formula of the complex.

answer .....[2]

(ii) The complex is a potassium salt. The complex anion present has an octahedral shape and has iron in the +2 oxidation state. Suggest a possible formula for the complex ion.

.....[1]

[Total: 14]

3 Sunglasses can be made from photochromic glass. Photochromic glass contains small amounts of silver chloride, AgC*l*, and copper(I) chloride, CuC*l*.

When bright light strikes photochromic glass, silver chloride decomposes to make silver atoms and chlorine atoms. This makes the glass darken. The chlorine atoms immediately react with copper(I) chloride to make copper(II) chloride.

When the exposure to bright light ends, silver atoms reduce copper(II) chloride back into copper(I) chloride and the glass lightens.

(a) Suggest which substance is formed to give the glass its dark colour.

.....[1]

(b) A sample of photochromic glass containing 0.0287 g of AgC*l* is placed in bright sunlight. Calculate the maximum mass, in g, of chlorine atoms that can be formed.

answer .....g [1]

(c) (i) Construct the equation for the reaction between silver and copper(II) chloride.

.....[1]

(ii) Use oxidation states to explain why this reaction involves both oxidation **and** reduction.

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.....[2]

(d) (i) Complete the electronic configuration of a copper(II) ion, Cu^{2+}.

$1s^2 2s^2 2p^6$.....[1]

(ii) Use the electronic configuration to explain why copper is a transition element.

.....

.....[1]

[Total: 7]

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

Lattice enthalpy is used to compare the strengths of ionic bonds.

- Define the term *lattice enthalpy*.
- Describe and explain the effect of ionic charge and ionic radius on the magnitude of a lattice enthalpy.
- Explain the trend in thermal decomposition of the carbonates of Group 2 elements.

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.....[12]

Quality of Written Communication [1]

[Total: 13]

END OF QUESTION PAPER

Mark Scheme Page 1 of 7	Unit Code 2815/01	Session June	Year 2004	Version Standardisation
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)	Correct electronic structures magnesium either 8 electrons in outer shell or none and oxide with 8 electrons in the outer shell (1); Correct charge on the ions, Mg^{2+} and O^{2-} (1)	2	**Allow** all dots or all crosses **Allow** diagrams that show the movement of electrons from magnesium to oxygen but electrons must not be shown twice **Ignore** inner shells
(b) (i)	Correct 'dot-and-cross' diagram showing two double covalent bonds shown to each oxygen atom and a lone pair on sulphur (1)	1	**Allow** dative bonds between sulphur and oxygen
(ii)	**Any three from** V-shaped / bent / non-linear (1); Bond angle of between 120-110° (1); Idea of electron pairs repel one another (1): Extra repulsion from the lone pair to explain bond angle less than 120° / three 'electron pairs repelling (equally) to explain an angle of 120° (1)	3	**Not** bonds or atoms repelling **Allow** ecf from wrong dot-and-cross diagram in (b) (i) Correct shape (1) Correct bond angle (1) Idea of electron pair repelling (1) Comment about number of electron pairs or lone pair (1) **If no dot and cross diagram** drawn in (b) (i) then the only marks allowed will be the correct shape of SO_2

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Question	Expected answers	Marks	Additional guidance
1 (c)	MgO - Strong (electrostatic) attraction between (positive and negative) ions / strong ionic bonds / strong giant ionic (lattice) (1); SO_2 - Weak intermolecular force / weak van der Waals forces / weak permanent dipole-dipole interaction (1)	2	The nature of the attractive force must be stated as well as an indication of the strength of the attraction **Allow** MgO is giant ionic and SO_2 is a simple molecule (1) if no other marks have been awarded
(d) (i)	Magnesium hydroxide / $Mg(OH)_2$ (1)	1	
(ii)	$SO_2 + H_2O == H_2SO_3$ / $SO_2 + H_2O == H^+ + HSO_3^-$ / $SO_2 + H_2O == 2H^+ + SO_3^{2-}$ (1)	1	**Allow** arrow or equilibrium symbol **Ignore** state symbols
(iii)	X is basic and Y is acidic / solution of X contains hydroxide ion and solution of Y contains hydrogen ions / Y can donate protons and X can accept them / it is an acid-base reaction / idea of neutralisation (1)	1	**Allow** an equation showing a correct reaction **Allow** an alkali-acid reaction **Ignore** makes a salt
		Total = 11	

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Question	Expected answers	Marks	Additional guidance
2 (a)	Octahedral shape with some indication of three dimensions (1); Bond angle 90° (1)	2	**Allow** use of wedges and dotted lines to indicate three dimensions **Allow** three dimensions if at least two bond angles of 90° are shown that clearly demonstrate 3D **If two different bond angles** do not award bond angle mark
(b)	Lone pair on oxygen / electron pair on oxygen (1); Donated to the (central) metal (ion) (1) **Or** A dative bond exists between water and the central metal (ion) (1) and if electron pair comes from oxygen (1)	2	**Allow** water is an electron pair donor **Allow** metal (ion) is an electron pair acceptor **Allow** marks from a diagram
(c) (i)	All Points plotted correctly (1); Two straight lines of best fit that intersect (1)	2	**Allow** to nearest half small square
(ii)	13.0 – 13.6 (1)	1	**Unit not needed** **Allow** ecf from incorrect graph
(iii)	Answer to part (ii) × 10^{-3} × 0.0500 (1)	1	**Allow** ecf
(iv)	20 – Answer to part (ii)	1	
(v)	Answer to part (iv) × 10^{-3} × 0.100 (1)	1	**Allow** ecf
(vi)	x = 1 and y = 5 (1)	1	**Allow** ecf of x and y that add up to 6
(d) (i)	Moles of K = 0.014, Fe = 0.0035, C = 0.021 and N = 0.021 / molar ratio is K:Fe:C:N is 14:3.5:21:21 (1); $K_4Fe(CN)_6$ / $K_4FeC_6N_6$ (1)	2	**Ignore** order of atoms in the formula
(ii)	$[Fe(CN)_6]^{4-}$ (1)	1	**Allow** $Fe(CN)_6^{4-}$ / $FeC_6N_6^{4-}$
		Total = 14	

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Question	Expected answers	Marks	Additional guidance
3 (a)	Silver (1)	1	
(b)	0.0071 (g) (1)	1	
(c) (i)	$Ag + CuCl_2 \rightarrow AgCl + CuCl$ (1)	1	
(ii)	Oxidation because oxidation state of silver changes from 0 to +1 (1); Reduction because oxidation state of copper changes from +2 to +1 (1)	2	**Allow** ecf from wrong equation
(d) (i)	$(1s^2 2s^2 2p^6) 3s^2 3p^6 3d^9$ (1)	1	
(ii)	Copper(II) ions have an incomplete set of 3d electrons / partially filled d (sub) shell / partially filled d orbital (1)	1	
		Total = 7	

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Question	Expected answers	Marks	Additional guidance
4		12	**Definition** maximum of two marks **Factors** maximum of four marks **Decomposition** maximum of six marks – marks can either come from the polarisation explanation or lattice enthalpy explanation but **not both**
	Definition – maximum of two marks The enthalpy change that accompanies the formation of one mole of a solid (compound) (1); from its constituent gaseous ions (1)		**Allow** marks from an equation **Allow** energy released / energy change **Not** energy required **Allow** ionic compound / salt
	Factors – maximum of four marks As ionic charge increases it becomes more exothermic / ora(1); Since there will be a stronger (electrostatic) attraction between the (positive and negative) ions / ora (1); As ionic radius decreases becomes more exothermic / ora (1); Since the ions become closer together / ora (1); so the (positive and negative) ions are more strongly attracted to one another / aw (1)		**Allow** lattice enthalpy becomes larger if it is clear from the definition that lattice enthalpy is exothermic / ora

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Question	Expected answers	Marks	Additional guidance
4	**Decomposition – Maximum of six marks** $MCO_3 \rightarrow MO + CO_2$ (where M = Mg, Ca etc.) (1); Ease of decomposition decreases as the atomic number of the group 2 element increases / decomposition temperature increases / aw (1); Down the group the positive ion has a greater ionic radius (1); But the ions have the same charge / formulae of at least two ions with 2+ (1); **Polarisation approach** Idea that decomposition of the carbonate is related to polarisation (by cation) (1) Idea that polarisation means a distortion of the CO_3^{2-} electron cloud / aw (1); Idea that the distortion or polarisation weakens carbon oxygen covalent bond within the carbonate ion (1) **OR** **Lattice enthalpy approach** Lattice enthalpy of the oxides and the carbonates become less exothermic down the group / ora (1); Rate of decrease of the lattice energy of the oxide is much more than that for the carbonate / lattice enthalpy of oxide is the driving force for the decomposition / aw (1); Correct energy cycle for decomposition (1); This means that the enthalpy change for the decomposition is less endothermic the higher the metal is in the group (1)		**Allow** either a general equation or one with a specific group 2 metal **Allow** smaller charge density of M^{2+} down the group (1) if no reference to ionic radius or charge on ion **Not** charge density of M / charge on magnesium atom / atomic radii If one of these has a comparison then it scores an **extra mark** e.g. e.g. Mg^{2+} is more polarising than Ca^{2+} (1) **Allow** marks from suitable diagrams **Allow** lattice enthalpy decreases if earlier it is clear that it is exothermic

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Question	Expected answers	Marks	Additional guidance
4	**QWC** One mark for the use of technical terms (1) Award one mark if candidate has illustrated answers with 3 correct and appropriate scientific terms from the following list charge density polarisation / polarised / polarising cation anion exothermic endothermic electrostatic covalent distortion electron cloud	1	**Ring** the technical words and put the tick by the QWC mark total
		Total = 13	