OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced GCE

CHEMISTRY 2815/01

Trends and Patterns

Tuesday **24 JUNE 2003** 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	18	
2	15	
3	12	
TOTAL	45	

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

SP (SC/KN) S39705/5

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[Turn over

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For Examiner's Use

Answer **all** the questions.

1 Calcium carbonate thermally decomposes into calcium oxide and carbon dioxide as shown in the equation.

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$

(a) Show that the thermal decomposition of calcium carbonate is **not** a redox reaction. Use oxidation states in your answer.

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..... [2]

(b) Magnesium carbonate also thermally decomposes. Describe and explain the difference in the ease of thermal decomposition between magnesium carbonate and calcium carbonate. Use ideas about charge density and polarisation in your answer.

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.....[3]

(c) Calculate the enthalpy change of reaction, ΔH_r, for the thermal decomposition of calcium carbonate using the enthalpy changes of formation given in the table.

compound	enthalpy change of formation, ΔH_f / kJ mol^{-1}
$CaCO_3(s)$	−1207
$CaO(s)$	−635
$CO_2(g)$	−393

answer ..... kJ mol^{-1} [2]

[Turn over

(d) The lattice enthalpy of magnesium oxide is –3916 kJ mol^{-1}.

Explain, with the aid of a suitable equation, what is meant by the statement the 'lattice enthalpy of magnesium oxide is –3916 kJ mol^{-1}'.

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..... [3]

(e) The table below shows the enthalpy changes needed to calculate the lattice enthalpy of magnesium oxide.

process	equation	enthalpy change / kJ mol^{-1}
first ionisation energy of magnesium	$Mg(g) \rightarrow Mg^+(g) + e^-$	+735
second ionisation energy of magnesium	$Mg^+(g) \rightarrow Mg^{2+}(g) + e^-$	+1445
first electron affinity of oxygen	$O(g) + e^- \rightarrow O^-(g)$	–141
second electron affinity of oxygen	$O^-(g) + e^- \rightarrow O^{2-}(g)$	+878
enthalpy change of formation for magnesium oxide	$Mg(s) + \frac{1}{2}O_2(g) \rightarrow MgO(s)$	–602
enthalpy change of atomisation for magnesium	$Mg(s) \rightarrow Mg(g)$	+150
....	$\frac{1}{2}O_2(g) \rightarrow O(g)$	+247

(i) Complete the table by writing in the missing process. [1]

(ii) Explain why the second ionisation energy of magnesium is **more endothermic** than the first ionisation energy.

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.....

.....[2]

For Examiner's Use

(iii) Draw a labelled Born-Haber cycle using the information in the table. Show, by calculation, that the lattice enthalpy of magnesium oxide is –3916 kJ mol^{-1}.

[4]

(f) State **one** use for magnesium oxide that relies on its high lattice enthalpy.

..... [1]

[Total: 18]

[Turn over

2 Aqueous copper(II) sulphate reacts with an excess of aqueous ammonia to give a dark blue solution. The solution contains the octahedral complex ion, $[Cu(NH_3)_x(H_2O)_y]^{2+}$.

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

- A student makes up six different mixtures of 1.00 mol dm^{-3} aqueous ammonia and 0.500 mol dm^{-3} aqueous copper(II) sulphate and water.
- She filters the mixtures to remove any precipitate that forms.
- The filtrate is a dark blue solution that contains the complex ion, $[Cu(NH_3)_x(H_2O)_y]^{2+}$.
- The student places the blue solution into a colorimeter and measures the absorbance of the solution.

The table below shows the relative absorbance of each mixture.

mixture	one	two	three	four	five	six
volume of 0.500 mol dm^{-3} $CuSO_4(aq)$ / cm^3	5.00	5.00	5.00	5.00	5.00	5.00
volume of 1.00 mol dm^{-3} $NH_3(aq)$ / cm^3	3.00	6.00	9.00	11.00	15.00	18.00
volume of $H_2O(l)$ / cm^3	17.00	14.00	11.00	9.00	5.00	2.00
relative absorbance	0.29	0.57	0.86	0.95	0.94	0.95

(a) Copper is a transition element. One typical property of a transition element is that it forms coloured complex ions.

State **two** other typical properties of a transition element.

1. .....

2. ..... [2]

(b) The precipitate formed when the student makes some of the mixtures is copper(II) hydroxide.

(i) Write an ionic equation to show the formation of copper(II) hydroxide from its ions.

..... [1]

(ii) If this precipitate is **not** removed, an inaccurate absorbance reading is obtained. Suggest why.

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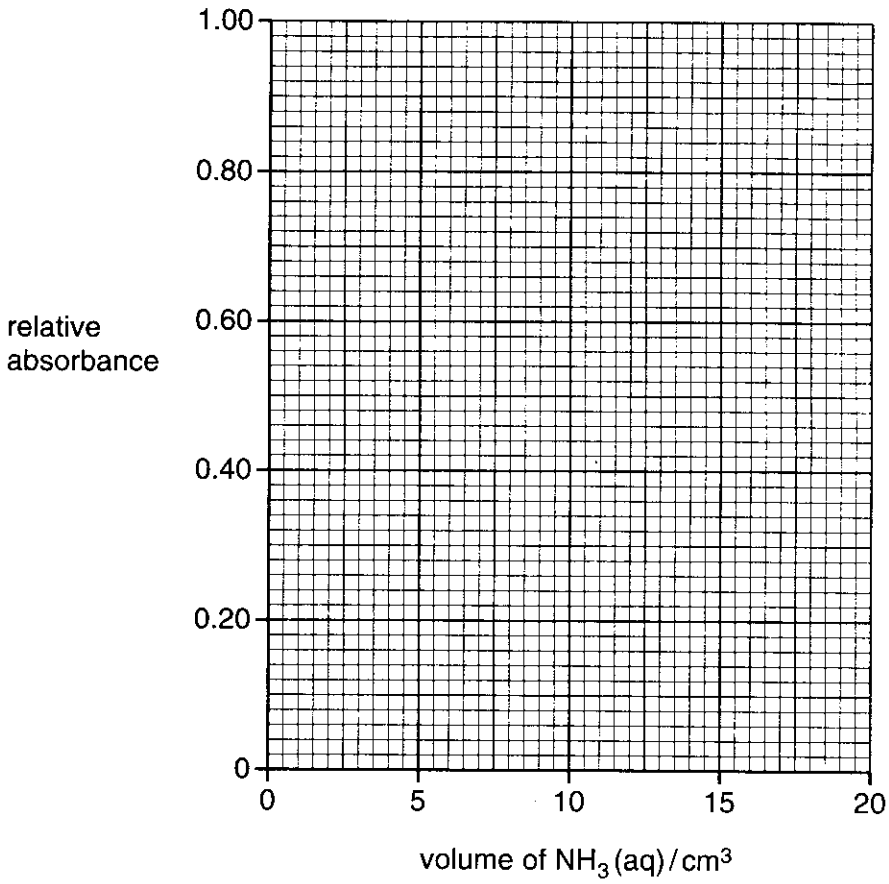
..... [1]

For Examiner's Use

(c) Draw a graph of the relative absorbance against the volume of aqueous ammonia using the grid below.



[2]

(d) **(i)** How many moles of copper(II) sulphate are there in 5.00 cm^3 of a 0.500 mol dm^{-3} solution?

answer ..... mol [1]

(ii) Use the graph to estimate the **smallest** volume of 1.00 mol dm^{-3} aqueous ammonia that gives the maximum relative absorbance.

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

(iii) How many moles of ammonia are there in the volume in **(ii)**?

answer ..... mol [1]

(iv) Deduce the values **x** and **y** in the formula of the octahedral complex ion, $[Cu(NH_3)_x(H_2O)_y]^{2+}$.

.....

.....[1]

[Turn over

(e) In the octahedral complex, $[Cu(NH_3)_x(H_2O)_y]^{2+}$, ammonia is a ligand.

(i) Explain why ammonia can behave as a ligand.

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..... [1]

(ii) The bond angle around the nitrogen atom in an ammonia molecule is 107° but it is 109.5° in the octahedral complex. Explain why the bond angles differ.

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..... [2]

(f) Aqueous copper(II) ions react with concentrated hydrochloric acid to give a yellow solution of $[CuCl_4]^{2-}(aq)$. This reaction is an example of ligand substitution.

(i) Write an equation to show the formation of $[CuCl_4]^{2-}(aq)$.

[1]

(ii) Draw the shape of the $[CuCl_4]^{2-}$ ion.

[1]

[Total: 15]

For Examiner's Use

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

We use our understanding of structure and bonding to explain physical and chemical properties of substances. Discuss this statement using examples taken from the oxides of the elements from Period 3 such as MgO, Al_2O_3 and SO_2.

Refer in your answer to

- physical properties such as electrical conductivity and melting point,
- chemical properties such as reaction with water.

[Turn over

For Examiner's Use

....[11]

Quality of Written Communication [1]

[Total: 12]