

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

CHEMISTRY

2815/01

Trends and Patterns

Friday

23 JANUARY 2004

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 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

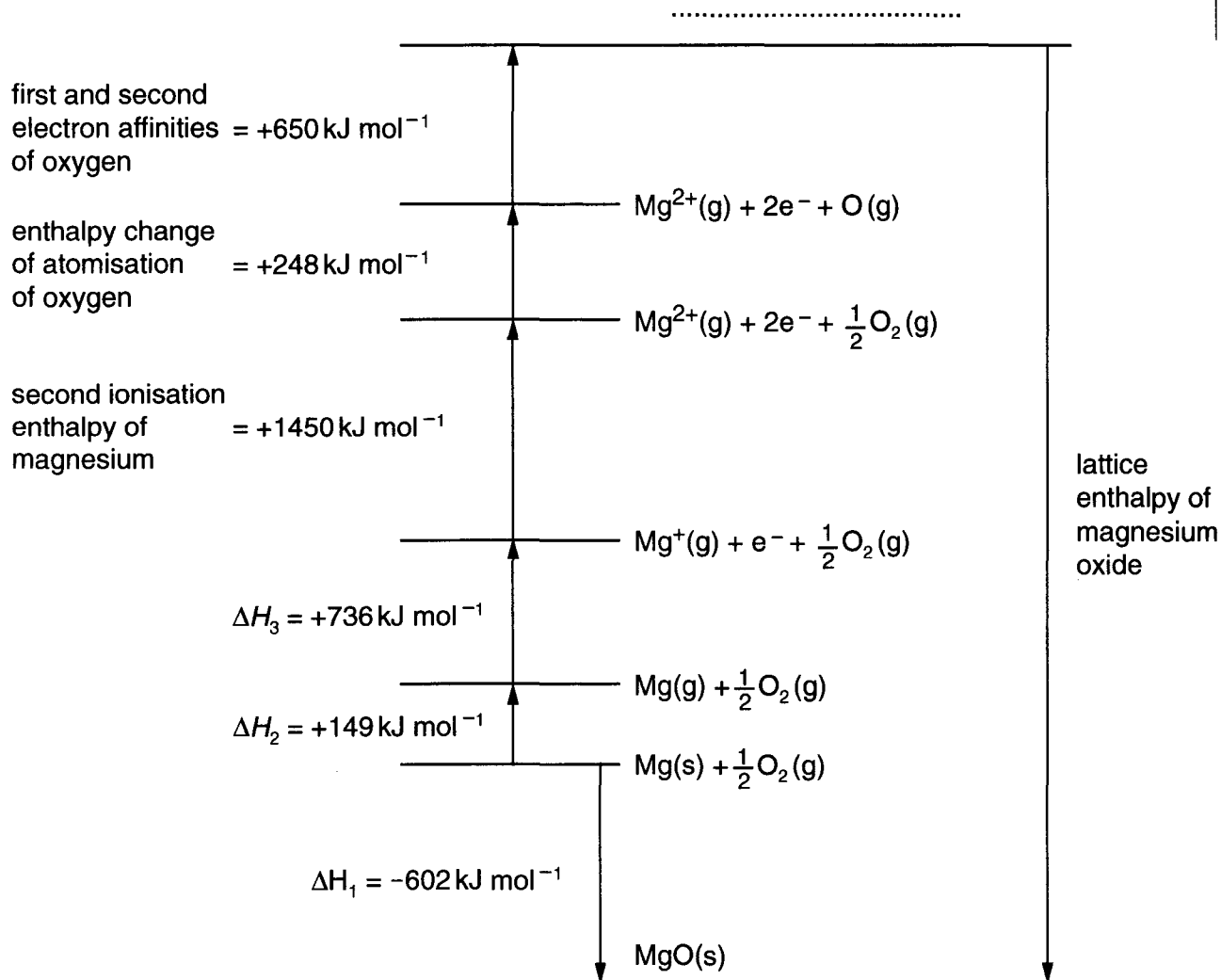
- The number of marks is given in brackets [] at the end of each question or part question.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use a scientific calculator.
- You may use the *Data Sheet for Chemistry*.
- You are advised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

FOR EXAMINER'S USE		
Qu	Max.	Mark
1	15	
2	7	
3	9	
4	14	
TOTAL	45	

This question paper consists of 11 printed pages and 1 blank page.

Answer **all** the questions.

- 1 The Born-Haber cycle below can be used to calculate the lattice enthalpy for magnesium oxide.



- (a) (i) Write down the name for each of the following enthalpy changes.

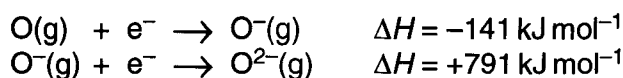
ΔH_1

ΔH_2

ΔH_3 [3]

- (ii) Write down the missing formulae on the dotted line at the **top** of the Born-Haber cycle. Include state symbols. [1]

- (iii) The equations representing the first and second electron affinities for oxygen are shown below.



Suggest why the enthalpy change for the second of these processes is positive.

.....
[1]

- (b) (i) Use the Born-Haber cycle to calculate the lattice enthalpy of magnesium oxide.

answer kJ mol⁻¹ [2]

- (ii) Describe how, and explain why, the lattice enthalpy of magnesium oxide differs from that of barium oxide.

.....

[3]

- (c) Give **one** reason why magnesium oxide is a good material to make the lining of a furnace.

.....[1]

(d) Magnesium carbonate and barium carbonate both decompose thermally.

(i) Write the equation for the decomposition of barium carbonate.

.....[1]

(ii) Describe and explain the difference between the decomposition temperature of barium carbonate and that of magnesium carbonate.

.....
.....
.....
.....
.....[3]

[Total: 15]

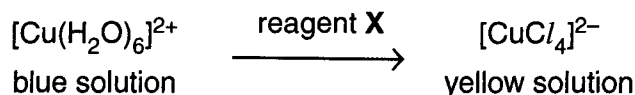
2 Copper is a typical transition element.

- It forms coloured compounds.
- It forms complex ions.
- It has more than one oxidation state in its compounds.

(a) State **one** other typical property of a transition element.

.....[1]

(b) Dilute aqueous copper(II) sulphate is a blue solution containing $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ ions. A ligand substitution involving $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ is shown below.



(i) Suggest a shape for the $[\text{CuCl}_4]^{2-}$ ion. Include the bond angles in your diagram.

[2]

(ii) State the **formula** of the ligand in $[\text{CuCl}_4]^{2-}$.

.....[1]

(iii) State the name or formula of reagent X.

.....[1]

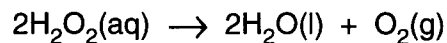
(iv) Explain, with the aid of a balanced equation, what is meant by the term *ligand substitution*.

.....

[2]

[Total: 7]

- 3 Aqueous hydrogen peroxide, H_2O_2 , is used to sterilise contact lenses. H_2O_2 decomposes to make oxygen and water as shown in the equation.



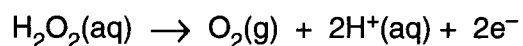
- (a) Decomposition of hydrogen peroxide is a redox reaction. Use oxidation numbers to show that oxidation and reduction take place.

.....

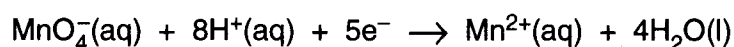
[2]

- (b) The concentration of an aqueous solution of hydrogen peroxide can be determined by titration. Aqueous potassium manganate(VII), KMnO_4 , is titrated against a solution of hydrogen peroxide in the presence of acid.

The half-equation for the oxidation of H_2O_2 is as follows.



The half-equation for the reduction of acidified MnO_4^- is as follows.



- (i) Construct the equation for the reaction between H_2O_2 , MnO_4^- ions and H^+ ions.

.....

[2]

- (ii) A student takes a 25.0 cm^3 sample of aqueous hydrogen peroxide and places this into a conical flask and then adds sulphuric acid to acidify the hydrogen peroxide.

The student titrates this sample of acidified hydrogen peroxide against a solution containing $0.0200 \text{ mol dm}^{-3} \text{ MnO}_4^-(\text{aq})$ ions. For complete reaction with the acidified hydrogen peroxide, the student uses 17.5 cm^3 of this solution containing $\text{MnO}_4^-(\text{aq})$ ions.

Calculate the concentration, in mol dm^{-3} , of the aqueous hydrogen peroxide.

2 mol MnO_4^- reacts with $5 \text{ mol H}_2\text{O}_2$.

concentration mol dm^{-3} [3]

- (c) Acidified hydrogen peroxide oxidises $\text{Fe}^{2+}(\text{aq})$ to $\text{Fe}^{3+}(\text{aq})$.

Describe a simple chemical test to show the presence of $\text{Fe}^{3+}(\text{aq})$.

name of reagent used

observation

.....[2]

[Total: 9]

.....[13]

Quality of Written Communication [1]

[Total: 14]

Subject: Trends and Patterns Code: 2815/01

Session: January Year: 2004

Mark Scheme

MAXIMUM MARK	45
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ADVICE TO EXAMINERS ON THE ANNOTATION OF SCRIPTS

1. Please ensure that you use the **final** version of the Mark Scheme.
You are advised to destroy all draft versions.
2. Please mark all post-standardisation scripts in red ink. A tick (✓) should be used for each answer judged worthy of a mark. Ticks should be placed as close as possible to the point in the answer where the mark has been awarded. The number of ticks should be the same as the number of marks awarded. If two (or more) responses are required for one mark, use only one tick. Half marks ($\frac{1}{2}$) should never be used.
3. The following annotations may be used when marking. No comments should be written on scripts unless they relate directly to the mark scheme. Remember that scripts may be returned to Centres.

x = incorrect response (errors may also be underlined)
^ = omission mark
bod = benefit of the doubt (where professional judgement has been used)
ecf = error carried forward (in consequential marking)
con = contradiction (in cases where candidates contradict themselves in the same response)
sf = error in the number of significant figures
4. The marks awarded for each part question should be indicated in the margin provided on the right hand side of the page. The mark total for each question should be ringed at the end of the question, on the right hand side. These totals should be added up to give the final total on the front of the paper.
5. In cases where candidates are required to give a specific number of answers, (e.g. 'give three reasons'), mark the first answer(s) given up to the total number required. Strike through the remainder. In specific cases where this rule cannot be applied, the exact procedure to be used is given in the mark scheme.
6. Correct answers to calculations should gain full credit even if no working is shown, unless otherwise indicated in the mark scheme. (An instruction on the paper to 'Show your working' is to help candidates, who may then gain partial credit even if their final answer is not correct.)
7. Strike through all blank spaces and/or pages in order to give a clear indication that the whole of the script has been considered.
8. An element of professional judgement is required in the marking of any written paper, and candidates may not use the exact words that appear in the mark scheme. If the science is correct and answers the question, then the mark(s) should normally be credited. If you are in doubt about the validity of any answer, contact your Team Leader/Principal Examiner for guidance.

Mark Scheme	Unit Code	Session	Year	Version
Page 1 of 5	2815/01	January	2004	2815_1_Jan_04MS
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) (i)	(Enthalpy change of) formation (of magnesium oxide) (1); (Enthalpy change of) atomisation (of magnesium) (1); <u>First</u> ionisation enthalpy (of magnesium) (1)	3	Allow (enthalpy change of) sublimation (of magnesium) Allow <u>first</u> ionisation energy	
(ii)	Mg ²⁺ (g) and O ²⁻ (g) (1)	1	State symbols essential	
(iii)	Electron being gained is repelled by the negative charge of the ion / aw (1)	1		
(b) (i)	Lattice enthalpy = -149 - 736 - 1450 - 248 - 650 - 602 (1); = -3835 (kJ mol ⁻¹) (1)	2	Allow ecf from one error (1)	
(ii)	Lattice enthalpy of barium oxide is less exothermic than that of magnesium oxide / lattice enthalpy is smaller in magnitude / ora (1); Mg ²⁺ has a smaller ionic radius than Ba ²⁺ / Mg ²⁺ has a higher charge density than Ba ²⁺ / ora (1); So stronger attraction between the positive and negative ion (1)	3	Not bigger or smaller lattice enthalpy Correct particles must be used e.g. not Mg has a smaller radius Allow so has stronger ionic bonds	
(c)	High melting point / (very) large lattice enthalpy / aw (1)	1	Not resistant to heat	
(d) (i)	BaCO ₃ → BaO + CO ₂ (1)	1	State symbols not essential	
(ii)	Decomposition temperature higher for BaCO ₃ / ora (1) Polarising ability of cation decreases from Mg ²⁺ to Ba ²⁺ (1); Polarisation causes distortion of the charge cloud around the carbonate ion / polarisation weakens the covalent bonds within the carbonate ion (1)	3	Particles used must be correct e.g. not Mg is more polarising Allow marks via a diagram	
		Total = 15		

Mark Scheme	Unit Code	Session	Year	Version
Page 2 of 5	2815/01	January	2004	FINAL
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Question	Expected answers	Marks	Additional guidance	
2 (a)	Often are catalysts (1)	1	Allow compounds are often paramagnetic Not metallic properties	
(b) (i)	Tetrahedral / or a clear drawing of a tetrahedral ion (1); Bond angle of $109.5 \pm 0.5^\circ$ (1)	2	Allow square planar (1) with bond angle of 90° (1) Tetrahedral structure must have at least one wedge	
(ii)	Cl ⁻ (1)	1		
(iii)	(Concentrated) hydrochloric acid / (concentrated) solution of an ionic chloride (1)	1	Allow correct formula	
(iv)	Suitable equation e.g. $[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 4\text{Cl}^- \rightarrow [\text{CuCl}_4]^{2-} + 6\text{H}_2\text{O}$ Or $[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 4\text{NH}_3 \rightarrow [\text{Cu}(\text{H}_2\text{O})_2(\text{NH}_3)_4]^{2+} + 4\text{H}_2\text{O}$; Reaction in which a ligand is swapped or displaced by another ligand / aw (1)	2	Not ligand is substituted	
		Total = 7		

Mark Scheme	Unit Code	Session	Year	Version
Page 3 of 5	2815/01	January	2004	2815_1_Jan_04MS
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Question	Expected answers	Marks	Additional guidance	
3 (a)	Oxidation - Oxidation number of oxygen changes from -1 to 0; Reduction – oxidation number of oxygen changes from -1 to -2 (1)	2	Allow one mark if all the oxidation numbers for oxygen (and hydrogen) are correct	
(b) (i)	$2\text{MnO}_4^- + 6\text{H}^+ + 5\text{H}_2\text{O}_2 \rightarrow 2\text{Mn}^{2+} + 8\text{H}_2\text{O} + 5\text{O}_2$ Correct reactants and products (1); Balancing (1)	2	Ignore electrons for the first mark	
(ii)	Moles of $\text{MnO}_4^- = 17.5 \times 10^{-3} \times 0.0200 / 3.5 \times 10^{-4}$ (1); Moles of $\text{H}_2\text{O}_2 = 2.5 \times \text{moles of } \text{MnO}_4^- / 8.75 \times 10^{-4}$ (1); Conc of $\text{H}_2\text{O}_2 = \frac{8.75 \times 10^{-4}}{0.025} = 0.0350$ (mol dm ⁻³) (1)	3	Allow ecf within question Allow 0.035 Not 0.04 / 0.03	
(c)	Aqueous sodium hydroxide / potassium thiocyanate / ammonium thiocyanate (1); Appropriate observation e.g. orange-red / brown / brown-red / foxy-red ppt with NaOH(aq) or (blood) red with KSCN (1)	2	Allow hydroxide (ions) or thiocyanate (ions)	
		Total = 9		

Mark Scheme	Unit Code 2815/01	Session January	Year 2004	Version 2815_1_Jan_04MS
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Question	Expected answers		Marks	Additional guidance
4	<p>Chemical formula Correct formula of all chlorides (1); Number of outer electrons per atom increases / oxidation number increases (1);</p> <p>Structure and bonding NaCl or MgCl₂ are ionic and AlCl₃ or SiCl₄ are covalent (1) NaCl or MgCl₂ are giant and AlCl₃ or SiCl₄ are simple (1) And any two from Correct 'dot-and-cross' diagram for one of the ionic chlorides (1); Correct 'dot-and-cross' diagram for one of the covalent chlorides (1); Correct structure/bonding for Al₂Cl₆ showing the dative bonding (1); Drawing of NaCl lattice (1);</p> <p>Action of water Any four from Ionic chlorides dissolve in water / NaCl or MgCl₂ dissolve in water (1); Ionic chlorides give a neutral solution / NaCl gives a neutral solution or pH 7 / MgCl₂ gives a slightly acidic solution or pH 6-7 (1); Covalent chlorides are hydrolysed / covalent chlorides react / SiCl₄ or AlCl₃ react or are hydrolysed (1); Covalent chlorides give acidic solutions / SiCl₄ or AlCl₃ give acidic solutions or pH less than 6 (1)</p> <p>Suitable equation e.g. SiCl₄ + 2H₂O → SiO₂ + 4HCl / (1)</p> <p>Melting points NaCl, MgCl₂ or ionic chlorides have electrostatic attraction between ions / attraction between positive and negative ions (1); AlCl₃, SiCl₄ or simple molecular lattice have van der Waals force of attraction (1); Strong ionic bonds and weak intermolecular forces (1)</p>		14	<p>Allow AlCl₃ or Al₂Cl₆</p> <p>Do not award mark if one bonding or one structure is wrong</p> <p>Do not penalise incorrect answers in these two marks</p> <p>Allow dissociate in water</p> <p>Allow polarisation of water molecules by Al³⁺ As alternative to hydrolysis mark</p> <p>Allow other species such as Si(OH)₄</p> <p>Not weak covalent bonds</p>

Mark Scheme	Unit Code 2815/01	Session January	Year 2004	Version 2815_1_Jan_04MS
Page 5 of 5				
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Question	Expected answers		Marks	Additional guidance
4	QWC – one mark for technical terms Award one mark if the candidate has illustrated the answers correctly using at least three of the technical terms (1) - hydrolysis, hydration, intermolecular, ionic covalent, lattice, electrostatic, van der Waals, polarisation, dative bonding.			
			Total = 14	