OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

CHEMISTRY **2815/01**

Trends and Patterns

Tuesday **25 JANUARY 2005** 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 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	**10**	
2	**15**	
3	**7**	
4	**13**	
TOTAL	**45**	

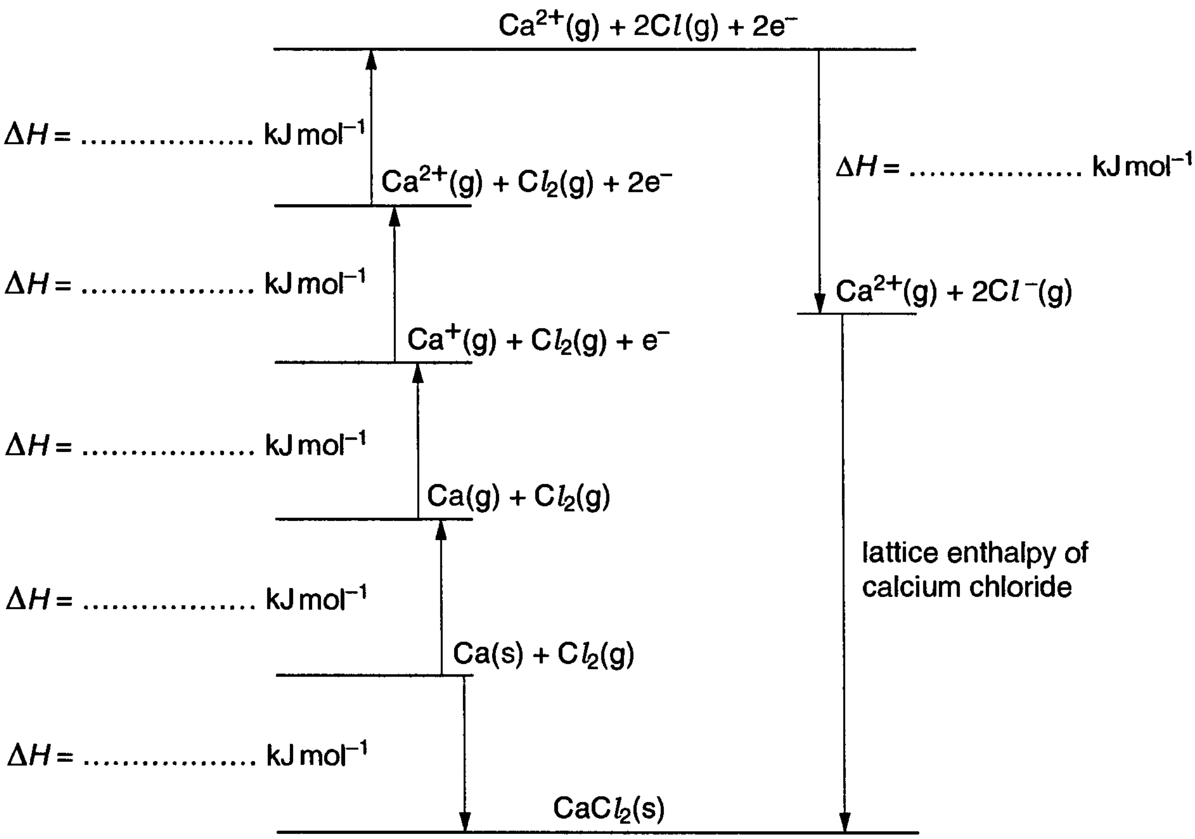
This question paper consists of 8 printed pages.

Answer **all** the questions.

1 The table below shows the enthalpy changes needed to calculate the lattice enthalpy of calcium chloride, $CaCl_2$.

process	enthalpy change / kJ mol^{-1}
first ionisation energy of calcium	+590
second ionisation energy of calcium	+1150
electron affinity of chlorine	–348
enthalpy change of formation for calcium chloride	–796
enthalpy change of atomisation for calcium	+178
enthalpy change of atomisation for chlorine	+122

(a) The Born-Haber cycle below can be used to calculate the lattice enthalpy for calcium chloride.



(i) Use the table of enthalpy changes to complete the Born-Haber cycle by putting in the correct numerical values on the appropriate dotted line. [3]

(ii) Use the Born-Haber cycle to calculate the lattice enthalpy of calcium chloride.

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

(iii) Describe how, and explain why, the lattice enthalpy of magnesium fluoride differs from that of calcium chloride.

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.... [3]

(b) Explain why the first ionisation energy of calcium is less positive than the second ionisation energy.

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.... [2]

[Total: 10]

For Examiner's Use

2 A moss killer contains iron(II) sulphate.

Some of the iron(II) sulphate gets oxidised to form iron(III) sulphate. During the oxidation iron(II) ions, Fe^{2+}, react with oxygen, O_2, and hydrogen ions to make water and iron(III) ions, Fe^{3+}.

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

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

....

.... [2]

(b) State **two** typical properties of **compounds** of a transition element.

1 ....

2 .... [2]

(c) Describe how aqueous sodium hydroxide can be used to distinguish between aqueous iron(II) sulphate and aqueous iron(III) sulphate.

....

....

.... [2]

(d) Construct the equation for the oxidation of acidified iron(II) ions by oxygen.

.... [2]

For Examiner's Use

(e) The percentage by mass of iron in a sample of moss killer can be determined by titration against acidified potassium manganate(VII).

- Stage 1 – A sample of moss killer is dissolved in excess sulphuric acid.
- Stage 2 – Copper turnings are added to the acidified sample of moss killer and the mixture is boiled carefully for five minutes. Copper reduces any iron(III) ions in the sample to give iron(II) ions.
- Stage 3 – The reaction mixture is filtered into a conical flask to remove excess copper.
- Stage 4 – The contents of the flask are titrated against aqueous potassium manganate(VII).

(i) Suggest why it is important to remove all the copper in stage 3 before titrating in stage 4.

....

.... [1]

(ii) The ionic equation for the redox reaction between acidified MnO_4^- and Fe^{2+} is given below.

$$MnO_4^-(aq) + 8H^+(aq) + 5Fe^{2+}(aq) \longrightarrow Mn^{2+}(aq) + 4H_2O(l) + 5Fe^{3+}(aq)$$

Explain, in terms of electron transfer, why this reaction involves both oxidation and reduction.

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....

.... [2]

(iii) A student analyses a 0.675 g sample of moss killer using the method described.

In stage 4, the student uses 22.5 cm^3 of 0.0200 mol dm^{-3} MnO_4^- to reach the end-point.

Calculate the percentage by mass of iron in the moss killer.

percentage .... [4]

[Total: 15]

[Turn over

For Examiner's Use

3 Aqueous copper(II) sulphate contains $[Cu(H_2O)_6]^{2+}$ ions. Aqueous ammonia is added drop by drop to a small volume of aqueous copper(II) sulphate. Two reactions take place, one after the other, as shown in the equations.

$$[Cu(H_2O)_6]^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(OH)_2(s) + 6H_2O(l)$$

$$Cu(OH)_2(s) + 2H_2O(l) + 4NH_3(aq) \rightarrow [Cu(NH_3)_4(H_2O)_2]^{2+}(aq) + 2OH^-(aq)$$

(a) Describe the observations that would be made as ammonia is added drop by drop until it is in an excess.

....

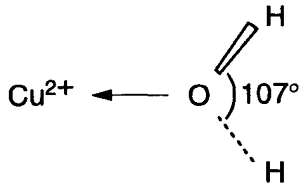
.... [2]

(b) Draw the shape for the $[Cu(H_2O)_6]^{2+}$ ion. Include the bond angles in your diagram.

[2]

(c) Water is a simple molecule. The H—O—H bond angle in an isolated water molecule is 104.5°.

The diagram shows part of the $[Cu(H_2O)_6]^{2+}$ ion and the H—O—H bond angle in the water ligand.



Explain why the H—O—H bond angle in the water ligand is 107° rather than 104.5°.

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....

....

.... [3]

[Total: 7]

4 In this question, one mark is available for the quality of use and organisation of scientific terms.

There are trends in the physical and chemical properties of the oxides of the elements of period 3.

Using only the oxides of the elements magnesium, aluminium and sulphur,

- describe and explain the trends in

  chemical formula

  structure and bonding

  action of water

- explain the trend in the melting points shown in the table.

oxide	magnesium oxide	aluminium oxide	sulphur dioxide
melting point / °C	2826	2072	−10

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For Examiner's Use

.... [12]

Quality of Written Communication [1]

[Total: 13]

END OF QUESTION PAPER

ADVANCED GCE UNIT

MARK SCHEME

MAXIMUM MARK: 45

Specification / Component: 2815/01

Chemistry: Trends and Patterns

Paper Set Date: 25/01/05

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 (½) 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 **Page 1 of 4**	**Unit Code** **2815/01**	**Session** January	**Year** 2005	**Version** Post-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) (i)	Electron affinity -696 (1 mark); Atomisation of Cl_2 +244 (1 mark); From top to bottom 2nd IE +1150, 1st IE +590, atomisation of Ca +178 formation -796 (1 mark)	3	**Allow** 244, 1150, 590 and 176 i.e. without plus sign
(ii)	-796 - 178 - 590 - 1150 - 244 + 696 (1); **But** -2262 (with no working) (2)	2	**Allow** ecf from the wrong figures on the Born-Haber cycle 1 error **max one mark** 2 errors **0 mark**
(iii)	Magnesium fluoride more exothermic than calcium chloride / ora because Ionic radius of Mg^{2+} is less than that of Ca^{2+} / charge density of magnesium ion is greater than that of calcium ion / ora (1); Ionic radius of F^- is less than that of Cl^- / charge density of fluoride ion is greater than that of chloride ion / ora (1); Stronger (electrostatic) attraction between cation and anion in MgF_2 than in $CaCl_2$ / stronger ionic bonds in MgF_2 (1)	3	Answer must refer to the correct particle. **Not** Mg or magnesium has a smaller radius or fluorine has a smaller radius **Allow** magnesium or fluorine has a smaller ionic radius
(b)	**Any two from** For second ionisation energy the electron lost is closer to the nucleus / AW (1); For second ionisation energy the electron is lost from a particle that is already positive (1); For second ionisation energy there is one more proton than electron (1) So outer electron more firmly attracted to the nucleus (1)	2	**Allow** ora
		Total = 10	

Mark Scheme Page 2 of 4	Unit Code **2815/01**	Session January	Year 2005	Version Post-Standardisation

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Question	Expected answers	Marks	Additional guidance
2 (a)	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$ (1); Has an incomplete set of 3d electrons (1)	2	**Allow** 3d orbitals are not completely occupied / incomplete 3d sub-shell **Allow** has half-filled d orbitals
(b) (i)	**Any two from** Variable oxidation state / variable valency (1); Act as catalysts (1); Form complexes / form complex ions (1); Form coloured compounds (1)	2	**Not** high melting point / good thermal and electrical conductors / high density etc
(c)	Iron (II) ions give a green ppt (1); Iron (III) ions give an orange-rust ppt (1)	2	Precipitate must be used once **Allow** solid instead of ppt
(d)	$4Fe^{2+} + O_2 + 4H^+ \rightarrow 4Fe^{3+} + 2H_2O$ Correct reactants and products (1); Correct balancing (1)	2	
(e) (i)	Copper may react with potassium manganate(VII) / iron(III) ions formed in titration may be reduced back to iron(II) ions by the copper (1)	1	
(ii)	MnO_4^- gains electrons and is reduced / Mn oxidation state changes from +7 to +2 so it is reduced (1); Fe^{2+} loses electrons and is oxidised / Fe oxidation state changes from +2 to +3 so it is oxidised (1)	2	
(iii)	Moles of MnO_4^- = 4.50×10^{-4} (1); Moles of Fe^{2+} = 5 × moles MnO_4^- / 2.25×10^{-3} (1); Mass of Fe = moles of Fe^{2+} × 55.8 / 0.1256 (1); Percentage = 18.6 % (1)	4	**Allow** answers that use 56 for A_r of Fe this gives 18.7 **Allow** ecf
		Total = 15	

Mark Scheme **Page 3 of 4**	**Unit Code** **2815/01**	**Session** January	**Year** 2005	**Version** Post-Standardisation
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Question	Expected answers	Marks	Additional guidance
3 (a)	(Pale blue solution) to a (light) blue ppt (1); with excess dark blue solution (1)	2	
(b)	Octahedral shape with clear indication of 3D either by construction lines or wedges etc (1); 90^o (1)	2	**Ignore** mistakes with the ligands question focuses on octahedral and the bond angle
(c)	Water molecule 2 lone pairs (and 2 bond pairs) (1); Water ligand 1 lone pair and 3 bond pairs / lone pair is now a bond pair / water has one less lone pair when it is a ligand (1); Lone pairs repel more than bond pairs (1)	3	**Not** atoms repel
		Total = 7	

Mark Scheme	Unit Code	Session	Year	Version
	2815/01	January	2005	Post-Standardisation

Abbreviations, annotations and conventions used in the Mark Scheme		
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Question	Expected answers	Marks	Additional guidance
4	**Twelve from** **Chemical formula** Correct formula of all oxides – MgO, Al_2O_3, SO_2 or SO_3 (1); Number of outer electrons per atom increases / oxidation state of element increases (1); **Structure and bonding – Any three from** Correct bonding – MgO is ionic, Al_2O_3 has intermediate bonding and SO_2 or SO_3 are covalent (1); Correct structure - MgO and Al_2O_3 both giant structures, SO_2 or SO_3 simple (1); Ionic 'dot-and-cross' diagram for MgO or Al_2O_3 (1); Covalent 'dot-and-cross' diagram for SO_2 or SO_3(1); **Action of water – Any four from** MgO reacts water to give an alkaline solution (1); because the oxide ions react with water molecules / $MgO + H_2O \rightarrow Mg(OH)_2$ / $O^{2-} + H_2O \rightarrow 2OH^-$ (1); Al_2O_3 does not react with water / does not dissolve in water (1); SO_2 or SO_3 reacts to give acidic solutions (1); $SO_2 + H_2O \rightarrow H_2SO_3$ / $SO_3 + H_2O \rightarrow H_2SO_4$ (1) **Melting points** MgO or Al_2O_3 has electrostatic attraction between ions (1); SO_2 or SO_3 has van der Waals forces / has permanent dipole-permanent dipole attraction / instantaneous dipole (1); Comparison of strength of forces in ionic and simple molecular e.g. strong and weak / comparison of forces in Al_2O_3 and simple molecule (1) **And** QWC – one mark for a well ordered and structured answer. Property clearly linked with explanation on at least two occasions (1)	13	**Ignore** any other formulae **Allow** marks from diagrams e.g. dot and cross or lattice **Allow** Al_2O_3 ionic bonding with covalent character / polar covalent (1) **Allow** attraction between positive and negative ions / attraction between magnesium ions and oxide ions **Allow** strong ionic bonds and weak intermolecular forces
		Total = 13	