OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

CHEMISTRY 2815/01

Trends and Patterns

Wednesday **30 JANUARY 2002** 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 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		
Question Number	Mark	Mark
1	10	
2	11	
3	9	
4	15	
TOTAL	45	

This question paper consists of 8 printed pages.

Registered Charity Number. 1066969
[Turn over

Answer **all** questions.

1 Enthalpy changes of formation can be calculated using Born-Haber cycles.

(a) Construct a labelled Born-Haber cycle for magnesium chloride, $MgCl_2$, using the information below.

enthalpy change	energy/kJ mol^{-1}
atomisation of magnesium	+148
atomisation of chlorine	+122
1st ionisation energy of magnesium	+738
2nd ionisation energy of magnesium	+1451
1st electron affinity of chlorine	–349
lattice enthalpy of magnesium chloride	–2526
formation of magnesium chloride	?

[5]

(b) Use the Born-Haber cycle to calculate a value for the enthalpy change of formation of magnesium chloride.

[2]

(c) State and explain which compound has the **most exothermic** lattice enthalpy; $MgCl_2$, $MgBr_2$ or MgI_2.

.....

.....

.....

.....[3]

[Total : 10]

[Turn over

2 Iron in compounds commonly exists as Fe^{2+} and Fe^{3+}.

(a) Complete the electronic configuration of the Fe^{3+} **ion**.

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

(b) **(i)** State **one** reason why transition metals are good catalysts.

.....

.....[1]

(ii) State **one** example of iron or a compound of iron being used as a catalyst in industry.

.....[1]

(c) Complete the following notes taken during a laboratory experiment.

Aqueous thiocyanate ions were added to aqueous iron(III) ions.
The solution changed colour

from ..... *to* .....

Equation:.....[4]

(d) Aqueous manganate(VII) ions were titrated against $25.0\,cm^3$ of $0.0500\,mol\,dm^{-3}$ Fe(II) ions in acid solution.

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

The volume of aqueous manganate(VII) ions required to reach the end point was $12.3\,cm^3$.

(i) State the colour change observed at the end point.

from ..... to.....[1]

(ii) Calculate the concentration of the aqueous manganate(VII) ions used in the titration.

Answer.....$mol\,dm^{-3}$ [3]

[Total : 11]

3 The compounds of magnesium are widely used and widely studied.

(a) State **one** reason why magnesium oxide is used to make high-temperature ceramic materials.

.....[1]

(b) Magnesium oxide reacts with hydrochloric acid to form magnesium chloride.

Write an equation, including state symbols, for this reaction.

.....[2]

(c) Predict the approximate pH of the solution formed when the following compounds are added to water.

magnesium oxide pH is .....

magnesium chloride pH is..... [2]

(d) State the bonding and structure in magnesium chloride.

bonding .....

structure .....[2]

(e) Explain why different temperatures are needed to decompose magnesium carbonate and calcium carbonate.

decomposition reaction	decomposition temperature/ °C
$MgCO_3(s) \rightarrow MgO(s) + CO_2(g)$	540
$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$	900

.....

.....

.....

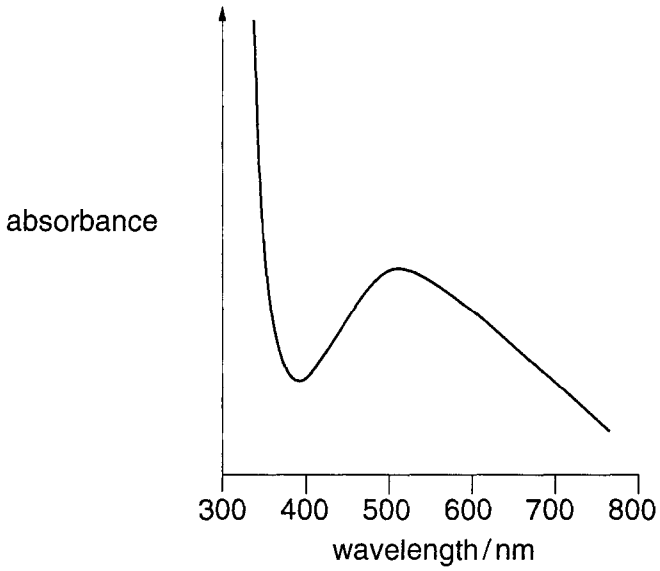
.....[2]

[Total : 9]

4 *(In this question, 1 mark is available for the quality of written communication.)*

Copper forms complex ions.

(a) The absorption spectrum of a complex ion in aqueous solution is shown below.



Predict the colour of the complex ion and explain your answer.

.....

.....

.....

.....[2]

(b) Using complex ions of copper as examples, explain what is meant by the terms *complex ion* and *ligand*.

Explain what is meant by *ligand substitution*, giving two examples that are accompanied by a colour change and including equations in your answer.

Describe, using suitable examples, two different shapes of complex ions. [13]

[Total : 15]

RECOGNISING ACHIEVEMENT

Subject: Chemistry A Code: 7882

Session: January Year: 2002

2815/01 Mark Scheme

MAXIMUM MARK	45

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
1	(a)	both atomisation steps	1
		1^{st} and 2^{nd} ionisation enthalpies	1
		electron affinity step	1
		lattice enthalpy	1
		enthalpy of formation	1
		all to be chemically correct and correctly labelled; penalise state symbols once only	
	(b)	ΔH_f = (+148) + (2×122) + (738) + (1451) + (2× -349) + (-2526)	1
		ΔH_f = -643 kJ mol^{-1} *(with units , correct answer = 2 marks)*	1
		allow ecf from (a)	
	(c)	$MgCl_2$	1
		Cl^- is the smallest anion *(reject chlorine ion)*	1
		strongest attraction / bonding	1

[Total: 10]

Question		Expected Answers	Marks
2 (a)		$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5$	1
(b)	(i)	energy of the d electrons approximately the same / transfer energy easily / adsorb well / hold reactants in place / variable oxidation state / easily transfer electrons / good bonding potential *not "cheap"*	1
(b)	(ii)	in the Haber process / $FeCl_3$ in Friedel Crafts	1
(c)		from yellow to (blood) red	2
		$[Fe(H_2O)_6]^{3+} + SCN^- \rightarrow [Fe(H_2O)_5SCN]^{2+} + H_2O$ *2 marks for correct equation* *allow one mark for correct formula and charge on complex ion*	2
(d)	(i)	from colourless / pale green (*NOT 'green'*) to pink/purple	1
(d)	(ii)	no mol Fe^{2+} = 25/1000 × 0 05 (= 0 00125 mol)	1
		no mol MnO_4^- = 0.00125 / 5 (= 0.00025 mol)	1
		concn MnO_4^- = 0 00025 / (12 3 × 10^{-3}) = 0.02(03) mol dm^{-3} *allow ecf from line 2, correct answer with units = 3 marks*	1

[Total: 11]

Question		Expected Answers	Marks
3	(a)	(very) high mp / strong lattice / large ΔH_{latt} / does not decompose on heating	1
	(b)	$MgO(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l)$ *one mark for the equation* *one mark for state symbols in correct equation*	2
	(c)	MgO pH = 8-12	1
		$MgCl_2$ pH = 4-7	1
	(d)	*bonding* ionic	1
		structure giant / lattice	1
	(e)	Mg^{2+} has greater charge density than Ca^{2+}	1
		so distorts the anion more / polarises the anion more	1

[Total: 9]

Question		Expected Answers	Marks
4	(a)	purple / violet / red	1
		absorption is in green / blue (*as appropriate*)	1
	(b)	*complex ion* metal atom or ion surrounded by ligands	1
		ligand a species able to donate a pair of electrons / form a dative/co-ordinate bond	1
		ligand substitution exchange of ligands	1
		example + colour change + equation	3×2

e g $[Cu(H_2O)_6]^{2+}$ + $4NH_3$ ⇌ $[Cu(H_2O)_2(NH_3)_4]^{2+}$ + $4H_2O$
blue dark blue

$[Cu(H_2O)_6]^{2+}$ + $4Cl^-$ ⇌ $[CuCl_4]^{2-}$ + $6H_2O$
blue yellow/green

octahedral + example $[Cu(H_2O)_2(NH_3)_4]^{2+}$

tetrahedral + example $[CuCl_4]^{2-}$

square planar + example $[PtCl_4]^{2-}$

linear + example $[Ag(NH_3)_2]^+$ 2
2

QWC, organisation of response Max 12
1

[Total: 15]