OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

CHEMISTRY 2815/01

Trends and Patterns

Tuesday **25 JUNE 2002** 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 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	11	
2	5	
3	13	
4	5	
5	11	
TOTAL	45	

This question paper consists of 8 printed pages.

Registered Charity Number: 1066969
[Turn over

Answer **all** questions.

1 **(a)** **(i)** Explain what is meant by the term *transition element.*

.....

.....[1]

(ii) Complete the electronic configuration of the vanadium atom.

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

(b) Aqueous transition metal ions can react with aqueous hydroxide ions.

(i) Complete the table below.

metal ion	**formula** and **state symbol** of the product of the reaction with $OH^-(aq)$	colour of product
$Fe^{2+}(aq)$		
$Fe^{3+}(aq)$		

[5]

(ii) Aqueous ammonia reacts with water in the following way.

$$NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$$

When aqueous ammonia is added dropwise to aqueous copper(II) ions, a very pale blue precipitate is observed which disappears in excess ammonia to give a deep blue solution.

Write equations to show the formation from aqueous copper(II) ions of

the pale blue precipitate,

.....

the deep blue solution.

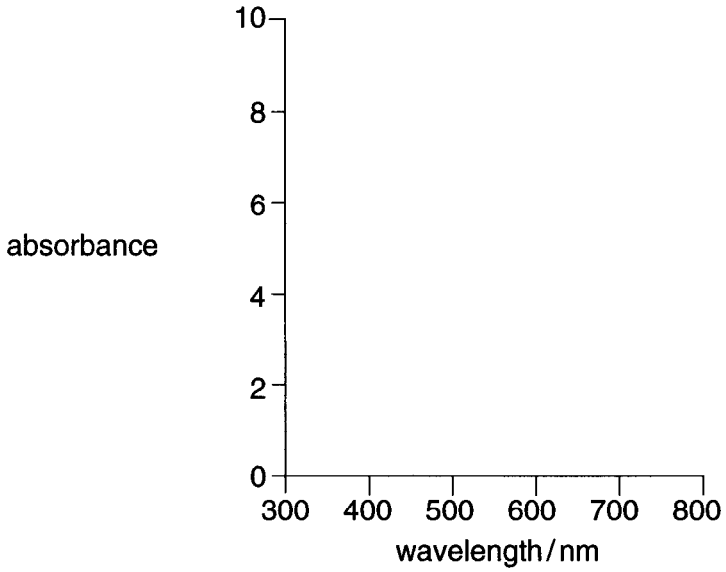
.....[4]

[Total : 11]

2 The transition metal compound **X** is analysed.

(a) The aqueous solution of **X** is yellow.

Sketch on the axes below the absorption spectrum you would predict for **X** in aqueous solution.



[1]

(b) Explain the shape of your sketch.

.....

.....[1]

(c) Calculate the empirical formula of **X** which has the following composition by mass: K, 32.0%; Cr, 21.3%; F, 46.7%.

[2]

(d) Suggest the identity of the **ligand** in **X**.

.....[1]

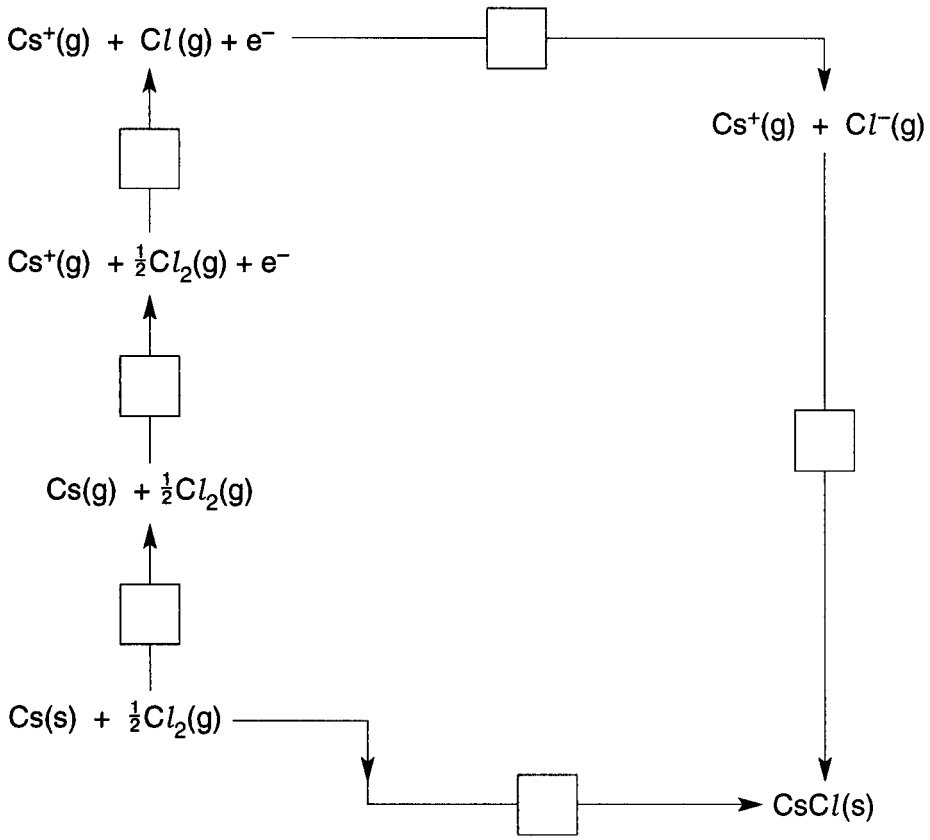
[Total : 5]

3 The lattice enthalpy of caesium chloride, Cs*Cl*, can be calculated using a Born-Haber cycle.

The table below shows the enthalpy changes and corresponding data for this cycle.

enthalpy change		energy/kJ mol^{-1}
lattice enthalpy of Cs*Cl*	**A**	?
atomisation of caesium	**B**	+76
atomisation of chlorine	**C**	+122
1st ionisation energy of caesium	**D**	+376
1st electron affinity of chlorine	**E**	–349
formation of Cs*Cl*	**F**	–443

(a) On the cycle below, put the letter for each enthalpy change in the appropriate box.



[3]

(b) Calculate the lattice enthalpy of caesium chloride.

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

(c) The lattice enthalpy of sodium chloride is **more exothermic** than the lattice enthalpy of caesium chloride.

State and explain the relative strengths of the ionic bonding in sodium chloride and caesium chloride.

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.....[3]

(d) What would you expect to observe when solid caesium chloride is added to water?

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.....[2]

(e) Describe how you would distinguish between aqueous caesium chloride and aqueous caesium iodide using a simple laboratory test. State the observations you would make.

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.....[3]

[Total : 13]

4 The manganate(VII) ion, MnO_4^-, is a strong oxidising agent frequently used in laboratory analysis. It reacts with the ethanedioate ion, $C_2O_4^{2-}$, in hot acidic solution to form CO_2 and Mn^{2+} ions.

$$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$$
$$C_2O_4^{2-} \rightarrow 2CO_2 + 2e^-$$

(a) Construct the full ionic equation for this reaction.

[2]

(b) Calculate the volume of 0.0200 mol dm^{-3} potassium manganate(VII) required to react with 25.0 cm^3 of 0.0400 mol dm^{-3} sodium ethanedioate.

[3]

[Total : 5]

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

Redox reactions are a common type of chemical reaction.

(a) Write an equation for the reaction between

- aluminium and oxygen,
- phosphorus and chlorine.

Explain why each reaction may be regarded as a redox reaction.

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.....[6]

(b) Water is added to the product of each of the reactions above.

Describe what you would observe in each case. Give an equation for any reaction that occurs, stating whether it is a redox reaction.

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.....[5]

[Total: 11]

[Total for paper : 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)	(i)	has at least one ion with a partially filled d-orbital		1
		(ii)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^3\ 4s^2$		1
	(b)	(i)	$Fe(OH)_2$	green	2
			$Fe(OH)_3$ / $Fe_2O_3.xH_2O$	brown/red-brown/rust coloured/orange-brown	2
			both solid		1
		(ii)	$[Cu(H_2O)_6]^{2+} + 2OH^- \rightarrow Cu(OH)_2 + 6H_2O$ / $Cu^{2+} + 2OH^- \rightarrow Cu(OH)_2$		1
			$Cu(OH)_2$ obtains 1 mark if not part of balanced equation		1
			$[Cu(H_2O)_6]^{2+} + 4NH_3 \rightarrow [Cu(NH_3)_4(H_2O)_2]^{2+} + 4H_2O$		1
			$[Cu(NH_3)_4(H_2O)_2]^{2+}$ / $[Cu(NH_3)_4]^{2+}$ =1mark if not part of balanced equation		1
			N.B. Correctly balanced equations obtain both marks		
				[Total: 11]	

Question		Expected Answers	Marks
2	(a)	absorbs violet/blue / 400 nm - 450 nm No other absorbance below 650 nm	1
	(b)	absorbs the complementary colour it transmits	1
	(c)	K · Cr . F = 0 818 · 0 410 . 2 46 (correct ratios obtain this mark)	1
		2K 1Cr 6F / K_2CrF_6	1
	(d)	F^- / fluoride	1
		Don't accept fluorine or F	
		[Total: 5]	

Question	Expected Answers	Marks
3 (a)	*correctly labelled* atomisation of chlorine + atomisation of caesium	1
	1st ionisation energy + 1st electron affinity	1
	formation of CsCl + LE	1
(b)	-443 = + 76 + (+122) + (+376) + (-349) + LE	1
	LE = -668 kJ mol^{-1} (allow ecf here if 1 mistake only in step 1)	1
(c)	Na^+ smaller than Cs^+ (don't accept sodium smaller first time)	1
	Na^+ has a larger charge density	1
	attracts the anion/Cl^- more strongly/ sodium chloride has the stronger bonding	1
(d)	dissolves / no reaction *do not accept "nothing"*	1
	colourless / neutral / pH 7	1
(e)	add aqueous $AgNO_3$	1
	chloride gives a white ppt	1
	iodide gives a yellow ppt	1
	Alternative answer	
	Pass chlorine/use NaOCl & HCl	
	No change with CsCl	
	Iodine displaced/brown solution with CsI	
	[Total:	**13]**

Question	Expected Answers	Marks
4 (a)	$2MnO_4^- + 16H^+ + 5C_2O_4^{2-} \rightarrow 2Mn^{2+} + 8H_2O + 10CO_2$	2
	1 mark for correct species, 1 mark for correct balancing including electrons if present	
(b)	amount of $C_2O_4^{2-}$ = (25.0/1000) × 0 0400 = 0 001 mol	1
	amount of MnO_4^- required = 0 001 × (2/5) = 0.0004 mol	1
	vol of MnO_4^- required = 0 0004/0.0200 × 1000 = 20 cm^3 / 0.02 dm^3	1
	(Allow ecf on parts 2 & 3)	
	[Total	**5]**

Question	Expected Answers	Marks
5 (a)	$2Al + {}^{3}/_{2}O_2 \rightarrow Al_2O_3$	1
	$2P + 3Cl_2 \rightarrow 2PCl_3$ / $2P + 5Cl_2 \rightarrow 2PCl_5$ / $P_4 + 6Cl_2 \rightarrow 4PCl_3$ / $P_4 + 10Cl_2 \rightarrow 4PCl_5$	1
	correct oxidation numbers in 2 equations	2
	show oxidation or reduction by increase/decrease in oxidation numbers	1
	Credit electron transfer if used for Al_2O_3	
	QWC for good organisation?	1
(b)	Al_2O_3 does not react / does not dissolve	1
	PCl_5 exothermic reaction/vigorous reaction	1
	White fumes/steamy fumes/misty fumes	1
	HCl produced/acidic solution produced	1
	$PCl_5 + 4H_2O \rightarrow H_3PO_4 + 5HCl$ / $PCl_3 + 3H_2O \rightarrow H_3PO_3 + 3HCl$ / $PCl_5 + H_2O \rightarrow POCl_3 + 2HCl$	1
	not a redox reaction	1
	N.B. max 5 marks	
	[Total: 11]	