OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

CHEMISTRY 2815/06

Transition Elements

Tuesday **25 JANUARY 2005** Afternoon 50 minutes

Candidates answer on the question paper.
Additional materials:
Data Sheet for Chemistry
Scientific calculator

Candidate Name	Centre Number	Candidate Number

TIME 50 minutes

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	**12**	
2	**11**	
3	**13**	
4	**9**	
TOTAL	**45**	

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

For Examiner's Use

Answer **all** the questions.

1 Vanadium is a hard corrosion-resistant metal which forms compounds with a number of different oxidation states.

(a) State a common use for vanadium or one of its compounds.

.... [1]

(b) The standard electrode potential of the V^{2+}/V redox system is –1.20 V.

Draw a labelled diagram to show how you would measure the standard electrode potential of the V^{2+}/V system.

[5]

(c) The most common oxidation states of vanadium are shown in the table below.

	V^{2+}	VO_2^+	VO^{2+}	V^{3+}
oxidation number of vanadium	+2			+3
colour	lilac	yellow		

(i) Complete the table by filling in the empty spaces. [4]

For Examiner's Use

(ii) Each oxidation state may be observed by carrying out the successive reduction of ammonium vanadate(V) using zinc in an acidic solution.

The final step converts $V^{3+}(aq)$ into $V^{2+}(aq)$.

Use the following standard electrode potentials to explain why the reduction process stops at the ion V^{2+}.

$$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s) \qquad E^\ominus = -0.76\,V$$

$$V^{2+}(aq) + 2e^- \rightleftharpoons V(s) \qquad E^\ominus = -1.20\,V$$

$$V^{3+}(aq) + e^- \rightleftharpoons V^{2+}(aq) \qquad E^\ominus = -0.26\,V$$

....

....

....

.... [2]

[Total: 12]

2 Transition metals readily form complex ions when they are combined with a suitable ligand.

(a) What is meant by the following terms?

(i) *complex ion*

....

.... [1]

(ii) *ligand*

....

.... [2]

(b) A common ligand which combines with a number of transition metal ions is ethane-1,2-diamine, $H_2NCH_2CH_2NH_2$. This is a bidentate ligand.

Explain the meaning of the term *bidentate*.

....

.... [1]

(c) The complex $[CoCl_2(H_2NCH_2CH_2NH_2)_2]$ is a neutral molecule. It shows two types of stereoisomerism. Use this molecule to explain what you understand by the term *stereoisomerism*. Your answer should include diagrams to show clearly the structures of the different isomers in both types of stereoisomerism.

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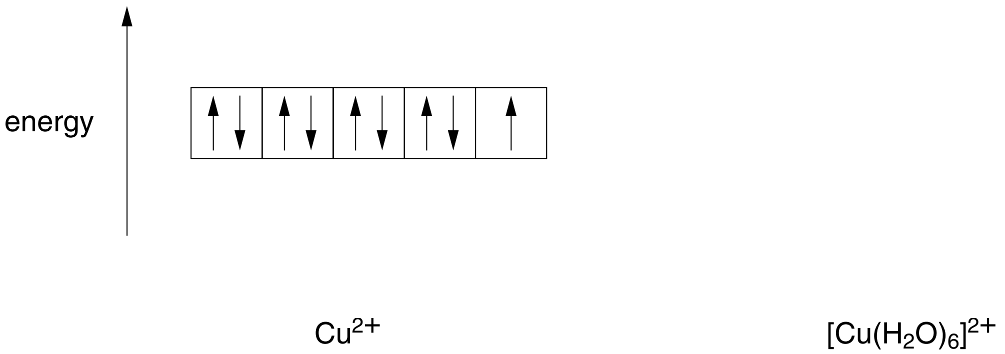
.... [7]

[Total: 11]

3 One common property of transition metal compounds is that they are coloured. When a transition metal ion forms a complex, splitting of the d-orbitals takes place.

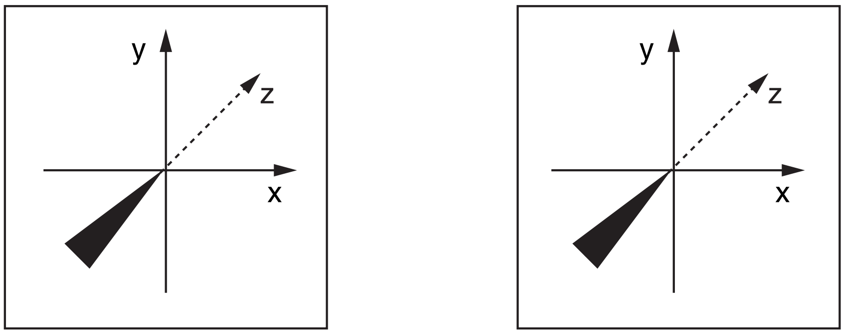
(a) In a Cu^{2+} ion, all five d-orbitals have the same energy. However, when the octahedral complex ion $[Cu(H_2O)_6]^{2+}$ is formed, the d-orbitals split into different energy levels.

(i) Complete the following diagram to show the splitting of d-orbitals in the complex ion.



[2]

(ii) Draw diagrams to show the shape of one lower energy d-orbital and one higher energy d-orbital in the boxes below.



lower energy d-orbital

higher energy d-orbital

[2]

For Examiner's Use

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

Complexes containing Cu^{2+} are coloured, whereas complexes of Cu^{+} are not coloured. Explain why.

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....

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....

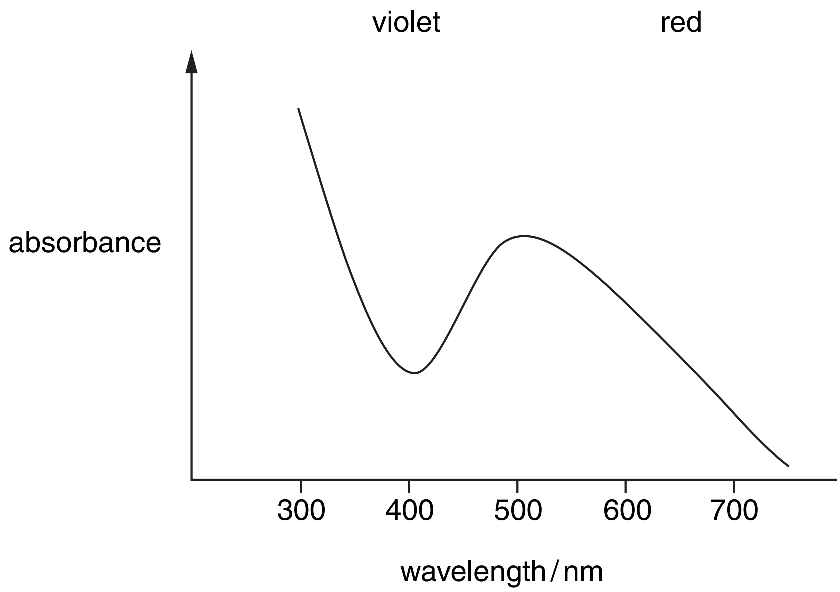
.... [6]

Quality of Written Communication [1]

For Examiner's Use

(c) If visible light is passed through a coloured solution, the light that is transmitted can be analysed by a visible spectrometer.

The visible spectrum for aqueous $[Ti(H_2O)_6]^{3+}$ is shown below.



The solution is purple. Explain how you can tell that it is purple by looking at the spectrum.

....

....

.... [2]

[Total: 13]

For Examiner's Use

4 Potassium dichromate(VI) can be used in a number of redox reactions. The standard electrode potentials for two half reactions are given below.

$$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightleftharpoons 2Cr^{3+} + 7H_2O \qquad E^\ominus = +1.33\,V$$

$$I_2 + 2e^- \rightleftharpoons 2I^- \qquad E^\ominus = +0.54\,V$$

(a) Acidified potassium dichromate(VI) is added to aqueous potassium iodide to give aqueous iodine.

(i) Construct an ionic equation to show the reaction taking place when acidified potassium dichromate(VI) is added to aqueous potassium iodide.

....

....

.... [2]

(ii) An excess of aqueous sodium thiosulphate was then added. Describe and explain what you would see.

....

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.... [3]

(b) Potassium dichromate(VI) also takes part in the following reaction.

$$Cr_2O_7^{2-} + 2OH^- \rightleftharpoons 2CrO_4^{2-} + H_2O$$

(i) Show that chromium is **not** taking part in a redox reaction.

....

....

.... [2]

(ii) Describe the colour change for the forward reaction.

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

(iii) Suggest a reagent that would convert CrO_4^{2-} back to $Cr_2O_7^{2-}$.

.... [1]

[Total: 9]

END OF QUESTION PAPER

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