



**ADVANCED GCE**  
**CHEMISTRY**  
 Transition Elements

**2815/06**

Candidates answer on the question paper  
 A calculator may be used for this paper

**OCR Supplied Materials:**

- *Data Sheet for Chemistry* (inserted)

**Other Materials Required:**

- Scientific calculator

**Wednesday 27 January 2010**  
**Morning**

**Duration:** 50 minutes



Candidate  
Forename

Candidate  
Surname

Centre Number

Candidate Number

**INSTRUCTIONS TO CANDIDATES**

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided, however additional paper may be used if necessary.

**INFORMATION FOR CANDIDATES**

- The number of marks is given in brackets [ ] at the end of each question or part question.
- The total number of marks for this paper is **45**.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use a scientific calculator.
- A copy of the *Data Sheet for Chemistry* is provided as an insert with this question paper.
- You are advised to show all the steps in any calculations.
- This document consists of **12** pages. Any blank pages are indicated.

Examiner's Use Only:

1			
2			
3			
4			
<b>Total</b>			



Answer **all** the questions.

**1** Transition metal compounds commonly undergo ligand substitution reactions.

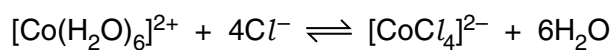
**(a)** What is meant by the term *ligand substitution*?

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.....

..... **[2]**

**(b)** The following equilibrium is readily established.

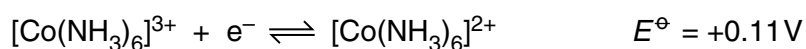
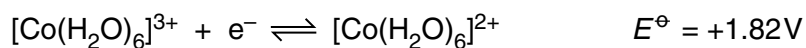


In the boxes below, draw the 3-D shape of each complex ion.

$[\text{Co}(\text{H}_2\text{O})_6]^{2+}$	$[\text{CoCl}_4]^{2-}$
--	------------------------

**[2]**

- (c) Cobalt also forms complex ions with an oxidation state of +3. The following standard electrode potentials refer to cobalt(III) complexes.



- (i) Which of the four complexes above is the strongest reducing agent?

Explain your answer.

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

- (ii) Suggest why the cobalt(III) oxidation state is more stable in ammonia than in water.

.....  
 .....  
 ..... [1]

- (d) Vanadium has several oxidation states in its aqueous ions.

Complete the table below.

	$\text{VO}_2^+(\text{aq})$	$\text{VO}^{2+}(\text{aq})$	$\text{V}^{3+}(\text{aq})$	$\text{V}^{2+}(\text{aq})$
oxidation state of vanadium			+3	+2
colour	yellow		green	

[4]

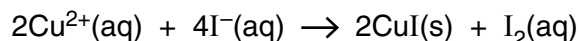
[Total: 12]

- 2 A sample of impure copper was analysed to find its percentage by mass of copper.

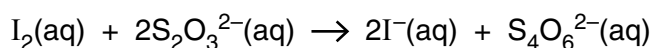
A solution was prepared by dissolving a sample of 8.95 g of the impure metal in dilute nitric acid to give 250 cm<sup>3</sup> of solution. The impurities did not dissolve and were filtered from the solution.

The copper was all converted into Cu<sup>2+</sup>.

An excess of potassium iodide, KI(aq), was added to 25.0 cm<sup>3</sup> of this solution. Iodine formed:



The iodine produced was titrated with 0.500 mol dm<sup>-3</sup> sodium thiosulphate.



Starch was added near the end-point to make the colour change easier to observe.

The average titre obtained was 23.50 cm<sup>3</sup> of the thiosulphate solution.

- (a) (i) State the oxidation number of sulphur in S<sub>2</sub>O<sub>3</sub><sup>2-</sup>.

..... [1]

- (ii) Calculate the amount, in moles, of S<sub>2</sub>O<sub>3</sub><sup>2-</sup> ions in the average titre.

answer = .....mol [1]

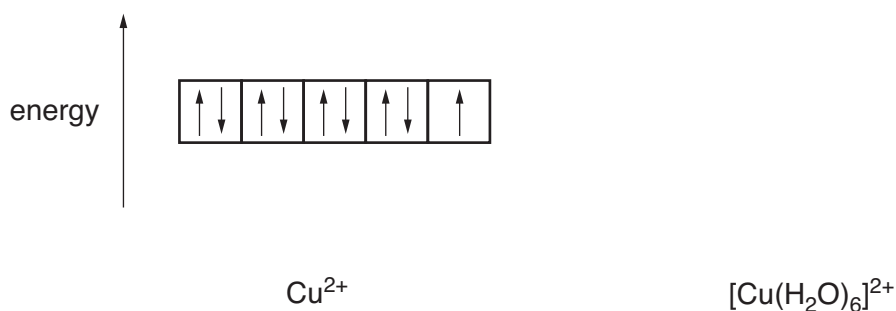
- (iii) Calculate the percentage, by mass, of copper present in the sample of the impure copper.

Give your answer to **three** significant figures.

answer = ..... % [5]

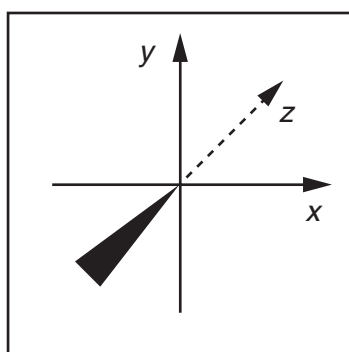
- (b) Copper can form compounds that are coloured. When a transition metal ion forms a complex, splitting of the d-orbitals takes place. In an isolated  $\text{Cu}^{2+}$  ion, all five orbitals have the same energy. However when the octahedral complex ion  $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$  is formed, the d-orbitals split into different energy levels.

- (i) Complete the following diagram to show the splitting of the d-orbitals in the  $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$  complex ion.

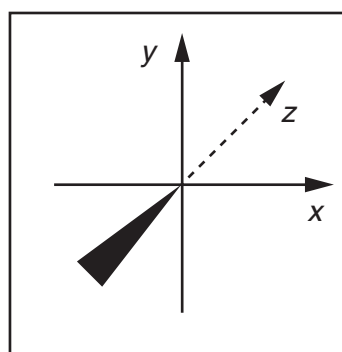


[2]

- (ii) Complete the diagrams below to show the shape of one lower energy orbital and the shape of one higher energy orbital.



lower energy  
d-orbital



higher energy  
d-orbital

[2]

- (c) Name an alloy of copper and give a use for your chosen alloy.

.....

..... [1]

[Total: 12]

- 3 (a) The standard electrode potentials for two redox systems are shown below.



- (i) Draw a labelled diagram of the standard cell formed using half-cells based on the two redox systems above.

[5]

- (ii) Calculate the standard cell potential,  $E^\ominus$ , for this cell.

..... [1]

- (iii) Write an equation for the overall cell reaction.

..... [1]

- (iv) Identify the redox system in which reduction occurs. Explain your answer.

redox system .....

explanation .....

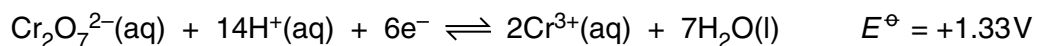
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..... [2]

- (b) An environmental chemist investigated the chloride ion concentration in a sample of water. She decided to convert the chloride ions into chlorine.

The standard electrode potentials of three redox systems are given below.



Suggest with reasons, whether acidified manganate(VII) and/or acidified dichromate(VI) would be suitable to convert chloride ions into chlorine.

suitable reagent(s) .....

reason .....

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..... [2]

[Total: 11]

- 4 In this question, one mark is available for the quality of spelling, punctuation and grammar.

This question relates to the chemistry of chromium.

4.000 g of hydrated chromium(III) chloride,  $\text{CrCl}_3 \cdot x\text{H}_2\text{O}$ , is reacted to remove **all** of its water of crystallisation.

After removal of the water of crystallisation, the residue weighed 2.380 g.

An aqueous solution of  $\text{CrCl}_3 \cdot x\text{H}_2\text{O}$  contains the complex ion  $[\text{Cr}(\text{H}_2\text{O})_4\text{Cl}_2]^+$  which shows stereoisomerism.

When an aqueous solution of chromium(III) chloride is reacted with aqueous sodium hydroxide, followed by hydrogen peroxide, a solution containing chromate(VI) ions is formed.

- Calculate the value of  $x$  in the formula  $\text{CrCl}_3 \cdot x\text{H}_2\text{O}$ .
- Using 3-D diagrams, describe the stereoisomerism in  $[\text{Cr}(\text{H}_2\text{O})_4\text{Cl}_2]^+$ .
- Outline how chromate(VI) ions can be converted into dichromate(VI) ions. Using a balanced equation, show the equilibrium that exists between chromate(VI) and dichromate(VI) ions in aqueous solution. State clearly any observations associated with this equilibrium.

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Quality of Written Communication [1]

[Total: 10]

**END OF QUESTION PAPER**

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