

**ADVANCED GCE  
CHEMISTRY**

Transition Elements

**THURSDAY 19 JUNE 2008**

**2815/06**

Morning

Time: 50 minutes

Candidates answer on the question paper.

**Additional materials:** Scientific calculator  
*Data Sheet for Chemistry* (Inserted)

Candidate  
Forename

Candidate  
Surname

Centre  
Number

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Candidate  
Number

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**INSTRUCTIONS TO CANDIDATES**

- Write your name in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use blue or 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.

**INFORMATION FOR CANDIDATES**

- The number of marks for each question 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.

**FOR EXAMINER'S USE**

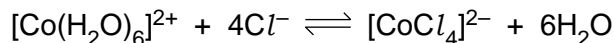
Qu.	Max	Mark
1	7	
2	8	
3	10	
4	5	
5	15	
<b>TOTAL</b>	<b>45</b>	

This document consists of **11** printed pages, **1** blank page and a *Data Sheet for Chemistry*.

Answer **all** the questions.

**1** This question is about complex ions of cobalt.

**(a)** The equilibrium below exists between two complex ions of cobalt(II).



**(i)** What colour change occurs during the reaction from left to right?

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

**(ii)** What is the shape of the  $[\text{CoCl}_4]^{2-}$  ion?

..... [1]

**(iii)** What type of reaction is this?

..... [1]

**(b)** Cobalt(III) forms a complex ion of formula  $[\text{Co}(\text{en})_3]^{3+}$  where 'en' is ethane-1,2-diamine,  $\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2$ .

Draw a displayed formula for ethane-1,2-diamine, showing clearly any lone pairs of electrons.

[1]

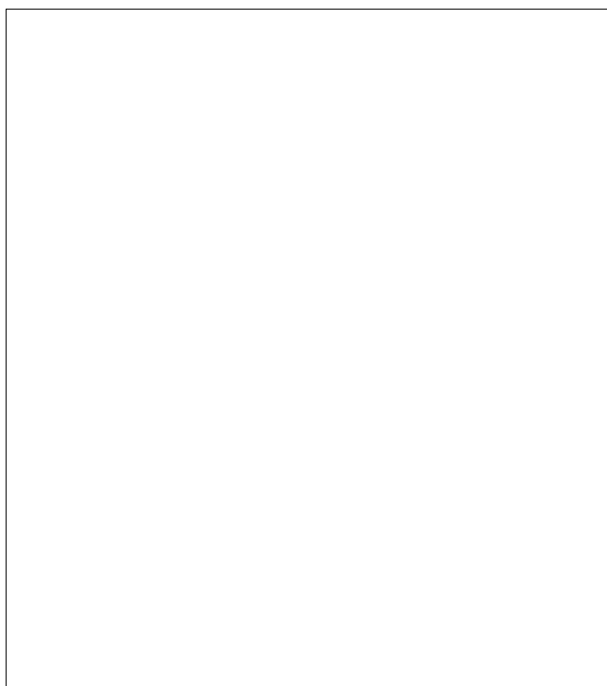
(c) The  $[\text{Co}(\text{en})_3]^{3+}$  ion shows a type of stereoisomerism.

(i) What type of stereoisomerism does it show?

..... [1]

(ii) Draw 3D diagrams to show the two stereoisomers of  $[\text{Co}(\text{en})_3]^{3+}$ .

You may use 'en' to represent the ethane-1,2-diamine ligand.



[2]

[Total: 7]

2 The standard electrode potential of  $\text{Fe}^{3+} + \text{e}^{-} \rightleftharpoons \text{Fe}^{2+}$  is +0.77 V.

(a) Define the standard electrode potential of  $\text{Fe}^{3+} + \text{e}^{-} \rightleftharpoons \text{Fe}^{2+}$ .

In your answer, include the conditions that apply when measuring the standard electrode potential.

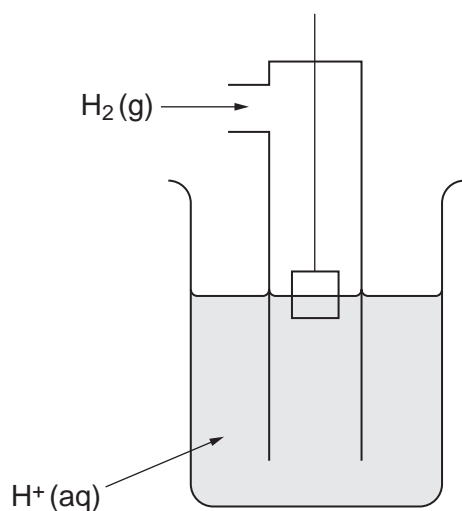
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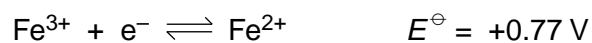
..... [3]

(b) Complete the diagram below of apparatus that would be used to measure the standard electrode potential of  $\text{Fe}^{3+} + \text{e}^{-} \rightleftharpoons \text{Fe}^{2+}$ .



[3]

(c) A standard cell is set up using the following redox equilibria.



(i) What is the standard cell potential of this cell?

standard cell potential of cell = ..... V [1]

(ii) The cell is used to provide a current.

Construct an equation for the overall cell reaction that takes place.

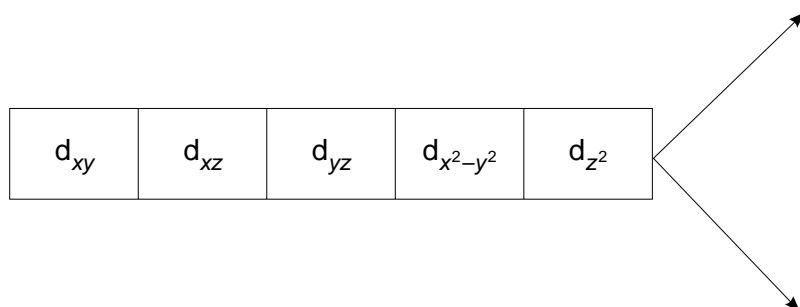
[1]

[Total: 8]

**3 (a)** There are five 3d orbitals.

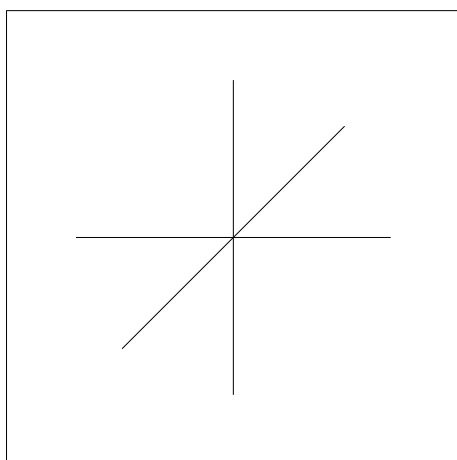
In octahedral complexes, the d-orbital energy levels split.

- Complete the diagram below to show how the d-orbital energy levels split.
- Label the orbitals.

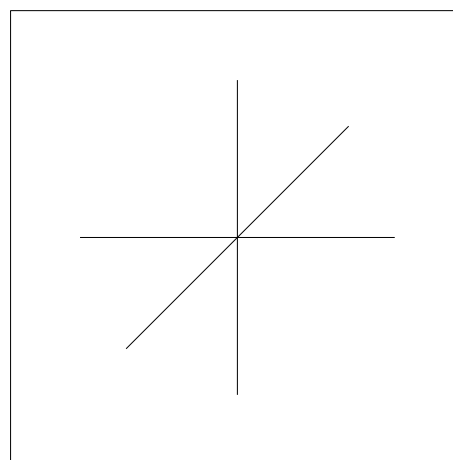


[2]

**(b)** Draw diagrams to show a  $d_{xy}$  and a  $d_{x^2-y^2}$  orbital. Label the axes.



$d_{xy}$  orbital



$d_{x^2-y^2}$  orbital

[2]

**(c)** Explain why d-orbital energy levels split in an octahedral complex.

.....

.....

.....

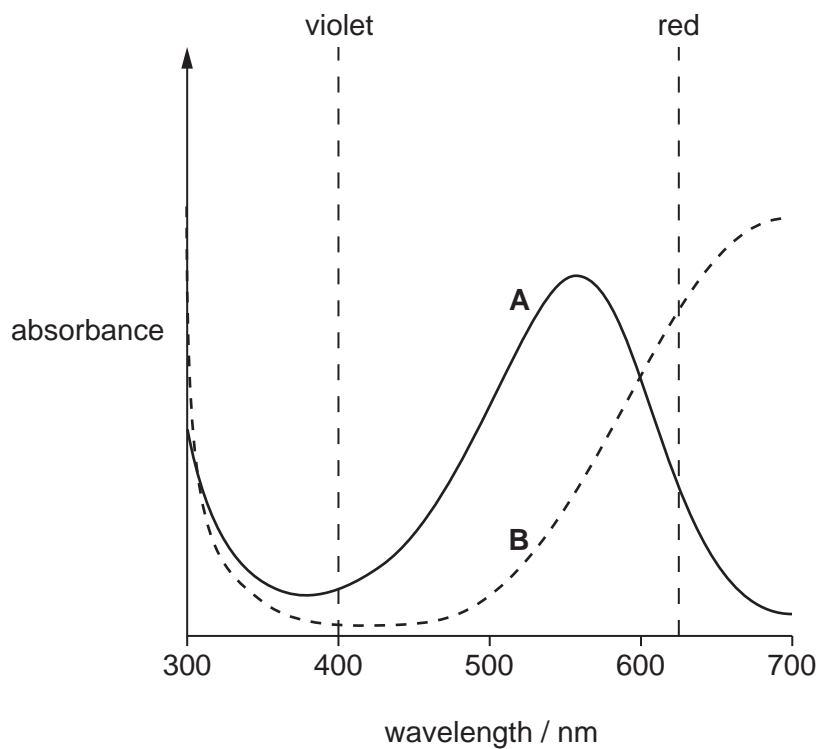
.....

..... [2]

- (d) Explain why different ligands, attached to the same transition metal ion, produce different colours.

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

- (e) The graphs below show the visible spectra of two different complex ions, **A** and **B**.



What colour is each complex?

complex **A** .....

complex **B** .....

[2]

[Total: 10]

- 4 Copper ions can exist in two different oxidation states,  $\text{Cu}^+$  and  $\text{Cu}^{2+}$ .

Some standard electrode potentials involving copper and its ions are given below.

	$E^\ominus / \text{V}$
$\text{Cu}^+ + \text{e}^- \rightleftharpoons \text{Cu}$	+0.52
$\text{Cu}^{2+} + \text{e}^- \rightleftharpoons \text{Cu}^+$	+0.15

- (a) Use these data to show that the reaction below is likely to occur.



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

- (b) The reaction in (a) is an example of *disproportionation*.

Explain the meaning of this term.

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

- (c) Suggest a condition under which copper(I) compounds are likely to be stable.

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

[Total: 5]



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**TURN OVER FOR QUESTION 5**

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

Copper is an element which finds many uses in alloys such as brass and bronze.

**(a)** Name the other element that is mixed with copper to form brass.

..... [1]

**(b)** The percentage of copper in brass can be estimated by titration.

The brass is completely reacted with concentrated nitric acid. The solution is then neutralised and an excess of  $\text{KI(aq)}$  is added. This mixture is then titrated with  $\text{Na}_2\text{S}_2\text{O}_3\text{(aq)}$ .

Describe how you would carry out this titration.

Your answer should:

- describe what you would see during the titration
- consider the indicator used and the end point of the titration
- include relevant equations.

[8]

Quality of Written Communication [1]

- (c) In an experiment to determine the percentage of copper in a sample of brass, 6.00 g of brass was reacted completely with nitric acid. The resulting solution was neutralised and made up to 500 cm<sup>3</sup> in a volumetric flask.

Excess KI(aq) was added to 25.0 cm<sup>3</sup> of this solution. The iodine formed required 18.90 cm<sup>3</sup> of 0.200 mol dm<sup>-3</sup> Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub>(aq) for complete reaction.

One mole of S<sub>2</sub>O<sub>3</sub><sup>2-</sup> is equivalent to one mole of Cu<sup>2+</sup>.

Determine the percentage of copper, by mass, in the sample of brass.

[5]

[Total: 15]

**END OF QUESTION PAPER**

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