

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

CHEMISTRY

2815/06

Transition Elements

Wednesday

25 JANUARY 2006

Afternoon

50 minutes

Candidates answer on the question paper.

Additional materials:

Data Sheet for Chemistry

Scientific calculator

Candidate Name

Centre Number

Candidate
Number

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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 blue or black ink, in the spaces provided on the question paper.
- Read each question carefully 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 calculations.

FOR EXAMINER'S USE		
Qu.	Max.	Mark
1	11	
2	9	
3	9	
4	8	
5	8	
TOTAL	45	

This question paper consists of 11 printed pages and 1 blank page.

Answer **all** the questions.

1 Cobalt readily forms complex ions in which the cobalt has an oxidation state of +2.

(a) One complex ion of cobalt is the hexaaquacobalt(II) ion $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$.

(i) What is the co-ordination number of Co^{2+} in this complex ion?

..... [1]

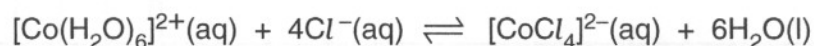
(ii) Water is acting as a ligand. Explain the meaning of the term *ligand*.

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..... [2]

(b) $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ readily undergoes the following reaction.



(i) What is the shape of each complex in this reaction?

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

$[\text{CoCl}_4]^{2-}$ shape [1]

(ii) What colour change would occur on going from left to right in this reaction?

from to [1]

(iii) What type of reaction is taking place when $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ reacts with Cl^{-} ?

..... [1]

(c) Co^{2+} forms the complex $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]$. This complex exists as two stereoisomers.

(i) Draw diagrams to show the two isomeric forms of this complex.



[2]

(ii) What type of stereoisomerism is shown by this complex?

..... [1]

(d) Cobalt also forms a complex with the formula $[\text{Co}(\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2)_2\text{Cl}_2]$. This complex shows the same kind of isomerism as $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]$ but it also shows a different type of stereoisomerism.

(i) Draw diagrams to show the two isomers of this different type of stereoisomerism.



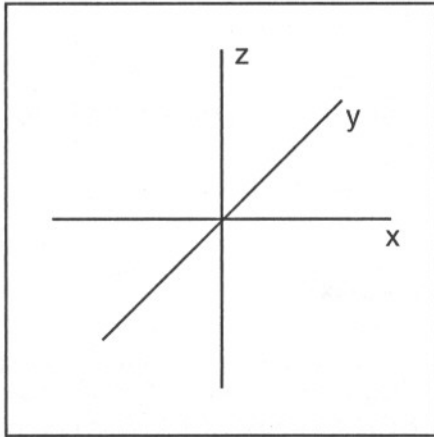
(ii) [2]

[Total: 11]

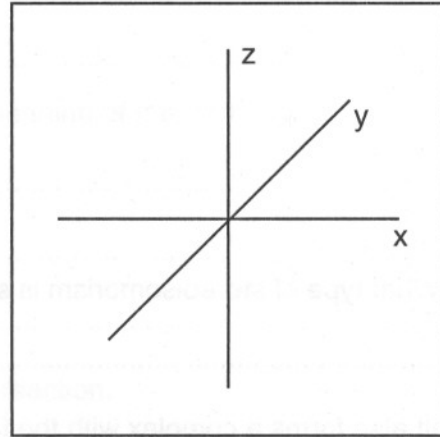
- 2 One important property of transition elements is their ability to form coloured compounds.

The splitting of d-orbital energy levels is instrumental in causing colour.

- (a) In the boxes below, draw one lower energy d-orbital and one higher energy d-orbital in an octahedral complex.



lower energy d-orbital



higher energy d-orbital

[2]

- (b) Explain how the splitting of d-orbital energy levels leads to colour in transition metal compounds.

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[4]

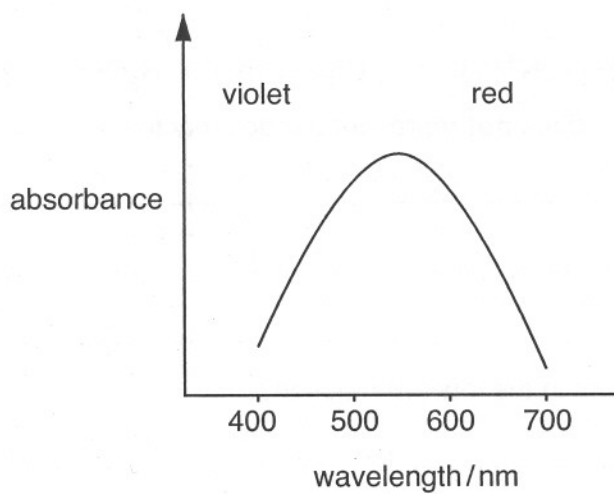
- (c) The compound $\text{CrCl}_3 \cdot 6\text{H}_2\text{O}$ can exist in three isomeric forms, which have different colours.

$[\text{Cr}(\text{H}_2\text{O})_6]\text{Cl}_3$ purple

$[\text{Cr}(\text{H}_2\text{O})_5\text{Cl}]\text{Cl}_2 \cdot \text{H}_2\text{O}$ grey-green

$[\text{Cr}(\text{H}_2\text{O})_4\text{Cl}_2]\text{Cl} \cdot 2\text{H}_2\text{O}$ green

The following visible spectrum was obtained from a solution of one of the isomers.



Identify the isomer and explain your answer.

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..... [3]

[Total: 9]

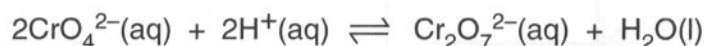
3 Chromium metal and its compounds have a number of important uses.

(a) State one use of chromium and explain why chromium is suitable for this purpose.

.....

 [1]

(b) CrO_4^{2-} ions and $\text{Cr}_2\text{O}_7^{2-}$ ions are both oxidising agents. They exist in the following equilibrium.



(i) Show that this equilibrium does **not** represent a redox reaction.

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 [1]

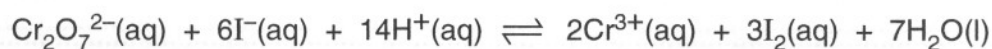
(ii) What colour change occurs in the forward reaction?

from to [1]

(iii) What reagent would you add to reverse this colour change?

..... [1]

(c) $\text{Cr}_2\text{O}_7^{2-}$ ions oxidise I^- ions to I_2 under acid conditions according to the following equation.



(i) If you carried out this reaction, how could you see that iodine is formed?

.....
 [1]

(ii) How could you use the formation of I_2 in this reaction to determine the concentration of a solution of $Cr_2O_7^{2-}$ ions?

In your answer

- state the method you would use
- state the reagents used
- show how you would use your results.

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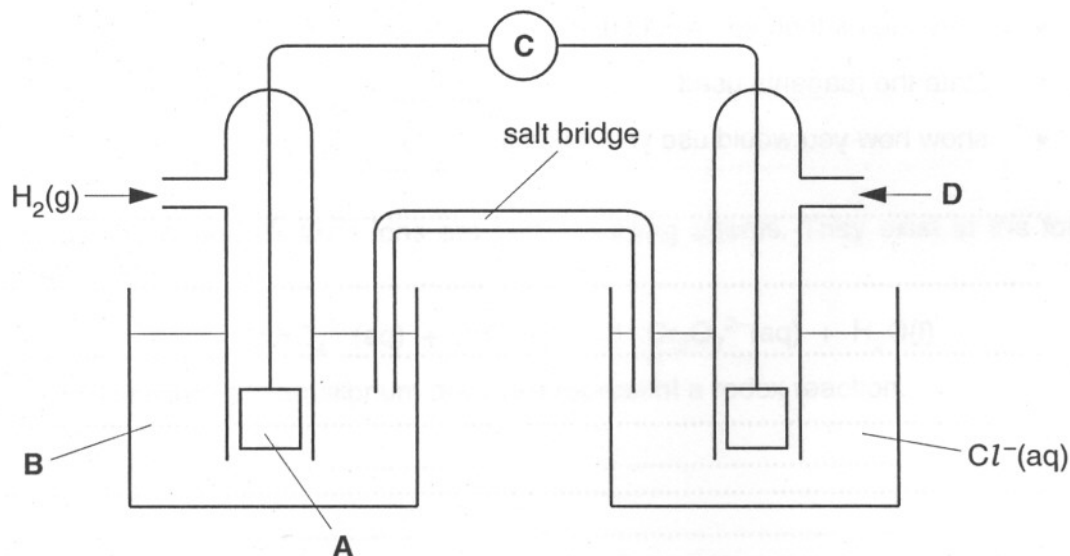
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[4]

[Total: 9]

- 4 The standard electrode potential of the $\frac{1}{2}\text{Cl}_2/\text{Cl}^-$ half-cell may be measured using the following apparatus.



- (a) Suggest suitable labels for A, B, C and D.

A

B

C

D [2]

- (b) The half cell reactions involved are shown below.



- (i) Use an arrow to show the direction of flow of electrons in the diagram of the apparatus. Explain your answer.

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..... [2]

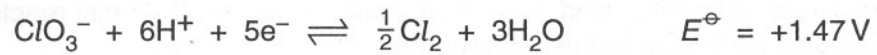
- (ii) The values of E^\ominus are measured under standard conditions. What are the standard conditions?

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..... [2]

(c) The half cell reaction for $\text{ClO}_3^- / \frac{1}{2} \text{Cl}_2$ is shown below.



What does this tell you about the oxidising ability of ClO_3^- compared with Cl_2 ?

Explain your answer.

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..... [2]

[Total: 8]

