OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

CHEMISTRY 2815/06

Transition Elements

Tuesday **29 JUNE 2004** Morning 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	13	
2	12	
3	14	
4	6	
TOTAL	45	

This question paper consists of 8 printed pages.

Registered Charity Number: 1066969
[Turn over

For Examiner's Use

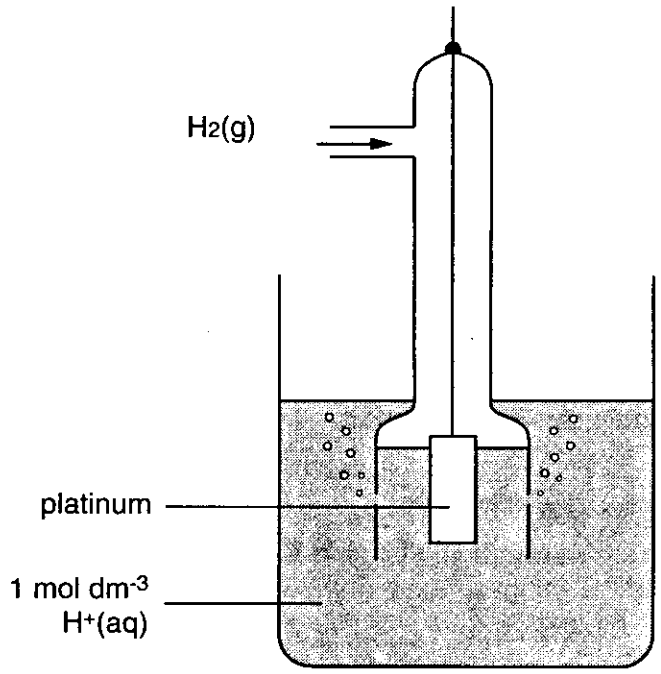
Answer **all** the questions.

1 Common chromium-containing ions include dichromate(VI), $Cr_2O_7^{2-}$, and chromium(III), Cr^{3+}. Dichromate(VI) can be converted to chromium(III) in a redox reaction.

(a) State the colour change that takes place in this conversion.

Colour change from ..... to ..... [2]

(b) **(i)** Complete the diagram below of a cell to measure an electrode potential for the $Cr_2O_7^{2-}/Cr^{3+}$ system. Label the diagram.



[4]

(ii) What conditions are needed to measure the **standard** electrode potential of the $Cr_2O_7^{2-}/Cr^{3+}$ system?

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.....[3]

(c) The half-equations for the reactions involved in the cell are shown below.

$$H^+ + e^- \rightleftharpoons \tfrac{1}{2}H_2 \qquad E^\ominus = 0.00V$$

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

Use these data to derive the equation for the overall reaction that occurs in the cell.

[2]

(d) The concentration of $Cr_2O_7^{2-}$ ions is increased and all other concentrations are kept constant. The cell potential increases.

Suggest why the cell potential increases in terms of the equilibria involved.

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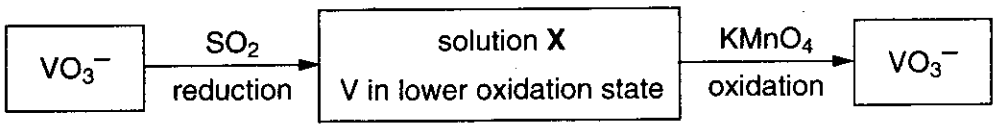
.....[2]

[Total: 13]

For Examiner's Use

2 A student was told that vanadium(V) can be reduced by sulphur dioxide. He did not know the oxidation state to which it was reduced. He decided to investigate the change in oxidation state practically by the process below.



(a) The student weighed out 2.23 g of ammonium vanadate(V), NH_4VO_3. The student then dissolved this amount of NH_4VO_3 in dilute sulphuric acid so that the final solution was 250 cm^3.

Calculate the amount, in mol, of NH_4VO_3 in the 2.23 g that the student weighed.

..... mol [2]

(b) In a fume cupboard, he **reduced** the NH_4VO_3 to a lower oxidation state. He bubbled SO_2 gas through the solution until there was no further colour change. The student boiled the resulting solution for 5 minutes and allowed the solution to cool. This solution is solution **X**.

Why did the student carry out this process in a fume cupboard?

.....[1]

(c) The student knew that the vanadium(V) had been reduced to vanadium in a lower oxidation state because the solution changed colour. The student decided to use manganate(VII) ions, MnO_4^-, to find the oxidation state of vanadium in solution **X**.

(i) He pipetted a 25.0 cm^3 sample from the 250 cm^3 solution **X**.

Use your answer to **(a)** to deduce the amount of vanadium in the 25.0 cm^3 pipetted sample.

..... mol [1]

(ii) He titrated this sample and needed 38.10 cm^3 of 0.0200 mol dm^{-3} $KMnO_4$ to oxidise the vanadium.

Calculate the amount of MnO_4^- used in the titration.

..... mol [1]

(iii) Deduce the number of moles of vanadium oxidised by 1 mole of MnO_4^-

..... mol [1]

For Examiner's Use

(d) In this titration,

- the manganate(VII) ions are **reduced** from the +7 to the +2 oxidation state,
- the vanadium in solution **X** is **oxidised** to the +5 oxidation state.

Use this information and your answer to **(c)(iii)** to show that the oxidation state of vanadium in solution **X** is +3. Explain how you reached your conclusion.

[2]

(e) Another student carried out a similar investigation but only boiled the solution for a short time. He found that he needed **more** MnO_4^- ions in his titration.
Suggest a reason for this observation.

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.....[2]

(f) Vanadium(V) compounds, such as vanadium(V) oxide, are useful in industry.

Describe an important industrial use for vanadium(V) oxide.

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.....[2]

[Total: 12]

[Turn over

3 This question is concerned with complexes formed by transition metals.

(a) For each of the following complexes, state the co-ordination number and the oxidation state of the metal present.

formula	co-ordination number	oxidation state
$[Ni(H_2O)_6]^{2+}$	.....	.....
$CuCl_2^-$	.....	.....

[4]

(b) In this question, one mark is available for the quality of written communication.

Transition metal complexes can show *cis-trans* and optical isomerism.

Discuss what is meant by *cis-trans* and optical isomerism in transition metal complexes.

For each type of isomerism give **one** example and labelled diagrams.

For Examiner's Use

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.....[9]

Quality of Written Communication [1]

[Total: 14]

Turn over for question 4

For Examiner's Use

4 The equations below show some reactions of transition metal ions.

$$Zn^{2+} + 2OH^- \longrightarrow Zn(OH)_2$$

$$CoCl_4^{2-} + 6NH_3 \rightleftharpoons [Co(NH_3)_6]^{2+} + 4Cl^-$$

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

$$2Cu^+ \longrightarrow Cu^{2+} + Cu$$

(a) Use **one** of these equations to describe what is meant by a redox reaction.

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.....[3]

(b) Use **one** of these equations to explain what is meant by a ligand exchange reaction.

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.....[3]

[Total: 6]

END OF QUESTION PAPER