Reactions and Applications of Transition Metals

Question Paper 2

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	Transition Metals & Organic Nitrogen Chemistry
Sub Topic	Reactions and Applications of Transition Metals
Booklet	Question Paper 2

Time Allowed: **69 minutes**

Score: **/57**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 Potassium manganate(VII) can be used in redox titrations to determine the concentration of iron(II) ions and ethanedioate ions in aqueous solution. Aqueous solutions of potassium manganate(VII) are unstable, so it is often standardized using solutions of iron(II) ammonium sulfate, freshly prepared from Mohr's salt, $Fe(NH_4)_2(SO_4)_2.6H_2O$.

(a) Use the relevant ionic half-equations, and standard reduction potentials on page 17 of the Data Booklet, to answer the following questions. State symbols are not required in the equations.

(i) Write the ionic half-equation for the reduction of manganate(VII) ions in acid solution.

(1)

(ii) Write the ionic half-equation for the oxidation of water to form oxygen and hydrogen ions.

(1)

(iii) Combine your answers to (a)(i) and (a)(ii) to derive an equation to show the production of oxygen in acidified manganate(VII) solution.

(1)

(iv) Calculate $E^{\ominus}_{cell}$ for the reaction in (a)(iii) and hence explain why aqueous solutions of potassium manganate(VII) are unstable.

(2)

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(b) 250 cm^3 of a solution containing 10.00 g of Mohr's salt was prepared. Separate 25.0 cm^3 samples of this solution were pipetted into conical flasks, excess sulfuric acid added and then each mixture was titrated against potassium manganate(VII) solution.

The mean titre was 25.85 cm^3.

*(i) Describe in outline how you would prepare the 250 cm^3 of Mohr's salt solution, given 10.00 g of the solid.

(4)

(ii) State what you would see at the end-point of the titration.

(1)

(iii) Write the ionic equation showing that 1 mol of manganate(VII) ions reacts with 5 mol of iron(II) ions in acid conditions. State symbols are not required.

(1)

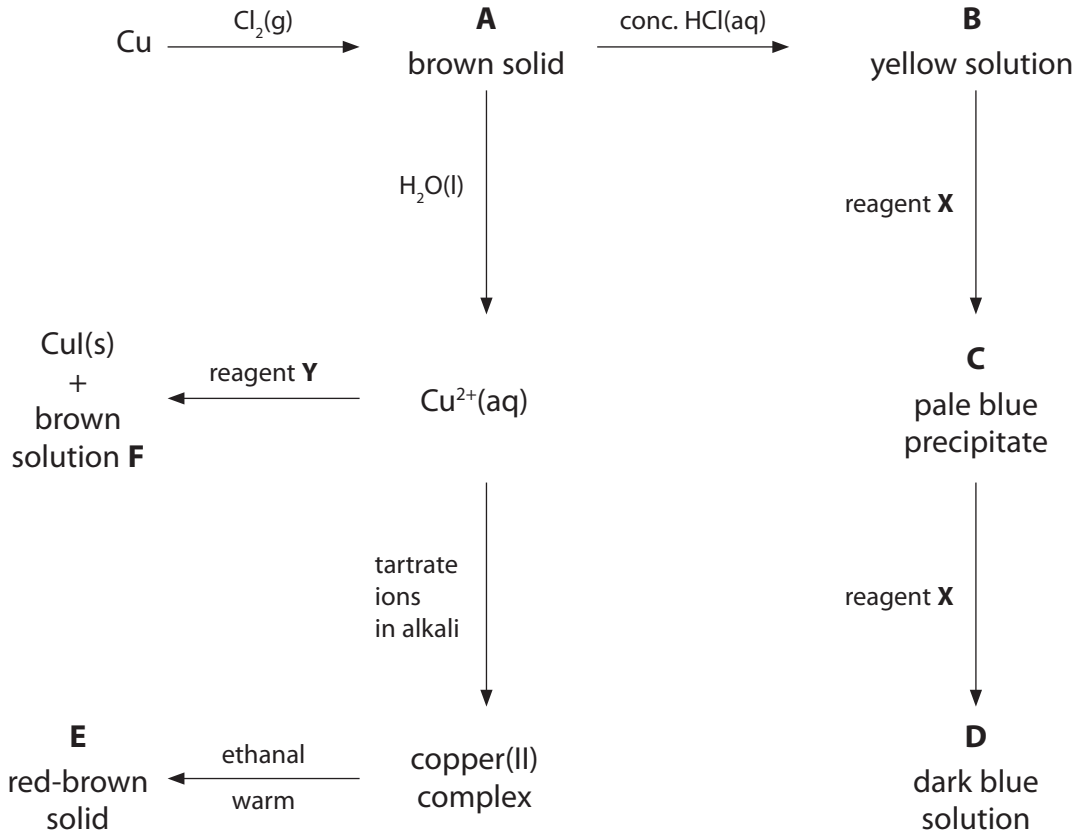
(iv) The concentration of the potassium manganate(VII) solution was stated to be 0.0200 mol dm^{-3}. Calculate the percentage of the potassium manganate(VII) that had reacted between its preparation and the titration.

The molar mass of Mohr's salt is 392 g mol^{-1}.

(4)

(Total for Question 1 = 15 marks)

2 The scheme below summarises some reactions of copper and its compounds.



(a) (i) Identify the copper containing species **A** to **E** either by name, including the oxidation number, or by formula. Also, identify the brown solution, **F**.

(6)

A .....

B .....

C .....

D .....

E .....

F .....

(ii) Identify the reagents **X** and **Y**.

(2)

X .....

Y .....

(iii) Identify the **organic** product of the reaction between the copper(II) complex and ethanal. Hence explain the role of ethanal in the reaction.

(2)

(iv) The reaction between $Cu^{2+}(aq)$ and reagent **Y** forms CuI(s) and a brown solution, **F**. This reaction is the first stage in a method for the determination of the concentration of $Cu^{2+}(aq)$.

Outline briefly how this method is used. Practical details are **not** required.

(1)

*(b) (i) Explain why **B** is coloured.

(4)

(ii) Explain why **B** and **D** have different colours.

(2)

(c) Aqueous copper(I) ions undergo a disproportionation reaction.

(i) Write the ionic equation for this reaction. Include state symbols in your answer.

(1)

(ii) Explain, stating the relevant oxidation numbers, why the reaction in (c)(i) is classified as a disproportionation.

(1)

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(iii) se the standard reduction potentials on page 17 of the Data Booklet to calculate $E^{\ominus}_{cell}$ for this disproportionation. Hence show that this reaction is thermodynamically feasible.

(2)

(Total for Question 2 = 21 marks)

3 This question is about the element chromium and some of its compounds.

(a) (i) Complete the electronic configuration of the chromium atom, using the s, p, d notation.

(1)

[Ar] .....

*(ii) State how this electronic configuration of the chromium atom is unusual compared with most other transition metals.

Give **two** reasons why chromium has this electronic configuration.

(2)

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(b) (i) A solution containing chromium(II) ions can be produced in the laboratory by reducing a solution of potassium dichromate(VI) using zinc in 50% hydrochloric acid. This reaction takes place in two steps. Dichromate(VI) ions are reduced to chromium(III) ions and the chromium(III) ions are then reduced to chromium(II) ions.

Use the relevant standard reduction potentials from page 17 or standard electrode potentials on pages 14 and 16 of the Data Booklet to calculate $E^{\ominus}_{cell}$ for each step.

Use your $E^{\ominus}_{cell}$ values to explain why both steps are spontaneous.

(3)

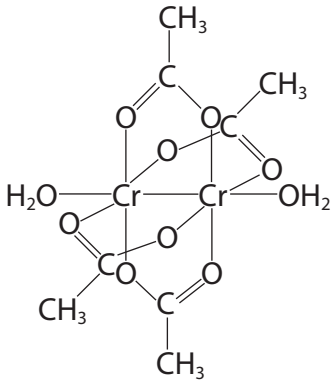
(ii) State the colour changes you would expect to see during this reaction.

(1)

(iii) A student suggests that the hydrogen produced by the reaction of the zinc with hydrochloric acid in this experiment is a serious risk. Evaluate the student's suggestion.

(1)

(c) Chromium(II) ions in aqueous solution are quickly oxidized by the oxygen in air. One method of stabilising chromium(II) ions is by adding a solution of sodium ethanoate, forming a complex, $[Cr_2(CH_3CO_2)_4(H_2O)_2]$. This complex may be represented by the structure below.



(i) What type of ligand is the ethanoate ion in this complex?

(1)

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(ii) State the type of bonding which occurs between the ligands and the chromium(II) ions.

(1)

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(iii) Suggest **two** unusual features in the structure and bonding of this complex.

(2)

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(iv) This complex is red.
Explain why the colour of chromium(II) ethanoate is different from that of $Cr(H_2O)_6^{2+}(aq)$.

(2)

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(v) Predict the number and relative areas of the peaks in the **low** resolution proton nmr spectrum of $Cr_2(CH_3CO_2)_4(H_2O)_2$.

Justify your answers.

(2)

(d) An experiment is carried out to check the oxidation number of chromium in chromium(II) ethanoate $Cr_2(CH_3CO_2)_4(H_2O)_2$.

1.00 g (2.66×10^{-3} mol) of chromium(II) ethanoate is dissolved in 25 cm^3 of 1.00 mol dm^{-3} sulfuric acid.

The solution is diluted with distilled water until the volume is 250 cm^3.

25.0 cm^3 portions of the diluted solution are titrated with 0.00750 mol dm^{-3} potassium manganate(VII).

Calculate the volume of potassium manganate(VII) needed to oxidize the chromium(II) ions present in each 25.0 cm^3 portion to the +6 oxidation state. The manganese is reduced to the +2 oxidation state.

Comment on your answer and suggest how the experiment could be improved to give a more suitable titre.

(5)

Comment .....

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(Total for Question 3 = 21 marks)