Transition Metals

Question Paper 2

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	Chemistry Lab Skills 2
Sub Topic	Transition Metals
Booklet	Question Paper 2

Time Allowed: **46 minutes**

Score: **/38**

Percentage: **/100**

Grade Boundaries:

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

1 This is an experiment to determine the oxidation number of vanadium in a purple solution, **T**, of a vanadium compound.

Preparation of solution T

Solution **T** was formed when 25.00 cm^3 of a 0.100 mol dm^{-3} solution of sodium vanadate(V), $NaVO_3$, was reduced by heating with excess zinc and dilute sulfuric acid.

When the reduction was complete, the yellow $NaVO_3$ solution had turned purple.

Titration of solution T

The mixture was filtered through glass wool, directly into 50.00 cm^3 of 0.0200 mol dm^{-3} potassium manganate(VII), $KMnO_4$, solution.

Further potassium manganate(VII) solution of the same concentration was added from a burette to this reaction mixture, which was kept at a temperature of about 80 °C. The end point is reached when all the vanadium ions had been oxidized back into vanadate(V) ions by the manganate(VII) ions.

The end point occurred when a further 25.00 cm^3 had been added.

(a) (i) Draw a diagram of the apparatus for carrying out the titration, while **keeping** the titration mixture at about 80 °C.

(2)

(ii) What is removed from the reaction mixture by filtering through glass wool?

(1)

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(iii) Suggest why the mixture is filtered directly into potassium manganate(VII) solution before carrying out the rest of the titration.

(1)

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(iv) Explain why an indicator is **not** required for this titration.

(1)

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(b) (i) Calculate the number of moles of vanadate(V) ions, VO_3^-, in 25.00 cm^3 of a 0.100 mol dm^{-3} solution of sodium vanadate(V), $NaVO_3$.

(1)

(ii) Calculate the **total** volume of potassium manganate(VII) solution.
Hence the **total** number of moles of potassium manganate(VII) used to oxidize the purple vanadium solution, **T**.

(2)

(iii) Complete the half equation for the reduction of manganate(VII) ions to manganese(II) ions.

(1)

$$MnO_4^- + \text{.....}H^+ + \text{.....}e^- \longrightarrow Mn^{2+} + \text{.....}H_2O$$

(iv) By considering either the number of electrons transferred or by using the changes in oxidation numbers, calculate the oxidation number of vanadium in the purple solution, **T**.

You **must** show your working.

(3)

(c) In acidic solution, the vanadate ions, VO_3^- are changed into VO_2^+.
Write an ionic equation for this reaction. State symbols are not required.

(1)

(d) Some standard electrode potentials of tin and vanadium are given below.

$Sn^{2+}(aq)\|Sn(s)$	–0.14 V
$V^{2+}(aq)\|V(s)$	–1.18 V
$V^{3+}(aq),V^{2+}(aq)\|Pt$	–0.26 V
$[VO^{2+}(aq) + 2H^{+}(aq)], [V^{3+}(aq) + H_2O(l)]\|Pt$	+0.34 V
$[VO_2^{+}(aq) + 2H^{+}(aq)], [VO^{2+}(aq) + H_2O(l)]\|Pt$	+1.00 V

Use these values to predict the lowest oxidation number of vanadium that can be produced from VO_2^{+} using tin as the reducing agent. Explain your reasoning.

(2)

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(Total for Question 1 = 15 marks)

2 **H** is an aqueous solution of chromium(III) sulfate.

(a) What is the colour of the solution?

(1)

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(b) Describe what you would **see** when sodium hydroxide solution is added to **H**, drop by drop, until the sodium hydroxide is in excess.

(2)

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(c) When hydrogen peroxide is added to the reaction mixture formed in (b), a yellow solution is formed.

Give the formula of the ion responsible for the yellow colour and state the type of reaction which has produced this ion.

(2)

Ion formula .....

Reaction type .....

(Total for Question 2 = 5 marks)

3 Substance **A** is a green solid which dissolves in water to form a green solution. Substance **A** is an ionic compound containing one cation and one anion.

(a) Give the **formulae** of **two** cations which could be responsible for the green colour in the solid.

(2)

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(b) A student added dilute sodium hydroxide, drop by drop, to an aqueous solution of **A**. Initially, a green precipitate was formed. The precipitate did not dissolve in excess sodium hydroxide solution. The precipitate darkened on standing to give a brown solid.

(i) Write the **formula** of the cation in substance **A**.

(1)

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(ii) Write a **formula** for the green precipitate.

(1)

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(iii) Write a **formula** for the brown solid.

(1)

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(iv) State the type of reaction involved when the green precipitate turns brown.

(1)

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(c) The student added a few drops of acidified potassium manganate(VII) solution to another sample of a solution of **A** in a test tube.

Describe the colour change that occurs.

(1)

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(d) The student acidified about 2 cm^3 of a solution of **A** with dilute nitric acid in a test tube and then added a few drops of aqueous silver nitrate solution. A white precipitate was formed.

(i) Give the **formula** of the anion present in **A**.

(1)

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(ii) The test in (d)(i) is usually followed by the addition of ammonia solution to test the solubility of the precipitate.

Explain why this is not a useful procedure in this case.

(2)

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(Total for Question 3 = 10 marks)

4 Solution **B** is copper(II) sulfate dissolved in water.

(a) When an excess of concentrated hydrochloric acid is added to solution **B**, the colour of **B** changes from blue to yellow.

Give the **formula** of the complex ion responsible for the yellow colour.

(1)

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(b) What would you observe as dilute ammonia solution is added, drop by drop, to another sample of solution **B**?

(3)

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(c) 20.0 cm^3 of solution **B** was added to excess aqueous potassium iodide solution and the volume made up to 250 cm^3. The following reaction occurred:

$$2Cu^{2+}(aq) + 4I^-(aq) \rightarrow 2CuI(s) + I_2(aq)$$

25.0 cm^3 samples of the resulting mixture were titrated with 0.120 mol dm^{-3} sodium thiosulfate solution. The mean titre was 17.85 cm^3.

(i) Complete the ionic equation for the reaction of thiosulfate ions with iodine. State symbols are not required.

(1)

$$2S_2O_3^{2-} + I_2 \rightarrow \text{.....} + \text{.....}$$

(ii) Calculate the concentration of solution **B**, in mol dm^{-3}.

(3)

(Total for Question 4 = 8 marks)