Transition Metals

Question Paper 1

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	Chemistry Lab Skills 2
Sub Topic	Transition Metals
Booklet	Question Paper 1

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 The inorganic salt **A** has one cation and one anion. Complete the table below.

	Test	Observations	Inferences	
(a)	Observe the appearance of **A**	**A** is a brown powder	The part of the Periodic Table in which the metal element in **A** is likely to be found is	**(1)**
(b)	Dissolve **A** in the minimum volume of concentrated hydrochloric acid	A yellow solution forms	The formula of the **cation** in **A** could be	**(1)**
(c)	Gradually dilute a portion of the solution from (b) with distilled water	The yellow solution turns dark green then pale blue	The formula of the cation in **A** is confirmed as	**(1)**
(d)	Place a sample of solid **A** in a test tube and heat it strongly	A pale green gas is evolved which turns damp blue litmus paper red and then bleaches it A white solid residue remains	The gas is ..... So the anion in **A** is	**(2)**
(e)	Add dilute hydrochloric acid to the white solid obtained in (d) Shake the mixture vigorously	A colourless solution forms The colourless solution turns blue	The white solid is .... The type of reaction which results in the change from colourless to blue is	**(2)**

(f) Suggest a further test to confirm the identity of the cation in **A**. Give the result of the test.

(2)

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(g) Suggest a test to confirm the identity of the anion in **A**. Give the result of the test.

(2)

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(h) Give the formulae of the ions that give the yellow colour to the solution described in (b), and the green colour to the solution described in (c).

(2)

Yellow colour .....

Green colour .....

(Total for Question 1 = 13 marks)

2 This question is about a student experiment to prepare crystals of iron(II) sulfate-7-water ($FeSO_4.7H_2O$) and then to determine the number of moles of water of crystallization in the sample which they have prepared.

(a) Each student was given 5.00 g of iron filings which was added to excess dilute sulfuric acid, warmed and allowed to stand until no further reaction occurred. The resulting solution was cooled and filtered, and the required crystals were obtained from the filtrate.

(i) Calculate the minimum volume of dilute sulfuric acid of concentration 2.00 mol dm^{-3} required to react completely with 5.00 g of pure iron filings. The equation for this reaction is

$$Fe(s) + H_2SO_4(aq) \rightarrow FeSO_4(aq) + H_2(g)$$

(2)

(ii) Why was the reaction mixture filtered?

(1)

(iii) Describe how pure crystals of iron(II) sulfate-7-water are obtained from the filtrate.

(2)

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(iv) One student obtained a yield of 89.5% from this preparation.

Taking the formula of the crystals as $FeSO_4.7H_2O$, calculate the mass of iron(II) sulfate-7-water obtained by this student. Assume that the iron filings were pure.

(3)

(b) A second student dissolved 6.75 g of their prepared crystals in about 150 cm^3 of dilute sulfuric acid in a beaker and used this solution to prepare exactly 250.0 cm^3 of a solution for titration.

25.0 cm^3 samples of this final solution were further acidified with dilute sulfuric acid.

These samples were titrated with potassium manganate(VII) solution to determine the number of moles of water of crystallization per mole of iron(II) sulfate.

(i) Describe in outline how you would prepare the 250.0 cm^3 of the solution for titration from the solution obtained by dissolving 6.75 g of the crystals in 150 cm^3 of dilute sulfuric acid.

(3)

(ii) Suggest what would happen to the solution of iron(II) sulfate if it was prepared using distilled water, rather than dilute sulfuric acid as the solvent. Describe and explain what you would see.

(2)

(iii) Describe the end point of the titration.

(1)

(iv) Using 6.75 g of their crystals and the method described in (b), the student obtained a mean titre of 25.35 cm^3.

The concentration of the potassium manganate(VII) solution was 0.0195 mol dm^{-3} and the equation for the titration reaction is

$$MnO_4^- + 8H^+ + 5Fe^{2+} \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$$

Calculate the molar mass of the crystals and hence the number of moles of water of crystallization per mole of iron(II) sulfate in the student's crystals. You must show your working.

(4)

(c) A third student carried out the experiment described in (b) and found that there was 7.1 mol of water of crystallization per mole of the iron(II) sulfate.

(i) The **total** experimental uncertainty associated with the determination of the molar mass is approximately ± 0.9%.

Use these data to show that the result obtained by this student is within this experimental uncertainty.

(2)

(ii) Most of the students in the class obtained values higher than the Data Book value of 7. Suggest a reason for this.

(1)

(Total for Question 2 = 21 marks)

3 A white solid, **A**, contains one cation and one anion. When water is added slowly, the solid turns blue and then dissolves to form a blue solution, **B**.

(a) When aqueous barium chloride is added to an acidified portion of solution **B**, a white precipitate forms.

(i) Give the **formula** of the anion in **B**.

(1)

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(ii) Name a suitable acid for acidifying solution **B** in this test.

(1)

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(b) When aqueous ammonia is added to another portion of solution **B**, a blue precipitate forms. When more aqueous ammonia is added, this precipitate dissolves to form a deep blue solution, **C**.

(i) Identify, by name or formula, the blue precipitate.

(1)

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(ii) Give the **formula** of the ion responsible for the deep blue colour of solution **C**.

(1)

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(c) Give the **formula** of the complex ion which gives the blue colour to solution **B**. Include the ligands in your answer.

(1)

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(d) Give the **formula** of the white solid **A**.

(1)

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(e) Why is solid **A** white and not coloured blue? Justify your answer.

(2)

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(Total for Question 3 = 8 marks)

4 Cupronickel is an alloy of copper and nickel. It is used to make 'silver' coins.

A coin is analysed by the following method.

Step 1 It is weighed on a balance which reads to two decimal places and found to have mass 4.00 g.

Step 2 Water is added to the coin in a beaker. Concentrated nitric and sulfuric acids are added and the coin dissolves.

Step 3 When the coin is completely dissolved, the solution is neutralized.

Step 4 The neutral solution is transferred, with the washings, to a 100 cm^3 volumetric flask, made up to the mark with water and mixed thoroughly.

Step 5 10 cm^3 samples of the solution are taken and an excess of potassium iodide is added, producing iodine.

Step 6 The iodine is titrated with 0.200 mol dm^{-3} sodium thiosulfate solution.

(a) Why, in **Step 2**, is water added before, rather than after, the acids?

(1)

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(b) What is the colour of an aqueous iodine solution?

(1)

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(c) (i) To make the end point of the titration more obvious, an indicator is added just before the colour of the iodine disappears.

Name this indicator.

(1)

.....

(ii) Suggest why the indicator is not added to the iodine solution earlier in the titration.

(1)

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(iii) e the colour change at the end point when the indicator is used in this titration.

(1)

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(d) The results for the titrations are shown below.

Titration number	1	2		
Burette reading (final) / cm^3	24.10	47.90	23.55	47.00
Burette reading (initial) / cm^3	0.00	24.10	0.00	23.55
Titre / cm^3				

(i) Complete the table.

(1)

(ii) Which titres should be used to calculate the mean? Explain your choice.

(1)

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(iii) Calculate the mean titre.

(1)

(iv) Calculate the percentage by mass of copper in the coin.

Use the equations below.

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

$$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^{-}(aq)$$

(5)

(v) The uncertainty in each burette reading is ±0.05 cm^3 and the uncertainty in each reading of the balance is ±0.005 g.

Calculate the percentage uncertainty in the third titre value and in the mass measurement. Use your results to decide whether using a balance that weighs to three decimal places would significantly improve the accuracy of the result.

(2)

(Total for Question 4 = 15 marks)