A2 LEVEL CHEMISTRY

5.3 TRANSITION METALS

TEST

Answer all questions

Max 56 marks

Name	……..
Mark	……../56 ……....% Grade ……

1. Copper and zinc are both d-block elements but only copper is a transition element. Copper forms compounds containing Cu^{2+} or Cu^{+} ions but zinc only forms compounds containing Zn^{2+} ions.

(a) Use the electronic configurations of Cu^{2+} and Zn^{2+} to explain why copper is a transition element and zinc is not.

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[2]

(b) Suggest **two** differences between compounds containing Zn^{2+} and Cu^{2+} ions.

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[2]

[Total 4 marks]

2. Transition metals readily form complex ions when they are combined with a suitable ligand.

What is meant by the following terms?

(i) *complex ion*

.....

.....

[1]

(ii) *ligand*

.....

.....

[2]

[Total 3 marks]

3. A sample of iron is heated with a stream of dry hydrogen chloride. A different chloride of iron is formed that contains the Fe^{2+} ion. This chloride dissolves in water to form a pale green solution that contains the hexaaquairon(II) complex ion.

(i) Complete the electronic configuration of Fe^{2+}.

$1s^2 2s^2 2p^6$ .....

[1]

(ii) Draw the shape of the hexaaquairon(II) complex ion. Include the bond angles on your diagram.

[2]

(iii) Aqueous sodium hydroxide is added to a solution containing $Fe^{2+}(aq)$.

State what you would observe.

.....

Write an ionic equation, with state symbols, for the reaction.

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[2]

[Total 5 marks]

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

$[Co(H_2O)_6]^{2+}$ readily undergoes the following reaction.

$$[Co(H_2O)_6]^{2+}(aq) + 4Cl^-(aq) \rightleftharpoons [CoCl_4]^{2-}(aq) + 6H_2O(l)$$

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

$[Co(H_2O)_6]^{2+}$ shape .....

$[CoCl_4]^{2-}$ 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 $[Co(H_2O)_6]^{2+}$ reacts with Cl^-?

.....

[1]

[Total 3 marks]

5. Aqueous copper(II) sulphate contains $[Cu(H_2O)_6]^{2+}$ ions. Aqueous ammonia is added drop by drop to a small volume of aqueous copper(II) sulphate. Two reactions take place, one after the other, as shown in the equations.

$$[Cu(H_2O)_6]^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(OH)_2(s) + 6H_2O(l)$$

$$Cu(OH)_2(s) + 2H_2O(l) + 4NH_3(aq) \rightarrow [Cu(NH_3)_4(H_2O)_2]^{2+}(aq) + 2OH^-(aq)$$

(a) Describe the observations that would be made as ammonia is added drop by drop until it is in an excess.

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[2]

(b) Draw the shape for the $[Cu(H_2O)_6]^{2+}$ ion. Include the bond angles in your diagram.

[2]

[Total 4 marks]

6. The Cr^{3+} ion forms a complex ion of formula $[Cr(C_2O_4)_2(H_2O)_2]^-$.

Use this complex to explain what is meant by the term stereoisomerism. Your answer should contain suitable diagrams.

[7]

Quality of Written Communication [1]

[Total 8 marks]

7. Describe the types of stereoisomerism found in transition metal complexes.

Use suitable examples to illustrate your answer.

[8]

Quality of Written Communication [1]

[Total 9 marks]

8. An unusual compound of iron has been detected on the surface of the planet Mars. This compound contains the ferrate(VI) ion.

When chlorine is bubbled through a suspension of iron(III) oxide in concentrated aqueous sodium hydroxide, a solution of aqueous sodium ferrate(VI) forms.

The two relevant redox systems are shown below.

$$Cl_2(aq) + 2e^- \rightarrow 2Cl^-(aq)$$

$$Fe_2O_3(s) + 10OH^-(aq) \rightarrow 2FeO_4^{2-}(aq) + 5H_2O(l) + 6e^-$$

Construct the redox equation for the reaction between chlorine, iron(III) oxide and hydroxide ions.

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[Total 2 marks]

9. The percentage by mass of iron in a sample of moss killer can be determined by titration against acidified potassium manganate(VII).

- Stage 1 – A sample of moss killer is dissolved in excess sulphuric acid.
- Stage 2 – Copper turnings are added to the acidified sample of moss killer and the mixture is boiled carefully for five minutes. Copper reduces any iron(III) ions in the sample to give iron(II) ions.
- Stage 3 – The reaction mixture is filtered into a conical flask to remove excess copper.
- Stage 4 – The contents of the flask are titrated against aqueous potassium manganate(VII).

(i) Suggest why it is important to remove all the copper in stage 3 before titrating in stage 4.

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[1]

(ii) The ionic equation for the redox reaction between acidified MnO_4^- and Fe^{2+} is given below.

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

Explain, in terms of electron transfer, why this reaction involves both oxidation and reduction.

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[2]

(iii) A student analyses a 0.675 g sample of moss killer using the method described.

In stage 4, the student uses 22.5 cm^3 of 0.0200 mol dm^{-3} MnO_4^- to reach the endpoint.

Calculate the percentage by mass of iron in the moss killer.

percentage .....

[4]

[Total 7 marks]

10. Brass is a widely used alloy of copper. It is possible to analyse a sample of brass by initially dissolving it in concentrated nitric acid.

(a) (i) What other metal is present in brass?

.....

[1]

(ii) Give **one** common use for brass and state the property of brass which makes it ideal for that purpose.

.....

.....

[1]

(b) During the analysis of brass, 1.65 g of the alloy was reacted with concentrated nitric acid. The resulting solution was neutralised, transferred to a volumetric flask and made up to 250 cm^3 using distilled water.

An excess of aqueous potassium iodide was added to a 25.0 cm^3 portion of the solution from the volumetric flask and the liberated iodine was titrated with 0.100 mol dm^{-3} sodium thiosulphate. 20.0 cm^3 of aqueous sodium thiosulphate were required to remove the iodine.

(i) What could be used to neutralise the excess nitric acid?

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[1]

(ii) What indicator is used in the titration of iodine with sodium thiosulphate?

.....

[1]

(iii) When is this indicator added to the titration mixture?

.....

[1]

(c) The reactions taking place in this titration may be summarised as follows.

$$2Cu^{2+} + 4I^- \rightarrow 2CuI + I_2$$

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

(i) Calculate the amount, in moles, of sodium thiosulphate in 20.0 cm^3 of solution.

answer ..... mol

[1]

(ii) For every one mole of Cu^{2+} ions present in solution, deduce the amount, in moles, of $S_2O_3^{2-}$ ions needed for the titration.

answer ..... mol

[1]

(iii) What is the amount, in moles, of Cu^{2+} ions present in 25.00 cm^3 of solution?

answer ..... mol

[1]

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

answer ..... % Cu

[3]

[Total 11 marks]