A LEVEL CHEMISTRY

TOPIC 15 – TRANSITION METALS AND COMPLEX IONS

TEST

Answer all questions

Max 50 marks

Name ……..
Mark ……../50 ……....% Grade ……

1. Transition elements form complex ions with a range of colours and shapes.

(a) By considering its electron arrangement, state how an element can be classified as a transition element.

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(1)

(b) Explain the meaning of the term *complex ion*.

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(2)

(c) In terms of electrons, explain why an aqueous solution of cobalt(II) sulfate has a red colour.

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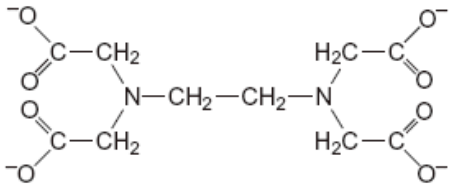
(3)

(d) The ligand $EDTA^{4-}$ is shown below.



(i) Draw circles around the atoms of **two** different elements that link to a transition metal ion by a co-ordinate bond when $EDTA^{4-}$ behaves as a ligand.

(2)

(ii) Write an equation for the reaction between $EDTA^{4-}$ and a $[Co(H_2O)_6]^{2+}$ ion. Use the abbreviation $EDTA^{4-}$ in your equation.

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(1)

(iii) Explain why the complex ion, formed as a product of the reaction in part (d) (ii), is more stable than the $[Co(H_2O)_6]^{2+}$ ion.

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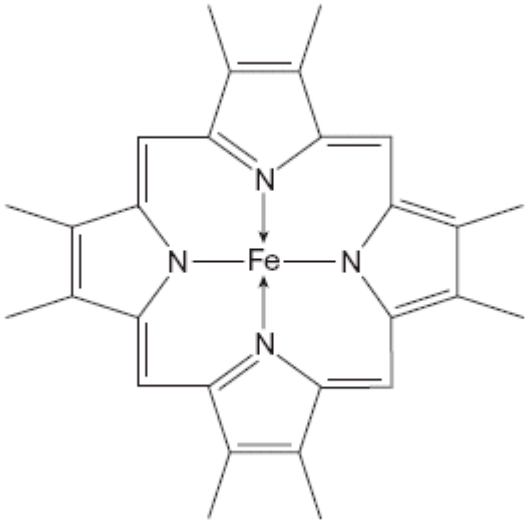
(2)

(e) The diagram below shows part of the structure of haemoglobin.



Haemoglobin contains an iron(II) ion bonded to five nitrogen atoms and one other ligand. The fifth nitrogen atom and the additional ligand are not shown in this diagram.

(i) In this diagram, bonds between nitrogen and iron are shown as N→Fe and as N—Fe.

State the meaning of each of these symbols.

Meaning of → .....

Meaning of — .....

(2)

(ii) State the function of haemoglobin in the blood.

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(1)

(iii) With reference to haemoglobin, explain why carbon monoxide is toxic.

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(2)

(Total 16 marks)

2. (a) Explain the meaning of the terms *ligand* and *bidentate* as applied to transition metal complexes.

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(2)

(b) Aqueous cobalt(II) ions react separately with an excess of chloride ions and with an excess of ammonia.

For each reaction, draw a diagram to illustrate the structure of, the shape of and the charge on the complex ion formed.

In each case, name the shape and indicate, on the diagram, a value for the ligand-metal-ligand bond angle.

(6)

(c) The complex ion formed in aqueous solution between cobalt(II) ions and chloride ions is a different colour from the $[Co(H_2O)_6]^{2+}$ ion.

Explain why these complex ions have different colours.

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(3)

(d) In aqueous ammonia, cobalt(II) ions are oxidised to cobalt(III) ions by hydrogen peroxide. The H_2O_2 is reduced to hydroxide ions.

Calculate the minimum volume of 5.00 mol dm^{-3} H_2O_2 solution required to oxidise the Co^{2+} ions in 9.87 g of $CoSO_4.7H_2O$

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(5)
(Total 16 marks)

3. When iodine molecules are dissolved in aqueous solutions containing iodide ions, they react to form triiodide ions (I_3^-).

$$I_2 + I^- \longrightarrow I_3^-$$

The reaction above between I^- ions and $S_2O_8^{2-}$ ions has a high activation energy and $S_2O_8^{2-}$ ions are only reduced slowly to SO_4^{2-} ions.
The reaction is catalysed by Fe^{2+} ions.

(a) Explain why the reaction between I^- ions and $S_2O_8^{2-}$ ions is slow.

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(1)

(b) Other than having variable oxidation states, explain why Fe^{2+} ions are good catalysts for this reaction.

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(1)

(c) Write a half-equation for the reduction of $S_2O_8^{2-}$ ions to SO_4^{2-} ions.

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(1)

(d) Construct an overall equation for the reaction between $S_2O_8^{2-}$ ions and I^- ions.

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(1)
(Total 4 marks)

4. A green solution, **X**, is thought to contain $[Fe(H_2O)_6]^{2+}$ ions.

(a) The presence of these ions can be confirmed by reacting separate samples of solution **X** with aqueous ammonia and with aqueous sodium carbonate.

Write equations for each of these reactions and describe what you would observe.

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(4)

(b) A 50.0 cm^3 sample of solution **X** was added to 50 cm^3 of dilute sulfuric acid and made up to 250 cm^3 of solution in a volumetric flask.

A 25.0 cm^3 sample of this solution from the volumetric flask was titrated with a 0.0205 mol dm^{-3} solution of $KMnO_4$
At the end point of the reaction, the volume of $KMnO_4$ solution added was 18.70 cm^3.

(i) State the colour change that occurs at the end point of this titration and give a reason for the colour change.

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(2)

(ii) Write an equation for the reaction between iron(II) ions and manganate(VII) ions.

Use this equation and the information given to calculate the concentration of iron(II) ions in the original solution **X**.

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(5)
(Total 11 marks)

5. The percentage of iron in a sample of impure iron(II) sulphate crystals can be determined by titrating solutions, made from separate weighed samples acidified with dilute sulphuric acid, against a standard solution of potassium manganate(VII).

Which one of the following would lead to an inaccurate result?

A transferring the weighed sample of iron(II) sulphate into a wet conical flask

B failing to measure accurately the volume of water used to dissolve each weighed sample of iron(II) sulphate

C transferring the standard solution of potassium manganate(VII) from its original container to the burette using a wet beaker

D failing to measure accurately the volume of dilute sulphuric acid added to the mixture before titration

(Total 1 mark)

6. Which one of the following contains the metal with the lowest oxidation state?

A CrO_2F_2

B $[Cr_2O_7]^{2}$

C $[MnCl_6]^{2-}$

D $[Mn(CN)_6]^{3-}$

(Total 1 mark)

7. Which one of the following could **not** act as a ligand?

A F^-

B CH_3CH_3

C NH_2NH_2

D CH_3OCH_3

(Total 1 mark)