



(iii) Give the reasons for carrying out Steps **3** and **4** of the procedure, referring particularly to the words in bold.

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**(Total for question = 10 marks)**

**Q2.**

Ammonium cobalt(II) sulfate is made by mixing aqueous solutions of ammonium sulfate and excess cobalt(II) sulfate.

Dry crystals of ammonium cobalt(II) sulfate,  $(\text{NH}_4)_2\text{SO}_4 \cdot \text{CoSO}_4 \cdot 6\text{H}_2\text{O}$ , are obtained by the procedure shown.

**Step 1** The reaction mixture is transferred to an evaporating basin, heated gently and then left to crystallise.

**Step 2** The crystals are separated by gravity filtration.

**Step 3** The crystals are then **rinsed** with a small amount of **ice-cold** water.

**Step 4** The rinsed crystals are placed in a **warm oven** for 30 minutes.

The percentage yield of this reaction is 70.0%.

Give **two** possible reasons, other than an incomplete reaction, why the yield is less than 100%.

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**(Total for question = 2 marks)**

## Q3.

This question is about transition metal chemistry.

Dilute aqueous ammonia is added, drop by drop, to an aqueous solution of copper(II) sulfate until the aqueous ammonia is in excess.

(i) Describe what you would **see** during this experiment.

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(ii) The reaction between aqueous copper(II) sulfate and **excess** aqueous ammonia is an example of a **ligand substitution** reaction.

Write an equation for the ligand substitution reaction that occurs, showing the formulae of the complex ions involved. State symbols are not required.

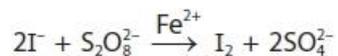
(2)

**(Total for question = 4 marks)**

**Q4.**

This is a question about catalysis.

The reaction between iodide ions and peroxodisulfate ions is catalysed by iron(II) ions.



(i) Give a reason why the reaction between iodide ions and peroxodisulfate ions has a high activation energy and is therefore very slow without a catalyst.

(1)

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(ii) Explain, with the aid of two equations, how the iron(II) ions catalyse this reaction. State symbols are not required.

(3)

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**(Total for question = 4 marks)**

**Q5.**

A student stated that 'the elements scandium and zinc are d-block elements but are not transition metals'.

Discuss this statement, using appropriate electronic configurations to support your answer.

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**(Total for question = 4 marks)**

**Q6.**

This question is about transition metals and transition metal complexes.

When chromium(III) sulfate dissolves in water, a green solution containing the  $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$  ion forms.

(i) Give the shape of this complex ion.

(1)

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(ii) Explain why the chromium complex ion is coloured.

(3)

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**(Total for question = 4 marks)**

**Q7.**

This is a question about chromium(III) and chromium(VI) compounds.

Describe the observations when aqueous sodium hydroxide is added drop by drop until in excess to a solution of chromium(III) ions.

(2)

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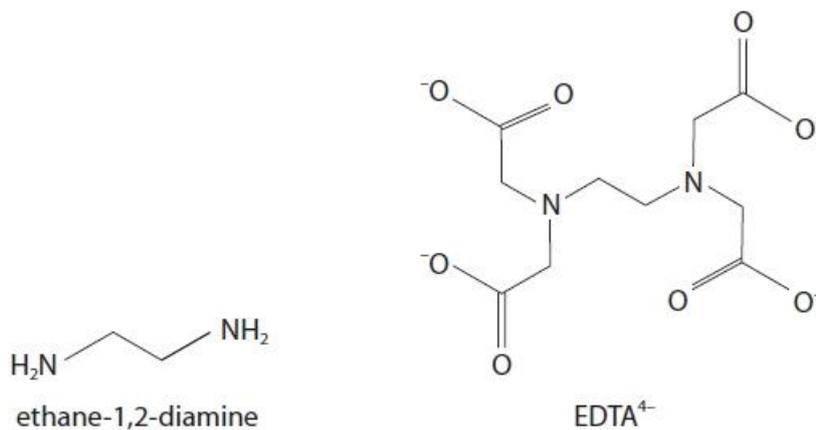
**(Total for question = 2 marks)**

**Q8.**

Transition metals form complex ions.

Compare and contrast the complex ions formed by cobalt(III) ions with the ligand ethane-1,2-diamine and with the ligand EDTA<sup>4-</sup>.

Ignore any difference in colour.



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**(Total for question = 4 marks)**

**Q9.**

\*"Cobalt(II) ions combine with substances in solution to form complex ions with different coordination numbers."

Discuss this statement by referring to **two** complex ions containing cobalt(II).

Include

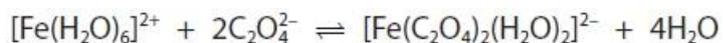
- reference to any difference in colour
- a definition of any terms used
- an explanation of the different shapes

**(Total for question = 6 marks)**

**Q10.**

Iron and zinc are in the d-block of the Periodic Table.

Hydrated iron(II) ions react with ethanedioate ions,  $\text{C}_2\text{O}_4^{2-}$ , to form a complex ion.



(i) Draw a structure of the  $[\text{Fe}(\text{C}_2\text{O}_4)_2(\text{H}_2\text{O})_2]^{2-}$  ion, showing **all** of the bonds.

(2)

(ii) Explain, in terms of entropy, why this reaction is feasible.

(2)

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**(Total for question = 4 marks)**



**Q12.**

Iron and zinc are in the d-block of the Periodic Table.

Iron(II) ions,  $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$ , form a pale green solution but zinc ions,  $[\text{Zn}(\text{H}_2\text{O})_6]^{2+}$ , form a colourless solution.

Explain why zinc ions are colourless.

(2)

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**(Total for question = 2 marks)**

**Q13.**

This question is about transition metals and their ions.

The complex ions of transition metals have different colours in aqueous solution.

Two factors that affect the colour of the solution are the oxidation number of the central metal ion, and the ligands present.

Give examples to illustrate these factors by referring to complex ions of iron and/or copper. Include the formula and colour of each complex.

An explanation of why transition metal ions are coloured is **not** required.

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**(Total for question = 3 marks)**

**Q14.**

Transition metals form complex ions.

Complex ions have a central metal ion surrounded by ligands.

(i) Give a reason why the ammonium ion cannot act as a ligand.

(1)

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(ii) Explain why the complex ions  $[\text{Co}(\text{NH}_3)_6]^{2+}$  and  $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$  are coloured and have different colours.

(4)

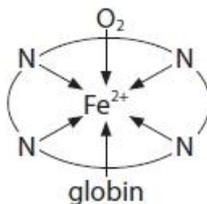
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**(Total for question = 5 marks)**

## Q15.

Some organic compounds contain metals.

Haemoglobin is an iron(II) complex. It carries oxygen around the body. Part of the structure of haemoglobin is shown.



The four nitrogen atoms are part of a multidentate ligand in the haem group.

Explain why inhaling carbon monoxide can be fatal.

(2)

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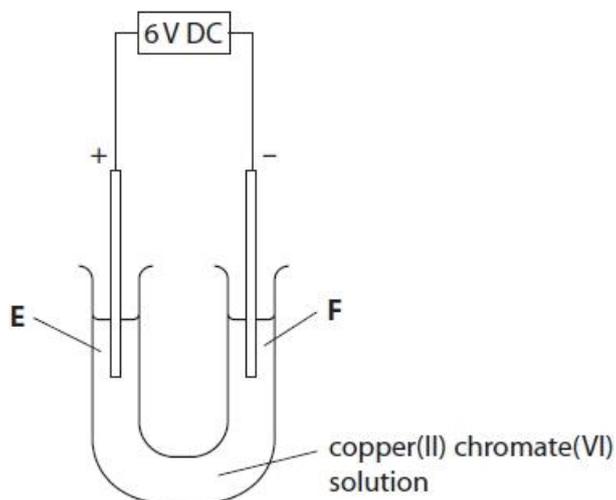
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**(Total for question = 2 marks)**

**Q16.**

This question is about structure and bonding.

An aqueous solution of copper(II) chromate(VI) was electrolysed using the apparatus shown in the diagram.



Deduce the colours of the solutions in regions **E** and **F** after the electrolysis has occurred.

(2)

Colour in region **E** .....

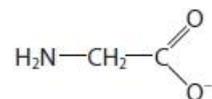
Colour in region **F** .....

**(Total for question = 2 marks)**

Q17.

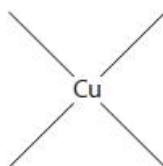
This question is about transition metals.

Glycinate ions are bidentate ligands and can be represented by the structure



Complete the diagram below to show the structure of the  $[\text{Cu}(\text{NH}_2\text{CH}_2\text{COO})_2]$  complex, which is square planar.

(2)

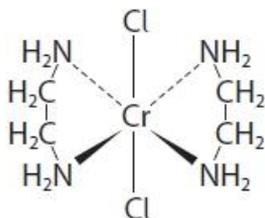


**(Total for question = 2 marks)**

**Q18.**

This question is about transition metals and their ions.

The **shape** of a complex ion formed from  $\text{Cr}^{3+}$  ions is shown.



(i) State the coordination number of  $\text{Cr}^{3+}$  in this complex ion.

(1)

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(ii) State the overall charge on this complex ion.

(1)

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**(Total for question = 2 marks)**

**Q19.**

Colour is often used in chemistry to identify substances.

Compare and contrast the origin of the colour of a copper(II) complex with the origin of the colour of the copper(II) ion in a flame test.

You do not need to state any specific colours.

**(6)**

**(Total for question = 6 marks)**