

# Transition Elements

## AS & A Level

### Question Paper 2

Level	A Level
Subject	Chemistry
Exam Board	OCR
Module	Physical Chemistry & Transition Elements
Topic	Transition Elements
Paper	AS & A Level
Booklet	Question Paper 2

**Time allowed:** 70 minutes

**Score:** /52

**Percentage:** /100

**Grade Boundaries:**

A*	A	B	C	D	E
>85%	73%	60%	47%	34%	21%

## Question 1

This question is about the chemistry of different transition elements.

- (a) Vanadium, V, is a typical transition element in the d-block of the Periodic Table. In its compounds and ions, vanadium has several common oxidation numbers, +2, +3, +4 and +5.

- (i) Show that vanadium is both a *d-block element* and *transition element*.

In your answer, include full electron configurations of vanadium in its 0 and +2 oxidation states. [4]

- (ii) An acidified solution containing  $\text{VO}_3^-$  ions reacts with zinc metal in a redox reaction. The resulting solution contains  $\text{Zn}^{2+}$  ions and  $\text{V}^{2+}$  ions.

The unbalanced half-equations are shown below.

Balance these half-equations and construct an overall equation for this reaction.



**Overall equation:** [3]

- (b) Platin,  $\text{Pt}(\text{NH}_3)_2\text{Cl}_2$ , is an uncharged complex of platinum(II) that has two stereoisomers. One of these stereoisomers is used in chemotherapy for the treatment of some cancers.

- (i) Explain why platin has no charge. [1]

- (ii) Draw labelled diagrams of the two stereoisomers of platin, showing clearly the atoms involved in bonding, and describe the bonding involving Pt with its ligands. [3]

- (iii) Describe the action of one of the stereoisomers of platin in the treatment of cancer patients. [1]

- (c) Aqueous cobalt(II) ions are reacted with aqueous sodium hydroxide and with concentrated hydrochloric acid.

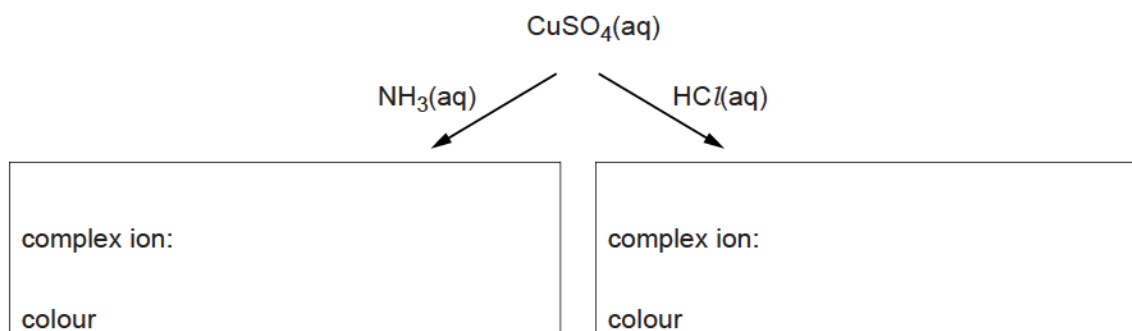
Describe these reactions. Include colours of the cobalt-containing species, ionic equations and the types of reaction taking place. [7]

**[Total: 19 Marks]**

This question is about the chemistry of copper compounds and complex ions.

(a) The flowchart shows two reactions of aqueous copper(II) sulfate.

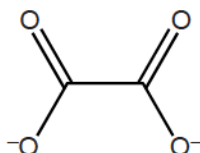
In the boxes, write the formulae and colours of the complex ions formed.



[3]

(b)  $\text{Cu}^{2+}$  ions form a complex ion **A** with two ethanedioate ions and two water molecules. The ethanedioate ion is a bidentate ligand.

The skeletal formula of the ethanedioate ion is shown in **Fig. 1.1** below.



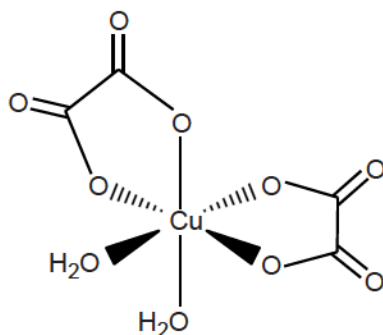
**Fig. 1.1**

(i) What is meant by the term *bidentate ligand*?

[1]

- (ii) The complex ion **A** exists as three stereoisomers.

The shape of one of the stereoisomers is shown below. The charge has been omitted.



**Complex A**

Complete the 3D diagrams of the other two stereoisomers of **A**.  
You do **not** need to include any charges.

Indicate with ticks whether the stereoisomers are *cis*, *trans*, optical or a combination of these types.

<b>Stereoisomer</b>														
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[3]

- (iii) What is the empirical formula, including the charge, of the complex ion **A**?

[2]

**[Total: 9 Marks]**

### Question 3

Hydroxide ions,  $\text{OH}^-$ , and cyanide ions,  $\text{CN}^-$ , can react with some aqueous solutions of transition metal compounds.

(a) When nickel(II) sulfate is dissolved in water, a pale green solution forms containing a six-coordinate complex ion **C**.

- Aqueous potassium hydroxide is added to aqueous nickel(II) sulfate. A green solid **D** forms.
  - An excess of aqueous potassium cyanide is added to aqueous nickel(II) sulfate. A yellow solution forms containing a four-coordinate complex ion **E** that contains **only** nickel, carbon and nitrogen.
- (i) In **C**, **D** and **E**, nickel has the +2 oxidation state. Suggest the formulae of **C**, **D** and **E**.

**Complex ion C:**

**Solid D:**

**Complex ion E:**

[3]

(ii) Write equations, and name the types of reaction, for the formation of **D** and **E**.

Formation of solid **D** from aqueous nickel(II) sulfate.

Equation:

Type of reaction:

Formation of complex ion **E** from complex ion **C**.

Equation:

Type of reaction:

[4]

(b) In some gold mines, cyanide is used to extract gold from its ore.

Gold metal in the ore reacts with cyanide ions, water and oxygen to form a water-soluble complex ion,  $[\text{Au}(\text{CN})_2]^-$ , with a bond angle of  $180^\circ$ . Hydroxide ions are also formed.

(i) Name the shape of  $[\text{Au}(\text{CN})_2]^-$ .

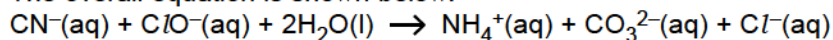
[1]

(ii) Using oxidation numbers, show that a redox reaction takes place. [2]

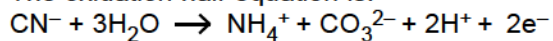
(iii) Construct the overall equation for this reaction. [2]  
State symbols are **not** required.

(iv) Some owners of gold mines remove cyanide ions from waste by adding oxidising agents, such as chlorate(I) ions, before discharge into watercourses.

The overall equation is shown below.



The oxidation half-equation is:



Construct the reduction half-equation.

State symbols are **not** required. [1]

**[Total: 13 Marks]**

Hydrated copper(II) methanoate,  $\text{Cu}(\text{HCOO})_2 \cdot x\text{H}_2\text{O}$ , is a copper salt.

A student carries out the procedure below to prepare  $\text{Cu}(\text{HCOO})_2 \cdot x\text{H}_2\text{O}$  and to determine the value of  $x$  in its formula.

**Step 1**

The student prepares  $\text{Cu}(\text{HCOO})_2 \cdot x\text{H}_2\text{O}$  by reacting a copper compound with aqueous methanoic acid to form  $\text{Cu}(\text{HCOO})_2(\text{aq})$  and allowing the solvent to evaporate.

**Step 2**

The student dissolves 2.226 g of  $\text{Cu}(\text{HCOO})_2 \cdot x\text{H}_2\text{O}$  in water and makes up the solution to  $250.0\text{cm}^3$ .

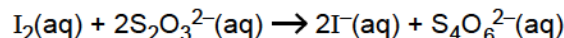
**Step 3**

Using a pipette, the student adds  $25.0\text{cm}^3$  of this solution to a conical flask followed by an excess of  $\text{KI}(\text{aq})$ .

The  $\text{Cu}^{2+}(\text{aq})$  ions react to form a precipitate of copper(I) iodide and  $\text{I}_2(\text{aq})$ .  
In this reaction, 2 mol  $\text{Cu}^{2+}$  form 1 mol  $\text{I}_2$ .

**Step 4**

The student titrates the iodine in the resulting mixture with  $0.0420\text{mol dm}^{-3}\text{Na}_2\text{S}_2\text{O}_3(\text{aq})$ .



$23.5\text{cm}^3$   $0.0420\text{mol dm}^{-3}\text{Na}_2\text{S}_2\text{O}_3(\text{aq})$  is required to reach the end point.

- (a) Complete the electron configuration of copper in

$\text{Cu}(\text{HCOO})_2 \cdot x\text{H}_2\text{O}$ :  $1s^2$

copper(I) iodide:  $1s^2$

[2]

- (b) Choose a suitable copper compound for **step 1**, and write the full equation for the reaction that would take place to form  $\text{Cu}(\text{HCOO})_2(\text{aq})$ .

State symbols are **not** required.

[1]

- (c) Write an ionic equation, including state symbols, for the reaction in **step 3**.

[1]

- (d) In **step 4**, the student adds a solution to observe the end point accurately.

Name the solution and state the colour change at the end point.

Solution added:.

Colour change:

[2]



(c) Write an ionic equation, including state symbols, for the reaction in **step 3**. [1]

(d) In **step 4**, the student adds a solution to observe the end point accurately.

Name the solution and state the colour change at the end point.

Solution added:.

Colour change: [2]

(e) Determine the value of  $x$  in  $\text{Cu}(\text{HCOO})_2 \cdot x\text{H}_2\text{O}$ .

Show your working. [5]

**[Total: 11 Marks]**