

1 (a) Define a transition element.

.....
.....
..... [1]

(b) The 3d orbitals in an isolated gaseous Cu^{2+} ion are degenerate.

(i) Define the term degenerate.

.....
..... [1]

(ii) Complete the electronic configuration of Cu^{2+} .

$1s^2$ [1]

(c) (i) State the colours of the aqueous solutions for the **two** copper(II) complex ions shown.

- $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}(\text{aq})$
- $[\text{CuCl}_4]^{2-}(\text{aq})$ [1]

(ii) Explain why aqueous complex ions of transition elements are usually coloured.

.....
.....
.....
.....
..... [3]

(d) (i) When an excess of $\text{NH}_3(\text{aq})$ is added to a solution of $[\text{CuCl}_4]^{2-}(\text{aq})$, $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}(\text{aq})$ is formed.

State the type of reaction.

Complete the equation for this reaction. State symbols are **not** required.

type of reaction

equation

$[\text{CuCl}_4]^{2-} + \dots\dots\dots \rightarrow [\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+} + \dots\dots\dots$ [2]

(ii) The $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$ complex ion shows stereoisomerism.

Complete the three-dimensional diagrams in Fig. 1.1 to show the **two** different stereoisomers of $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$.

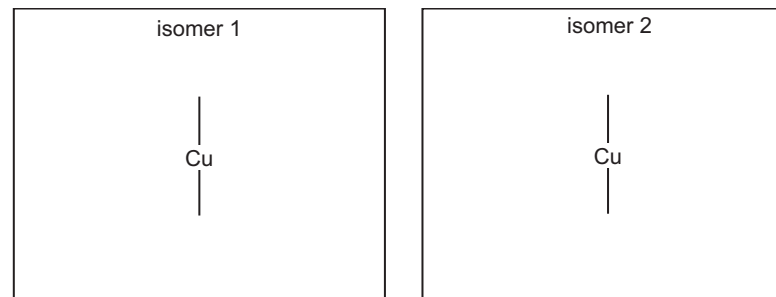


Fig. 1.1

[2]

(iii) Deduce which stereoisomer in (d)(ii) is polar.

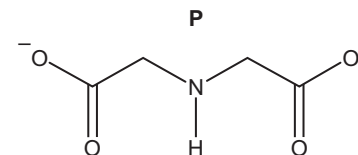
Explain your answer.

polar isomer

explanation

[1]

(e) The dianion **P** can act as a tridentate ligand.



(i) Suggest how **P** can form **three** dative covalent bonds.

.....
.....
..... [1]

(ii) 2 moles of dianion **P**, $\text{C}_4\text{H}_5\text{NO}_4^{2-}$, react with 1 mole of aqueous cobalt(III) ions, $[\text{Co}(\text{H}_2\text{O})_6]^{3+}$ to form 1 mole of complex ion **Q**.

Deduce the formula and charge of **Q**.

..... [1]

- (f) Table 1.1 shows values for the stability constants, K_{stab} , of some silver(I) complexes.

Table 1.1

complex	value of K_{stab}
$[\text{Ag}(\text{CN})_2]^{-}(\text{aq})$	1.1×10^{18}
$[\text{Ag}(\text{NH}_3)_2]^{+}(\text{aq})$	1.2×10^7
$[\text{Ag}(\text{S}_2\text{O}_3)_2]^{3-}(\text{aq})$	2.9×10^{13}

- (i) Define the stability constant of a complex.

.....
.....
..... [1]

- (ii) Use the information in Table 1.1 to identify the most stable silver(I) complex.

Explain your answer.

most stable

explanation

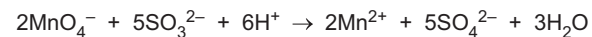
..... [1]

- (g) Sodium sulfite, Na_2SO_3 , is used as a food preservative.

A 3.75 g sample of impure Na_2SO_3 is dissolved in distilled water and made up to 250 cm^3 in a volumetric flask.

10.0 cm^3 of this solution requires 18.70 cm^3 of acidified $0.0150\text{ mol dm}^{-3}$ $\text{MnO}_4^{-}(\text{aq})$ to reach the end-point.

The equation for the reaction is shown.



Calculate the percentage by mass of Na_2SO_3 in the sample.

percentage by mass of Na_2SO_3 = [3]

[Total: 19]