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.

- $[Cu(NH_3)_4(H_2O)_2]^{2+}(aq)$ .....
- $[CuCl_4]^{2-}(aq)$ .....

[1]

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

.....

.....

.....

.....

..... [3]

(d) **(i)** When an excess of $NH_3(aq)$ is added to a solution of $[CuCl_4]^{2-}(aq)$, $[Cu(NH_3)_4(H_2O)_2]^{2+}(aq)$ is formed.

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

type of reaction .....

equation

$[CuCl_4]^{2-}$ + ... → $[Cu(NH_3)_4(H_2O)_2]^{2+}$ + ...

[2]

(ii) The $[Cu(NH_3)_4(H_2O)_2]^{2+}$ complex ion shows stereoisomerism.

Complete the three-dimensional diagrams in Fig. 1.1 to show the **two** different stereoisomers of $[Cu(NH_3)_4(H_2O)_2]^{2+}$.

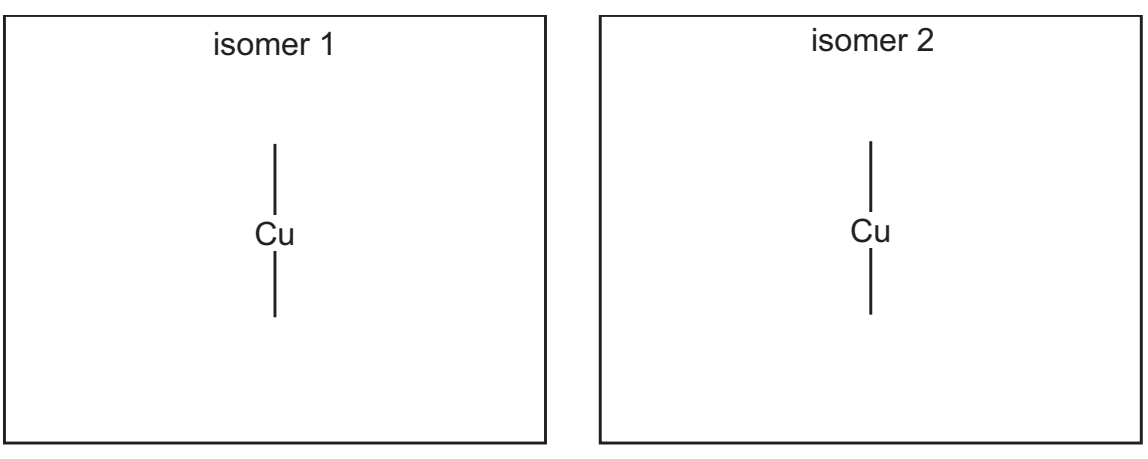


Fig. 1.1

[2]

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

Explain your answer.

polar isomer .....

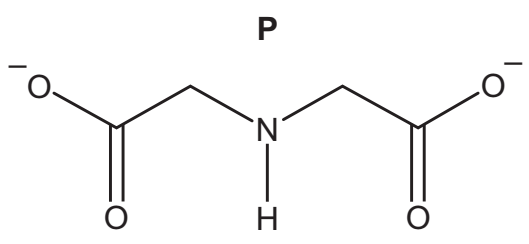
explanation .....

.....

[1]

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

P



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

.....

.....

..... [1]

(ii) 2 moles of dianion **P**, $C_4H_5NO_4^{2-}$, react with 1 mole of aqueous cobalt(III) ions, $[Co(H_2O)_6]^{3+}$ 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}
$[Ag(CN)_2]^-(aq)$	1.1×10^{18}
$[Ag(NH_3)_2]^+(aq)$	1.2×10^{7}
$[Ag(S_2O_3)_2]^{3-}(aq)$	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 mol dm^{-3} $MnO_4^-(aq)$ to reach the end-point.

The equation for the reaction is shown.

$$2MnO_4^- + 5SO_3^{2-} + 6H^+ \rightarrow 2Mn^{2+} + 5SO_4^{2-} + 3H_2O$$

Calculate the percentage by mass of Na_2SO_3 in the sample.

percentage by mass of Na_2SO_3 = ... [3]

[Total: 19]