

28.2 Ligands and complexes

Name: _____ Class: _____ Date: _____

Total: 12 marks

Objective

Build the skills to answer exam questions on **ligands and complexes** 配体和配合物—**denticity** 齿数, complex shapes, **coordination number** 配位数, and **ligand exchange** 配体交换.

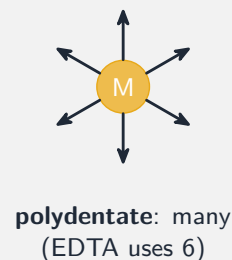
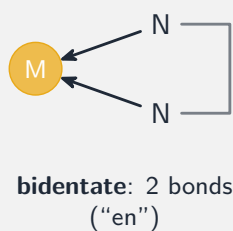
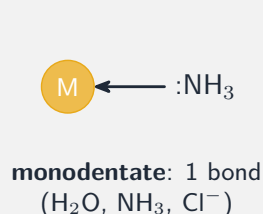
You must be able to:

- define a ligand and classify ligands as mono-, bi- or polydentate
- describe complex shapes and deduce coordination number and charge
- describe the ligand-exchange reactions of copper(II) and cobalt(II)

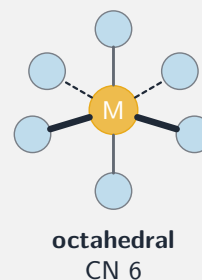
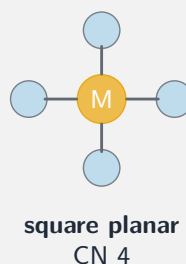
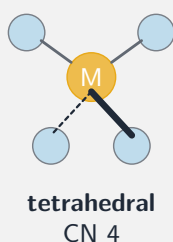
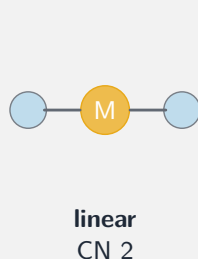
1 Worked examples

■ Ligands and complexes

A **ligand** has a lone pair that forms a **dative covalent bond** to the central metal ion.

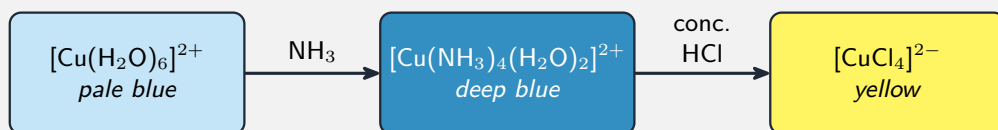


Monodentate (1 bond: H_2O , NH_3 , Cl^- , CN^-); bidentate (2: en, C_2O^{2-}); polydentate (EDTA, 6)



Coordination number → shape: 2 linear, 4 tetrahedral or square planar, 6 octahedral

■ Ligand exchange



Ligand exchange changes colour: $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ (pale blue) $\rightarrow$ $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$ (deep blue) $\rightarrow$ $[\text{CuCl}_4]^{2-}$ (yellow)

2 Practice

2.1 Define a **ligand**. [2]

2.2 State the coordination number and shape of $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$. [2]

3 Exam-style questions

3.1 Which is a **bidentate** ligand? [1]

- A H O
- B Cl
- C 1,2-diaminoethane (en)
- D NH

3.2 The overall charge on $[\text{CuCl}_4]^{2-}$ shows copper is in oxidation state: [1]

- A +1
- B +2
- C +3
- D +4

3.3 (a) Write the formula and state the colour of the complex formed when excess am-

monia is added to $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$. [2]

(b) State what is meant by **ligand exchange**. [2]

3.4 Deduce the coordination number and shape of $[\text{CuCl}_4]^{2-}$. [2]

4 Go further

You are now ready for the real exam questions on this subtopic. Open the **28.2 Ligands and complexes** past-paper sheet in the Library, or try these in **Practice mode**:

- 9701/31 N25 —Q3 (ligands and complexes)
- 9701/33 N25 —Q3 (ligands and complexes)
- 9701/34 N25 —Q3 (ligands and complexes)

Solutions

2.1 a species with a lone pair of electrons that forms a dative (coordinate) bond to a central metal ion.

2.2 coordination number 6; octahedral.

3.1 C. 1,2-diaminoethane (en) forms two dative bonds —bidentate.

3.2 B. $x + 4(-1) = -2 \Rightarrow x = +2$.

3.3 (a) $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$; deep blue.

(b) one ligand is replaced by another ligand around the central metal ion, often with a colour change.

3.4 coordination number 4; tetrahedral.