

高等医药院校中英双语教材

# 医药配位化学

Medicinal Coordination Chemistry

于 丽 主编



天津科技翻译出版公司



高等医药院校中英双语教材

# 医药配位化学

**Medicinal Coordination Chemistry**

于 丽 主 编

应荣多 主 审



天津科技翻译出版公司

---

## 图书在版编目 (CIP) 数据

医药配位化学 / 于丽主编. —天津:天津科技翻译出版公司, 2006.9

ISBN 7-5433-2081-9

I. 医... II. 于... III. 医用化学:络合物化学—英、汉 IV. R313

中国版本图书馆CIP数据核字 (2006) 第095807 号

---

出 版: 天津科技翻译出版公司

出 版 人: 蔡 颖

地 址: 天津市南开区白堤路 244 号

邮政编码: 300192

电 话: (022) 87894896

传 真: (022) 87895650

网 址: [www.tsttpc.com](http://www.tsttpc.com)

印 刷: 天津市宝坻区第二印刷厂

发 行: 全国新华书店

版本记录: 880×1230 32 开本 3.5 印张 80 千字

2006 年 9 月第 1 版 2006 年 9 月第 1 次印刷

定价: 15.00 元

(如发现印装问题, 可与出版社调换)

## 内 容 简 介

配位化学是无机化学的一个分支学科，它与医学、药学关系密切，是高等医药院校必修基础化学课的内容。我们根据医药院校的专业特点，适当取舍，突出了配位化学与医药学的相关内容，介绍了交叉学科的新成就，编写了这本《医药配位化学》(*Medicinal Coordination Chemistry*) 中英双语教材。本教材内容简明新颖、图文并茂，适合医药院校各专业本科生、专科生及高职院校学生使用，也可作为与无机化学配套的教学参考用书。

## 前 言

为了使国内高等医药院校的基础化学教学尽快与国外大学接轨，引入一些新的专业理念和知识，我们参考近年出版的相关英文教科书，编写了这本《医药配位化学》(*Medicinal Coordination Chemistry*) 中英双语教材。

本教材讲述了配位化学的基本概念和基础理论、配位化合物在生命过程中的重要作用，并介绍了我们发表在国内外专业期刊上的最新研究论文的相关内容。书中的英文阅读材料，不仅可以扩充大学生的专业知识，而且还可以丰富专业英语词汇，提高专业英语阅读水平。

本教材由于丽主编，耿思莹、赵晶、程向辉、刘照胜等参编，应荣多教授、王润玲教授审校。

由于时间仓促，编著者水平有限，恳请读者批评指正。

编著者

2006 年 7 月

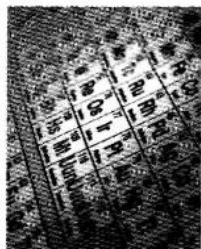


# Contents

## 目 录

---

- Chapter 1** The Structures of Complexes  
配位化合物的结构 /1
- Chapter 2** Chelates  
螯合物 /6
- Chapter 3** Isomerism  
异构现象 /12
- Chapter 4** Color and Magnetism  
颜色和磁性 /18
- Chapter 5** Crystal-Field Theory  
晶体场理论 /21
- Chapter 6** Metals and Chelates in Living Systems  
生命体系中的金属元素和螯合物 /29
- Chapter 7** Coordination Chemistry and Life  
配位化学与生命 /35
- Chapter 8** The Introduction of New Complexes  
介绍几个新的配合物 /40
- Chapter 9** English Readings  
英文阅读材料 /49
- 参考译文 /69
- 参考文献 /107



# Chapter 1

## The Structures of Complexes

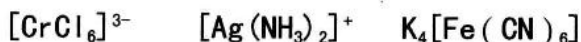
### 配位化合物的结构

---

#### Abstract

Compounds that contain complexes—a central metal ion bonded to surrounding molecules or ions—are called coordination compounds. The terms *ligand*, *coordination sphere*, and *coordination number* are introduced in this section. The geometries associated with various coordination numbers are shown. You will learn how to write formulas for metal complexes and how to determine the charge on the central metal ion. ♦

A metal complex, or simply a **complex**, is a metal ion bound to a group of surrounding ions or molecules. When a complex is charged, it is called a **complex ion**. **Coordination compounds** are compounds that contain complexes.



Note that the complexes are enclosed by square brackets.

The molecules or ions that surround a metal ion in a complex are called **ligands**. Ligands may be anions or polar

molecules. Some common ligands are water, ammonia, hydroxide, cyanide, and chloride. Each of these has at least one unshared pair of electrons that can be used to *coordinate* (form a **coordinate covalent bond** to the metal ion). Metal ions can act as Lewis acids, accepting electrons from ligands, which act as Lewis bases. The atom that is bound directly to the metal ion is called the **donor atom**. It's the atom that donates a lone pair of electrons to the metal ion.

The metal ion and the ligands that are covalently bound to it make up the **coordination sphere** of the complex. The number of donor atoms bound to the metal ion is the **coordination number**.

Coordination numbers of 2, 4, and 6 are common. The geometry of a complex is determined in part by its coordination number. (Size of the ligands can also impact the geometry.)

Coordination Number	Geometry
2	Linear
4	Tetrahedral or square planar
6	Octahedral

The charge on a central metal ion can be determined in much the same way that oxidation numbers are determined in molecular compounds. It is important to recognize common molecules, to remember that they are neutral, and to know the



charges on both monoatomic and polyatomic ions. The sum of charges on the metal ion and the ligands must equal the net charge on the complex.

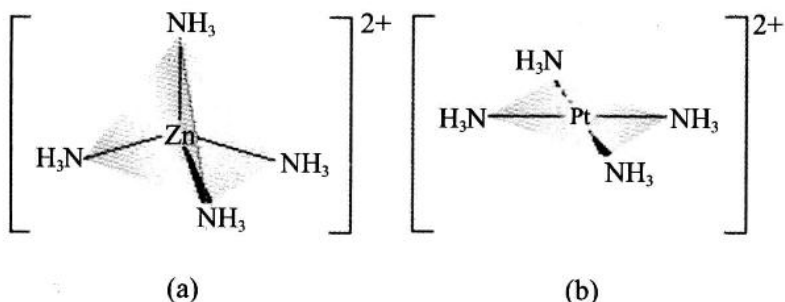


Figure 1.1 Structures of (a)  $[\text{Zn}(\text{NH}_3)_4]^{2+}$  and (b)  $[\text{Pt}(\text{NH}_3)_4]^{2+}$ , illustrating the tetrahedral and square-planar geometries, respectively. These are the two common geometries for complexes in which the metal ion has a coordination number of 4. The shaded surfaces shown in the figure are not bonds; there are included merely to assist in visualizing the shape of the metal complex.

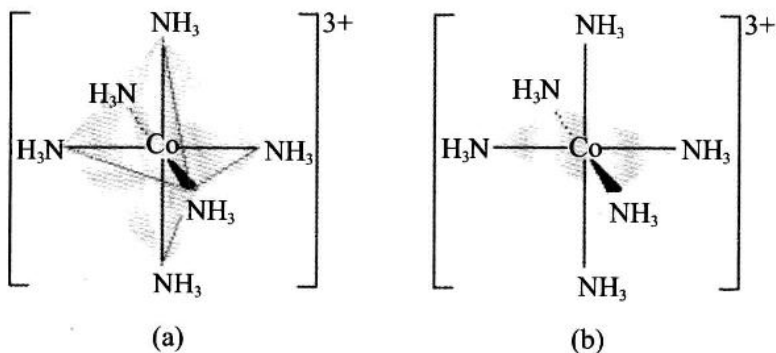
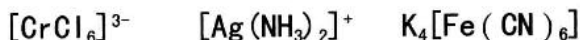


Figure 1.2 Two representations of an octahedral coordination sphere, the common geometric arrangement for complexes in which the metal ion has a coordination number of 6.

Point to each metal ion or ligand to see its charge.



### QUESTIONS

---

- ① What is the charge on the nickel ion in the complex ion  $[\text{Ni}(\text{NH}_3)_6]^{2+}$ ?
  - A. +6
  - B. +2
  - C. +8
  - D. -4
  
- ② What is the coordination number of chromium in the complex ion  $[\text{Cr}(\text{H}_2\text{O})_4\text{Cl}_2]^+$ ?
  - A. 2
  - B. 4
  - C. 5
  - D. 6



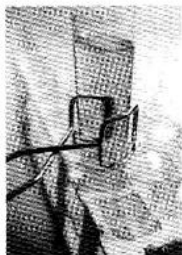
### NOTES

---

- \* **complex ion (complex):** An assembly of a metal ion and the Lewis bases (ligands) bonded to it.
- \* **ligand:** An ion or molecule that coordinates to a metal atom or to a metal ion to form a complex.
- \* **Coordination covalent bond:** A covalent bond in which

one atom involved in the bond donates both of the electrons to be shared.

- \* **donor atom:** The atom of a ligand that bonds to the metal.
- \* **coordination sphere:** The metal ion and its surrounding ligands.
- \* **coordination number:** The number of adjacent atoms to which an atom is directly bonded. In a complex, the coordination number of the metal ion is the number of donor atoms to which it is bonded.



## Chapter 2

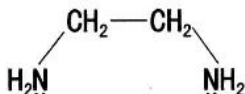
### Chelates

### 螯合物

#### Abstract

In this section you will see ligands that can attach to a metal ion with more than one bond. Such ligands are called polydentate ligands, or chelating agents. The rules of nomenclature for coordination compounds are introduced; you will practice deducing the name of a compound given its formula, and vice versa. ♦

Each of the ligands encountered so far has been a **monodentate ligand**, meaning that they each have only one donor atom. **Polydentate ligands** have two or more donor atoms and are also known as **chelating agents**. A common polydentate ligand is the molecule ethylenediamine, abbreviated en.



Each of ethylenediamine's nitrogen atoms has an unshared pair of electrons that can be donated to a metal ion. Ethylenediamine is a **bidentate ligand**. Another common

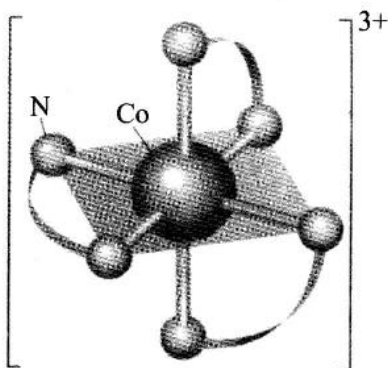


Figure 2.1

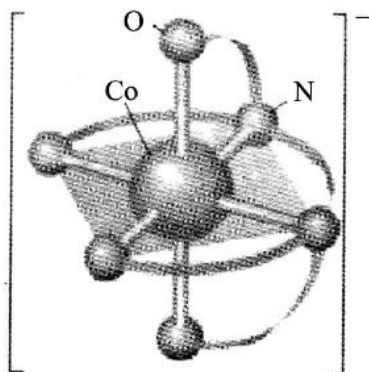
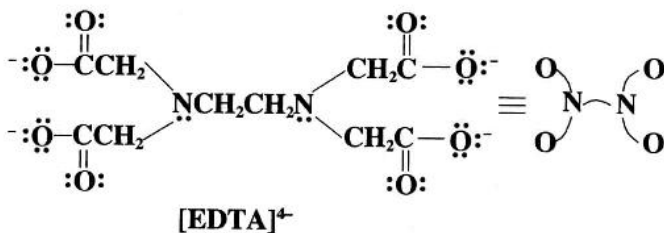


Figure 2.2

Figure 2.1  $[\text{Co}(\text{en})_3]^{3+}$  ion, showing how each bidentate ethylenediamine ligand is able to occupy two positions in the coordination sphere.

Figure 2.2 The  $[\text{CoEDTA}]^-$  ion, showing how the ethylenediaminetetraacetate ion is able to wrap around a metal ion, occupying six positions in the coordination sphere.

chelating agent is the ethylenediaminetetraacetate ion or EDTA. EDTA has *six* potential donor atoms: four oxygens and two nitrogens. EDTA is a *hexadentate* ligand and is able to wrap around a metal ion, coordinating to it with all six donor atoms.



Polydentate ligands tend to coordinate more readily and

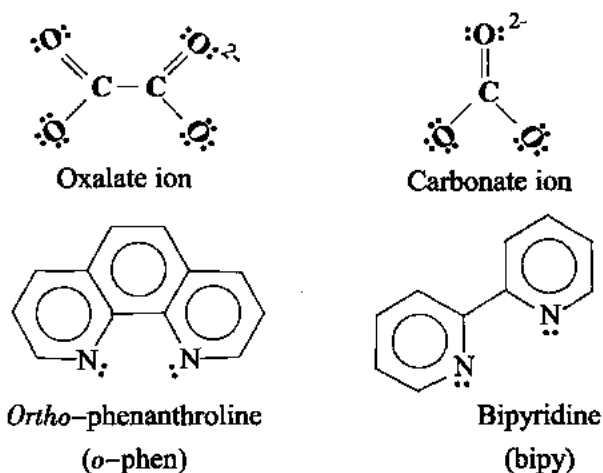


Figure 2.3 Structures of other bidentate ligands. The coordinating atoms are shown in blue.

form more stable complexes than monodentate ligands. This phenomenon is known as the **chelate effect**.

The system for naming coordination compounds is as follows:

(1) *In naming salts, the name of the cation is given before the name of the anion.* Thus, in  $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$  we name the  $[\text{Co}(\text{NH}_3)_5\text{Cl}]^{2+}$  and then the  $\text{Cl}^-$ .

(2) *Within a complex ion or molecule, the ligands are named before the metal. Ligands are listed in alphabetical order, regardless of the charge on the ligand. Prefixes that give the number of ligands are not considered part of the ligand name in determining alphabetical order.* Thus, in the  $[\text{Co}(\text{NH}_3)_5\text{Cl}]^{2+}$  ion we name the ammonia ligands first, then the

chloride, then the metal: pentaamminechlorocobalt( III ). Note, however, that in writing the formula, the metal is listed first.

(3) *The names of the anionic ligands end in the letter o, whereas neutral ones ordinarily bear the name of the molecule.* Special names are given to  $\text{H}_2\text{O}$  (aqua) and  $\text{NH}_3$  (ammine). For example, the terms *chloro* and *ammine* occur in the name for  $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$ .

(4) *A Greek prefix (for example, di-, tri-, tetra-, penta-, and hexa-) is used to indicate the number of each kind of ligand when more than one is present.* Therefore, in the name for  $[\text{Co}(\text{NH}_3)_5\text{Cl}]^{2+}$  we have pentaammine, indicating five ligands. *If the name of the ligand itself contains a Greek prefix, such as mono- or di-, the name of the ligand is enclosed in parentheses, and alternate prefixes (bis-, tris-, tetrakis-, pentakis-, and hexakis-) are used.* For example, the name for  $[\text{Co}(\text{en})_3]\text{Cl}_3$  is tris(ethylenediamine)cobalt( III ) chloride.

(5) *If the complex is an anion, its name ends in -ate.* For example, in  $\text{K}_4[\text{Fe}(\text{CN})_6]$  the anion is called the hexacyanoferrate( II ) ion. The suffix *-ate* is often added to the Latin stem, as in this example.

(6) *The oxidation number of the metal is given in parentheses in Roman numerals following the numeral III is used to indicate the +3 oxidation state of cobalt in  $[\text{Co}(\text{NH}_3)_5\text{Cl}]^{2+}$ .*



## QUESTIONS

- 1 Which name is correct for the coordination compound  $[\text{Fe}(\text{en})_2\text{Cl}_2]\text{Cl}$ ?
  - A. dichlorobisethylenediamineiron(III) chloride
  - B. diethylenediaminechlorineiron(I) chloride
  - C. iron(III) bisethylenediaminedichloro chloride
  - D. iron(III) trichloridebisethylenediamine
- 2 What is the coordination number of iron in  $[\text{Fe}(\text{en})_2\text{Cl}_2]\text{Cl}$ ?
  - A. 2
  - B. 4
  - C. 6
- 3 Name the following coordination compounds.
  - A.  $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]\text{Cl}$
  - B.  $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$
  - C.  $\text{K}_2[\text{Ni}(\text{C}_2\text{O}_4)_2]$
  - D.  $[\text{Cr}(\text{NH}_3)_5\text{H}_2\text{O}](\text{NO}_3)_3$



## NOTES

- \* **monodentate ligand:** A ligand that binds to the metal ion via a single donor atom. It occupies one position in the coordination sphere.
- \* **polydentate ligand:** A ligand in which two or more donor atoms can coordinate to the same metal ion.



- \* **chelating agent:** A polydentate ligand that is capable of occupying two or more sites in the coordination sphere.
- \* **bidentate ligand:** A ligand in which two coordinating atoms are bound to a metal.
- \* **chelate effect:** The generally larger formation constants for polydentate ligands as compared with the corresponding monodentate ligands.