

Chapter 17 Summary

Section 17.1 Students should know that a **Lewis base** is a substance that donates pairs of electrons to a **Lewis acid** during a chemical reaction. This donated pair forms a new covalent bond. In some of these reactions, such as that between CaO and SO₂, other bonds must break to accommodate the new one.

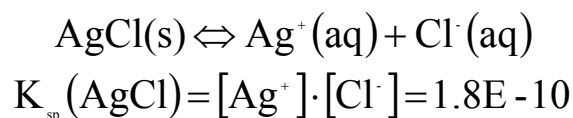
Section 17.2 Students should know that transition metal ions form **complex ions** when **ligands** donate pairs of electrons to empty valence-shell orbitals on the metal ion, thereby forming **coordinate (covalent) bonds**. The number of coordinate bonds in a complex defines the **coordination number** of the metal ion. The most common coordination numbers are 6, 4, and 2. It is very important that you know that the metal ion in a complex ion acts as a **Lewis acid (electron-pair acceptor)** and the ligands act as **Lewis bases (electron-pair donors)**. Compounds that contain complex ions are called **coordination compounds**; the net charges on complex ions are balanced by charges from **counter ions**. Ligands occupy binding sites in the **inner coordination sphere** of a metal ion. Counter ions surround complex ions in their compounds and dissociate from the complex ions when the compounds dissolve.

Section 17.3 Students should know that the stability of complex ions is expressed mathematically by their **formation constants (K_f)**, which can be used to calculate the equilibrium concentration of free metal ions, Mⁿ⁺(aq), in solutions of their complex ions.

Section 17.4 Students should know that hydrated metal ions with charges of 2+ or greater can act as **Brønsted-Lowry acids**, which is why solutions of their soluble salts are acidic. Most transition metal ions have limited solubility in strongly basic solutions. An exception (for example) is Cr(III), which forms an anionic complex with the formula Cr(OH)₄⁻.

Section 17.5 Students should know that the solubility of slightly soluble compounds is described by their **K_{sp}** or **Solubility Product**, which is the value of the equilibrium constant for their dissolution (see Table A5.4 in Appendix 5).

For example the slightly soluble salt AgCl :



Section 17.6 Students should know that a molecule or ion of a **monodentate ligand** donates only one pair of electrons in a complex ion; **polydentate ligands** donate more than one in a process called **chelation**. EDTA is a particularly effective chelating and **sequestering agent**. It prevents metal ions in solution from reacting with other substances.

Section 17.7 Students should know that polydentate ligands are particularly effective in forming complex ions. This phenomenon is called the **chelate effect** and can be explained by the increase in entropy that accompanies the chelation process.

Section 17.8 Students should know that the colors of transition metals in crystalline solids and in solutions can be explained by the interactions between electrons in different *d* orbitals and the lone pairs of electrons on surrounding ligands. Different interactions create **crystal field splitting** of the energies (labeled Δ) of the *d* orbitals. A **spectrochemical series** ranks ligands on the basis of their field strengths and the wavelengths of electromagnetic radiation absorbed by their complex ions; the stronger the field the ligand produces, the shorter the wavelength of radiation the complex absorbs. The color of a complex ion in solution or in a crystalline solid is the complement of the color(s) it absorbs.

Section 17.9 Students should know that strong repulsions and large values of Δ can lead to electron pairing in lower-energy orbitals and an electron configuration called a low-spin state. Metals and their ions are less para-magnetic in low-spin states than when their *d* electrons are evenly distributed across all the *d* orbitals in their valence shell – a configuration called a high-spin state.

Section 17.10 Students should know that the names of complex ions and coordinate compounds provide information about the identities and number of ligands, the identity and oxidation state of the central metal ion, and identity of any counter ions whose charges balance the net charge of the complex ion.

Section 17.11 Students should know that complex metal ions containing more than one type of ligand may form geometric isomers. For example, when one type occupies two adjacent corners of a square planar complex, the complex is a *cis* isomer; when the same ligand occupies opposite corners, it is a *trans* isomer. The chemical and biochemical properties of coordination compounds that are geometric isomers can be very different, as illustrated by the difference between the chemotherapeutic power of cisplatin and that of its *trans* isomer.

Section 17.12 Students should know that metal ion complexes play key roles in many biochemical processes. Among these are photosynthesis, which is mediated by chlorophyll, in which tetradentate **porphyrin rings** coordinately bond to central Mg^{2+} ions; oxygen transport in the body based on the reversible bonding of O_2 molecules to heme groups of Fe^{2+} ions in **porphyrin rings** (hemoglobin); and energy production in cells, which is mediated by molecules called cytochromes that contain metals in different oxidation states.