***Learning Objectives***

After completing this course, each student should be able to:

* rationalize the different periodic trends that are observed for the elements in the periodic table (atomic radius, first ionization energy, higher ionization energies)
* calculate the effective nuclear charge felt by an electron in a molecule/ complex ion using Slater’s Rules,
* identify the presence of a complex cation and/or anion from a structural representation of the compound,
* calculate the charge on the metal center in a complex ion,
* determine the number of d electrons on the metal center,
* classify ligands and metal complexes [MLlXxZz] using the Covalent Bond Classification (CBC) method,
* differentiate between different types of ligands that can be bound to metal centers,
* assign the coordination number and geometry adopted by a metal center,
* convert between the name of a coordination complex and its structure (in both directions),
* differentiate between the different types of isomers possible for coordination complexes,
* identify and name the isomer observed in a coordination complex,
* recall the basic symmetry operations (reflection and rotation) and determine if the related symmetry elements (mirror plane and proper axis of rotation) are present in a complex,
* determine whether or not a complex is optically active,
* relate the symmetry present in a complex to its spectroscopic data.
* identify chelating and macrocyclic ligands,
* determine the denticity or hapticity of a ligand,
* identify the Lewis acid and the Lewis base in a reaction,
* differentiate between coordinate bonds and covalent/ionic bonds,
* determine the hybridization of a transition metal center in a complex,
* identify which metal d orbitals should be used to form the hybrid orbitals needed to bond to the attached ligands,
* describe how to determine a d orbital splitting pattern for a metal ion in a ligand field,
* draw the correct d orbital splitting pattern for a given ligand field ,
* fill in the split d orbitals with the appropriate number of d electrons,
* recall how the position of the ligand in the spectrochemical series, the size of the metal ion, and the charge on the metal ion influences the magnitude of the d orbital splitting (Δoct),
* determine the spin state (high spin or low spin) for a metal ion in a given complex,
* calculate the crystal field stabilization energy (CFSE) for a particular metal ion (including the pairing energy),
* identify the possible electronic transitions in a transition metal using the appropriate Tanabe-Sugano diagram,
* correlate the observed transitions in a UV-visible spectrum with electronic transitions from Tanabe-Sugano diagrams,
* calculate the Δo for a transition metal complex from UV-visible spectroscopic data,
* calculate the spin-only magnetic moment (μS) for a complex given the number of unpaired electrons, and
* determine the number of unpaired electrons in a complex from the calculated μeff and μs values and determine the spin state of the complex from this information.
* recall the characteristics of the five main types of reactions observed in coordination compounds
* identify the type of reaction observed in a coordination compounds when provided with a reaction equation,
* describe how oxidative addition and reductive elimination reactions are combinations of two other reaction types,
* identify the reaction types in the steps of a catalytic cycle,
* recall the definitions of labile, inert, stable, and unstable as used to describe coordination compounds,
* compare and contrast the properties of abile, inert, stable, and unstable coordination complexes,
* recall the three mechanistic pathways followed in ligand substitution reactions of octahedral complexes,
* compare and contrast the different pathways and recall how to use reaction order and kinetic data to differentiate between the pathways,
* describe and provide evidence why the dissociative mechanism is most commonly observed for octahedral complexes,
* use linear free energy relationships (such as that in Figure 5.6, pg. 106) to gain information about reaction mechanisms,
* calculate the ΔCFSE for dissociative reactions of octahedral complexes (such as those in Table 5.4),
* explain the inertness or lability of a complex based upon its ΔCFSE value,
* identify redox reactions,
* determine which coordination complex is being oxidized and which is being reduced,
* recall the factors that make an inner sphere electron transfer reaction possible,
* determine the mechanism of the redox reaction (inner sphere vs. outer sphere),
* explain the structure and composition of the products of inner sphere electron transfer reactions,
* provide reasons for the observed rates of outer sphere electron transfer reactions based upon their structures.
* describe how the kinetic trans effect influences substitution reactions in square planar complexes;
* determine the product of a substitution reaction in square planar complexes using the kinetic trans effect;
* recall the factors that influence the stability of coordination complexes,
* describe the chelate and macrocyclic effects;
* classify acids and bases as hard or soft based upon HSAB theory (Table 6.1, pg. 131),
* recall the differences between hard/soft acids/bases,
* determine the relative stability of complexes based upon HSAB theory,
* determine the most stable combinations of acids and bases using HSAB theory and predict what might happen in a reaction,
* recall the thermodynamic factors that give rise to the chelate and macrocyclic effects,
* explain observed trends in equilibrium data and stability based upon the chelate and macrocyclic effects,
* recall the different roles that metals play in biological systems,
* describe how metal ions bind to proteins and other biological macromolecules,
* explain why certain metal ions bind to biological macromolecules in the manner that they do,
* explain how the coordination environment around a metal ion in a biological setting influences its chemical properties and reactivity,
* identify different types of solid-state structures (including crystalline and framework structures),
* identify different lattice types and packing arrangements,
* calculate the density for a given lattice,
* determine the number of nearest neighbors to an ion/atom in a lattice,
* explain why certain types of holes are filled/empty in a lattice using ionic radii,
* recall the different methods used to calculate the lattice energy of an ionic solid and when to employ each method,
* calculate the lattice energy of an ionic solid,
* define the behaviors of insulators, conductors, semiconductors, and superconductors,
* choose the appropriate band diagram for insulators, conductors, and semiconductors,
* explain the manner in which conductors and semiconductors allow for the movement of electrons, and
* describe how p- and n-type semiconductors are created and how they allow for electrical conduction.