Equilibria: The Big Picture

1. A (bio)chemical system is at equilibrium when its free energy, ΔG, is zero and the concentrations of all reactants and products are constant.
2. An equilibrium constant, K, describes the composition of a (bio)chemical system when it reaches equilibrium.
3. Although there is, for any temperature, a single value of K for a (bio)chemical system, there are an infinite number of ways for the system to be at equilibrium.
4. To determine the composition of a (bio)chemical system at equilibrium you must (i) identify the reaction that describes the system at equilibrium, (ii) determine that reaction's equilibrium constant expression and its value, (iii) define what you know about the system's initial and equilibrium condition in terms of known concentrations or a single variable, and (iv) solve for that one variable.
5. Standard values for K are available for just a small subset of possible reaction types: acid dissociation reactions, K_a, base dissocation reactions, K_b, solubility reactions, K_{sp}, step-wise metal-ligand complex formation reactions, K_i, overall metal-ligand complex formation reactions, β_i, and water's dissocation reaction, K_w. The equilibrium constant for any other (bio)chemical system is derived using one or more of these standard equilibrium constants.
6. An ICE (***i***nitial, ***c***hange, ***e***quilibrium) table is a useful tool for keeping track of what you know about a (bio)chemical system at equilibrium. Details about how a solution is prepared provide information about the system's inital composition; details about measurements made on the system, provide information about the system's equilibrium composition.
7. There are many ways to solve for the composition of a (bio)chemical system at equilibrium: a rigorous algebraic solution, simplifying the algebra by making and testing one or more assumptions, using a calculator's solver function to find the equation's roots, and graphing the equation. Be sure you are comfortable with at least two approaches, one of which is a rigorous algebraic solution.
8. If you push a (bio)chemical system out of equilibrium by adding or removing a reactant or product, by diluting or concentrating the solution, or by changing the temperature, the system will return to equilibrium by counteracting the change; this is Le Châtelier's Principle.
9. A (bio)chemical system's experimental equilibrium constant may not agree with its thermodynamic value due to non-ideal interactions arising from the interactions between ions.