

# Study Guide for Final Exam, Ch. 14-21, 24-25

## Chem1B, General Chemistry II

---

### MEMORIZE

- Rate Law,  $\text{rate} = k[A]^m[B]^n$
- $K_c = ([\text{products}])/([\text{reactants}])$ ,  $Q = ([\text{products}])/([\text{reactants}])$
- List of strong acids/bases
- $K_w = 1.0 \times 10^{-14} = [\text{H}_3\text{O}^+][\text{OH}^-] = K_a \times K_b$  (for conjugates)
- $\text{pH} = -\log[\text{H}_3\text{O}^+]$ ;  $\text{pOH} = -\log[\text{OH}^-]$ ;  $14.00 = \text{pH} + \text{pOH}$
- $\text{percent ionization} = \frac{[\text{H}^+]_{\text{at equilibrium}}}{[\text{HA}]_{\text{initial}}}$
- $\text{pH} = \text{p}K_a + \log([\text{conj. base}]/[\text{acid}])$
- $\Delta S_T = \Delta S_{\text{surr}} + \Delta S_{\text{sys}}$ ,  $\Delta S_{\text{surr}} = (-\Delta H_{\text{rxn}})/T$
- $\Delta S^\circ_{\text{sys}} = \sum m(S^\circ_{\text{products}}) - \sum n(S^\circ_{\text{reactants}})$
- $\Delta G^\circ = \sum m(G^\circ_{\text{products}}) - \sum n(G^\circ_{\text{reactants}})$
- $E^\circ_{\text{cell}} = E^\circ_{\text{red, cathode}} - E^\circ_{\text{red, anode}}$
- $E_{\text{cell}} = E^\circ_{\text{cell}} - \frac{0.0592 \text{ V}}{n} \log Q$  when  $T = 298 \text{ K}$
- Spontaneity conditions ( $\Delta S$ ,  $\Delta G$ ,  $E_{\text{cell}}$ ), equilibrium condition ( $\Delta G = 0$ )
- Types of radioactive decay ( $\alpha$ -decay,  $\beta$ -decay, positron emission, electron capture)
- Mass Number ( $A$ ) = protons + neutrons, atomic number ( $Z$ ) = protons
- $\Delta E = \Delta m c^2$
- mass defect = mass of nucleons – nuclear mass
- $1 \text{ gram} = 6.022 \times 10^{23} \text{ amu}$  OR  $1 \text{ mole} = 6.022 \times 10^{23} \text{ atoms}$
- $E = h(c/\lambda)$
- Splitting patterns for the d-orbitals for octahedral complexes
- Paramagnetism (unpaired  $e^-$ ) vs. diamagnetism (paired  $e^-$ )
- Isomerizations (constitutional vs. conformational vs. cis-trans vs. enantiomerism)
- IUPAC nomenclature for alkanes, alkenes, alkynes, cycloalkanes, haloalkanes.
- Isomerization (constitutional, conformational, cis-trans, enantiomers)
- Reactions for alkanes (combustion), alkenes/alkynes (halogenations, hydration)

### WILL BE PROVIDED

- Integrated Rate Laws (zeroth, first, and second order) and half-life equations (first, second order)
- Arrhenius Equation,  $\ln(k) = -(E_a/R)(1/T) + \ln(A)$  ( $R = 8.314 \text{ J}/(\text{mol} \cdot \text{K})$ )
- $K_p = K_c(RT)^{\Delta n}$
- $\Delta G^\circ = -RT \ln K$  ( $R = 8.314 \text{ J}/(\text{mol} \cdot \text{K})$ )
- $\Delta G = \Delta G^\circ + RT \ln Q$
- $\Delta G = \Delta H - T\Delta S$
- $\Delta G = -nFE_{\text{cell}}$  ( $F = 96485 \text{ J}/(\text{V} \cdot \text{mol})$ )

- $1 \text{ V} = 1 \text{ J/C}$  ;  $1 \text{ amp} = 1 \text{ C/sec}$  ;  $1 \text{ e}^- = 1.60 \times 10^{-19} \text{ C}$  ;  $1 \text{ kWh} = 3.60 \times 10^6 \text{ J}$
- “Magic numbers”; belt of stability
- mass of electron =  $5.4858799 \times 10^{-4} \text{ amu}$ , mass of neutron =  $1.008665 \text{ amu}$ , mass of proton =  $1.007276 \text{ amu}$
- “Magic numbers”; belt of stability
- $c = 2.9979 \times 10^8 \text{ m/s}$  ;  $h = 6.626 \times 10^{-34} \text{ J}\cdot\text{s}$
- Spectrochemical series, dentate patterns, formulas, and charges for ligands, color wheel

## Chapter 14: Chemical Kinetics

**I. Reaction Rates (14.1-2):** Know how the physical state, concentrations, or temperatures of reactants affect reaction rate. Given the overall reaction rate, be able to use stoichiometry to calculate the rate for any species in the reaction.

**II. Rate Laws (14.3-4):** Know how to write the complete rate law for a reaction, including determining the order of reaction for reactants from rates and initial concentrations. Know how to calculate the rate constant from a rate law. Be able to match the integrated rate laws, linear plots, and half-life equations to the overall order of reaction to calculate the changes in concentration and/or rate constant over time.

**III. Transition State Theory (14.5, 7):** Know how to use the Arrhenius Equation to be able to solve for the rate constant, activation energy, or collision frequency factor given the other two. Be able to identify the enthalpy, activation energy, and transition state on a reaction pathway diagram and the effect of a catalyst on the graph.

**IV. Reaction Mechanisms (14.6):** Be able to identify the rate determining step in a multistep mechanism, given an initial slow step, or fast steps followed by a slow step and propose a plausible elementary rate law. Be able to distinguish between an intermediate, a transition state, and a catalyst.

## Chapter 15: Chemical Equilibrium

**I. Equilibrium Constants (15.1-4):** Know how to write and solve the equilibrium constant expression in terms of concentration or partial pressures. Know how to use the equilibrium constant value to predict whether reactants or products are favored. Know how to manipulate the  $K_c$  value when the equilibria are changed (multiplied, reversed, etc.).

**II. ICE Tables (15.5):** Given the equilibrium concentration, equilibrium constant, and one or more initial concentrations for a system, be able to calculate the rest. Given initial concentrations and an equilibrium constant, be able to calculate the equilibrium concentrations of every species in the system.

**III. Reaction Quotient (15.6):** Given concentrations at any moment, be able to calculate the reaction quotient (Q) for a given equilibrium system and use its value compared to  $K_c$  to determine which direction the system will shift to reach equilibrium.

**IV. Le Chatelier's Principle (15.7):** Be able to apply Le Chatelier's Principle to predict shifts in a disturbed system due to changes in reactant or product concentration, volume and pressure changes, temperature changes, or the effect of adding a catalyst.

## **Chapter 16: Acid-Base Equilibria**

**I. Acids and Bases (16.1-2, 5):** Be able to identify Arrhenius/Brønsted-Lowry acids/bases and their conjugates. Know the difference between strong acids/bases and weak, and memorize the former. Know to arrange acids/bases by strength, stability of their conjugate, percent ionization, or pH/pOH.

**II. The pH Scale (16.3-4):** Be able to calculate the  $[\text{H}_3\text{O}^+]$ ,  $[\text{OH}^-]$ , pH, and pOH of a solution from just one of the four. Know how to calculate the pH/pOH for a strong acid/base solution.

**III. Dissociation Constants (16.6-9):** Be able to predict the equilibria present with weak acids/bases in aqueous solution. Know how to use the appropriate  $K_a/K_b$  expression to determine the pH/pOH or percent ionization of an aqueous solution of a weak acid or base. Know when simplifying assumptions can be made. Know how to determine the pH/pOH of a salt solution that contains one or more conjugates of a weak acid/base.

## **Chapter 17: Additional Aspects of Equilibria**

**I. The Common Ion Effect (17.1):** Know how to calculate the pH/pOH of a mixture of weak and strong electrolyte containing a common ion.

**II. Titrations (17.3):** Be able to calculate the pH during a strong acid-strong base or weak acid-strong base titration before, at, and after equivalence point given different volumes of titrant added.

**III. Solubility Equilibria (17.4-6):** Know how to use the  $K_{sp}$  for a given compound to calculate the molar solubility, whether alone, in the presence of common ions, at different pH levels, or in the presence of a Lewis base to form a complex ion. Know how to use the values of  $Q$  versus  $K_{sp}$  to determine whether a compound will precipitate or not.

## **Chapter 19: Chemical Thermodynamics**

**I. Entropy (19.2-4):** Be able to calculate entropy changes for phase changes given heat of fusion/vaporization. Be able to calculate the total entropy change for the universe from the entropy change for the system and the change for the surroundings. Be able to make qualitative predictions about the sign of the change in entropy based on number of particles, phases involved, temperature, and/or volume. Be able to calculate change in entropy for a reaction given standard molar entropy values. Know how to calculate  $\Delta S_{\text{total}}$ ,  $\Delta S_{\text{surr}}$ , and/or  $\Delta S_{\text{sys}}$  using entropies of formation (appendix), heat of reactions ( $q/T$ ), or  $\Delta G$  and  $\Delta H$  values ( $\Delta G = \Delta H - T\Delta S$  equation).

**II. Gibbs Free Energy (19.5-6):** Be able to calculate  $\Delta G$  at standard conditions with energies of formation (appendix) or at nonstandard conditions with changes in temperature (from  $\Delta H$  and  $\Delta S$ ). Be able to use  $\Delta G$  to determine whether a process is spontaneous or not.

**III. Gibbs Free Energy and Equilibrium (19.7):** Be able to calculate  $\Delta G$  at systems not at equilibrium ( $\ln Q$  equation). Be able to calculate the equilibrium constant from  $\Delta G$ , or vice versa ( $\ln K$  equation).

## Chapter 20: Electrochemistry

**I. Oxidation-Reduction (Redox) Reactions (20.1-2):** Be able to identify what elements are being oxidized and which are reduced in a redox reaction. Know how to balance redox reactions in aqueous solution in both acidic and basic conditions.

**II. Voltaic Cells (20.3):** When given two half-reactions, be able to determine the anode and the cathode and what half-reactions will be occurring at each. Be able to balance the overall net redox reaction. Be able to identify in which directions  $e^-$  will move and to which side the ions in the salt bridge will be attracted.

**III. Standard Cell Potential (20.4-5):** When given reduction potentials, know how to identify the cathode and anode to determine the overall potential for the cell ( $E^\circ_{\text{cell}}$ ) in standard conditions. Know how to calculate  $\Delta G^\circ$  from  $E^\circ_{\text{cell}}$ , or vice versa, and go on to calculate  $K_{\text{eq}}$ . Be able to use either  $E^\circ_{\text{cell}}$  or  $\Delta G$  to determine whether the process is spontaneous.

**IV. Nonstandard Conditions (20.6):** Know how to use the Nernst equation to solve for  $E_{\text{cell}}$  and/or  $Q$  and/or the concentrations of species in the system at nonstandard conditions. Know how to use the Nernst equation to solve for  $E_{\text{cell}}$  and/or  $Q$  and/or concentrations of species in a concentration cell (when  $E^\circ_{\text{cell}} = 0$ ), and relate this back to  $K_{\text{sp}}$ .

**V. Electrolysis (20.9):** Know how to use the applied amperage and time applied to solve for grams of metal produced via electrolysis, or vice versa.

## Chapter 21: Nuclear Chemistry

**I. Nuclear Equations (21.1-3):** Know how to write balanced nuclear equations and identify the type of radioactive decay ( $\alpha$ -decay,  $\beta$ -decay, positron emission, or electron capture). Be able to use the belt of stability in order to determine what type of radioactive decay the nuclei is most likely to undergo. Know how to balance nuclear reactions for nuclear transmutations (collisions with neutrons or other nuclei).

**II. Rates of Decay (21.4):** Know how to identify and use the half-life equation for radioactive decay (first order reaction) and be able to use it to convert between amount and time, or vice versa.

**III. Energy Changes (21.6):** Know how to calculate the energy change for a nuclear reaction using  $\Delta E = c^2 \Delta m$ . Be able to calculate the binding energy for a nucleus in J/mole, J/atom, and J/nucleon.

## **Chapter 24: Chemistry of Coordination Compounds**

**I. Coordination Compounds (24.1-3):** Know how to determine the oxidation state of the metal, coordination number, and overall charge of a compound. Know how to name inorganic coordination compounds.

**II. Crystal Field Theory (24.5-6):** Know how to write and fill the splitting patterns for a metal's d-orbitals in an octahedral, tetrahedral, and square planar fields for weak field (high spin) and strong field (low spin) complexes and determine whether the compound will be paramagnetic or diamagnetic. Know how to convert the wavelength/color of the complex back to the crystal-field splitting energy ( $\Delta_o$ ), or vice versa.

## **Chapter 25: Organic and Biological Chemistry**

**I. IUPAC Nomenclature (25.2-3):** Be able to systematically name any alkane, alkene, alkyne, cycloalkane, or haloalkane, or use the systematic name to draw the structure (line-angle OR Lewis structure).

**II. Isomerization (25.3):** Be able to identify constitutional vs. conformational isomers vs. enantiomers.

**II. Hydrocarbon Reactions (25.3):** Be able to predict the products from the combustion, (all hydrocarbons) hydrogenation, halogenations, hydrohalogenation, or hydration (for alkenes) reactions.

**III. Functional Groups (25.4):** Be able to identify alcohols, ethers, amines, aldehydes, ketones, carboxylic acids, esters, and amides in structures.