Review for Final Exam

The final exam in Chem, 173 is a year-long comprehensive standardized General Chemistry Exam prepared by the American Chemical Society. This exam consists of 70 multiple choice questions that fall into the 10 categories outlined below. I have tried to list related sub-topics for each category to help you organize your studying, and have also indicated the chapters in your text that are relevant. Also included in this handout is a list of some of the equations that you have seen and used during the year.

You will be given a periodic table and a list of some constants for your use on the exam, but no equations will be provided. A non-programmable calculator is required. The exam time limit is 110 minutes - or 1 hour 50 minutes.

My suggestion for preparing for the exam is to review the categories below in addition to the summaries at the end of each chapter to determine the areas on which you need to concentrate. All of the handouts (exam reviews as well as others) that I have used in Chem 171-2-3 are available on my web page - feel free to use those if you find them helpful. Keep in mind that this exam is 70 questions that cover a whole year of Chemistry! This means that for the most part the questions will relate to the big concepts - not obscure details and calculations with infrequently used equations.

A few things that don’t fit into any ONE of the following categories, but that you need to know:
- NOMENCLATURE!!!! and recognizing ionic vs. molecular compounds vs. acids
- use of dimensional analysis, conversion factors and significant figures in calculations
- characteristics of different reaction types - predicting products, writing balanced chemical and ionic equations
  - combustion
  - formation
  - precipitation
  - neutralization
  - redox
  - nuclear

I. Atomic Structure
- fundamental structure of matter
- composition of atoms
  - protons, neutrons and electrons - how many and where are they?
  - significance of atomic number and mass number
  - isotopes
  - cation and anion formation
- electronic structure and quantum mechanics
  - electromagnetic radiation - energy, wavelength, frequency
  - orbitals
  - electron configurations and quantum numbers
  - energy considerations of electron transitions; spectroscopy and spectrophotometry
- nuclear chemistry and nuclear transformations

II. Molecular Structure and Bonding
- spatial arrangement of atoms in a molecule
- Lewis dot structures
- valence bond theory
- VSEPR theory
  - molecular shapes, bond angles, orbital hybridization
- MO theory
- bond types: covalent, ionic, metallic
- intermolecular forces

See chapters 2, 3, and 7

See chapters 2, 8, 9 and 10
III. **Stoichiometry**
- how things combine - atoms and ions to make compounds, or reactants to make products
- mole concept, using mole ratios as mole to mole conversion factors
- molar mass, using molar mass as mass to mole conversion factor
- compound stoichiometry
  - empirical and molecular formula determination
  - mass percent composition
- reaction stoichiometry
  - writing and balancing chemical equations
  - reaction yields
  - identifying limiting reactants

IV. **States of Matter and Solutions**
- 3 common states of matter: solid, liquid, and gas
- qualitative characteristics of solids vs. liquids vs. gases
  - structure, density, diffusion, compressibility
- solids
  - crystal structures, bonding types, solubility rules, conductivity
- liquids
  - miscibility, vapor pressure
- gases
  - gas laws, kinetic molecular theory of gas behavior, effusion and diffusion
- solutions
  - expressions of concentration; molarity, molality, mass %, mole fraction
  - dilution and preparation of solutions
  - properties related to solute type
  - colligative properties
- phase diagrams

V. **Energetics**
- thermodynamics, energy considerations in chemical and physical change
- system, surroundings and universe - direction of energy flow
- standard states
  - \( \Delta E, q \) and \( w \); 1st Law of Thermodynamics
  - enthalpy, \( \Delta H^\circ \) and calorimetry
  - entropy, \( \Delta S^\circ \) and the 2nd Law of Thermodynamics
  - Gibbs free energy, \( \Delta G^\circ \)
  - relationship to spontaneous processes and equilibrium

VI. **Dynamics (i.e. kinetics)**
- rates of reactions and how rates change with concentration and temperature
- rate laws - show how rates change with concentration
  - rate constant, \( k \) and appropriate units
  - order of reaction with respect to reactant and overall
  - determination of rate law from experimental data
- integrated rate laws - show how concentrations change with time
  - characteristics of 0, 1st and 2nd order reactions
  - half-lives
- Arrhenius equation - shows how rate (\( k \)) changes with temperature
  - significance of activation energy (\( E_a \)), addition of a catalyst
- reaction mechanisms
  - writing overall reaction given elementary steps
  - identifying reaction intermediates and catalysts
  - significance of the rate determining step
- reaction profiles (for single or multi-step processes); \( E_a, \Delta E \), slow vs. fast steps
- nuclear decay kinetics

See chapters 3, 4 and 5
See chapters 4, 5, 10 and 11
See chapters 6 and 16
See chapters 12 and 18
VII. **Equilibrium**

- characteristics of dynamic chemical equilibrium with respect to concentrations of species and rates of forward and reverse reactions
- equilibrium constant, \( K \) and the law of mass action
- reaction quotient, \( Q \) and prediction of the direction of reaction
- using equilibrium table for calculations - determination of \( K \) or equil. composition of a mixture
- Le Chatelier's Principle and prediction of the response to a stress on the system
- acid-base equilibria
  - calculation of pH of weak acid, weak base and salt solutions
  - buffer solutions and change in pH upon addition of strong acid or strong base
  - titration calculations and titration curves, indicators
- solubility equilibria
  - calculation of solubility or \( K_{sp} \), factors affecting solubility

VIII. **Electrochemistry and Redox**

- electron transfer chemistry
- oxidation and reduction
  - definitions
  - assigning oxidation numbers
  - writing oxidation and reduction half reactions
  - balancing net redox equations
  - identifying elements oxidized and reduced, and oxidizing and reducing agents
- Galvanic cells - spontaneous chemical reaction producing electrical current
  - setup, description, line notation
  - anode vs. cathode; anode and cathode half reactions
  - net cell reaction
- cell potential, \( E^\circ \)
  - standard reduction potentials and \( E^\circ_{\text{cell}} \)
  - relationship of \( E^\circ \) to \( \Delta G^\circ \) and \( K \); Nernst equation
- electrolytic cells - electrical current used to drive non-spontaneous chemical reaction

IX. **Descriptive Chemistry and Periodicity**

- periodic table
  - arrangement of elements within the table, names and symbols of elements
  - identification of groups and periods by various numbering schemes or special names
  - metals (main group, transition), nonmetals, metalloids, noble gases, lantanides, actinides
  - element position and its relationship to electron configuration and occupied orbitals
- periodic trends
  - atomic size
  - ionization energy
  - electronegativity
  - effective nuclear charge
  - ion formation - cation or anion? charge?
  - chemical reactivity - relative reactivity as well as types of reactions

X. **Laboratory or Experimental**

- instruments and glassware used
- experimental techniques
- measurements
  - how are they made?
  - significant figures recorded?
- data analysis
Chem 171-172-173 Equation Sheet

This is not an exhaustive list, but it should help you get started. This should be roughly in the order that these equations appear in the book.

$$M_iV_i = M_fV_f$$

**Gases:** (M = molar mass)

$$P_1V_1 = P_2V_2$$
$$V_1/T_1 = V_2/T_2$$
$$PV = nRT$$
$$PV = nRT$$
$$P = dRT$$
$$u = (3RT/M)^{1/2}$$

rate eff/rate eff = $$(M_A/M_B)^{1/2}$$

**Atomic/Electronic Structure:**

$$\sum_i = c$$
$$E = h\sum_i$$
$$\sum_i = R(1/n_i^2 - 1/n^2)$$
$$\sum_i = h/m\sum_i$$

**Expressions of Concentration:**

Molarity, M = mol solute/L soln
Mass % A = (mass A/total mass)100
mol fraction, $$\alpha_A = \text{mol A}/\text{total mol}$$
molality, m = mol solute/kg solvent

**Properties of Solutions:**

Henry’s Law: $$P = kC$$
Raoult’s Law: $$P_{solv} = \sum_i^n P^o_{solv}$$
boiling point elevation: $$T_b = k_p m_{solute}$$
freezing point depression: $$T_f = k_v m_{solute}$$
osmotic pressure: $$\sum_i = MRT$$

**Thermochemistry:**

$$E = q + w$$
$$\sum_i = \sum_i - PV$$
$$H^o = \sum_i H^o_{prod} - \sum_i H^o_{react}$$
$$S^o = \sum_i S^o_{prod} - \sum_i S^o_{react}$$
$$S = q/T; \sum_i S^o_{solv} = -\sum_i H/T$$
$$G^o = \sum_i G^o_{prod} - \sum_i G^o_{react}$$
$$G^o = \left[H^o - T\sum_i S^o\right]$$
$$G = [G^o + RTlnQ]$$
$$G^o = -RTlnK$$

**Electrochemistry:**

$$w_{max} = G^o = -nFE^o$$

at 25°C: $$E = E^o - (0.0592/n)\log Q$$
at 25°C: $$E^o = (0.0592/n)\log K$$

**Kinetics:**

Rate of reaction = $$/i[X]/!t$$

1st order rxn: $$\ln([A]_o/[A]) = kt$$
$$t_{1/2} = 0.693/k$$

2nd order rxn: $$1/[A] = (1/[A]_o) + kt$$
$$t_{1/2} = 1/(k[A]_o)$$

Arrhenius eqn: $$k = e^{-Ea/RT}$$

$$\ln \left(\frac{k_2}{k_1}\right) = \left(E_a/R\right)\left(1/T_2 - 1/T_1\right)$$

**Equilibrium:**

$$K_p = K_c(RT)^{\delta n}$$

**Acid/Base Chemistry:**

$$pK_a = p\text{H} + p\text{OH}$$
$$pK_c = pK_a + pK_b$$
$$p\text{H} = pK_a + \log ([\text{base}]/[\text{acid}])$$