General Chemistry Study Guide
Fall 2001

Exam I

Chapter 1: What is Chemistry?

Matter & Its Transformation
- Definition of matter
- Pure substances
    - elemental substances & compounds
- Mixtures
    - Homogeneous & heterogeneous mixtures

Physical transformations of matter
- physical properties

Chemical transformations of matter

Chemical reactions
- nomenclature

History of Chemistry - won't be covered on final

Chapter 3- Elements & Atomic Structure

Dalton's atomic theory
- Law of conservation of matter
- Law of definite proportions
- Law of multiple proportions

Structure of the atom
- subatomic particles (proton, electron, neutron)
- Thomson's "Plum Pudding" model
- Rutherford's "atomic bullets"
    - the nucleus

Nomenclature of atoms
- atomic number (Z)
- Mass number
    - isotopes
- Atomic weight

Exam II

Chapter 4 - Modern Model of the Atom

Periodicity (Relationship to atomic size & ionization energy)

Periodic Table

- Group Identifications (alkalai metals, halogens, noble gases, etc.)

Atomic models

- nature of light and the electromagnetic spectrum

Classical vs. Quantum Physics

Bohr Theory of atomic structure

- electron orbits
- principal quantum no.
- maximum electron capacity/shell ($2n^2$)
- energy level diagrams
- Group no. and valence shell electrons
- electron transitions b/w energy levels
- line spectra
- Failures of the Bohr model

Subshells & Electron Configuration

- Types of subshells (*s, p, d, f*)
- Subshell spacing (relative energy levels)
- Electron configuration
    - Full & Noble gas abbreviations

Modern Quantum Mechanical Model of the Atom

- Electron *orbitals* vs orbits
- Heisenberg uncertaintly principle and electron location

Ch 5: Covalent & Ionic Bonds

Molecules, Compounds & elements

Covalent Bonds

- Definition
- Role of Valence Electrons
- Octet Rule

Lewis Dot Structures

- Group No. & valence electrons

- Predicting no. bonds through group no.
- Predicting molecular formulas through group no.
- Lewis dot diagrams for elements
- Lewis dot diagrams for compounds
- Multiple bonds (double & triple bonds)
    - Resonance forms

Ionic Bonding

- definition
- Electronegativity
    - definition
    - periodic trend in values
    - polar covalent bonds
    - predicting the bond *type* (covalent, ionic or polar covalent) from

Nomenclature

- binary ionic compounds
- polyatomic ionic compounds
- covalent compounds

CH 6 Stucture of Molecules

Valence Shell Electron Pair Repulsion Theory (VSEPR)

- Electron group repulsion
- Molecular Geometry
    - bond angles & electron groups
    - Bonding pairs vs. lone pairs - effect on 3D structure
    - Common Arrangements:
        - 2 electron groups: linear
        - 3 electron groups: trigonal planar
        - 4 electron groups: tetrahedral, pyramidal, bent

Valence Bond Theory

- describes electronic nature of covalent bonds
- bond strength ~ orbital overlap
- creation of hybrid orbitals b/w *s* and *p* orbitals to form bonding orbitals

    -sp^3, sp^2, *sp*

Molecular Orbital Theory

- Another theory for why/how covalent bonds form
- Concerned with *molecular* vs. *atomic* orbitals
- Says only *2 ways* for electrons in atomic orbitals to interact:
    1. Bonding orbitals
    2. Antibonding orbitals
- When equivalent no. of valence electrons in each orbital, antibondign orbital cancels bonding orbital and no bond forms
- When no. of valence electrons in bonding orbital > no. electrons in antibonding orbital, a covalent bond *can* form

Polarity of molecules

- No. valence electrons
- Lewis dot structure
- shape (VSEPR)
- bond type
    - En differences
    - partial (+) and (-) charges
    - dipole moments
        - associated *magnitude* and *direction*
        - *additive* and *negative* effects
- Polar interactions b/w molecules
    - phase consequences (solid, liquid, gaseous)
    - strength relative to ionic or covalent bonds

Chapter & - Chemical Reactions

Balancing chemical equations

- equivalence of no. of atoms

Stoichiometry

The mole

- definition (Avagadro's number)
- definition (^{12}C)
- Molar mass
- Calculation of molar mass from formula

Reaction stoichiometry

- reactant & product quantities
- theoretical vs. actual yields

Conversion factors & stoichiometry
- moles to grams & grams to moles
- moles to moles

Combustion analysis
- formulas & percent composition
- mass percent
- empirical formulas

Limiting reactants

Chapter 8 - Redox Reactions

Electricity
- definition/voltage/current

Electron bookeeping
- Oxidation state method
    (i) Oxidation states
        a. electron ownership
            1. lone pairs
            2. bonding pairs
            3. Lewis dot diagrams
        b. Oxidation state determination
            1. valence vs. oxidation state method
    (ii) (+) or (-) oxidation states
- Oxidation state vs. octet rule
    - double counting vs. “ownership”
    - shortcut rules

Recognizing electron transfer reactions
- reduction
- oxidation
- oxidizing & reducing agents

Electricity from redox reactions
- oxidant vs. reductant
- creating electricity

- batteries
    a. electrodes (anode vs. cathode)
    b. salt bridges/ spectator ions
    c. process of e^- movement

EMF series
- metal activity
- roles as anodes vs. cathodes

Oxidation, burning & corrosion
- old concepts (combining with oxygen)
- new concept (transfer of e^- ownership)

Chapter 11 - Chemical Kinetics

Collisions, breakage & reformation of bonds

Studying reaction mechanisms
- limitations
- indirect study (rates of product formation)

Energy changes & chemical reactions
- bond energy
- exothermic reactions
- endothermic reactions
- reaction energy profile
- reversible reactions
- energy input/output for bond breakage & reformation

Reaction Rates & Activation Energy
- activation energy
- transition state
- effect of temperature on reaction rates
- molecular orientation & reaction rates
- catalysts

Effect of concentration on reaction rates
- rate constants

Rate Laws
- definition

- reaction orders
    - kinetics experiments

Reaction orders & Reaction mechanisms
- mechanisms
- elementary steps
    - balanced equations
    - other evidence

Chapter 12 - Chemical Equilibrium

Dynamic equilibrium

Equilibrium positions
- towards products (right) or reactants (left)

Why reactions reach equilibrium
- rates of forward & reverse reactions
    - reactant depletion & product build-up

The equilibrium constant K_{eq}
- information K_{eq} provides on equilibrium position
- calculation of K_{eq}

Le Chatelier's principle
- temperature changes

Exam IV

Chapter 9 - Intermolecular Forces & Phases of Matter

Different phases of matter
- solids, liquids & gases
- kinetic energy of molecules
- forces of attraction b/w molecules
- phase changes

Models of gases, liquids & solids
- kinetic energy relationships

Intermolecular forces of attraction
- London forces (van der Waals)
- Dipolar forces

- Hydrogen bonding

Nonmolecular Substances

The gas phase model

- Ideal gases
  - pressure
  - volume
  - temperature
  - amount of gas

Mathematical description of a gas

- ideal gas equation: $P=\frac{nRT}{V}$

Chapter 10 - Solutions

Solutions, solvents & solutes

- liquid, gaseous & solid solutions

Energy & the formation of solutions

- Breaking solute-solute interactions
- Breaking solvent-solvent interactions
- forming solute-solvent bonds

Nonpolar solutions

- role of entropy

Entropy

- defintion

Solubility, temperature & pressure

- effect of temperature on dissolved solid solutes
- effect of temperature on dissolved gases
- effect of pressure on dissolved gases (Henry’s law)

Saturated solutions

Soaps & detergents

- getting nonpolar compounds to dissolve in polar solvents
- hydrophillic and hydophobic structures

Concentration - Molarity

- moles/liter of solution
- molarity as a conversion factor

Concentration - Percent composition of solutions

- percent by mass (wt%)
- percent by volume (vol %)
- percent mass/volume (wt/vol%)

Chapter 13 - Electrolytes, Acids & Bases

Physical properties of acids & bases

Electrolytes

- conduction of electric current
- formation of ions
- weak & strong electrolytes

Acids

- Arrhenius definition
- relationship to electrolytes
- strong & weak acids - definitions
- polyprotic acids

Bases

- Arrhenius definition
- strong & weak bases
- Bronsted Lowry defintion of bases & acids

Water, autodissociation & K_W

- *How* acidic or basic is a solution
- general definitions of acidic or basic solutions
- Ion product constant (K_W) of water
    - autodissoction into H_3O^+ and OH^-
    - mathematical definition of K_W
- Acidic solutions & $[H_3O^+]$(concentration)
- basic solutions & $[OH^-]$
- Determination of $[H_3O^+]$ from K_W and $[OH^-]$
- determination of $[OH^-]$ from K_W and $[H_3O^+]$

The pH scale

- pH mathematical definition

- logarithms
- the pH scale
    - acidic and basic solution ranges
    - pH scale units and $[H_3O^+]$

Buffers

- definition
- conjugate acid base pairs
    - interconversion
- Buffers & the prevention of pH changes
    - conversion of strong acids to weak acids
    - conversion of strong bases to weak bases