CH131 Fall 2020 topics and assigned problems
Oxtoby et al., Principles of Modern Chemistry, 8e.

Chapter 1, Appendices A, B.1, and C.3: The atom in modern chemistry
- Periodic table is the master key to chemical properties
- Isotopes, atomic weight
- Chemist's dozen: The mole
- Chapter 1 problems: 5, 7, 11, 13, 17, 19, 21, 23, 25, 27, 31, 33, 35
- Appendix A problems: 1, 7, 11, 13, 17, 19
- Appendix B.1 problems: 1, 7, 9
- Appendix C.3 problems: 13, 17, 19

Chapter 2: Chemical formulas, equations, and reaction yields
- Significant figures: $a \times b, a + b, 10^a, \log(b)$
- Example problems
- Limiting reagent recipe
- Chapter 2 problems: 1, 5, 7, 11, 13, 19, 21, 23, 25, 27, 29, 31, 35, 37, 49;

Chapter 3: Atomic shells and classical models of chemical bonding
- Ionization energy: $X(g) \rightarrow X^+(g) + e-$, electron cloud shell structure
- Electron affinity: $X^-(g) \rightarrow X(g) + e-$
- Electronegativity: $EN \sim IE_1 + EA$
- Dipole moment and ionic character: $\sim \Delta EN$
- Lewis diagrams; formal charge
- Shapes and polarity of molecules
- Chapter 3 problems: 9, 15, 21, 23, 33, 39, 41, 43, 45, 47, 51, 53, 55, 57, 59, 61, 65, 69

Chapter 9: The gaseous state
- Gas properties: Temperature, volume, amount, and pressure
- Ideal gas law: $\boldsymbol{PV = nRT}$
- Gas constant $\boldsymbol{R}$, **STP**, and **SATP**
- Gas law calculations recipe
- Dalton's law of partial pressures
- **LR (Limiting Reagent) tables** in calculations of gaseous chemical reactions
- Kinetic theory of gases
- Why the ideal gas law does not depend of particle mass
- **Maxwell-Boltzmann** distribution of molecular speeds
- Real gases: **van der Waals equation**, van der Waals $\boldsymbol{a}$ and $\boldsymbol{b}$
- Chapter 9 problems: 5, 9, 11, 19, 21, 25, 27, 31, 33, 35, 37, 41, 43, 47, 53, 55

Chapter 10: Solids, liquids, and phase transitions
- IMFs: H-bond, dipole-dipole, London.
- Determinants of relative boiling points: H-bond > London (size, lone pairs) > dipole-dipole
- Vapor pressure: Liquid-vapor equilibrium; vapor-pressure and boiling (include altitude for which boiling point is body temperature)
- Phase diagrams: phase equilibrium; triple point; supercritical region
- Chapter 10 problems: 15, 17, 21, 23, 25, 27, 31, 35, 37, 39, 43, 45, 47

Chapter 11: Colligative properties:

Vapor pressure lowering
Boiling point elevation
Freezing point depression
Osmotic pressure
Chapter 11 problems: 1, 3, 5, 11, 41, 43, 45, 47, 51, 53, 55, 57, 59, 61

Chapter 12: Thermodynamic processes and thermochemistry

System and surroundings
First law: $\Delta \boldsymbol{U} = \boldsymbol{q} + \boldsymbol{w}$, all system quantities
$q_{\text{sys}} = -q_{\text{sur}} = mc\Delta T_{\text{sur}}$
$w_{\text{sys}} = w_{\text{PV}} = -P_{\text{sur}}\Delta V_{\text{sys}}$
$\Delta U = q_{\text{V}}$
If $w \neq 0$, then $\Delta \boldsymbol{H} \equiv \boldsymbol{q}_{\mathbf{P}} \neq q_{\text{V}}$
Typically, $\Delta U - \Delta H = w_{\text{PV}}$ is small
$\Delta H \equiv q_{\text{P}}$ appropriate for constant pressure processes
$\Delta \boldsymbol{H}_{\mathbf{rxn}}$ is q_{P} for 1 unit of reaction; q_{P} depends on how many units of reaction occur
Hess's law
$\Delta \boldsymbol{H}^{\circ}_{\mathbf{rxn}}$ is q_{P} for 1 unit of reaction when each reactant and product is in its **standard state**
$\Delta \boldsymbol{H}^{\circ}_{\mathbf{f}}$ is q_{P} for 1 mole of substances formed from its elements, each in their standard state.
$\Delta \boldsymbol{H}^{\circ}_{\mathbf{rxn}} = \mathbf{products}\ \Delta \boldsymbol{H}^{\circ}_{\mathbf{f}} - \mathbf{reactants}\ \Delta \boldsymbol{H}^{\circ}_{\mathbf{f}}$
Bond enthalpies, $\Delta \boldsymbol{H}_{\mathbf{bond}}$
$\Delta \boldsymbol{H}^{\circ}_{\mathbf{rxn}} \approx \mathbf{reactants}\ \Delta \boldsymbol{H}_{\mathbf{bond}} - \mathbf{products}\ \Delta \boldsymbol{H}_{\mathbf{bond}}$
Chapter 12 problems: 1, 7, 9, 11, 17, 19, 21, 27, 31, 33, 35, 39, 43, 45, 47, 55, 57

Chapter 13: Spontaneous processes

Spontaneous: $W_f > W_i$
Second Law: Entropy: $S = k_B \ln(W)$, $\Delta S = k_B \ln\left(\frac{W_f}{W_i}\right)$
$\Delta S = \frac{\Delta H}{T}$
Spontaneity of phase transitions: $\Delta S_{\text{tot}} = \Delta S_{\text{sur}} + \Delta S_{\text{sys}} = -\frac{\Delta H_{\text{tran}}}{T} + \frac{\Delta H_{\text{tran}}}{T_{\text{tran}}}$
Third Law: Absolute entropies, S°
$\Delta \boldsymbol{S}^{\circ}_{\mathbf{rxn}} = \mathbf{products}\ \boldsymbol{S}^{\circ} - \mathbf{reactants}\ \boldsymbol{S}^{\circ}$
Spontaneity of chemical reactions: $\Delta S_{\text{tot}} = \Delta S_{\text{sur}} + \Delta S_{\text{sys}} = -\frac{\Delta H^{\circ}_{\text{rxn}}}{T} + \Delta S^{\circ}_{\text{rxn}}$
Gibbs free emery change: $\Delta \boldsymbol{G}^{\circ}_{\mathbf{rxn}} \equiv -\boldsymbol{T}\Delta \boldsymbol{S}_{\mathbf{tot}} = \Delta \boldsymbol{H}^{\circ}_{\mathbf{rxn}} - \boldsymbol{T}\Delta \boldsymbol{S}^{\circ}_{\mathbf{rxn}}$
Chapter 13 problems: 3, 9, 11, 13, 15, 17, 21, 25, 29, 31, 33, 35, 57

Chapter 14: Chemical equilibrium

Approach to equilibrium
Law of mass action; empirical equilibrium constant; thermodynamic equilibrium constant
$\Delta \boldsymbol{G} = \boldsymbol{RT}\ \mathbf{ln}\left(\frac{\boldsymbol{Q}}{\boldsymbol{K}}\right) = \Delta \boldsymbol{G}^{\circ} + \boldsymbol{RT}\ \mathbf{ln}\ (\boldsymbol{Q})$ and $\Delta \boldsymbol{G}^{\circ} = -\boldsymbol{RT}\ \mathbf{ln}\ (\boldsymbol{K})$
Q/K predicts direction of change
Using **ICE (Initial, Change, Equilibrium) tables** to calculate equilibrium values
Exact calculations when K is close to 1.
Approximate calculation when $\boldsymbol{K \ll 1}$: Initially arrange to be all reactants
Approximate calculation when $\boldsymbol{K \gg 1}$: Initially arrange to be all products
Temperature dependence of K to get $\Delta H^{\circ}_{\text{rxn}}$ and $\Delta S^{\circ}_{\text{rxn}}$
Van't Hoff equation: Predict temperature dependence of K
Response to disturbing equilibrium: Volume, pressure, amounts
Le Châtelier's principle
Chapter 14 problems: 1, 5, 9, 11, 13, 15, 17, 19, 21, 25, 27, 31, 33, 39, 41, 45, 49, 51, 53, 61, 63, 65, 67

Chapter 15: Acid-base equilibria

- Water autoionization, pH, temperature dependence
- Acids and bases
- Strong acids; strong bases
- Weak acids; weak bases
- Weak acid titration; weak base titration
- Chapter 15 problems: 1, 13, 15, 17, 21, 23, 27, 29, 31, 33, 35, 37, 39, 41, 51, 53

Chapter 16: Solubility equilibria

- Five kinds of problems
- Practice
- Chapter 16 problems: 3, 5, 7, 9, 13, 15, 17, 19, 21, 23, 25, 27, 31, 33

Chapter 17: Electron transfer reactions and electrochemistry

- Oxidation number; oxidation and reduction
- Balancing redox equations
- Electrochemical cells
- Cell voltage and standard reduction potentials
- **Nernst equation**: Cell voltage, electrical work, and free energy change
- Concentration cells
- Chapter 17 problems: 1, 3, 5, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29, 31, 33, 35, 37, 39, 41, 51, 53, 57