01 Basics of Chemistry

01-01 **States of Matter: Descriptive, Properties** [] physical states: solid, liquid, gas
01-02 **Element Names, Symbols**
01-03 **Chemical and Physical Properties and Changes** [] def sublimation
01-04 **Extensive, Intensive Properties**
01-05 **Mixtures, Cmpds, Elements, Atoms, & Molecules** [] classification of matter, homogeneous/heterogeneous, basic allotrope concept
01-06 **Units and SI System: Definitions** [] basic, derived
01-07 **Metric Prefixes: Definitions** [] increasing/decreasing order
01-08 **Scientific Notation and Decimal Notation**
01-09 **Measurements and Significant Figures** [] accuracy, precision, % error
01-10 **Error Analysis** [] confidence interval
01-11 **Area, Volume**
01-12 **Unit Conversions** [] English to metric, metric to English
01-13 **Density and Specific Gravity**
01-14 **Temperature Conversions** [] (see 19:11 *specific heat*)
01-15 **Energy, Heat and Electrical Power**
01-16 **Basic Chemical Laws**
01-17 **Scientific Method**
01-18 **Math Review Problems**
01-19 **Lab Safety**
01-50 **Multi-concept and Complex Questions** [] mass ↔ weight
01-99 Associated problems in Chapter 01

02 Atoms and Molecules

02-01 **Origins of Atomic Theory** [] early history/observations
02-02 **Dalton's Atomic Theory**
02-03 **Early Experiments** [] canal rays, gold foil: Rutherford, oil drop: Milikan, Thomson
02-04 **Nuclear Model** [] atomic structure, fundamental particles, protons, neutrons, electrons, mass number, charge, simple valence
02-05 **Fundamentals of Isotopes** [] $Z = p + n$, carbon-13, etc.
02-06 **Isotopic Abundance**
02-07 **Periodic Table: Introduction** [] groups, periods, families, properties due to position, Mendeleev
02-08 **Molecules and Formulae** [] allotropes: not crystalline solids, diatomic molec
02-09 **Ions and Formula Units** [] predict ionic formulae
02-10 **Nomenclature: Ionic (Polyatomic Ions)**
02-11 **Nomenclature: Molecules** [] inorganic, covalent
02-12 **Nomenclature: Acids and Other Compounds**
02-13 **Common Names for Substances**
02-50 **Multi-concept and Complex Questions**
02-99 Associated problems in Chapter 02

03 Composition Stoichiometry

03-01 **Atomic Mass** [] unit amu
03-02 **The Mole: Basics, Descriptive** [] Avogadro's number
03-03 **Molar Mass** [] formula mass
03-04 **Percent Composition** [] % by mass
03-05 **Laws of Definite and Multiple Proportions** [] no reactant left over, definite com-

position/proportions, multiple proportions
03-06 **Conversions with Mass, Moles, Entities**
03-07 **Determining Formulae: Empirical, Molecular**
03-50 **Multi-concept and Complex Questions**
03-99 Associated problems in Chapter 03

04 Reaction Stoichiometry
04-01 **Basics, Descriptive**
04-02 **Balancing: Equation Given**
04-03 **Balancing: Names Given**
04-04 **Stoichiometry: mol-mol** [] mol $\rightarrow$ mol
04-05 **Stoichiometry: Mass** [] g $\rightarrow$ mol, g $\rightarrow$ g, mol$\rightarrow$ g
04-06 **Stoichiometry: Avogadro's Number**
04-07 **Stoichiometry: Percent**
04-08 **Combustion Analysis**
04-09 **Limiting Reactant**
04-10 **Purity**
04-11 **Percent Yield**
04-12 **Sequential Reactions**
04-50 **Multi-concept and Complex Questions**
04-99 Associated problems in Chapter 04

05 Solution Basics
05-01 **Solution Basics** [] solute, solvent, heterogeneous, homogeneous, types of solutions
05-02 **Expressing Concentration: Mass %, Vol %**
05-03 **Expressing Concentration: Molarity** [] $M = \frac{\text{mol solute}}{\text{L soln}} = \frac{\text{g/MW}}{\text{L}}$, molar mass $= \frac{\text{g}}{\text{mol}}$
05-04 **Molarity Conversions** [] vol $\rightarrow$ mol, no stoichiometry
05-05 **Density and Molarity**
05-06 **Expressing Concentration: ppm, ppb** [] ppm $= \frac{1\text{ g solute}}{10^6\text{ g H}_2\text{O}} = \frac{1\text{ mg solute}}{1\text{ L H}_2\text{O}} = \frac{\text{mass solute}}{\text{mass soln}} \times 10^6$, ppb $= \frac{1\text{ g solute}}{10^9\text{ g H}_2\text{O}} = \frac{1\ \mu\text{g solute}}{1\text{ L H}_2\text{O}} = \frac{\text{mass solute}}{\text{mass soln}} \times 10^9$
05-07 **Expressing Concentration: Molality** [] $m = \frac{\text{mol solute}}{\text{kg solvent}} = \frac{\text{g/MM solute}}{\text{kg solvent}}$
05-08 **Expressing Concentration: Mole Fraction** [] $X_\text{A} = \frac{\text{mol A}}{\text{total mol}}$
05-09 **Concentration Conversions**
05-10 **Dilutions** [] $M_1 V_1 = M_2 V_2$
05-50 **Multi-concept and Complex Questions**
05-99 Associated problems in Chapter 05

06 Solution Stoichiometry
06-01 **Laboratory Preparation of Solutions**
06-02 **Stoichiometry and Calculations** [] actual/theoretical yields, molarity with stoichiometry, simple titration calculations
06-03 **Percent Solution Calculations** [] given % by mass/vol
06-04 **Primary Standards and Titrations**
06-50 **Multi-concept and Complex Questions**
06-99 Associated problems in Chapter 06

07 Chemical Reactions

07-01 **Solubility Rules**
07-02 **Electrolytes** [] conductive solution
07-03 **Oxidation Numbers** [] charge per atom
07-04 **Reactions in Water: Introduction**
07-05 **Hydrolysis**
07-06 **Reaction Type: Precipitation**
07-07 **Reaction Type: Acid/Base** [] neutralization
07-08 **Reaction Type: Redox** [] oxidation numbers change, oxidation/reduction
07-09 **Predict Reaction Type**
07-10 **Alternate Reaction Type: Combination**
07-11 **Alternate Reaction Type: Decomposition**
07-12 **Alternate Reaction Type: Single Displacement** [] activity series
07-13 **Alternate Reaction Type: Double Displacement** [] activity series
07-50 **Multi-concept and Complex Questions**
07-99 Associated problems in Chapter 07

08 Quantum Concepts

08-01 **Waves, Electromagnetic Radiation** [] $c = \lambda\,\nu$, EM scale
08-02 **Photons, Planck, and Photoelectric** [] $E = m\,c^2$, $E = h\,\nu = \frac{h\,c}{\lambda}$, Wien's law, work function
08-03 **Uncertainty Principle, Duality** [] wave nature/characteristics of matter, de Broglie: $\lambda = \frac{h}{p} = \frac{h}{m\,v}$, $\Delta x\,\Delta v = \frac{\hbar}{2\,m}$
08-04 **Bohr's Model, H-atom** [] $\Delta E = h\,\nu$, line spectrum, Balmer series
08-05 **Rydberg and Changing Energy Levels** [] Rydberg: $\nu = \mathcal{R}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$
08-06 **Schrodinger and Wave Functions** [] particle in a box, quantum mechanical model
08-07 **Quantum Numbers** n, l, m_ℓ
08-08 **Atomic Orbitals** [] orbital shapes, nodal planes/cones, # electrons, s, p, d, f
08-09 **Electron Spin**
08-10 **Quantum Numbers and Spin Revisited** [] Pauli Exclusion Principle
08-11 **Periodic Table: Orbital View**
08-12 **Electron Configurations** [] Aufbau, Building-Up, Hund's rule, molecular config: [Ar] $2s^2$
08-13 **Electronic Configuration of Ions** [] isoelectronic
08-14 **Paramagnetic, Diamagnetic**
08-50 **Multi-concept and Complex Questions**
08-99 Associated problems in Chapter 08

09 Periodicity

09-01 **Atomic Radius** [] effective nuclear charge
09-02 **Ionic Radius**
09-03 **Ionization Energy**
09-04 **Electron Affinity** [] energy to remove electron
09-05 **Electronegativity** [] attract electrons toward itself
09-06 **Metallic Trends**
09-07 **Periodicity: Other Trends** [] lattice energy/periodicity, oxide periodicity, polarizability of atoms/ions
09-08 **Periodicity Revisited**
09-50 **Multi-concept and Complex Questions**

09-99 Associated problems in Chapter 09

10 Types of Bonding

10-01 **Determine Bond Types, Basics**
10-02 **Ionic Bonding: Model, Properties** [] electron dot representation, electron transfer, greatest electronegative difference
10-03 **Covalent Bonding: Model, Properties** [] share electrons
10-04 **Metallic Bonding: Model, Properties** [] ductility, malleability
10-05 **Lattice Energy, Calculations** [] Coulomb PE calculations, Madelung constant, lattice enthalpy
10-06 **Born-Haber Cycle**
10-07 **Bond Polarity** [] dipole moment, polar covalent character, polar bonds
10-08 **Polarizability of Ionic Bonds**
10-09 **Bond Length, Strength, and Stability** [] single/double/triple bonds
10-50 **Multi-concept and Complex Questions**
10-99 Associated problems in Chapter 10

11 Lewis Structures

11-01 **Lewis Symbols of Atoms** [] valence
11-02 **Lewis Symbols of Ions, Ionic Compounds**
11-03 $S = N - A$
11-04 **Octet Rule Strictly Obeyed**
11-05 **Incomplete Octet**
11-06 **Expanded Octet**
11-07 **Resonance**
11-08 **Formal Charge**
11-09 **Radicals and Reactivity** [] free radicals
11-50 **Multi-concept and Complex Questions**
11-99 Associated problems in Chapter 11

12 3D Structures: VESPR

12-01 **VSEPR Model: Terms, Basics**
12-02 **VSEPR: Two Electron Groups (2 RHED)**
12-03 **VSEPR: Three Electron Groups**
12-04 **VSEPR: Four Electron Groups**
12-05 **VSEPR: Five Electron Groups**
12-06 **VSEPR: Six Electron Groups**
12-07 **VSEPR: More than One Central Atom**
12-08 **Molecular Polarity** [] dipole moment
12-09 **Applications of Polarity**
12-50 **Multi-concept and Complex Questions**
12-99 Associated problems in Chapter 12

13 Bonding Orbital Theories

13-01 **Valence Bond (VB): Orbital Hybridization** [] hybridization of orbitals
13-02 **VB: Sigma and Pi Bonds** [] double bond: no rotation
13-03 **VB: More than One Central Atom**
13-04 **Molecular Orbital (MO) Theory: Introduction** [] antibonding, energy level diagram, molecular orbital diagram

13-05 **MO: Homonuclear Diatomics for Period 2**
13-06 **MO: Other Homonuclear Diatomics**
13-07 **MO: Heteronuclear Diatomics**
13-08 **MO: Delocalization** [] electron delocalization
13-09 **MO: Other**
13-10 **MO: Characterizations** [] bond order, length, strength, stability, paramagnetism, diamagnetism
13-50 **Multi-concept and Complex Questions**
13-99 Associated problems in Chapter 13

14 Gases

14-01 **Pressure** [] pressure units (atm, bar, torr), barometer, manometer, Pascal, pressure of a column of liquid: $P = d\,h\,g$
14-02 **Boyle's Law** [] $P_1\,V_1 = P_2\,V_2$
14-03 **Charles' Law** [] $\frac{V_1}{T_1} = \frac{V_2}{T_2}$
14-04 **Combined Gas Law** [] before-and-after systems, $\frac{P_1\,V_1}{T_1} = \frac{P_2\,V_2}{T_2}$
14-05 **Avogadro's Principle and STP** [] $V \propto n$, standard molar volume of ideal gas: 22.414 L/mol at STP
14-06 **Ideal Gas Law** [] $P\,V = n\,R\,T$
14-07 **Gas Laws: Molecular Weights, Formulae, Density** [] molar mass $\leftrightarrow$ gas density
14-08 **Stoichiometry of Gases** [] amt of reagent needed to react with an amt of gas
14-09 **Partial Pressures** [] partial pressures in mixtures, Dalton: $P_{\text{total}} = \sum_i P_i$, mole fraction X_i
14-10 **Kinetic Molecular Theory for Gases** [] root mean square speed, kinetic model, molar heat capacity, average molec speed: $\overline{u} \propto \sqrt{\frac{T}{\text{MW}}}$, average molec KE: $\overline{KE} \propto T$
14-11 **Maxwell Distribution**
14-12 **Diffusion and Effusion** [] Graham's Law: rate eff $\propto \frac{1}{\sqrt{\text{MW}}}$,
14-13 **Real Gases** [] van der Waals equation
14-50 **Multi-concept and Complex Questions**
14-99 Associated problems in Chapter 14

15 Solids and Liquids (Intermol Forces)

15-01 **Phases & Phase Changes: Descriptive** [] no calculations, change of state, sublimation
15-02 **Kinetic-Molecular Description** [] heating/cooling curves
15-03 **Intermolecular Forces (IF)** [] dipole-dipole, ion-ion/ion-dipole/London dispersion forces, hydrogen bonding, qualitative prediction of hydration
15-04 **Properties of Liquid State: Surface Tension** [] $\gamma = \frac{d\,h\,g\,r}{2}$
15-05 **Properties of Liquid State: Capillary Action**
15-06 **Properties of Liquid State: Viscosity** [] fluid flow
15-07 **Vapor Pressure & IF**
15-08 **Melting, Boiling & IF** [] relative order of substances,
15-09 **Vapor Pressure and Temperature** [] ΔVP with temperature, Clausius-Clapeyron: $\ln\left(\frac{P_2}{P_1}\right) = \frac{\Delta H_{\text{vap}}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$
15-10 **Phase Diagrams** [] critical/triple point
15-11 **The Uniqueness of Water**
15-12 **Amorphous Solids**

15-13 **Crystalline Solids: Intro** [] body-centered cubic, fraction of occupied space for crystal lattice, coordination number, face-centered cubic, packing, unit cell
15-14 **Crystalline Solids: Metallic Solids** [] basic properties (maleability, ducile, conductivity, brittle)
15-15 **Crystalline Solids: Ionic Solids**
15-16 **Crystalline Solids: Molecular Solids**
15-17 **Crystalline Solids: Network Solids** [] allotropes, network bonding/compounds
15-18 **Band Theory** [] band gap, semiconductor in band theory, p-type, n-type
15-19 **Identify the Solid**
15-50 **Multi-concept and Complex Questions**
15-99 Associated problems in Chapter 15

16 Advanced Materials
16-01 **Electronic Materials, Semiconductors** [] semiconductor as a product or material
16-02 **Liquid Crystals**
16-03 **Ceramics**
16-04 **Nanotechnology**
16-05 **Thin Films**
16-06 **Polymers**
16-07 **Alloys** [] (related problems in 28:02 Metallurgy)
16-50 **Multi-concept and Complex Questions**
16-99 Associated problems in Chapter 16

17 Properties of Mixtures
17-01 **Nature of Dissolving: Descriptive** [] saturation, solvation, solubility
17-02 **Solute, Solvent Interactions: Like Dissolves Like** [] dissolution, hydrophilic, hydrophobic, influence of polarity in dissolution, predict relative solubilities using IF, predict solubility using polarity (no calc)
17-03 **Applications: Like Dissolves Like** [] alloys, antibiotics, soap
17-04 **Temperature and Solubility: Liquids**
17-05 **Pressure and Solubility: Gases** [] Henry's law: $S = k_{\mathrm{H}}\, P$
17-06 **Temperature and Solubility: Gases**
17-07 **Solution Formation** [] enthalpy of hydration/solution, entropy, free/hydration energy, Δtemp and enthalpy, $n\,\Delta H = m\,C\,\Delta T$
17-08 **Colloids** [] Tyndall effect
17-50 **Multi-concept and Complex Questions**
17-99 Associated problems in Chapter 17

18 Colligative Properties for Solutions
18-01 **Colligative Properties: Overview**
18-02 **Vapor Pressure Lowering: Ideal Mixture** [] Raoult's Law: $P_{\mathrm{solvent}} = X_{\mathrm{solvent}}\, P^{\circ}_{\mathrm{pure\ solvent}}$
18-03 **Boiling Point Elevation** [] $\Delta T_{\mathrm{b}} = i\, k_{\mathrm{b}}\, m$
18-04 **Freezing Point Depression** [] $\Delta T_{\mathrm{f}} = i\, k_{\mathrm{f}}\, m$, simplified Gibbs: $\Delta H^{\circ}_{\mathrm{vap}} - T_{\mathrm{B}}\, \Delta S^{\circ}_{\mathrm{vap}} = 0$
18-05 **Applications: Osmotic Pressure** [] osmosis, flow through membrane, $\Pi = i\, R\, T\, M$
18-06 **Applications: Fractional Distillation**
18-07 **Applications: Other**
18-08 **Lowering Vapor Pressure: Non-ideal Mixtures** [] azeotropes, van't Hoff factor i

18-09 **Effective Molality** [] $n_{\text{eff}} = i \, \frac{\left(\frac{\text{mass solute}}{\text{FW solute}}\right)}{\text{kg solute}}$
18-50 **Multi-concept and Complex Questions**
18-99 Associated problems in Chapter 18

19 Thermodynamics: First Law

19-01 **Basics, Introduction** [] energy in systems (surr, univ, closed, open, isolated), types of energy, energy units (cal, Cal, J, etc.), heat as energy
19-02 **Heat and Work** [] $W = P\,\Delta V = \Delta n\,R\,T$, isothermal expansion: $w = -n\,R\,T\,\ln\left(\frac{V_f}{V_i}\right)$
19-03 **Changes in Internal Energy (ΔU)** [] ΔU due to heat/work, changes in gas due to expansion, $\Delta U = q + w$
19-04 **First Law of Thermodynamics** [] conservation of energy
19-05 **Standard States, Standard Enthalpy Changes** [] state functions
19-06 **Changes in Enthalpy (ΔH)** [] heat output of a fuel, reaction enthalpy at different temp, enthalpy of fusion/vaporization, enthalpy as part of phase changes, Kirchoff's law: $\Delta H^\circ_{\text{r}}(T_2) = \Delta H^\circ_{\text{r}}(T_1) + (T_2 - T_1)\,\Delta C_{\text{p}}$
19-07 **Calorimetry: Basics**
19-08 **Calorimetry: Constant Pressure** [] styrofoam cup
19-09 **Calorimetry: Constant Volume, Bomb**
19-10 **Calorimetry: Constant Volume & Pressure**
19-11 **Simple Heat Transfer** [] one step, heat of fusion/vaporization, phase change calculations, specific heat
19-12 **Complex Heat Transfer** [] multistep calculations, heating/ cooling curves/ calculations/ interpretation, (see 10:06 Born-Haber)
19-13 **Thermochemical Equations** [] chem rxn, scaling amounts, combustion
19-14 **Hess' Law: Rxn Combination**
19-15 **Hess' Law: Formation Rxn (ΔH_{f})** [] heat of formation, $\Delta H^\circ_{\text{rxn}} = \sum_n H^\circ_{\text{f prod}} - \sum_n H^\circ_{\text{f rct}}$
19-16 **Hess' Law: Bond Energies** [] bond enthalpy, standard enthalpy from average bond enthalpies, Hess: $\Delta H^\circ_{\text{rxn}} = \sum \Delta\text{BE}_{\text{rct}} - \sum \Delta\text{BE}_{\text{prod}}$
19-17 **Combining ΔH and ΔU** [] compare/contrast internal energy/enthalpy, $\Delta H = \Delta U - w$
19-18 **Applications of the First Law**
19-19 **Internal Energy: Trans and Rotat Components**
19-20 **Adiabatic Expansion**
19-50 **Multi-concept and Complex Questions**
19-99 Associated problems in Chapter 19

20 Thermodynamics: Second and Third Laws

20-01 **Spontaneity and the Second Law of Thermodynamics** [] entrop univ increases for spontaneous rxns
20-02 **Entropy: Definitions, Descriptions** [] entropy of sys or surr may incr/decr
20-03 **Standard Molar Entropies (ΔS) & the Third Law** [] calculate entropy of system, standard molar entropies, entropy (molecular interpretation, predicting relative values), $\Delta S^\circ_{\text{rxn}} = \sum n\,S^\circ_{\text{f prod}} - \sum n\,S^\circ_{\text{f rct}}$, $\frac{\text{heat}}{\text{temp}}$, (units: J/mol·K, cal/g·K), $\Delta S_{\text{surr}} = \frac{q}{T} = \frac{\Delta H_{\text{sys}}}{T}$, $\Delta S_{\text{total}} = \Delta S_{\text{surr}} + \Delta S$, $\Delta S = n\,C_{\text{v}}\,\ln\left(\frac{T_2}{T_1}\right)$
20-04 **Entropy Changes** [] entropy of vaporization, Δentropy due to temp, $dS = \frac{dq}{T} = P\,\frac{dV}{dT} = \frac{n\,R}{V}\,dV$, Δmolar entropy $\Delta S = n\,R\,\ln\left(\frac{P_{\text{ini}}}{P_{\text{fin}}}\right)$

20-05 **Free Energy Change** [] standard free energy, Gibbs: $\Delta G^\circ_{\mathrm{rxn}} = \Delta H^\circ_{\mathrm{rxn}} - T\,\Delta S_{\mathrm{rxn}}$
20-06 **Predicting Spontaneity** [] spon: $\Delta G < 0$, calculate/predict temp at which reaction becomes spontaneous
20-07 **Boltzmann Formula:** $S = k\,\ln W$ [] positional entropy
20-08 **Entropy: Phase Changes** [] $\Delta G = 0$ in Gibbs, $T_{\mathrm{BP}} = \frac{\Delta H_{\mathrm{vap}}}{\Delta S_{\mathrm{vap}}}$, $T_{\mathrm{FP}} = \frac{\Delta H_{\mathrm{fus}}}{\Delta S_{\mathrm{fus}}}$, Trouton: $\Delta S_{\mathrm{vap}} \approx$ the same for common substances (85 J/K/mol)
20-50 **Multi-concept and Complex Questions**
20-99 Associated problems in Chapter 20

21 Kinetics

21-01 **Reaction Rate and Concentration** [] instantaneous rate, rate of reaction as expression of Δconcentration over time: $\frac{[\mathrm{A}]}{t}$, units: $\frac{\mathrm{mol/L}}{\mathrm{s}}$, etc.
21-02 **Rxn Rates and Rate Law: Terms, Descriptive** [] initial rates, factors affecting reaction rate
21-03 **Determining Rate Law, k, Reaction Order** [] calculate rate constant/reaction order, rate $= k\,\Pi_i\,[\mathrm{rct}_i]^{order}$
21-04 **Conc *vs* Time: Integrated Rate Equation** [] zero order: rate is constant, $[\mathrm{A}]_0$ - $[\mathrm{A}] = a\,k\,t$, first order: ln[A] *vs* t is a straight line $\ln\left(\frac{[\mathrm{A}]_0}{[\mathrm{A}]}\right) = a\,k\,t$ or $[\mathrm{A}] = [\mathrm{A}]_0\,e^{-k\,t}$ (units: s^{-1}, min^{-1}), second order: $\ln\left(\frac{1}{[\mathrm{A}]}\right)$ *vs* t is a straight line, $\frac{1}{[\mathrm{A}]} - \frac{1}{[\mathrm{A}]_0} = a\,k\,t$ (units: L/mol/min, L/mol/s)
21-05 **Half-lives** [] first-order half-life equation. zero order: $\frac{[\mathrm{A}]_0}{t_{1/2}}$ is constant, first order: $t_{1/2}$ is independent of $[\mathrm{A}]_0$, second order: $t_{1/2} = \frac{1}{a\,k}\,\frac{1}{[\mathrm{A}]_0}$ ($t_{1/2}\,[\mathrm{A}]_0$ is constant)
21-06 **Reaction Mechanisms** [] rate law from reaction mechanism, multistep, Michaelis constant: $K_{\mathrm{m}} = \frac{k_1' + k_2}{k_1}$, Michaelis-Menten:
21-07 **Temperature: The Arrhenius Equation** [] activation energy from rate constant and temp, Arrhenius: $\ln\left(\frac{k'}{k}\right) = \frac{E_{\mathrm{a}}}{\mathcal{R}}\,\left(\frac{1}{T} - \frac{1}{T'}\right)$ or rate $= A\,e^{-E_{\mathrm{a}}/(R\,T)}$
21-08 **Collision Model** [] speed, mean relative speed
21-09 **Transition State Theory & Reaction Profile** [] activated complex theory, reaction energy diagrams, reaction profile
21-10 **Catalysis: Basics** [] effect on reaction profile
21-11 **Catalysis: Applications, Types** [] biochemical (enzymes), homogeneous, heterogeneous, catalytic converters
21-50 **Multi-concept and Complex Questions**
21-99 Associated problems in Chapter 21

22 Chemical Equilibrium

22-01 **Basic Concepts and Theory**
22-02 **Mass Action Expression: Q and K** [] (pure liq, solids excluded), $k = \frac{\Pi_{\mathrm{i}}\,[\mathrm{prod}]^{\mathrm{coeff}}}{\Pi_{\mathrm{i}}\,[\mathrm{rct}]^{\mathrm{coeff}}}$ gases: $k = \frac{\Pi_i\,P_{\mathrm{prod}}}{\Pi_i\,P_{\mathrm{rct}}}$
22-03 **Extent of Reaction: K**
22-04 **Form of K (Multiplying, Combining Equations)** [] $K_{\mathrm{reverse}} = \frac{1}{K_{\mathrm{forward}}}$
22-05 **Thermo Equil: ΔG, K, and Q Relationship** [] $K = e^{-\Delta G/(R\,T)}$, $\Delta G_{\mathrm{r}} = R\,T\,\ln\left(\frac{Q}{K}\right)$
22-06 **Kinetic Equil: Rate Constants and K** [] $K = \frac{k_{\mathrm{f}}}{k_{\mathrm{r}}}$
22-07 **K_{c} to K_{p}** [] $K_{\mathrm{p}} = K_{\mathrm{c}}\,(R\,T)^{\Delta n}$ where $\Delta n = n_{\mathrm{gas\,prod}} - n_{\mathrm{gas\,rct}}$

22-08 **Initial, Change, Final (ICE) Table Setup**
22-09 **Mathematical Equation Solving**
22-10 **Getting Q and Comparing to K** [] equil shift
22-11 **Calculations 1: All Eq Conc Given** [] K = fraction: solve for either K or a concentration
22-12 **Calculations 2: One Final Conc Given** [] not much to solve
22-13 **Calculations 3: ICE Solve for x** [] eqtn reduced to linear
22-14 **Calculations 4: ICE Quadratic Needed** [] quad formula
22-15 **Rxn Stress: Le Chatelier's Principle (L, R, NC)** [] system in equilibrium responds (shifts) to relieve stress
22-16 **Temperature Dependence of K** [] van't Hoff: $\ln\left(\frac{K_2}{K_1}\right) = \frac{\Delta H_{\text{rxn}}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$
22-17 **Equilibrium: Specific Applications** [] Haber
22-50 **Multi-concept and Complex Questions**
22-99 Associated problems in Chapter 22

23 Acids and Bases

23-01 **Basics and Properties** [] conceptual, recall, acidic $< 7 <$ basic
23-02 **Production, Use and Application** [] some reactions (not necessarily acid/base) that produce acids/bases
23-03 **Arrhenius Theory of Acids and Bases** [] acid contains H and produces H^+ (protons) in water, base produces OH^- in water
23-04 **Autoionization of Water, Conversions with K_w** [] autoprotolysis constant of water: $K_w = [H_3O^+] \cdot [OH^-]$, def neutral water
23-05 **Bronsted-Lowry Theory of Acids and Bases** [] in water acid donates H^+ (to form hydronium ion H_3O^+), base accepts H^+ (supplies $OH^- \rightarrow H_2O$), identify conjugate
23-06 **Lewis Theory of Acids and Bases** [] acid is e^- pair acceptor, base is e^- pair donor
23-07 **Relative Strengths of Acids or of Bases** [] order given K_a, K_b (more than just formula), relative conjugate strengths
23-08 **pH and pOH: Descriptive, Basics** [] simple calculations: $\text{pH} = -\log[H^+]$, $\text{pH} \leftrightarrow [H_3O^+]$
23-09 **pH and pOH: Calculations, Conversions** [] $\text{pH} \leftrightarrow [OH^-]$, $\text{pOH} \leftrightarrow [H^+]$, $\text{pH} + \text{pOH} = 14$
23-10 **Acid/Base Strengths** [] identify strong/weak acid/base/salt from formula
23-11 **Comparing Solutions** [] calculations
23-12 **Equivalent Weights and Normality** [] normality unit N
23-13 **Acidic and Basic Salts: General** [] amphoterism, acidic cations
23-14 **Neutralizations (Titrations)** [] no equilibria, strong acid/base, no K_a nor K_b needed
23-15 **Leveling Effect**
23-16 **Hydrides: Acid/Base Perspective**
23-17 **Acid Strength: Electronegativity, Series**
23-50 **Multi-concept and Complex Questions**
23-99 Associated problems in Chapter 23

24 Equilibria: Acids and Bases [] one species in soln

24-01 **Weak Mono Acids (K_a)** [] K_a from pH, percent dissociation, equilibria, pH from K_a and initial acid concentration
24-02 **Weak Mono Bases (K_b)** [] K_b from K_w: $K_w = K_a \cdot K_b$, pH from K_b and initial base concentration or equilibria
24-03 **Polyprotic Acids, Bases** [] K_{a1}, K_{a2}, K_{a3}, K_{b1}, K_{b2}, K_{b3}

24-04 **Molecular Structure and Acid Strength** [] predict relative strengths of acids/bases (molecular level), like $HClO_3$ *vs* $HClO_4$
24-05 **Oxides** [] amphoteric, anhydride, relative acid strength
24-06 **Salts of Strong Bases and Strong Acids** [] K_a and K_b in calculations
24-07 **Salts of Strong Bases and Weak Acids** [] K_a and K_b in calculations
24-08 **Salts of Weak Bases and Strong Acids** [] K_a and K_b in calculations
24-09 **Salts of Weak Bases and Weak Acids** [] K_a and K_b in calculations
24-10 **Very Dilute Solutions** [] importance of autoprotolysis of water in calculations,
24-11 **Systematic Treatment of Equilibrium**
24-50 **Multi-concept and Complex Questions**
24-99 Associated problems in Chapter 24

25 Buffer Systems [] two species
25-01 **Buffer Basics, Descriptive**
25-02 **Prepare a Buffer** [] how to prepare/design, pH of buffer solution, solute concentrations based on desired pH,
25-03 **Buffer Systems and Common Ion Effect** [] Henderson-Hasselbach: $\mathrm{pH} = \mathrm{p}K_a + \log\left(\frac{A^-}{HA}\right)$
25-04 **Buffer Capacity, Range, Response to Stress**
25-05 **Acid-Base Indicators**
25-06 **Titration Curves** [] pH curve/features, pH at specific point in titration curve, equivalence point
25-07 **Polyprotic Buffers**
25-08 **Fraction of Species Curves**
25-50 **Multi-concept and Complex Questions**
25-99 Associated problems in Chapter 25

26 Equilibria: Slightly Soluble Ionic Cmpds
26-01 **Solubility Product Constants** [] K_{sp}, molar solubility
26-02 **Fractional Precipitation**
26-03 **Slightly Soluble Compounds: Simultaneous Equil**
26-04 **Dissolving Precipitates**
26-05 **Complex Ions**
26-06 **Applications of Ionic Equilibria**
26-50 **Multi-concept and Complex Questions**
26-99 Associated problems in Chapter 26

27 Electrochemistry
27-01 **Balancing Redox Reactions in Acid**
27-02 **Balancing Redox Reactions in Base**
27-03 **Electrical Conduction and Electrodes** [] oxidation, reduction
27-04 **Coulometry: Faraday's Law of Electrolysis** [] amount of product formed or reactant consumed by electrolysis current ≈ amount of electrons supplied, $q = I\,t$, $n = \frac{Q}{F}$, Faraday's constant F
27-05 **Electrolysis/Electrolytic Cells** [] Hall process
27-06 **Voltaic Cells** [] spontaneous chemical reaction, galvanic, fuel cell, mercury cell
27-07 **Standard Electrode Potentials/SHE**
27-08 **Nernst Equation** [] $E = E^\circ - \frac{RT}{nF}\ln Q$, estimate EMF of cells under nonstandard

conditions
27-09 **E, ΔG, and K Relationships** [] $\Delta G = -n\,F\,E = -R\,T\,\ln(K_{\mathrm{sp}})$
27-10 **Find Concentrations: Electrochemical Cells**
27-50 **Multi-concept and Complex Questions**
27-99 Associated problems in Chapter 27

28 Batteries
28-01 **Battery Design and Use**
28-02 **Primary** [] not rechargeable: dry/alkaline/silver cells
28-03 **Secondary** [] rechargeable: lead-acid/lithium-ion/sodium-sulfur cells
28-04 **Fuel Cells**
28-50 **Multi-concept and Complex Questions**
28-99 Associated problems in Chapter 28

29 Metals
29-01 **Occurrence of Metals**
29-02 **Metallurgy**
29-03 **Alkali Metals**
29-04 **Alkaline Earth Metals**
29-05 **Post-Transition Metals**
29-06 **d-Transition Metals**
29-07 **Gems and Minerals**
29-50 **Multi-concept and Complex Questions**
29-99 Associated problems in Chapter 29

30 Nonmetals and Metalloids
30-01 **Noble Gases**
30-02 **Halogens**
30-03 **Silicon**
30-04 **Hydrogen and Hydrides**
30-05 **Other Nonmetals**
30-06 **Carbon and Its Uses**
30-50 **Multi-concept and Complex Questions**
30-99 Associated problems in Chapter 30

31 Coordination Compounds
31-01 **Coordination Compounds** [] ligand compounds
31-02 **Amine Complexes**
31-03 **Nomenclature**
31-04 **Structures**
31-05 **Isomerism**
31-06 **Bonding: Crystal Field Theory**
31-50 **Multi-concept and Complex Questions**
31-99 Associated problems in Chapter 31

32 Instrumental Methods
32-01 **IR**
32-02 **UV-Vis**
32-03 **X-Ray Diffraction**

32-04 **Chromatography** [] liquid, gas
32-05 **Mass Spectrometry**
32-06 **NMR**
32-50 **Multi-concept and Complex Questions**
32-99 Associated problems in Chapter 32

33 Nuclear Chemistry
33-01 **Neutron-Proton Ratio and Nuclear Stability**
33-02 **Binding Energy and Nuclear Stability** [] mass defect (mass lost during nuclear change)
33-03 **Radioactive Decay**
33-04 **Equations for Nuclear Reactions**
33-05 **Detection of Radiation**
33-06 **Rates of Decay and Half-life**
33-07 **Disintegration Series**
33-08 **Uses of Radionuclides**
33-09 **Artificial Transmutations of Elements**
33-10 **Nuclear Fission**
33-11 **Nuclear Weapons**
33-12 **Nuclear Fusion**
33-50 **Multi-concept and Complex Questions**
33-99 Associated problems in Chapter 33

34 Energy Production and Fuels [] (see 19:13 for combustion)
34-01 **Petroleum and Its Products**
34-02 **Coal**
34-03 **Natural Gas**
34-04 **Conventional Energy Plants**
34-05 **Alternative Energies**
34-06 **Hydroelectric Energy**
34-07 **Nuclear Reactors**
34-08 **Nuclear Waste**
34-50 **Multi-concept and Complex Questions**
34-99 Associated problems in Chapter 34

35 Basic Organic Chemistry
35-01 **Hydrocarbons**
35-02 **Isomerism: Structural & Stereoisomers**
35-03 **Substitution Reactions**
35-04 **Addition Reactions**
35-05 **Elimination Reactions**
35-06 **Polymerization Reactions**
35-07 **Functional Groups**
35-50 **Multi-concept and Complex Questions**
35-99 Associated problems in Chapter 35

36 Polymers and Plastics
36-01 **General Polymer Properties and Structures**
36-02 **Cross-linking of Polymers**

36-03 **Addition Polymers**
36-04 **Condensation Polymers**
36-05 **Natural Polymers**
36-06 **Polyamides**
36-07 **Polyesters**
36-08 **Plastics: Use and Application**
36-50 **Multi-concept and Complex Questions**
36-99 Associated problems in Chapter 36

37 Food and Nutrition
37-01 **Carbohydrates**
37-02 **Proteins and Amino Acids**
37-03 **Fats and Lipids**
37-04 **Vitamins and Minerals**
37-05 **Artificial Sweeteners**
37-06 **Food Preservation**
37-07 **Energy and Nutrition From Food**
37-50 **Multi-concept and Complex Questions**
37-99 Associated problems in Chapter 37

38 Drugs and Poisons
38-01 **Pain Killers**
38-02 **Allergy**
38-03 **Narcotics**
38-04 **Barbiturates**
38-05 **Tranquilizers**
38-06 **Steroids**
38-07 **Birth Control**
38-08 **Cancer/Chemotherapy**
38-09 **Other Drugs**
38-10 **Heavy Metals**
38-11 **Neurotoxins**
38-12 **Other Poisons**
38-13 **Drug Design and Development**
38-14 **Hormones and Enzymes**
38-15 **Herbal Medicine**
38-50 **Multi-concept and Complex Questions**
38-99 Associated problems in Chapter 38

39 Genetics
39-01 **Nucleic Acids**
39-02 **DNA and RNA**
39-03 **Proteins: Production and Structure**
39-04 **Carcinogens, Mutagens, Teratogens**
39-05 **Viruses**
39-06 **Diagnosis of Genetic Problems, Gene Therapy**
39-07 **PCR and Genetic Techniques**
39-08 **Transgenic Organisms**
39-09 **Cloning**

39-50 **Multi-concept and Complex Questions**
39-99 Associated problems in Chapter 39

40 Environmental Issues
40-01 **Air Pollution** [] calculation (ppm)
40-02 **Ozone Layer** [] free radicals, CFC, HFC, uv radiation, Chapman cycle
40-03 **Global Warming** [] carbon sequestration, greenhouse gas, IR
40-04 **Acid Rain** [] sulfur combustion, nitrogen cycle
40-05 **Water Supply, Pollution, Treatment**
40-06 **Recycling**
40-07 **Other Environmental Issues**
40-50 **Multi-concept and Complex Questions**
40-99 Associated problems in Chapter 40

41 Risk Assessment
41-01 **Drugs**
41-02 **Industry**
41-03 **Fuels**
41-04 **Laws and Regulations**
41-50 **Multi-concept and Complex Questions**
41-99 Associated problems in Chapter 41

42 Industry, Agriculture, and Earth Chemistry
42-01 **Fertilizers**
42-02 **Pesticides**
42-03 **Other Agricultural Chemicals**
42-04 **Earth's Crust Composition**
42-05 **Metals and Ores**
42-06 **Ceramics and Cement**
42-07 **Glass**
42-08 **Commercial Production of Chemicals**
42-50 **Multi-concept and Complex Questions**
42-99 Associated problems in Chapter 42

43 Household Chemistry
43-01 **Surfactants**
43-02 **Soaps, Detergents, and Bleaches**
43-03 **Paints and Solvents**
43-04 **Lotions, Creams, and Cosmetics**
43-05 **Perfumes**
43-06 **Toothpaste and Deodorant**
43-07 **Hair Products**
43-08 **Sunscreens**
43-09 **Other Household Chemicals**
43-50 **Multi-concept and Complex Questions**
43-99 Associated problems in Chapter 43

44 Advanced Organic Chemistry
44-01 **Introduction**

44-50 **Multi-concept and Complex Questions**
44-99 Associated problems in Chapter 44

45 Biochemistry
45-01 **Foundations of Biochemistry**
45-02 **Water**
45-03 **Amino Acids, Peptides, and Proteins**
45-04 **The Three-Dimensional Structure of Proteins**
45-05 **Protein Function**
45-06 **Enzymes**
45-07 **Carbohydrates and Glycobiology**
45-08 **Nucleotides and Nucleic Acids**
45-09 **DNA-Based Information Technologies**
45-10 **Lipids**
45-11 **Biological Membranes and Transport**
45-12 **Biosignaling**
45-13 **Principles of Bioenergetics**
45-14 **Glycolysis, Gluconeogenesis, Pentose Pathway**
45-15 **Principles of Metabolic Regulation**
45-16 **The Citric Acid Cycle**
45-17 **Fatty Acid Catabolism**
45-18 **Amino Acid Oxidation; Production of Urea**
45-19 **Phosphorylation and Photophosphorylation**
45-20 **Plant, Bacteria Carbohydrate Biosynthesis**
45-21 **Lipid Biosynthesis**
45-22 **Biosynthesis of Amino Acids, Nucleotides,** *etc.*
45-23 **Mammalian Metabolism Regulation, Integration**
45-24 **Genes and Chromosomes**
45-25 **DNA Metabolism**
45-26 **RNA Metabolism**
45-27 **Protein Metabolism**
45-28 **Regulation of Gene Expression**
45-50 **Multi-concept and Complex Questions**
45-99 Associated problems in Chapter 45

46 Analytical Chemistry
46-01 **Introduction**
46-50 **Multi-concept and Complex Questions**
46-99 Associated problems in Chapter 46

47 Physical Chemistry
47-01 **Introduction**
47-50 **Multi-concept and Complex Questions**
47-99 Associated problems in Chapter 47

48 Inorganic Chemistry
48-01 **Introduction**
48-50 **Multi-concept and Complex Questions**
48-99 Associated problems in Chapter 48