AP Chemistry Unit Content and Objectives

UNIT CONTENT	CONTENT LEARNING OBJECTIVES	HANDS-ON LABS
STRUCTURE OF MATTER **Chemical Foundations** Text: 1.3-1.7, 10.8, 10.9	**1.1** Be able to correctly record measurements **1.2** Determine the number of significant figures in a measurement and be able to express the results of a calculation with the proper number of significant figures. **1.3** Be able to convert measurements, especially within the metric system, using dimensional analysis. **1.4** Extract information from simple phase diagrams **1.5** Extract Information from heating/cooling curves. Label the parts of a heating curve and be able to explain each segment in terms of potential and kinetic energy of the particles. Explain the difference between sensible and latent heat **1.6** Describe each of the states of matter and phase changes in terms of kinetic energy, potential energy, and particle spacing.	Heating Curve Lab Significant Figures Lab
STRUCTURE OF MATTER **Atoms, Molecules, and Ions** Text: 2.5-8	**2.1** Distinguish between physical and chemical properties and changes. **2.2** Understand the difference between elements, compounds, and mixtures. Identify common substances as elements, compounds or mixtures. **2.3** Identify metals, nonmetals, and metalloids based on an element's position on the periodic table. Identify an element as a metal, nonmetal, or metalloid based on its properties. **2.4** Locate alkali metals, alkaline earth metals, halogens, noble gases, transition metals, actinides and lanthanides on the periodic table. Be familiar with basic properties of these groups. **2.5** Given a mixture, propose a reasonable method for separating its components and explain why the method is appropriate. **2.6** Given the chemical formulas or names of compounds, predict whether their bonds will be more ionic or covalent in nature. **2.7** Be able to write the correct name of an inorganic compound from its formula and vice versa.	Paperclip Activity Mixture Separation Lab
REACTIONS **Stoichiometry - Compounds** Text: 2.1-4; 3.1-6	**3.1** Identify key scientists and explain how their discoveries contributed to development of the model of the atom. **3.2** Distinguish between protons, neutrons, and electrons and be able to describe the composition of an atom, isotope, and ion of any particular element in terms of these subatomic particles. **3.3** Calculate the atomic weight (average atomic mass) of an element from the relative abundances and masses of its naturally occurring isotopes **3.4** Calculate the molar mass of a substance from its chemical formula. Calculate the percentage composition of a compound form its formula. **3.5** Be able to inter convert between moles, mass, and number of particles of a substance. **3.6** Calculate the empirical formula of a compound from either elemental percent composition or quantity of CO_2 and H_2O produced from its combustion. **3.7** Calculate the molecular formula of a compound from the empirical formula and molecular weight.	Determination of Empirical Formula of Silver Oxide (Vonderbrink exp. 1) Hydrates (Hall exp. 12)
REACTIONS **Stoichiometry- Reactions** Text: 3.7-10	**4.1** Be able to balance chemical equations. **4.2** Write balanced chemical equations from word descriptions. **4.3** Find the mass of any substance in a chemical reaction from the mass of one substance. **4.4** Determine the limiting reactant (limiting reagent) in a reaction and then calculate the amount of each product and the mass of the excess	Synthesis and analysis of alum (Vonderbrink – 1995 exp. 3&4 (#1,2,16)

UNIT CONTENT	CONTENT LEARNING OBJECTIVES	HANDS-ON LABS
	reactant left over. **4.5** Calculate theoretical yield and percent yield from experimental data.	
REACTIONS **Types of Chemical Reactions** Text: 4.1-4.6; 4.8-9	**5.1** Given the reactants, characterize the reaction type as one of the following: double replacement, single replacement, synthesis, decomposition, neutralization, and combustion reactions. **5.2** Predict the products and write balanced equations for double replacement (precipitation) reactions. **5.3** Predict the products and write balanced equations for acid-base (neutralization) reactions. **5.4** Predict the products and write balanced equations for synthesis reactions. **5.5** Predict the products and write balanced equations for decomposition reactions. **5.6** Predict the products and write balanced equations for combustion reactions. **5.7** Predict the products and write balanced equations for single replacement reactions. **5.8** Predict to some extent whether a substance will be a strong electrolyte, weak electrolyte, or nonelectrolyte. Predict the ions that an electrolyte dissociates into. Identify substances as acids, bases, and salts. **5.9** Using solubility rules, predict if a precipitate forms in a metathesis reaction. **5.10** Given a balanced molecular equation, write a complete ionic equation. **5.11** Given a complete ionic equation, be able to identify spectator ions and write the net ionic equations. **5.12** Use the activity series to predict whether a Redox reaction will occur and be able to write the molecular and net ionic equations if it does.	Solubility Trends Lab (SMG)
REACTIONS **Solution Stoichiometry** Text: 4.7-8	**6.1** Calculate moles of solute, volume of solution, or Molarity of the solution from the other two. Convert the molarity of an ionic compound into molarity of its constituent ions. **6.2** Recognize and work dilution problems. **6.3** Perform reaction stoichiometry using concentrations. **6.4** Calculate mass of solute or concentration of an unknown solution from titration data.	A Standard NaOH Solution – Beran 21A Analysis of Acids – Beran 21B
STATES OF MATTER ***REACTIONS*** **Gases** Text: Chap. 5	**7.1** Describe properties of gases compared to other physical states. Understand the kinetic molecular theory. **7.2** Describe how gases respond to changes in V, n, P, and T. Be able to work problems using combined and ideal gas equations. Define and use common units of gas pressure in calculations. **7.3** Describe how the relative rates of diffusion and effusion of gases depend on their molar masses. **7.4** Understand the conditions under which real gases deviate from ideal gases. Know the existence of the real gas equation with corrections for particle attraction and size. **7.5** Be able to calculate molar mass from gas density and vice versa. **7.6** Perform calculations involving mixtures of gases. Calculate partial pressure / mole fraction of any gas from the composition of its mixture. Understand the process and calculation of the pressure of a gas collected over water. **7.7** Be able to work gas stoichiometry problems.	Determination of molar mass of volatile liquids – Vonderbrink 9 (#3) Determination of the molar volume of a gas – Vonderbrink 8 (#5)
REACTIONS **Thermochemistry**	**8.1** Understand what the First Law of Thermodynamics means. Understand what the system, the surroundings, and the universe mean. Be familiar with how the internal energy of a system is affected by exchanges of heat and work between the system and the surroundings.	Thermodynamics – Enthalpy of Reaction and Hess Law –

UNIT CONTENT	CONTENT LEARNING OBJECTIVES	HANDS-ON LABS
Text: Chap. 6	**8.2** Understand the concept of enthalpy. Know what the sign of the enthalpy indicates about the reaction. Be able to calculate the amount of heat released or absorbed by a reaction knowing the quantity of the reactants and the enthalpy of the reaction on a mole basis. **8.3** Define Heat Capacity and Specific Heat (Capacity). Be able to work problems involving Calorimetry. Calculate the enthalpy change of a reaction using calorimetry data. **8.4** State and apply Hess's Law of Constant Heat **8.5** Define and illustrate what Standard Enthalpy of Formation means. Know what the Standard State of an element or compound is. Calculate the enthalpy change of a reaction using a table of standard enthalpies of formation.	Vonderbrink 6 (#13)
REACTIONS Chemical Equilibrium Text Chap. 13; 15.6	**9.1** Understand the meaning of dynamic equilibrium. Write the equilibrium expression for any chemical reaction. Understand the meaning of the magnitude of the value of K. **9.2** Calculate K_c or K_p when given appropriate data. Interconvert K_c and K_p. **9.3** Knowing initial concentrations and at least one equilibrium concentration, calculate the value of K **9.4** Knowing the value of K and initial concentrations, calculate equilibrium concentrations. **9.5** Calculate Q, the reaction quotient, to determine if a reaction is at equilibrium and if not, determine its direction. **9.6** Explain how an equilibrium is shifted by stresses (changes in temperature, pressure, or concentration)–Le Chatelier's Principle. Explain how temperature changes the value of K. **9.7** Write the Ksp expression for a salt. Interconvert between solubility and Ksp. **9.8** Calculate the effect of a common ion on the solubility of a slightly soluble salt. Predict whether a precipitate will form when two solutions are mixed.	Determination of the solubility product of an ionic compound – Vonderbrink 18 (#10)
REACTIONS ***Spontaneity, Entropy, and Free Energy*** Text: Chap. 16	**10.1** Define entropy as it pertains to the second law of thermodynamics. Predict the sign of the entropy of a given process, and state the third law of thermodynamics. **10.2** Define free energy in terms of enthalpy and entropy, and explain the relationship of the sign of ΔG and the spontaneity of a reaction. Given information about a reaction, predict spontaneity of the reaction. **10.3** Calculate $\Delta S°$ for a reaction using a table of absolute entropies, S°. Calculate $\Delta G°$ for a reaction using a table of $\Delta G_f°$ for the reactants and products. **10.4** Interconvert $\Delta G°$ and K for a reaction. **10.5** Calculate the free energy change for a reaction at nonstandard conditions, ΔG, knowing $\Delta G°$, T, and the data needed to calculate Q.	
STRUCTURE OF MATTER **Atomic Structure** Text: 7.1-11	**11.1** Identify key scientists and explain how their discoveries contributed to development of the model of the atom. Have a basic knowledge of the development of electron theory (Planck, Einstein, DeBroglie, Bohr, Schrodinger) **11.2** Understand the concept of quantized atom and its relationship to line spectra of atoms. Understand the relationships $c = \lambda v$ and $E = h\ v$. **11.3** Perform calculations related to electron energy and energy levels using equations developed by Planck, Bohr, and DeBroglie **11.4** Describe the quantum numbers as to how they define electron orbitals and their value limitations. Describe the Uncertainty Principle and its effect on atomic theory. Describe the shapes of the orbital types. Understand the concept of electron spin and what it has to do with electron configuration.	Determining the Limiting reactant and percent yield in a precipitation reaction – Ess. Exp. 6D (#9)

UNIT CONTENT	CONTENT LEARNING OBJECTIVES	HANDS-ON LABS
	11.5 Write the orbital diagram for any element. **11.6** Be able to write electron configurations, especially valence configurations for any element using the periodic table with the knowledge of the s, p, d, f blocks.	
STRUCTURE OF MATTER **Periodicity** Text: 7.12-13	**12.1** Describe the variations of atomic radii in the groups and periods on the periodic table and the underlying reasons for the variations. **12.2** Describe the variations in first ionization energies in the groups and periods on the periodic table and the underlying reasons for the variations. **12.3** Describe and explain the observed changes in successive ionization energies for a given atom. **12.4** Describe the variations of electron affinity in the groups and periods on the periodic table **12.5** Be able to write the electron configuration of an ion. **12.6** Describe what happens to radius when an atom forms an ion. Be able to explain the variation in size of an isoelectronic series.	
STRUCTURE OF MATTER **Bonding: General Concepts** Text: 8.1-12	**13.1** Compare and contrast covalent, ionic, and metallic bonds. **13.2** Understand the energies involved in the formation of ionic bonds—ionization energy, electron affinity, and lattice energy. **13.3** Qualitatively compare lattice energies for ionic compounds **13.4** Predict the formula of an ionic compound between representative elements using the octet rule, and predict an atom's probable valence, using the periodic table. Be able to write the Lewis symbol for any atom. **13.5** Be able to show covalent bond formation using Lewis symbols. Write correct Lewis structures for any simple molecule or ion even when there is an exception to the octet rule. **13.6** Be able to write resonance structures when no one structure is adequate. Use formal charges to determine the most plausible Lewis structure for a molecule. **13.7** Explain electonegativity, how it varies on the periodic table, and its relationship to the nature of the bond between two atoms. Predict the polarities of bonds between any two atoms from their electonegativities or their positions on the periodic table. **13.8** Use bond energies to estimate the enthalpy of a reaction.	Using a reactant in excess in an Aluminum-copper replacement reaction – Ess.Exp. 6E (#9)
STRUCTURE OF MATTER **Covalent Bonding: Orbitals** Text: 8.13; 9.1-5	**14.1** Relate the number of electron domains in the valence shell of an atom to the geometric arrangement of electrons around the atom. **14.2** Predict the molecular shape of a molecule or ion from its Lewis structure. Understand that the relative degree of repulsion between nonbonding pairs is greater than between bonding pairs of electrons. **14.3** Predict, from its molecular shape and the electonegativities of the atoms involved, whether a molecule is polar (has a dipole). **14.4** Explain the types of hybridization. Assign the type of hybridization on the basis of the electron geometry of the valence shell of an atom. **14.5** Describe the bonding between atoms in a molecule as σ or π. Explain the concept of delocalization in πbonds**.**	
Organic Nomenclature Text: Chap. 22	**15.1** Distinguish between empirical, molecular, and structural formulas. **15.2** Given the IUPAC name, be able to draw full, condensed, and line structures of organic molecules containing common substitutents and functional groups. **15.3** Given the structure, derive the IUPAC name for organic molecule containing common substituents and functional groups.	
STATES OF MATTER **Liquids and Solids**	**16.1** Predict the type of solid (ionic, molecular, metallic, or covalent network) a substance is, and the properties it has because of this. **16.2** For molecular substances, describe the types of intermolecular forces and be able to state the type expected for a substance knowing	Separation of a mixture by paper chromotography – Ess. Exp 3B

UNIT CONTENT	CONTENT LEARNING OBJECTIVES	HANDS-ON LABS
Text: Chap. 10	its molecular structure. **16.3** Know the meaning of viscosity, surface tension, capillary action, boiling point and melting point and how they relate to the intermolecular force. Understand how vapor pressure depends on intermolecular attraction and temperature. **16.4** Explain and apply the relationship between properties of solids and the type of solid (ionic, molecular, metallic, or covalent network) a substance is. **16.5** Calculate density, molar mass, and unit cell dimensions given data on the unit cell of a solid. **16.6** From the heat capacities and enthalpies of state change, be able to calculate the amount of heat to change a substance from one temperature and state to another.	(#18)
STATES OF MATTER ***Properties of Solutions*** Text: Chap. 11	**17.1** Describe the energy changes associated with the formation of a solution -"Like dissolves like!" Identify the intermolecular forces associated with solute-solvent combinations. **17.2** Explain effects of temperature and pressure on solubility. Perform calculations using Henry's Law. **17.3**Define units of concentration, mass percent, ppm, mole fraction, molarity, and molality, and be able to calculate each from appropriate data. **17.4** Be able to convert a concentration from one unit to the other. **17.5** Describe the effect of solute (or solvent) concentration on vapor pressure. Be able to calculate any of these effects from concentration data for electrolyte and nonelectrolyte solutes. **17.6** Describe the effect of solute (or solvent) concentration on boiling point and freezing point. Be able to calculate any of these effects from concentration data for electrolyte and nonelectrolyte solutes. **17.7** Describe the effect of solute (or solvent) concentration on osmotic pressure. Be able to calculate any of these effects from concentration data for electrolyte and nonelectrolyte solutes. ------ **17.8** Calculate the concentration and molar mass of a nonvolatile, nonelectrolyte from its effect on a colligative property. ------- **17.9** Describe the effect of solute (or solvent) concentration on vapor pressure. Be able to calculate this effect using Raoult's Law	Molar mass by freezing point depression – Ess. Exp. 16B (#4) – 1 block Beer's Law Lab
REACTIONS ***Chemical Kinetics*** Text: Chap 12; 18.1-18.3; 18.6	**18.1** Express the rate of a reaction in terms of changes in the concentration of a reactant or a product per time. **18.2** Explain the meaning of the reaction rate law and the rate law constant. Understand what is meant by order in terms of a reactant as well as the overall order. **18.3** Be able to determine a differential rate law for a reaction from initial rate data. Calculate the rate law constant (including units) Use the rate law in calulations. **18.4** Be able to determine an integrated rate law for a reaction from experimental data. Calculate the rate law constant (including units) after finding the rate law. Use the rate law in calculations. **18.5** Explain what is meant by a reaction mechanism and know the meaning of elementary steps, rate-determining step, and intermediate species. Be able to explain and show how a rate law is derived from a certain reaction mechanism. **18.6** Use Collision Theory to explain the effects of reactant concentration, temperature, state of reactants and presence of a catalyst on reaction rate. Draw and explain reaction energy diagrams. Explain graphically the concept of activation energy. **18.7** Understand how temperature affects the rate law constant for a reaction. Use the Arrhenius equation to calculate the effects of	Kinetics of a reaction – Vonderbrink 12 (#12) –

UNIT CONTENT	CONTENT LEARNING OBJECTIVES	HANDS-ON LABS
	temperature and a catalyst on reaction rate **18.8** Be able to write, balance, and predict the products of nuclear reactions. **18.9** Understand the meaning of half-life. Perform calculations involving radioactive decay	
REACTIONS ***Acids and Bases*** Text: Chap. 14	**19.1** List general properties that characterize acidic and basic solutions and the ions responsible. Understand what is meant by strength of an acid or a base. Explain the autoionization of water and write the K_w expression. **19.2** Understand the Brönsted-Lowry Theory and be able to identify conjugate acids and bases. Understand the relationship between the strength of an acid and the strength of its conjugate base; interconvert between K_a and K_b. **19.3** Define an acid and a base in the Lewis sense. **19.4** Understand the relationship between molecular structure and acid strength **19.5** Define pH and be able to interconvert between $[H^+]$, $[OH^-]$, pH, and pOH. **19.6** Given the acid concentration, be able to interconvert between K_a and pH. **19.7** Given the base concentration, be able to interconvert between K_b and pH. **19.8** Calculate the percent ionization from the K_a or the K_b, and vice versa. **19.9** Predict whether the solution of a particular salt will be acidic, basic, or neutral. **19.10** Calculate the pH of a salt solution	Determination of Ka of weak acids – Vonderbrink 14 (#10) – 1 block
REACTIONS ***Applications of Aqueous Equilibria*** 15.1-6	**20.1** Describe how a buffer solution works and how one can be made at a particular pH. **20.2** Calculate the change in pH of a buffer upon the addition of a strong acid or a strong base. **20.3** Distinguish between the various titration curves. **20.4** Calculate the concentration of each species in a solution formed by mixing an acid and a base. Calculate the pH at any point in an acid-base titration. **20.5** Understand how indicators work and be able to choose an appropriate indicator for a given titration using pH ranges and/or Ka values of the indicators **20.6** Understand the effect of pH on solubility of a slightly soluble salt.	Selecting Indicators for Acid-Base Titrations – Vonderbrink 16 (#11) – 1 block Preparation and Properties of Buffer Solutions – Vonderbrink 17 (#19) – 1 block
REACTIONS ***Electrochemistry***	**21.1** Be able to assign oxidation numbers to the atoms in a compound. **21.2** Identify species that are oxidized and reduced in a redox reaction. Identify redox reactions, the species oxidized, reduced, the oxidizing agent, and the reducing agent. **21.3** Balance redox reactions by using oxidation number method and half-reactions method. **21.4** Diagram and label electrochemical cells, both voltaic and electrolytic. **21.5** Given electrode potentials, predict if a reaction is spontaneous. Calculate the emf of voltaic cell given electrode potentials. **21.6** Calculate the cell potential for a "concentration Cell" **21.7** Be able to calculate any variable in the Nernst equation given the others. **21.8** Calculate the maximum electrical work performed by a voltaic cell. Interconvert E°, ΔG°, and K for a redox reaction. **21.9** Calculate time, current, or amount of a substance produced by electrolysis, given the other two.	Determination of electrochemical series-Vonderbrink 7 (#20) – 1 block Electrochemical cells-Vonderbrink 22 (#21) – 1 block Electrolysis – Vonderbrink 23 (#21) – 1 block Analysis of a commercial bleach – Vonderbrink 21 (#8) – 1 block

UNIT CONTENT	CONTENT LEARNING OBJECTIVES	HANDS-ON LABS
REACTIONS ***Organic Chemistry*** Text: Chap 22	**22.1** Understand and be able to identify structural isomers. **22.2** Predict products and write balanced molecular equations for addition, substitution, combustion and dehydration reactions.	Synthesis, isolation and purification of an ester – Vonderbrink 25 (#22)
REACTIONS ***Complex Ions*** Text: 21.3	**23.1** Given the name of a complex ion, write its formula. **23.2** Given the formula of a complex ion, write its name. **23.3** Predict the products and write balanced molecular equations for formations of complexes of common ligands. **23.4** Predict the products and write balanced molecular equations for lewis acid-base reactions.	Separation and qualitative analysis of cations and anions – Vonderbrink 19 (#14)
DESCRIPTIVE CHEMISTRY (This content is integrated with other units throughout both semesters) ***The Representative Elements: Groups 1A Through 4A*** ***The Representative Elements: Groups 5A Through 8A*** ***Transition Metals and Coordination Chemistry*** ***Organic and Biological Molecules***	Be able to predict products of chemical reactions and write balanced molecular, ionic and net ionic chemical equations.	