Course Description:
The stated purpose of Advanced Placement Chemistry is to provide a college level course in chemistry to which a student can apply to receive college credit. However, many of my students who qualify for credit have chosen to take the first-year Chemistry in college anyway. Our school offers one section of AP Chemistry which will meet for a full year. The section is broken down into a lecture block which meets for a full year meeting every other day for 87 minutes (approximately 130 hours) and and lab block which meets for the first semester meeting every other day for 87 minutes (approximately 75 hours). We will do labs during lecture sessions and visa versa as needed in order to complete the required 16 labs before the AP Exam. This has been a struggle in the past as our school as never had extra classes built into the schedule until now.

It is required to have a full year of Honors Chemistry (approximately 130 hours, meeting every other day for 87 minutes) prior to taking AP Chemistry and follows the AP Chemistry framework, thus has been included in our AP Chemistry curriculum. The delivery model results in over 270 hours chemistry instruction during their high school years.

Expectations (Assessment Information):
1. Students are expected to collaborate with other students in flexible working groups to complete the study guides, computer simulations, and other guided activities. Google Classroom will be used for distributing certain assignments.

2. Students should expect homework daily. Answers will be posted and/or we will go over the assignment. Students will receive credit for completing it prior to the assessment. Homework is practice and is of little use after an exam. Homework not completed prior to the assessment will receive a grade equivalent to the assessment grade.

3. Unit tests are given upon completion of each topic. In addition, our school has initiated a program where students complete a Benchmark Assessments These are designed to mimic a standardized test in the subject area. The results are used to identify areas where students may need more support and to drive instruction. A comprehensive, standardized semester exam is administered at the end of 1st semester (January) and a final exam at the end of the year (June). The AP Exam will serve in this capacity.

4. The laboratory portion of this class is designed to be the equivalent of a college laboratory experience. All of the experiments are designed to be hands-on with students working as a team. Students collect, process, manipulate, and graph data from both qualitative and quantitative observations. The laboratory work requires students to design, carry out, and analyze data using guided inquiry principles. All of the labs have been or are currently being modified to focus on inquiry and to ensure the following seven Science Practices are being fulfilled.

Objectives:
1. Learn the inquiry process through numerous laboratory investigations.
2. Gain an understanding of the six big ideas as articulated in the Curriculum Framework.
3. Apply mathematical and scientific knowledge and skills to solve problems.
4. Apply basic arithmetic, algebraic, and geometric concepts.
5. Formulate strategies for the development and testing of hypotheses.
6. Use basic statistical concepts to draw both inferences and conclusions from data.
7. Identify implications and consequences of drawn conclusions.
8. Use manipulative and technological tools including the PASCO GSX 300 and DataStudio.
9. Measure, compare, order, scale, locate, and code accurately.
10. Do scientific research and report and display the results of this research.
11. Learn to think critically in order to solve problems.

Textbook, Laboratory Manuals, and Study Guides:
Laboratory:
The laboratory portion of this class is designed to be the equivalent of a college laboratory experience. All of the experiments are designed to be hands-on with students working as a team. Students collect, process, manipulate, and graph data from both qualitative and quantitative observations. The laboratory work requires students to design, carry out, and analyze data using guided inquiry principles. All of the labs have been or are currently being modified to focus on inquiry and to ensure the following seven Science Practices are being fulfilled.

Science Practice 1: The student can use representations and models to communicate scientific phenomena and solve scientific problems.

Science Practice 2: The student can use mathematics appropriately.

Science Practice 3: The student can engage in scientific questioning to extend thinking or to guide investigations within the context of the AP course.

Science Practice 4: The student can plan and implement data collection strategies in relation to a particular scientific question.

Science Practice 5: The student can perform data analysis and evaluation of evidence.

Science Practice 6: The student can work with scientific explanations and theories.

Science Practice 7: The student is able to connect and relate knowledge across various scales, concepts, and representations in and across domains.

Students are required to report the purpose, procedure, all data, data analysis, error analysis, results, and conclusions in a lab report that is submitted for grading. However, Inquiry labs do not necessarily lend themselves to traditional lab reports and assessment. With this in mind I switched from a traditional format to a different structure for student lab write-ups to the Science Writing Heuristic (SWH) format described in the AP Chemistry – Guided Inquiry Experiments manual (2013). Students do their write-ups in a lab notebook and answer a series of directed questions the same as or similar to the following:

- What is the beginning question?
- How will I conduct the investigation?
- How will I stay safe?
- What observations and measurements did I make?
- What can I claim? What evidence do I have to support the claim?
- How do my ideas and results compare with others and to the literature?
- How have my ideas changed?
Labs will be assessed using the following (or similar) scoring rubric:

<table>
<thead>
<tr>
<th>Criteria (each given 0–4 points)</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
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</thead>
<tbody>
<tr>
<td>1. Can the beginning questions be potentially answered by the results of the lab?</td>
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<td>2. What is the quality of the data and observations?</td>
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<td>3. Are the claims a direct result of the data and observations?</td>
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<td>4. How well are your data and observations used in your evidence?</td>
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<tr>
<td>5. Are the claims backed up in the evidence?</td>
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<tr>
<td>6. How well does the student answer all of the questions asked in the lab report write-up for this experiment?</td>
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<tr>
<td>7. How well does the student analyze the data and observations to make the experimental measurements of observations meaningful?</td>
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<tr>
<td>8. Do the results of the experiment come close to the accepted values or identify an unknown compound correctly or show an accepted comparison, trend, etc.?</td>
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<td>9. In the reflection and readings how many sources are used and how are they connected?</td>
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<tr>
<td>10. Do the student’s reading and reflection discuss the student’s initial questions?</td>
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<tr>
<td>Do they aid the student’s claims and evidence?</td>
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<tr>
<td>TOTAL POINTS EARNED (out of 40)</td>
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</tbody>
</table>

Since using this format with my Honors Chemistry and Extended Chemistry, I have increased my on-time collection rates to nearly 100% even in my Extended Classes. Student understanding has also increased as they collaborate to develop experimental designs themselves. Perhaps the best indicator of success for this method is that they prefer this approach.

Students are encouraged to collaborate when writing portions of their lab reports. In some cases they are required to use Google Docs, which allows students to create, store, and share documents and spreadsheets in order for the whole class to compare the collected data.

For the AP Chemistry specific lab investigations, we will be using the Advanced Inquiry Labs for AP* Chemistry 16-Kit Bundle from Flinn Scientific, Inc. has the necessary supplies for completing the new recommended AP Chemistry Laboratory Investigations.

At a minimum, twenty-five percent of instructional time will be spent in the laboratory.

Laboratory Notebook:
A laboratory notebook is required for the course. All completed lab reports documenting all lab experiences must be included in the notebook. The notebook will be checked every periodically and will be saved as it serves as a record which may be requested by the Chemistry Department at a college or university.

Tests:
Unit tests are given upon completion of each topic. In addition, our school has initiated a program where students complete a Benchmark Assessment designed to mimic a standardized test in the subject area. The results are used to identify areas where students may need more support and to drive instruction. A comprehensive, standardized semester exam is administered at the end of 1st semester (January) and a final exam at the end of the year (June).

Emphasis for all assessments is placed on depth of understanding of a topic, rather than breadth of topics.

AP Exam Review:
Students are strongly encouraged to take the Local Chemistry Olympiad test administered by the New Haven section of the ACS in March.

The final five full class days (87 min.) before the AP Chemistry Exam are used for exam review and practice
tests using old AP Chemistry exam materials. Students work in cooperative groups to solve a packet of free response problems from previous exams. Students practice net ionic equations and are quizzed on their progress. Several practice AP Exams are administered as part of the two-week review prior to the AP Chemistry Exam.

Note:
After the AP Exam is administered students complete a Final Exhibition Project. Students will demonstrate mastery of several topics we have covered during the past year and quite possibly, some we haven’t! Working in a team or individually students will demonstrate mastery by creating a multimedia and written document that will be presented to the class. This project will be more in-depth than the project that students completed in Honors Chemistry.

Also, for the past three years our district has had two weeks of weather related days off. In fact this year our school year does not end until June 28. Therefore, due to time constraints, it is possible that a lab may be completed after the AP Exam is given.
### Course Outline: Honors Chemistry

<table>
<thead>
<tr>
<th>Chemistry Topic</th>
<th>Reference: Chang Chemistry</th>
<th>Chapters: Buthelezi Chemistry</th>
</tr>
</thead>
</table>
| **Unit 1** Chemistry – The Study of Change *(BI 2)* | 1) Chemistry: The Study of Change | 1) Introduction to Chemistry  
2) Analyzing Data  
3) Matter – Properties and Changes |
| **Unit 2** Atoms, Molecules, & Ions - Part 1) Atomic Theory - Part 2) Periodic Law - Part 3) Nomenclature *(BI 1 & 2)* | 2) Atoms, Molecules, and Ions  
7) Quantum Chemistry  
8) Periodic Relationships | 4) The Structure of the Atoms  
5) Electrons in Atoms  
6) The Periodic Table and Periodic Law  
7.3) Names and Formulas for Ionic Compounds  
8.2) Naming Molecules |
| **Unit 3** Chemical Bonding *(BI 1 & 2)* | 9) Chemical Bonding I  
10) Chemical Bonding II | 7) Ionic Compounds and Metals  
8) Covalent Bonding |
| **Unit 5** Chemical Bonding *(BI 1 & 2)* | 9) Chemical Bonding I  
10) Chemical Bonding II | 7) Ionic Compounds and Metals  
8) Covalent Bonding |
| **Unit 6** Solutions *(BI 2)* | 12) Physical Properties of Solutions  
15) Acids and Bases | 14) Mixtures and Solutions  
18) Acids and Bases |
| **Unit 7** Solids and Liquids *(BI 1 & 2)* | 11) Intermolecular Forces and Liquids and Solids | 12.2-12.4, 15.1) States of Matter |
| **Unit 8** Gases *(BI 1 & 2)* | 5) Gases | 12.1, 13) Gases |

### Course Outline: AP Chemistry

<table>
<thead>
<tr>
<th>AP Chemistry Topic</th>
<th>Chapters: Chang Chemistry</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Review</strong> - Honors Chemistry <em>(BI 1 - 3)</em></td>
<td>1-5, 7, 8, 9-11</td>
</tr>
<tr>
<td><strong>Unit 9</strong> Thermochemistry <em>(BI 5)</em></td>
<td>6) Thermochemistry</td>
</tr>
<tr>
<td><strong>Unit 10</strong> Thermodynamics <em>(BI 5)</em></td>
<td>18) Entropy, Free Energy, and Equilibrium</td>
</tr>
<tr>
<td><strong>Unit 11</strong> Solutions and Solubility <em>(BI 2)</em></td>
<td>12) Physical Properties of Solutions</td>
</tr>
<tr>
<td><strong>Unit 12</strong> Kinetics <em>(BI 4)</em></td>
<td>13) Chemical Kinetics</td>
</tr>
<tr>
<td><strong>Unit 13</strong> Chemical Equilibrium <em>(BI 6)</em></td>
<td>14) Chemical Equilibrium</td>
</tr>
</tbody>
</table>
| **Unit 14** Acid Base Chemistry *(BI 6)* | 15) Acids and Bases  
16) Acid-Base Equilibria and Solubility Equilibria |
| **Unit 15** Electrochemistry *(BI 3)* | 19) Electrochemistry |
| **Review** - All Topics *(BI 1 - 6)* | AP Chemistry Exam Review |

**AP CHEMISTRY**

**REVIEW - Honors Chemistry (2.0 weeks)**

Class Periods (87 minutes): 6

<table>
<thead>
<tr>
<th>Learning Objectives</th>
<th>(LO 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 1.14, 1.15, 1.19, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.9, 2.10, 2.11, 2.12, 2.13, 2.16, 2.19, 2.20, 5.10, 5.11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>The student can justify the observation that the ratio of the masses of the constituent elements in any pure sample of that compound is always identical on the basis of the atomic molecular theory. [Essential knowledge 1.A.1]</td>
</tr>
<tr>
<td>1.2</td>
<td>The student is able to select and apply mathematical routines to mass data to identify or infer the composition of pure substances and/or mixtures. [Essential knowledge 1.A.2]</td>
</tr>
<tr>
<td>1.3</td>
<td>The student is able to select and apply mathematical relationships to mass data in order to justify a claim regarding the identity and/or estimated purity of a substance. [Essential knowledge 1.A.2]</td>
</tr>
<tr>
<td>1.4</td>
<td>The student is able to connect the number of particles, moles, mass, and volume of substances to one another, both qualitatively and quantitatively. [Essential knowledge 1.A.3]</td>
</tr>
<tr>
<td>1.5</td>
<td>The student is able to explain the distribution of electrons in an atom or ion based upon data. [Essential knowledge 1.B.1]</td>
</tr>
<tr>
<td>1.6</td>
<td>The student is able to analyze data relating to electron energies for patterns and relationships. [Essential knowledge 1.B.1]</td>
</tr>
<tr>
<td>1.7</td>
<td>The student is able to describe the electronic structure of the atom, using PES data, ionization energy data, and/or Coulomb’s law to construct explanations of how the energies of electrons within shells in atoms vary. [Essential knowledge 1.B.2]</td>
</tr>
<tr>
<td>1.8</td>
<td>The student is able to explain the distribution of electrons using Coulomb’s law to analyze measured energies. [Essential knowledge 1.B.2]</td>
</tr>
<tr>
<td>1.9</td>
<td>The student is able to predict and/or justify trends in atomic properties based on location on the periodic table and/or the shell model. [Essential knowledge 1.C.1]</td>
</tr>
<tr>
<td>1.14</td>
<td>The student is able to use data from mass spectrometry to identify the elements and the masses of individual atoms of a specific element. [Essential knowledge 1.D.2]</td>
</tr>
<tr>
<td>1.15</td>
<td>The student can justify the selection of a particular type of spectroscopy to measure properties associated with vibrational or electronic motions of molecules. [Essential knowledge 1.D.3]</td>
</tr>
<tr>
<td>1.19</td>
<td>The student can design, and/or interpret data from, an experiment that uses gravimetric analysis to determine the concentration of an analyte in a solution. [Essential knowledge 1.E.2]</td>
</tr>
<tr>
<td>2.1</td>
<td>Students can predict properties of substances based on their chemical formulas, and provide explanations of their properties based on particle views. [Essential knowledge components of 2.A–2.D]</td>
</tr>
<tr>
<td>2.2</td>
<td>The student is able to explain the relative strengths of acids and bases based on molecular structure, interparticle forces, and solution equilibrium. [Essential knowledge components of 2.A–2.D]</td>
</tr>
<tr>
<td>2.3</td>
<td>The student is able to use aspects of particulate models (i.e., particle spacing, motion, and forces of attraction) to reason about observed differences between solid and liquid phases and among solid and liquid materials. [Essential knowledge 2.A.1]</td>
</tr>
<tr>
<td>2.4</td>
<td>The student is able to use KMT and concepts of intermolecular forces to make predictions about the macroscopic properties of gases, including both ideal and nonideal behaviors. [Essential knowledge 2.A.2]</td>
</tr>
<tr>
<td>2.5</td>
<td>The student is able to refine multiple representations of a sample of matter in the gas phase to accurately represent the effect of changes in macroscopic properties on the sample. [Essential knowledge 2.A.2]</td>
</tr>
<tr>
<td>---------</td>
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</tr>
<tr>
<td>1.A.1</td>
<td>Molecules are composed of specific combinations of atoms; different molecules are composed of combinations of different elements and of combinations of the same elements in differing amounts and proportions.</td>
</tr>
<tr>
<td>1.A.2</td>
<td>Chemical analysis provides a method for determining the relative number of atoms in a substance, which can be used to identify the substance or determine its purity.</td>
</tr>
<tr>
<td>1.A.3</td>
<td>The mole is the fundamental unit for counting numbers of particles on the macroscopic level and allows quantitative connections to be drawn between laboratory experiments, which occur at the macroscopic level, and chemical processes, which occur at the atomic level.</td>
</tr>
<tr>
<td>1.B.1</td>
<td>The atom is composed of negatively charged electrons, which can leave the atom, and a positively charged nucleus that is made of protons and neutrons. The attraction of the electrons to the nucleus is the basis of the structure of the atom. Coulomb’s law is qualitatively useful for understanding the structure of the atom.</td>
</tr>
</tbody>
</table>
1.B.2 The electronic structure of the atom can be described using an electron configuration that reflects the concept of electrons in quantized energy levels or shells; the energetics of the electrons in the atom can be understood by consideration of Coulomb’s law.

1.C.1 Many properties of atoms exhibit periodic trends that are reflective of the periodicity of electronic structure.

1.D.2 An early model of the atom stated that all atoms of an element are identical. Mass spectrometry data demonstrate evidence that contradicts this early model.

1.D.3 The interaction of electromagnetic waves or light with matter is a powerful means to probe the structure of atoms and molecules, and to measure their concentration.

1.E.2 Conservation of atoms makes it possible to compute the masses of substances involved in physical and chemical processes. Chemical processes result in the formation of new substances, and the amount of these depends on the number and the types and masses of elements in the reactants, as well as the efficiency of the transformation.

2.A.1 The different properties of solids and liquids can be explained by differences in their structures, both at the particulate level and in their supramolecular structures.

2.A.2 The gaseous state can be effectively modeled with a mathematical equation relating various macroscopic properties. A gas has neither a definite volume nor a definite shape; because the effects of attractive forces are minimal, we usually assume that the particles move independently.

2.A.3 Solutions are homogenous mixtures in which the physical properties are dependent on the concentration of the solute and the strengths of all interactions among the particles of the solutes and solvent.

2.B.1 London dispersion forces are attractive forces present between all atoms and molecules. London dispersion forces are often the strongest net intermolecular force between large molecules.

2.B.2 Dipole forces result from the attraction among the positive ends and negative ends of polar molecules. Hydrogen bonding is a strong type of dipole-dipole force that exists when very electronegative atoms (N, O, and F) are involved.

2.B.3 Intermolecular forces play a key role in determining the properties of substances, including biological structures and interactions.

2.C.1 In covalent bonding, electrons are shared between the nuclei of two atoms to form a molecule or polyatomic ion. Electronegativity differences between the two atoms account for the distribution of the shared electrons and the polarity of the bond.

2.C.2 Ionic bonding results from the net attraction between oppositely charged ions, closely packed together in a crystal lattice.

2.C.3 Metallic bonding describes an array of positively charged metal cores surrounded by a sea of mobile valence electrons.

2.C.4 The localized electron bonding model describes and predicts molecular geometry using Lewis diagrams and the VSEPR model.

2.D.1 Ionic solids have high melting points, are brittle, and conduct electricity only when molten or in solution.

2.D.2 Metallic solids are good conductors of heat and electricity, have a wide range of melting points, and are shiny, malleable, ductile, and readily alloyed.

2.D.3 Covalent network solids generally have extremely high melting points, are hard, and are thermal insulators. Some conduct electricity.

2.D.4 Molecular solids with low molecular weight usually have low melting points and are not expected to conduct electricity as solids, in solution, or when molten.

5.D.2 At the particulate scale, chemical processes can be distinguished from physical processes because chemical bonds can be distinguished from intermolecular interactions.
| Assignments | Review Summer Assignment  
Selected activities from 5 Steps to a 5 AP Chemistry  
Previous Chemistry Olympiad Questions |
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Other Activities</td>
<td>Students use a mass spectrometer printout of relative masses of isotopes of an element to determine (a) the percentages of the isotopes and (b) the average atomic mass of the element.</td>
</tr>
</tbody>
</table>
| Laboratory Experiments | **GUIDED INQUIRY Lab 1:** What Makes Water Hard (LO 1.19, SP 4.2, 5.1, 6.4)  
**GUIDED INQUIRY Lab 2:** Separation of a Dye Mixture Using Chromatography (LO 2.1, SP 4.2, 5.1, 6.4) |
Two systems with different temperatures that are in thermal contact will exchange energy. The quantity of thermal energy transferred from one system to another is called heat. (5.A)

Energy is neither created nor destroyed, but only transformed from one form to another. (5.B)

Breaking bonds requires energy, and making bonds releases energy. (5.C)

(LO 3.11, 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8)

3.11 The student is able to interpret observations regarding macroscopic energy changes associated with a reaction or process to generate a relevant symbolic and/or graphical representation of the energy changes. [Essential knowledge 3.C.2]

5.1 The student is able to create or use graphical representations in order to connect the dependence of potential energy to the distance between atoms and factors, such as bond order (for covalent interactions) and polarity (for intermolecular interactions), which influence the interaction strength. [Essential knowledge 5.A – 5.E]

5.2 The student is able to relate temperature to the motions of particles, either via particulate representations, such as drawings of particles with arrows indicating velocities, and/or via representations of average kinetic energy and distribution of kinetic energies of the particles, such as plots of the Maxwell-Boltzmann distribution. [Essential knowledge 5.A.1]

5.3 The student can generate explanations or make predictions about the transfer of thermal energy between systems based on this transfer being due to a kinetic energy transfer between systems arising from molecular collisions. [Essential knowledge 5.A.2]

5.4 The student is able to use conservation of energy to relate the magnitudes of the energy changes occurring in two or more interacting systems, including identification of the systems, the type (heat versus work), or the direction of energy flow. [Essential knowledge 5.B.1, 5.B.2]

5.5 The student is able to use conservation of energy to relate the magnitudes of the energy changes when two nonreacting substances are mixed or brought into contact with one another. [Essential knowledge 5.B.1, 5.B.2]

5.6 The student is able to use calculations or estimations to relate energy changes associated with heating/cooling a substance to the heat capacity, relate energy changes associated with a phase transition to the enthalpy of fusion/vaporization, relate energy changes associated with a chemical reaction to the enthalpy of the reaction, and relate energy changes to PΔV work. [Essential knowledge 5.B.3]

5.7 The student is able to design and/or interpret the results of an experiment in which calorimetry is used to determine the change in enthalpy of a chemical process (heating/cooling, phase transition, or chemical reaction) at constant pressure. [Essential knowledge 5.B.4]

5.8 The student is able to draw qualitative and quantitative connections between the reaction enthalpy and the energies involved in the breaking and formation of chemical bonds. [Essential knowledge 5.C.2]
5.B.2 When two systems are in contact with each other and are otherwise isolated, the energy that comes out of one system is equal to the energy that goes into the other system. The combined energy of the two systems remains fixed. Energy transfer can occur through either heat exchange or work.

5.B.3 Chemical systems undergo three main processes that change their energy: heating/cooling, phase transitions, and chemical reactions.

5.B.4 Calorimetry is an experimental technique that is used to determine the heat exchanged/transferred in a chemical system.

5.C.1 Potential energy is associated with a particular geometric arrangement of atoms or ions and the electrostatic interactions between them.

5.C.2 The net energy change during a reaction is the sum of the energy required to break the bonds in the reactant molecules and the energy released in forming the bonds of the product molecules. The net change in energy may be positive for endothermic reactions where energy is required, or negative for exothermic reactions where energy is released.

5.D.1 Potential energy is associated with the interaction of molecules; as molecules draw near each other, they experience an attractive force.

5.D.2 At the particulate scale, chemical processes can be distinguished from physical processes because chemical bonds can be distinguished from intermolecular interactions.

5.D.3 Noncovalent and intermolecular interactions play important roles in many biological and polymer systems.

5.E.1 Entropy is a measure of the dispersal of matter and energy.

5.E.2 Some physical or chemical processes involve both a decrease in the internal energy of the components (ΔH° < 0) under consideration and an increase in the entropy of those components (ΔS° > 0). These processes are necessarily “thermodynamically favored” (ΔG° < 0).

5.E.3 If a chemical or physical process is not driven by both entropy and enthalpy changes, then the Gibbs free energy change can be used to determine whether the process is thermodynamically favored.

5.E.4 External sources of energy can be used to drive change in cases where the Gibbs free energy change is positive.

5.E.5 A thermodynamically favored process may not occur due to kinetic constraints (kinetic vs. thermodynamic control).


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**Assignments**

**Chapter 6 – Thermochemistry**

Read: Pages 229-273

Problems: 14, 16, 22, 26, 28, 32, 33, 34, 36, 52, 53, 54, 56, 62, 63, 64, 80

(NOTE: problems may be omitted or change)

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**Laboratory Experiments**

**GUIDED INQUIRY** Lab 3: Designing a Hand Warmer (LO 5.7, 5.6; SP 2.2, 2.3, 4.2, 5.1, 6.4)

**GUIDED INQUIRY** Lab 4: Qualitative Analysis and Chemical Bonding (LO 2.22, 2.24; SP 1.1, 4.2, 6.2, 6.4, 7.1)

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**Other Activities**

Working with partners students will complete classroom activities where they determine the heats of reaction. Students check their understanding by completing online quizzes from the Glencoe Learning Center.

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**Review**

Woodrum (Chang Study Guide) Chapter 6: pages 133-134, exercises 1-18

(NOTE: problems may be omitted or change)
UNIT 10: Thermodynamics
Class Periods (87 minutes): 10

Enduring Understanding

- Chemical or physical processes are driven by a decrease in enthalpy or an increase in entropy, or both. (5.E)
- The equilibrium constant is related to temperature and the difference in Gibbs free energy between reactants and products. (6.D)

Learning Objectives

(3.10, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.12, 5.13, 5.14, 5.15, 5.16, 5.17, 5.18, 6.24, 6.25)

3.10 The student is able to evaluate the classification of a process as a physical change, chemical change, or ambiguous change based on both macroscopic observations and the distinction between rearrangement of covalent interactions and noncovalent interactions. [See SP 1.4, 6.1; Essential knowledge 3.C.1, connects to 5.D.2]

5.3 The student can generate explanations or make predictions about the transfer of thermal energy between systems based on this transfer being due to a kinetic energy transfer between systems arising from molecular collisions. [See SP 7.1; Essential knowledge 5.A.2]

5.4 The student is able to use conservation of energy to relate the magnitudes of the energy changes occurring in two or more interacting systems, including identification of the systems, the type (heat versus work), or the direction of energy flow. [See SP 1.4, 2.2, connects to Essential knowledge 5.B.1, 5.B.2]

5.5 The student is able to use conservation of energy to relate the magnitudes of the energy changes when two nonreacting substances are mixed or brought into contact with one another. [See SP 2.2, connects to Essential knowledge 5.B.1, 5.B.2]

5.6 The student is able to use calculations or estimations to relate energy changes associated with heating/cooling a substance to the heat capacity, relate energy changes associated with a phase transition to the enthalpy of fusion/vaporization, relate energy changes associated with a chemical reaction to the enthalpy of the reaction, and relate energy changes to PΔV work. [See SP 2.2, 2.3; Essential knowledge 5.B.3]

5.7 The student is able to design and/or interpret the results of an experiment in which calorimetry is used to determine the change in enthalpy of a chemical process (heating/cooling, phase transition, or chemical reaction) at constant pressure. [See SP 4.2, 5.1; Essential knowledge 5.B.4]

5.8 The student is able to draw qualitative and quantitative connections between the reaction enthalpy and the energies involved in the breaking and formation of chemical bonds. [See SP 2.3, 7.1, 7.2; Essential knowledge 5.C.2]

5.12 The student is able to use representations and models to predict the sign and relative magnitude of the entropy change associated with chemical or physical processes. [See SP 1.4; Essential knowledge 5.E.1]

5.13 The student is able to predict whether or not a physical or chemical process is thermodynamically favored by determination of (either quantitatively or qualitatively) the signs of both ΔH° and ΔS°, and calculation or estimation of ΔG° when needed. [See SP 2.2, 2.3, 6.4; Essential knowledge 5.E.2, connects to 5.E.3]

5.14 The student is able to determine whether a chemical or physical process is thermodynamically favorable by calculating the change in standard Gibbs free energy. [See SP 2.2; Essential knowledge 5.E.3, connects to 5.E.2]

5.15 The student is able to explain how the application of external energy sources or the coupling of favorable with unfavorable reactions can be used to cause processes that are not thermodynamically favorable to become favorable. [See SP 6.2; Essential
<table>
<thead>
<tr>
<th>Knowledge &amp; Assignments</th>
<th>Content</th>
<th>Assignments</th>
<th>Laboratory Experiments</th>
<th>Other Activities</th>
<th>Review</th>
</tr>
</thead>
</table>
| 5.16 The student can use LeChatelier’s principle to make qualitative predictions for systems in which coupled reactions that share a common intermediate drive formation of a product. [See SP 6.4; Essential knowledge 5.E.4, connects to 6.B.1] | Three Laws of Thermodynamics, Spontaneous Processes, Entropy, Gibbs Free Energy, and Equilibrium. | Chapter 18 – Entropy, Free Energy & Equilibrium
Read: Pages 801-834
Problems: 3, 5, 9, 10, 11, 12, 15, 16, 18, 20, 21, 22, 23, 24, 26, 27, 28 (NOTE: problems may be omitted or change) | GUIDED INQUIRY Lab 5: Separation of a Synthetic Pain Relief Mixture (LO 3.10; SP 1.4, 6.1) | Working with partners students will complete classroom activities where they predict whether reactions occur spontaneously or not based on thermodynamic data. Students check their understanding by completing online quizzes from the Glencoe Learning Center. | Woodrum (Chang Study Guide) Chapter 18: pages 423-424, exercises 1-14 (NOTE: problems may be omitted or change) Selected activities from 5 Steps to a 5 AP Chemistry Previous Chemistry Olympiad Questions |
## Enduring Understanding

- Chemical changes are represented by a balanced chemical equation that identifies the ratios with which reactants react and products form. (3.A)
- Chemical and physical transformations may be observed in several ways and typically involve a change in energy. (3.C)

## Learning Objectives

### (1.15, 1.16, 1.19, 1.20, 2.8, 2.9, 2.14, 2.15, 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7)

#### 1.15
The student can justify the selection of a particular type of spectroscopy to measure properties associated with vibrational or electronic motions of molecules. [See SP 4.1; Essential knowledge 1.D.3]

#### 1.16
The student can design and/or interpret the results of an experiment regarding the absorption of light to determine the concentration of an absorbing species in a solution. [See SP 4.2, 5.1; Essential knowledge 1.D.3]

#### 1.19
The student can design, and/or interpret data from, an experiment that uses gravimetric analysis to determine the concentration of an analyte in a solution. [See SP 4.2, 5.1; Essential knowledge 1.E.2]

#### 1.20
The student can design, and/or interpret data from, an experiment that uses titration to determine the concentration of an analyte in a solution. [See SP 4.2, 5.1; Essential knowledge 1.E.2]

#### 2.8
The student can draw and/or interpret representations of solutions that show the interactions between the solute and solvent. [See SP 1.1, 1.2, 6.4; Essential knowledge 2.A.3]

#### 2.9
The student is able to create or interpret representations that link the concept of molarity with particle views of solutions. [See SP 1.1, 1.4; Essential knowledge 2.A.3]

#### 2.14
The student is able to apply Coulomb’s Law qualitatively (including using representations) to describe the interactions of ions, and the attractions between ions and solvents to explain the factors that contribute to the solubility of ionic compounds. [See SP 1.4, 6.4; Essential knowledge 2.B.2]

#### 2.15
The student is able to explain observations regarding the solubility of ionic solids and molecules in water and other solvents on the basis of particle views that include intermolecular interactions and entropic effects. [See SP 1.4, 6.2; Essential knowledge 2.B.3, connects to 5.E.1]

#### 3.1
Students can translate among macroscopic observations of change, chemical equations, and particle views. [See SP 1.5, 7.1; Essential knowledge components of 3.A-3.C]

#### 3.2
The student can translate an observed chemical change into a balanced chemical equation and justify the choice of equation type (molecular, ionic, or net ionic) in terms of utility for the given circumstances. [See SP 1.5, 7.1; Essential knowledge 3.A.1]

#### 3.3
The student is able to use stoichiometric calculations to predict the results of performing a reaction in the laboratory and/or to analyze deviations from the expected results. [See SP 2.2, 5.1; Essential knowledge 3.A.2]

#### 3.4
The student is able to relate quantities (measured mass of substances, volumes of solutions, or volumes and pressures of gases) to identify stoichiometric relationships for a reaction, including situations involving limiting reactants and situations in which the reaction has not gone to completion. [See SP 2.2, 5.1, 6.4; Essential knowledge 3.A.2]

#### 3.5
The student is able to design a plan in order to collect data on the synthesis or decomposition of a compound to confirm the conservation of matter and the law of definite proportions. [See SP 2.1, 4.2; Essential knowledge 3.B.1]

#### 3.6
The student is able to use data from synthesis or decomposition of a compound to confirm the conservation of matter and the law of definite proportions. [See SP 2.2, 6.1; Essential knowledge 3.B.1]
### Content
Types of Solutions, Energy/Solution Formation, Concentration - (% mass, M, m), effects of temperature and pressure (Henry’s Law) on solubility.

**Note:** This unit involves a more in depth study than was done in Honors Chemistry.

### Assignments
**Chapter 12 – Physical Properties of Solutions**
- **Read:** Pages 512-525 (546-547)
- **Problems:** 5, 6, 8, 10, 12, 14, 15, 16, 18, 21, 24, 27, 28, 36, 37

(NOTE: problems may be omitted or change)

### Laboratory Experiments
**GUIDED INQUIRY Lab 6: Analysis of Food Dyes in Beverages** (LO 1.15, 1.16; SP 4.1, 4.2, 5.1, 6.4)

### Other Activities
- Working with partners students will complete classroom activities where they prepare standard solutions. Also, students will use PhET computer simulations to complete problems dealing with molarity, concentrations, and solubility.

Students check their understanding by completing online quizzes from the Glencoe Learning Center.

### Review
Woodrum (Chang Study Guide) Chapter 12: pages 268-270, exercises 3-5, 7, 11, 12, 15, 22-28

(NOTE: problems may be omitted or change)

Selected activities from 5 Steps to a 5 AP Chemistry

Previous Chemistry Olympiad Questions

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**UNIT 12: Kinetics**

**Class Periods (87 minutes): 13**

### Enduring Understanding
- Reaction rates that depend on temperature and other environmental factors are determined by measuring changes in concentrations of reactants or products over time. (4.A)
- Elementary reactions are mediated by collisions between molecules. Only collisions having sufficient energy and proper relative orientation of reactants lead to products. (4.B)
- Many reactions proceed via a series of elementary reactions. (4.C)
- Reaction rates may be increased by the presence of a catalyst. (4.D)

### Learning Objectives

#### 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9

4.1 The student is able to design and/or interpret the results of an experiment regarding the factors (i.e., temperature, concentration, surface area) that may influence the rate of a reaction. [See SP 4.2, 5.1; Essential knowledge 4.A.1]

4.2 The student is able to analyze concentration vs. time data to determine the rate law for a zeroth-, first-, or second-order reaction. [See SP 5.1; Essential knowledge 4.A.2, connects to 4.A.3]

4.3 The student is able to connect the half-life of a reaction to the rate constant of a first-order reaction and justify the use of this relation in terms of the reaction being a first-order reaction. [See SP 2.1, 2.2; Essential knowledge 4.A.3]

4.4 The student is able to connect the rate law for an elementary reaction to the frequency and success of molecular collisions, including connecting the frequency and success to the order and rate constant, respectively. [See SP 7.1; Essential knowledge 4.B.1, connects to 4.A.3, 4.B.2]

4.5 The student is able to explain the difference between collisions that convert
reactants to products and those that do not in terms of energy distributions and molecular orientation. [See SP 6.2; Essential knowledge 4.B.2]

4.6 The student is able to use representations of the energy profile for an elementary reaction (from the reactants, through the transition state, to the products) to make qualitative predictions regarding the relative temperature dependence of the reaction rate. [See SP 1.4, 6.4; Essential knowledge 4.B.3]

4.7 The student is able to evaluate alternative explanations, as expressed by reaction mechanisms, to determine which are consistent with data regarding the overall rate of a reaction, and data that can be used to infer the presence of a reaction intermediate. [See SP 6.5; connects to Essential knowledge 4.C.1, 4.C.2, 4.C.3]

4.8 The student can translate among reaction energy profile representations, particulate representations, and symbolic representations (chemical equations) of a chemical reaction occurring in the presence and absence of a catalyst. [See SP 1.5; Essential knowledge 4.D.1]

4.9 The student is able to explain changes in reaction rates arising from the use of acid-base catalysts, surface catalysts, or enzyme catalysts, including selecting appropriate mechanisms with or without the catalyst present. [See SP 6.2, 7.2; Essential knowledge 4.D.2]

Content
- Reaction Rates, Factors Affecting Reaction Rate, Collision Theory, Activation Energy, Arrhenius Equation, PE Diagrams, Rate Laws (Integrated), Half Life of Zero, 1st, and 2nd, Reaction Mechanisms, Catalysis

Assignments
- Chapter 13 – Chemical Kinetics
  - Read: Pages 556-613
  - Problems: 6, 8, 12, 14, 15, 20, 21, 25, 26, 28, 37*, 38, 40, 42, 52, 55, 62, 64, 66, 73, 74
  - (NOTE: problems may be omitted or change)

Laboratory Experiments
- GUIDED INQUIRY Lab 7: Rate of Decomposition of Calcium Carbonate (LO 4.1, 4.2; SP 4.2, 5.1, 6.4)
- GUIDED INQUIRY Lab 8: kinetics of Violet Fading (LO 4.2; SP 4.2, 5.1)

Other Activities
- Working in a team students will complete classroom activities where they determine rate at which reactions occur. In addition, students will use PhET computer simulations to examine first and second order reactions. Also, two POGIL activities.

  Students check their understanding by completing online quizzes from the Glencoe Learning Center.

Review
- Woodrum (Chang Study Guide) Chapter 13: pages 296-298, exercises 1-13, 19, 21
  - (NOTE: problems may be omitted or change)
- Selected activities from 5 Steps to a 5 AP Chemistry
- Previous Chemistry Olympiad Questions

UNIT 13: Chemical Equilibrium

Class Periods (87 minutes): 11

Enduring Understanding
- Chemical equilibrium is a dynamic, reversible state in which rates of opposing processes are equal. (6.A)
- Systems at equilibrium are responsive to external perturbations, with the response leading to a change in the composition of the system. (6.B)
- The equilibrium constant is related to temperature and the difference in Gibbs free energy between reactants and products. (6.D)
<table>
<thead>
<tr>
<th>Learning Objectives</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1.16, 3.3, 3.5, 5.17, 5.18, 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7, 6.8, 6.9)</td>
<td>The Equilibrium State, The Equilibrium Constant, Relationship Between Kinetics and Equilibrium, Le Chatelier’s Principle, Equilibrium Calculations</td>
</tr>
<tr>
<td><strong>1.16</strong> The student can design and/or interpret the results of an experiment regarding the absorption of light to determine the concentration of an absorbing species in a solution. [See SP 4.2, 5.1; Essential knowledge 1.D.3]</td>
<td></td>
</tr>
<tr>
<td><strong>3.3</strong> The student is able to use stoichiometric calculations to predict the results of performing a reaction in the laboratory and/or to analyze deviations from the expected results. [See SP 2.2, 5.1; Essential knowledge 3.A.2]</td>
<td></td>
</tr>
<tr>
<td><strong>3.5</strong> The student is able to design a plan in order to collect data on the synthesis or decomposition of a compound to confirm the conservation of matter and the law of definite proportions. [See SP 2.1, 4.2, 6.4; Essential knowledge 3.B.1]</td>
<td></td>
</tr>
<tr>
<td><strong>5.17</strong> The student can make quantitative predictions for systems involving coupled reactions that share a common intermediate, based on the equilibrium constant for the combined reaction. [See SP 6.4; Essential knowledge 5.E.4, connects to 6.A.2]</td>
<td></td>
</tr>
<tr>
<td><strong>5.18</strong> The student can explain why a thermodynamically favored chemical reaction may not produce large amounts of product (based on consideration of both initial conditions and kinetic effects), or why a thermodynamically unfavored chemical reaction can produce large amounts of product for certain sets of initial conditions. [See SP 1.3, 7.2; Essential knowledge 5.E.5, connects to 6.D.1]</td>
<td></td>
</tr>
<tr>
<td><strong>6.1</strong> The student is able to, given a set of experimental observations regarding physical, chemical, biological, or environmental processes that are reversible, construct an explanation that connects the observations to the reversibility of the underlying chemical reactions or processes. [See SP 6.2; Essential knowledge 6.A.1]</td>
<td></td>
</tr>
<tr>
<td><strong>6.2</strong> The student can, given a manipulation of a chemical reaction or set of reactions (e.g., reversal of reaction or addition of two reactions), determine the effects of that manipulation on Q or K. [See SP 2.2; Essential knowledge 6.A.2]</td>
<td></td>
</tr>
<tr>
<td><strong>6.3</strong> The student can connect kinetics to equilibrium by using reasoning about equilibrium, such as Le Chatelier’s principle, to infer the relative rates of the forward and reverse reactions. [See SP 7.2; Essential knowledge 6.A.3]</td>
<td></td>
</tr>
<tr>
<td><strong>6.4</strong> The student can, given a set of initial conditions (concentrations or partial pressures) and the equilibrium constant, K, use the tendency of Q to approach K to predict and justify the prediction as to whether the reaction will proceed toward products or reactants as equilibrium is approached. [See SP 2.2, 6.4; Essential knowledge 6.A.3]</td>
<td></td>
</tr>
<tr>
<td><strong>6.5</strong> The student can, given data (tabular, graphical, etc.) from which the state of a system at equilibrium can be obtained, calculate the equilibrium constant, K. [See SP 2.2; Essential knowledge 6.A.3]</td>
<td></td>
</tr>
<tr>
<td><strong>6.6</strong> The student can, given a set of initial conditions (concentrations or partial pressures) and the equilibrium constant, K, use stoichiometric relationships and the law of mass action (Q equals K at equilibrium) to determine qualitatively and/or quantitatively the conditions at equilibrium for a system involving a single reversible reaction. [See SP 2.2, 6.4; Essential knowledge 6.A.3]</td>
<td></td>
</tr>
<tr>
<td><strong>6.7</strong> The student is able, for a reversible reaction that has a large or small K, to determine which chemical species will have very large versus very small concentrations at equilibrium. [See SP 2.2, 2.3; Essential knowledge 6.A.4]</td>
<td></td>
</tr>
<tr>
<td><strong>6.8</strong> The student is able to use Le Chatelier’s principle to predict the direction of the shift resulting from various possible stresses on a system at chemical equilibrium. [See SP 1.4, 6.4; Essential knowledge 6.B.1]</td>
<td></td>
</tr>
<tr>
<td><strong>6.9</strong> The student is able to use Le Chatelier’s principle to design a set of conditions that will optimize a desired outcome, such as product yield. [See SP 4.2; Essential knowledge 6.B.1]</td>
<td></td>
</tr>
<tr>
<td><strong>Assignments</strong></td>
<td><strong>Chapter 14 – Chemical Equilibrium</strong></td>
</tr>
</tbody>
</table>
| laboratory experiments | GUIDED INQUIRY Lab 9: Green Chemistry Analysis of a Mixture (LO 3.3, 3.5; SP 2.1, 2.2, 4.2, 5.1, 6.4)  
GUIDED INQUIRY Lab 10: Applications of LeChatelier’s Principle (LO 6.9; SP 4.2) |
|---|---|
| other activities | Working in a team students will complete classroom activities where they develop equilibrium expressions based on reactions. Also, students will use PhET computer simulations to perform a Beer’s Law experiment.  
Students check their understanding by completing online quizzes from the Glencoe Learning Center. |
| review | Woodrum (Chang Study Guide) Chapter 14: pages 312-324, exercises 1-14  
(NOTE: problems may be omitted or change)  
Selected activities from 5 Steps to a 5 AP Chemistry  
Previous Chemistry Olympiad Questions |
<table>
<thead>
<tr>
<th>Enduring Understanding</th>
<th>Chemical equilibrium plays an important role in acid-base chemistry and in solubility. (6.C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning Objectives</td>
<td>(1.18, 1.20, 2.2, 2.8, 2.9, 3.7, 6.1, 6.7, 6.11, 6.12, 6.13, 6.14, 6.15, 6.16, 6.17, 6.18, 6.19, 6.20, 6.21, 6.22, 6.23)</td>
</tr>
<tr>
<td>1.18</td>
<td>The student is able to apply conservation of atoms to the rearrangement of atoms in various processes. [See SP 1.4; Essential knowledge 1.E.2]</td>
</tr>
<tr>
<td>1.20</td>
<td>The student can design, and/or interpret data from, an experiment that uses titration to determine the concentration of an analyte in a solution. [See SP 4.2, 5.1, 6.4; Essential knowledge 1.E.2]</td>
</tr>
<tr>
<td>2.2</td>
<td>The student is able to explain the relative strengths of acids and bases based on molecular structure, interparticle forces, and solution equilibrium. [See SP 7.2, connects to Big Idea 5, Big Idea 6; Essential knowledge components of 2.A–2.D]</td>
</tr>
<tr>
<td>2.8</td>
<td>The student can draw and/or interpret representations of solutions that show the interactions between the solute and solvent. [See SP 1.1, 1.2, 6.4; Essential knowledge 2.A.3]</td>
</tr>
<tr>
<td>2.9</td>
<td>The student is able to create or interpret representations that link the concept of molarity with particle views of solutions. [See SP 1.1, 1.4; Essential knowledge 2.A.3]</td>
</tr>
<tr>
<td>3.7</td>
<td>The student is able to identify compounds as Brønsted-Lowry acids, bases, and/or conjugate acid-base pairs, using proton-transfer reactions to justify the identification. [See SP 6.1; Essential knowledge 3.B.2]</td>
</tr>
<tr>
<td>6.1</td>
<td>The student is able to, given a set of experimental observations regarding physical, chemical, biological, or environmental processes that are reversible, construct an explanation that connects the observations to the reversibility of the underlying chemical reactions or processes. [See SP 6.2; Essential knowledge 6.A.1]</td>
</tr>
<tr>
<td>6.7</td>
<td>The student is able, for a reversible reaction that has a large or small K, to determine which chemical species will have very large versus very small concentrations at equilibrium. [See SP 2.2, 2.3; Essential knowledge 6.A.4]</td>
</tr>
<tr>
<td>6.11</td>
<td>The student can generate or use a particulate representation of an acid (strong or weak or polyprotic) and a strong base to explain the species that will have large versus small concentrations at equilibrium. [See SP 1.1, 1.4, 2.3; Essential knowledge 6.C.1]</td>
</tr>
<tr>
<td>6.12</td>
<td>The student can reason about the distinction between strong and weak acid solutions with similar values of pH, including the percent ionization of the acids, the concentrations needed to achieve the same pH, and the amount of base needed to reach the equivalence point in a titration. [See SP 1.4, 6.4; Essential knowledge 6.C.1, connects to 1.E.2]</td>
</tr>
<tr>
<td>6.13</td>
<td>The student can interpret titration data for monoprotic or polyprotic acids involving titration of a weak or strong acid by a strong base (or a weak or strong base by a strong acid) to determine the concentration of the titrant and the pKa for a weak acid, or the pKb for a weak base. [See SP 5.1, 6.4; Essential knowledge 6.C.1, connects to 1.E.2]</td>
</tr>
<tr>
<td>6.14</td>
<td>The student can, based on the dependence of Kw on temperature, reason that neutrality requires ([H^+] = [OH^-]) as opposed to requiring pH = 7, including especially the applications to biological systems. [See SP 2.2, 6.2; Essential knowledge 6.C.1]</td>
</tr>
<tr>
<td>6.15</td>
<td>The student can identify a given solution as containing a mixture of strong acids and/or bases and calculate or estimate the pH (and concentrations of all chemical species) in the resulting solution. [See SP 2.2, 2.3, 6.4; Essential knowledge 6.C.1]</td>
</tr>
<tr>
<td>6.16</td>
<td>The student can identify a given solution as being the solution of a monoprotic weak acid or base (including salts in which one ion is a weak acid or base), calculate the pH and concentration of all species</td>
</tr>
</tbody>
</table>
in the solution, and/or infer the relative strengths of the weak acids or bases from
given equilibrium concentrations. [See SP 2.2, 6.4; Essential knowledge 6.C.1]

6.17 The student can, given an arbitrary mixture of weak and strong acids and bases
(including polyprotic systems), determine which species will react strongly with one
another (i.e., with $K > 1$) and what species will be present in large concentrations at
equilibrium. [See SP 6.4; Essential knowledge 6.C.1]

6.18 The student can design a buffer solution with a target pH and buffer capacity by
selecting an appropriate conjugate acid-base pair and estimating the concentrations
needed to achieve the desired capacity. [See SP 2.3, 4.2, 6.4; Essential knowledge
6.C.2]

6.19 The student can relate the predominant form of a chemical species involving a
labile proton (i.e., protonated/deprotonated form of a weak acid) to the pH of a
solution and the pKa associated with the labile proton. [See SP 2.3, 5.1, 6.4; Essential
knowledge 6.C.2]

6.20 The student can identify a solution as being a buffer solution and explain the
buffer mechanism in terms of the reactions that would occur on addition of acid or
base. [See SP 6.4; Essential knowledge 6.C.2]

6.21 The student can predict the solubility of a salt, or rank the solubility of salts,
given the relevant Ksp values. [See SP 2.2, 2.3, 6.4; Essential knowledge 6.C.3]

6.22 The student can interpret data regarding solubility of salts to determine, or rank,
the relevant Ksp values. [See SP 2.2, 2.3, 6.4; Essential knowledge 6.C.3]

6.23 The student can interpret data regarding the relative solubility of salts in terms
of factors (common ions, pH) that influence the solubility. [See SP 5.1, 6.4; Essential
knowledge 6.C.3]

<table>
<thead>
<tr>
<th>Content</th>
<th>Assignments</th>
</tr>
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<tbody>
<tr>
<td>Nomenclature, Arrhenius, Bronsted-Lowry, Kw, Weak Acids and Bases, Ka and Kb, Polyprotic Acids and Bases, Hydrolysis of Salts, Trends in Binary and Oxoacids, Common Ion Effect/Complex Ions</td>
<td>Chapter 15 – Acids and Bases</td>
</tr>
<tr>
<td></td>
<td>Read: Pages 659-709</td>
</tr>
<tr>
<td></td>
<td>Problems: 5-8, 16, 18, 24-26, 33-35, 43, 46, 49, 53, 55, 57, 62, 63, 67, 68, 75, 76, 80, 86, 88</td>
</tr>
<tr>
<td>Chapter 16 – Acid-Base Equilibria and Solubility Equilibria</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Read: Pages 712-767</td>
</tr>
<tr>
<td></td>
<td>Problems: 6, 9, 11, 14, 15, 25, 27, 32</td>
</tr>
<tr>
<td></td>
<td>(NOTE: problems may be omitted or change)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Laboratory Experiments</th>
<th>Other Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>GUIDED INQUIRY Lab 11: Acid-Base Titrations (LO 1.18, 1.20, 6.13; SP 1.4, 4.2, 5.1, 6.4)</td>
<td>Working in a team students will complete classroom activities where they prepare solutions of given a pH. Also, students will use PhET computer simulations and investigate different combinations of strength/concentrations that result in same pH values.</td>
</tr>
<tr>
<td>GUIDED INQUIRY Lab 12: Acidity of Beverages</td>
<td>Students check their understanding by completing online quizzes from the Glencoe Learning Center.</td>
</tr>
<tr>
<td>GUIDED INQUIRY Lab 13: Buffers in Household Products (LO 6.20; SP 6.4)</td>
<td></td>
</tr>
<tr>
<td>GUIDED INQUIRY Lab 14: Properties of Buffer Solutions</td>
<td></td>
</tr>
</tbody>
</table>
Woodrum (Chang Study Guide) Chapter 16: pages 390-392, exercises 1-15  
(NOTE: problems may be omitted or change)  
Selected activities from 5 Steps to a 5 AP Chemistry  
Previous Chemistry Olympiad Questions |
### Enduring Understanding

- Chemical reactions can be classified by considering what the reactants are, what the products are, or how they change from one into the other. Classes of chemical reactions include synthesis, decomposition, acid-base, and oxidation-reduction reactions. (3.B)
- Chemical and physical transformations may be observed in several ways and typically involve a change in energy. (3.C)

### Learning Objectives

(1.9, 1.10, 1.11, 3.2, 3.8, 3.9, 3.12, 3.13)

1.9 The student is able to predict and/or justify trends in atomic properties based on location on the periodic table and/or the shell model. [See SP 6.4; Essential knowledge 1.C.1]

1.10 Students can justify with evidence the arrangement of the periodic table and can apply periodic properties to chemical reactivity. [See SP 6.1; Essential knowledge 1.C.1]

1.11 The student can analyze data, based on periodicity and the properties of binary compounds, to identify patterns and generate hypotheses related to the molecular design of compounds for which data are not supplied. [See SP 3.1, 5.1; Essential knowledge 1.C.1]

3.2 The student can translate an observed chemical change into a balanced chemical equation and justify the choice of equation type (molecular, ionic, or net ionic) in terms of utility for the given circumstances. [See SP 1.5, 7.1; Essential knowledge 3.A.1]

3.8 The student is able to identify redox reactions and justify the identification in terms of electron transfer. [See SP 6.1; Essential knowledge 3.B.3]

3.9 The student is able to design and/or interpret the results of an experiment involving a redox titration. [See SP 4.2, 5.1; Essential knowledge 3.B.3]

3.12 The student can make qualitative or quantitative predictions about galvanic or electrolytic reactions based on half-cell reactions and potentials and/or Faraday’s laws. [See SP 2.2, 2.3, 6.4; Essential knowledge 3.C.3]

3.13 The student can analyze data regarding galvanic or electrolytic cells to identify properties of the underlying redox reactions. [See SP 5.1; Essential knowledge 3.C.3]

### Content

Redox Reactions, Galvanic Cells, Standard Reduction Potentials, Thermodynamics of Redox Rxns, Concentration and Cell Emf, Batteries, Corrosion, Electrolysis

### Assignments

**Chapter 19 – Electrochemistry**

Read: Pages 836-883

Problems: 11, 13, 15, 16, 21, 22, 24, 29, 32, 34, 37a, 45, 51, 52, 65, 67, 73

(NOTE: problems may be omitted or change)

### Laboratory Experiments

**GUIDED INQUIRY** Lab 15: Analysis of Hydrogen Peroxide? (LO 3.9; SP 4.2, 5.1)

### Other Activities

Working with partners students will complete hands on classroom activities where they design and construct electrolytic cells in order to electroplate various items. Students check their understanding by completing online quizzes from the Glencoe Learning Center.

### Review

Woodrum (Chang Study Guide) Chapter 16: pages 452-454, exercises 1-17

(NOTE: problems may be omitted or change)

Selected activities from 5 Steps to a 5 AP Chemistry

Previous Chemistry Olympiad Questions
Tutorial Topics and Review
Class Periods (87 minutes): 18 (After Exam ~10 Periods for Final Project)


Exam Review (3 Full AP exams) and numerous Part 2 written response exams

| Laboratory Experiments | Lab 14: Buffer Design: The Preparation and Testing of an Effective Buffer: How Do Components Influence a Buffer’s pH and Capacity (LO 6.18; SP 2.3, 4.2, 6.4)
Lab 15: Titration: How Much Acid Is in Fruit Juice and Soft Drinks? (LO 1.20; SP 4.2, 5.1, 6.4)
GUIDED INQUIRY Lab 16: Percent of Copper in Brass (LO 3.4; SP 2.2, 5.1, 6.4)

| Other Activities | The students are given Energy Curves with Potential Energy and compare single, double, and triple bonds - looking for patterns and investigating strength of the different types of bonds.

Selected activities from 5 Steps to a 5 AP Chemistry
Previous Chemistry Olympiad Questions

HONORS CHEMISTRY LAB LIST

Lab 1: Burning Candle
Description: Students make qualitative and quantitative observations of a burning candle and determine how candle diameter affects the burning rate.

Lab 2: Separation of a Mixture
Description: Students separate a mixture of two solids (Al₂O₃ or SiO₂ and NaCl or KCl) and determine the percent composition of the original mixture.

Lab 3: Atomic Mass of Candium
Description: Students analyze the isotopes of candium (a mixture of M&Ms, Reeses Pieces, and Skittles) calculate its relative mass, percent abundance, and atomic mass.

Lab 4: Density of Solids and Liquids
Description: Students determine the densities of various solid blocks, metal cylinders using its measured dimensions and then using the water displacement method to determine its volume, and identify three different unknown liquids by density determinations.

Lab 5: Identifying Compounds Using Flame Test
Description: Students observe the colors emitted by various metallic elements and then use flame tests to identify the metallic elements contained in the products of a chemical reaction.

Lab 6: The Periodic Law
Description: Students investigate the periodic variation of density and solubility of compounds within groups, make density predictions for elements in Group 14 (Group IVA), and identify an unknown Group 2 (Group IIA) element based on solubility tests.
Lab 7: Counting Moles
Description: Students measure the mass of various substances and determine the number of moles and then number of particles (molecules, ions or atoms) present in each sample.

Lab 8: Chemical Formula of a Hydrate
Description: Students determine the percentage by mass of water, determine the formula and name of the hydrate of copper (II) sulfate. Students then repeat this experiment with iron (II) sulfate.

Lab 9: Moles to Coefficients
Description: Students determine the ratio of the number of moles of a reactant to the number of moles of a product of a chemical reaction and relate this ratio to the coefficients of these substances in the balanced equation for the reaction.

Lab 10: Types of Reactions
Description: Students determine the relative activity of 5 different metals: Zn, Al, Cu, Fe, Mg and compare experimental findings to the Activity Series of the Elements. Students observe double replacement reactions and write balanced equations to represent the double replacement reactions.

Lab 11: Chemical Changes and Equations
Description: Students perform four types of chemical reactions, identify some of the products of the reactions, and write and balance equations for the reactions observed.

Lab 12: Properties of Ionic and Covalent Compounds
Description: Students compare and contrast general properties of ionic and covalent compounds and determine melting points of covalent compounds.

Lab 13: Solubility
Description: Students determine the effect of temperature on the solubility of a salt (KNO₃ and NaNO₃) in water.

Lab 14: Properties of Acids and Bases
Description: Students measure or observe some general properties and reactions of acids and bases.

Lab 15: Titration
Description: Students determine the molarity of a NaOH solution by titrating it with a standard HCl having a concentration of 0.100 M and use the NaOH to determine the molarity of a sample of vinegar.

Lab 16: Heat of Fusion
Description: Students determine the heat of fusion of ice by using water to melt ice and the calculate energy lost by the water. Since the energy lost equals the energy gained by the ice, the students the student calculate the Heat of Fusion. Results are shared among the classes using Google.

Lab 17: Molar Volume of a Gas
Description: Students determine the volume of ONE mole of hydrogen gas at STP using experimental data, known mathematical relationships, and a balanced chemical equation.

AP CHEMISTRY LAB LIST
Lab 1 (GUIDED INQUIRY 1): Gravimetric Analysis: What Makes Water Hard
Description: Six samples of water will be analyzed for their quantities of water hardness through principles of metal ion precipitation and separation. The samples will then be ranked in order of increasing water hardness.
Lab 2 (GUIDED INQUIRY 2): Chromatography: Sticky Question: How Do You Separate Molecules That Are Attracted to One Another?
Description: Students design and/or interpret the results of a separation experiment (filtration, paper chromatography, column chromatography, or distillation) in terms of the relative strength of interactions among and between the components.

Lab 3: Bonding in Solids: What’s in That Bottle
Description: Students design and/or evaluate a plan to collect and/or interpret data needed to deduce the type of bonding in a sample of a solid. The student is able to explain a representation that connects properties of an ionic solid to its structural attributes and to the interactions present at the atomic level.

Description: Students design and/or interpret the results of an experiment in which calorimetry is used to determine the change in enthalpy of a chemical process (heating/cooling, phase transition, or chemical reaction) at constant pressure. The student is able to use calculations or estimates to relate energy changes associated with heating/cooling a substance to the heat capacity, relate energy changes associated with a phase transition to the enthalpy of fusion/vaporization, relate energy changes associated with a chemical reaction to the enthalpy of the reaction, and relate energy changes to PΔV work.

Lab 5: Physical and Chemical Changes: Can the Individual Components of Quick Ache Relief Be Used to Resolve Consumer Complaints
Description: Students evaluate the classification of a process as a physical change, chemical change, or ambiguous change based on both macroscopic observations and the distinction between rearrangement of covalent interactions and noncovalent interactions.

Lab 6: Spectroscopy: What is the Relationship Between the Concentration of a Solution and the Amount of Transmitted Light Through the Solution
Description: The students justify the selection of a particular type of spectroscopy to measure properties associated with vibrational or electronic motions of molecules. Students design and/or interpret the results of an experiment regarding the absorption of light to determine the concentration of an absorbing species in a solution.

Lab 7 (GUIDED INQUIRY 5): Kinetics: Rate of Reaction: How Long Will That Marble Statue Last?
Description: Students design and/or interpret the results of an experiment regarding the factors (i.e., temperature, concentration, surface area) that may influence the rate of a reaction. Students analyze concentration vs. time data to determine the rate law for a zeroth-, first-, or second-order reaction. [See

Lab 8: Kinetics: Rate Laws: What is the Rate Law of the Fading of Crystal Violet Using Beer’s Law?
Description: Students design and/or interpret the results of an experiment regarding the factors (i.e., temperature, concentration, surface area) that may influence the rate of a reaction.

Lab 9: Stoichiometry: Using the Principle That Each Substance Has Unique Properties to Purify a Mixture: An Experiment in Applying Green Chemistry to Purification
Description: Students design a plan in order to collect data on the synthesis or decomposition of a compound to confirm the conservation of matter and the law of definite proportions. Students use stoichiometric calculations to predict the results of performing a reaction that is assumed to go to completion in the laboratory, and/or to analyze deviations from the expected results.

Lab 10: Equilibrium: Can We Make the Colors of the Rainbow? An Application of LeChatelier’s Principle
Description: Students use LeChatelier’s principle to design a set of conditions that will optimize a desired
outcome, such as product yield.

**Lab 11 (GUIDED INQUIRY 6): Acid-Base Titration: How Do the Initial Concentration of an Acid and a Base Influence the pH of the Resultant Solution During a Titration?**

**Description:** Students interpret titration data for monoprotic or polyprotic acids involving titration of a weak or strong acid by a strong base (or a weak or strong base by a strong acid) to determine the concentration of the titrant and the pKa for a weak acid, or the pKb for a weak base. The student is able to apply conservation of atoms to the rearrangement of atoms in various processes. Students design, and/or interpret data from, an experiment that uses titration to determine the concentration of an analyte in a solution.

**Lab 12:** Titration: How Much Acid Is in Fruit Juice and Soft Drinks?

**Description:** Students design, and/or interpret data from an experiment that uses titration to determine the concentration of an analyte in a solution.

**Lab 13:** Buffer Design: The Preparation and Testing of an Effective Buffer: How Do Components Influence a Buffer's pH and Capacity

**Description:** Students design a buffer solution with a target pH and buffer capacity by selecting an appropriate conjugate acid-base pair and estimating the concentrations needed to achieve the desired capacity.

**Lab 14:** Buffering Activity: To What Extent Do Common Household Products Have Buffering Activity

**Description:** Students identify a solution as being a buffer solution, and explain the buffer mechanism in terms of the reactions that would occur on addition of acid or base.

**Lab 15:** Redox Titration: How Can We Determine the Actual Percentage of $\text{H}_2\text{O}_2$ in a Drugstore Bottle of Hydrogen Peroxide?

**Description:** Students design and/or interpret the results of an experiment involving a redox titration.

**Lab 16 (GUIDED INQUIRY 4): Spectroscopy: How Can Color Be Used to Determine the Mass Percent of Copper in Brass**

**Description:** Students relate quantities (measured mass of substances, volumes of solutions, or volumes and pressures of gases) to identify stoichiometric relationships for a reaction, including situations involving limiting reactants and situations in which the reaction has not gone to completion.