CURRICULUM MANAGEMENT SYSTEM

MONROE TOWNSHIP SCHOOLS

Course Name: Thermodynamics & Equilibrium Chemistry
Grade: 11-12

For adoption by all regular education programs as specified and for adoption or adaptation by all Special Education Programs in accordance with Board of Education Policy # 2220.

Board Approved: October 2011

TABLE OF CONTENTS

MONROE TOWNSHIP SCHOOL DISTRICT

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ACKNOWLEDGEMENTS

The following individuals are acknowledged for their assistance in the preparation of this Curriculum Management System:

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VISION, MISSION, AND GOALS

Vision Statement

The Monroe Township Board of Education commits itself to all children by preparing them to reach their full potential and to function in a global society through a preeminent education.

Mission Statement

The Monroe Public Schools in collaboration with the members of the community shall ensure that all children receive an exemplary education by well trained committed staff in a safe and orderly environment.

Goals

Raise achievement for all students paying particular attention to disparities between subgroups.

Systematically collect, analyze, and evaluate available data to inform all decisions.

Improve business efficiencies where possible to reduce overall operating costs.

Provide support programs for students across the continuum of academic achievement with an emphasis on those who are in the middle.

Provide early interventions for all students who are at risk of not reaching their full potential.

PHILOSOPHY

Our philosophy is to provide students with a multitude of opportunities in which they can experience a quality education. While our educational programs take into account the physical, social, and emotional needs of our students, the primary educational focus continues to be largely academic in nature. We believe that students learn best when they are able to actively construct meaning. Science is a process, a way of thinking about and investigating the world in which we live. Emphasis in science is placed on students being actively engaged in real-life problem solving. We believe that learning is best experienced when it is student-centered and challenges the capacity to hypothesize, theorize and clearly articulate responses. We recognize that students come to school with prior knowledge and pre-existing assumptions about the world around them. We believe that the science curriculum should be problem and/or scenario based and allow students to interact with the content.

The curriculum represents the expressions of educational ideas in practice. Our curriculum is guided by the use of essential Questions and Big Ideas that help facilitate student-thought and content integration. As our students continue to grow in an interconnected and changing world, it is our belief that they must become equipped to be global citizens by learning skills of effective cooperation and collaboration for global problem solving.

STEM Academy

The Monroe Township High School STEM Academy (Science, Technology, Engineering, & Mathematics) is predicated on research that supports the creation of a rich, student-centered, inquiry-based, innovative learning community. Our STEM philosophy endeavors to incorporate a challenging, multi-disciplinary-integrated curriculum model that is infused with a variety of real-world applications for global problem-solving. With the clear integration of the sciences, technology, engineering, and mathematics students can navigate through an interconnected framework of courses designed to expand conceptual understanding, promote critical thinking, and enhance scientific literacy to support research and discovery. Our overarching goal is to foster a rigorous academic environment that is highly engaging, collaborative, and challenges each individual learner to become fully college and career ready for work in our global society.

EDUCATIONAL GOALS

Thermodynamics and Equilibrium Chemistry is a one semester laboratory course designed for students interested in taking Advanced Placement Chemistry or those preparing to take the SAT II Chemistry subject test. Enrollment in Thermodynamics and Equilibrium Chemistry requires that students have a strong foundational knowledge from Honors Chemistry, as this course will build on those topics. Conceptual themes including acid/base reactions, equilibrium & reaction rates, electrochemistry, thermodynamics, organic chemistry, and descriptive chemistry will provide a rich framework for course exploration. Laboratory experiences will promote the practical application of these concepts. Students will acquire a greater facility in analytical and critical thinking, a firm foundation on which to build further scientific studies and a better understanding of the role of chemistry in today's world.

NJDOE: CORE CURRICULUM CONTENT STANDARDS

A note about Common Core State Standards for Science

The New Jersey State Standards for Science were adopted by the state of New Jersey in 2009. The Cumulative Progress Indicators (CPIs) referenced in this curriculum guide refer to these new standards and may be found in the Curriculum folder on the district servers. A complete copy of the new Common Core State Standards for Science may also be found at:

http://www.state.nj.us/education/cccs/2009/final.htm

The Common Core State Stadards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects, and Mathematics ("the standards") are the culmination of an extended, broad-based effort to create the next generation of K-12 standards, in order to help ensure that all students are college and career ready in literacy no later than the end of high school. These standards have also been integrates into the district wide science curriculum.

http://www.corestandards.org/the-standards/mathematics

http://www.corestandards.org/the-standards/english-language-arts-standards

SCOPE AND SEQUENCE:

Quarter I

Big Idea I: Change

Thermodynamics

- A. Heat & Temperature
- B. State Functions
- C. System Energy
- D. Chemical Energy
  - a. Exothermic Reactions
  - b. Endothermic Reactions
- E. Work Done by Gases
- F. Enthalpy & Calorimetry
- G. Hess's Law
- H. Standard Enthalpies of Formation

Big Idea II: Behavior

Reaction Kinetics

- A. Chemical Kinetics
- B. Reaction Rates
- C. Rate Laws
- D. The Integrated Rate Law
- E. Reaction Mechanisms
- F. Activation Energy
- G. Catalysis

Quarter I

Big Idea III: Systems

Aqueous Equilibria

- A. Acid/Base Review
  - a. pH curves & Titration
  - b. Acid/Base indicators
- B. Common Ion Effect
- C. Equilibrium Calculations
- D. Buffered Solutions
  - a. Buffering Capacity
  - b. Preparing a Buffer
  - c. Henderson-Hasselbalch Equation
- E. Solubility Equilibria
- F. Solubility Product

SCOPE AND SEQUENCE:

Quarter II	
Big Idea IV: Order	**Big Idea V: Transfer**
Spontaneity, Entropy, and Free Energy A. Spontaneous Processes B. Entropy and the 2nd Law of Thermodynamics C. Effect of Temperature on Spontaneity D. Gibbs Free Energy E. Entropy Changes in Chemical Reactions F. Free Energy in Chemical Reactions G. Free Energy and Equilibrium	**Electrochemistry** A. Galvanic Cells B. Oxidation-Reduction Reactions C. Reduction Potential D. Cell Potential, Electric Work, & Free Energy E. Batteries F. Corrosion G. Electrolysis H. Electroplating
Quarter II	
Big Idea VI: Structure	
Organic Chemistry A. Alkanes a. Nomenclature of Alkanes b. Structural Isomers c. Cycloalkanes B. Alkenes & Alkynes a. Geometric Isomers C. Aromatic Hydrocarbons a. Structure of Aromatics b. Reactions of Aromatics	

BIG IDEA I:

BIG IDEA I: Change

Curriculum Management System

COURSE NAME: Thermodynamics & Equilibrium Chemistry

OVERARCHING GOALS

1. All students will understand that science is both a body of knowledge and evidence-based, model-building enterprise that continually extends, refines, and revises knowledge.
2. Investigate, research, and synthesize data and information to understand meaningful real-world problems.

ESSENTIAL QUESTIONS

- Why is enthalpy of reaction for an industrial process an important consideration with regard to air pollution?
- How does calorimetry impact dieting and metabolism for humans?

SUGGESTED BLOCKS FOR INSTRUCTION: 8

BIG IDEA I:

KNOW	UNDERSTAND	DO
Students will know that:	***Students will understand that:***	***Students will be able to:***
• Temperature reflects random. motion of particles in a substance. • Heat is a measure of energy content • Heat is what is transferred during a temperature change. (5.2.12.C.2)	• Heating increases the energy of the atoms composing elements and the molecules or ions composing compounds. As the kinetic energy of the atoms, molecules, or ions increases, the temperature of the matter increases. • Heat flow associated with a chemical reaction is measured by calorimetry, a technique that involves measuring temperature changes when a body absorbs or discharges heat.	• Explain the connection between temperature, heat, and energy.
• State functions depend only on the present state of a system, not what *has* happened in the system, or what *might* happen in the system in the future. • State functions are independent of the pathway taken to get to that state. (5.2.12.C.1)	**Sample Conceptual Understandings** **Heat and Work** 1. A system releases 125 kJ of heat while 104kJ of work is done on it. Calculate ΔE. 2. A balloon filled with 39.1 mol helium has a volume of 876 L at 0.0°C and 1.00 atm pressure. The temperature of the balloon is increased to 38.0°C as it expands to a volume of 998 L, the pressure remaining constant. Calculate q, w, and ΔE for the helium in the balloon. (The molar heat capacity for helium gas is 20.8 J/°C·mol)	• Define "state function." • Differentiate between a state function and a property that is not considered a state function.
• Exothermic reactions give off energy as they progress. • Endothermic reactions absorb energy from the surroundings. (5.2.12.D.2)	**Properties of Enthalpy** 1. The reaction: $SO_2\ (g) + H_2O\ (\ell) \rightarrow H_2SO_4\ (aq)$	• Write and balance chemical equations, indicating energy absorbed or released. • Calculate ΔE for a system undergoing an endothermic/exothermic process. • Construct an energy diagram for an endothermic and an exothermic reaction.
• Within a system, energy can be related by a mathematical equation to heat & work. (5.2.12.D.2)	is the last step in the commercial production of sulfuric acid. The enthalpy change for this reaction is –227 kJ. In designing a sulfuric acid plant, is it necessary to provide for heating or cooling of the reaction mixture? Explain.	• Describe the relationship between work, heat, and energy. • Derive a mathematical equation relating work, pressure, and change in volume for a gas. • Calculate work, pressure, or change in volume given two of the three.

BIG IDEA I:

KNOW	UNDERSTAND	DO
Students will know that:	***Students will understand that:***	***Students will be able to:***
• In systems at constant pressure, where the only work is PV, the change in enthalpy is due only to energy flow as heat. (5.2.12.D.2)	**Calorimetry and Heat Capacity** 1. In a coffee-cup calorimeter, 1.60 g of NH_4NO_3 is mixed with 75.0 g of water at an initial temperature of 25.00°C. After dissolution of the salt, the final temperature of the calorimeter contents is 23.34°C. Assuming the solution has a heat calacity of 4.18 J/g·°C, and assuming no heat loss to the calorimeter, calculate the enthalpy change for the dissolution of NH_4NO_3 in units of kJ/mol.	• Calculate the work associated with the expansion of a gas. • Calculate the ΔH for a given system.
• In going from a particular set of reactants to a particular set of products, the change in enthalpy (ΔH) is the same whether the reaction takes place in one step or in a series of steps. (5.2.12.C.1)	**Hess's Law** 1. Given the following data: $2\ O_3\ (g) \rightarrow 3\ O_2\ (g)$ ΔH = -427kJ $O_2\ (g) \rightarrow 2\ O\ (g)$ ΔH = +495kJ $NO\ (g) + O_3\ (g) \rightarrow NO_2\ (g) + O_2\ (g)$ ΔH = -199kJ calculate ΔH for the reaction: $NO\ (g) + O\ (g) \rightarrow NO_2(g)$	• Describe Hess's Law. • Calculate ΔH for multi-step processes.
• Standard enthalpy of formation (ΔH_f) is the change in enthalpy that accompanies the formation of one mole of a compound from its elements with all elements in their standard state. (5.2.12.C.1)		• Define standard enthalpy of formation ($\Delta H°_f$). • Use standard enthalpies of formation to calculate the standard enthalpy change for the overall reaction.

BIG IDEA I:

21st Century Skills		
Creativity and Innovation	***Critical Thinking and Problem Solving***	***Communication and Collaboration***
Information Literacy	***Media Literacy***	***ICT Literacy***
Life and Career Skills	***Technology Based Activities***	
http://www.p21.org/index.php?option=com_content&task=view&id=254&Itemid=119 http://www.iste.org/standards/nets-for-students.aspx		

Learning Activities	
Laboratory Activities: 1) B.6 "Heats of Combustion" from Chemistry in the Community W.H. Freeman & Co. (2006); 2) "*Thermodynmics in a Bag*" kit from Flinn Scientific; 3) "*Discovering Instant Cold Packs"* kit from Flinn Scientific; 4) "*Thermodynamics: Enthalpy of Reaction and Hess's Law*" kit from Flinn Scientific;	
Performance Assessment Task Sample	*You are a government-appointed research scientist*. You are charged with investigating various fuel types for the purpose of finding a safe, energy efficient, and cost-effective fuel. You will research and experiment with heats of combustion in order to accomplish this. You must recommend 3 potential fuel sources for investigation. You will design a means for collecting heat of combustion data, you will analyze your data, and you will report your findings to the US government. You will submit a report that includes: • Short description of the data collection process • Neat, accurate, and readable data tables • Communication of experiment's results with recommendations for government Teacher Ask the students: • Why are some fuels not viable despite their efficiency? • What is the limitation of these type of lab tests for conducting these experiments? (Analysis, Synthesis, Evaluation)

Assessment Models

- **NOTE: The assessment models provided in this document are suggestions for the teacher. If the teacher chooses to develop his/her own model, *it must be of equal or better quality and at the same or higher cognitive levels (as noted in parentheses*).**
- **Depending upon the needs of the class, the assessment questions may be answered in the form of essays, quizzes, mobiles, PowerPoint, oral reports, booklets, or other formats of measurement used by the teacher.**

Diagnostic/Pre-Assessment:

- Anticipatory sets used to assess prior knowledge of the topic.
- Course Pre-assessment to assess information retained from Honors Chemistry.

Open-Ended (Formative) Assessment:

- Differentiated group and individual work is assigned daily, from various sources *(Synthesis, Analysis, and Evaluation).*
- Introductory and Closing Activities will be done every day to pre-assess student knowledge and assess understanding of topics *(Synthesis, Analysis, and Evaluation).*
- Homework will be assigned daily.

Summative Assessment:

- Assessment questions should be open-ended and should follow the general format illustrated in the Essential Questions/Sample Conceptual Understanding section. *(Synthesis, Analysis, Evaluation)*
- Assessment strategies will address a diverse array of learning modalities.
- Students will record laboratory data in laboratory notebook, a process that will be supplemented by the iPad2 technology.

(RST 1, 2, 3, 5, 7, 10)(WHST 2, 4, 5, 8)

Additional Resources

Chemistry. 6th ed. Zumdahl & Zumdahl. (2006)
Chapter 6 (pp. 241 – 287)

Chemistry in the Community W.H. Freeman and Company (2006)
Unit 3 Activity B.6 Heats of Combustion

Online Resources

http://www2.estrellamountain.edu/faculty/farabee/biobk/biobookener1.html
http://www.grc.nasa.gov/WWW/k-12/airplane/thermo1.html

BIG IDEA II:

BIG IDEA II: Behavior

Curriculum Management System

COURSE NAME: Thermodynamics & Equilibrium Chemistry

OVERARCHING GOALS

1. All students will understand that science is both a body of knowledge and evidence-based, model-building enterprise that continually extends, refines, and revises knowledge.
2. Investigate, research, and synthesize data and information to understand meaningful real-world problems.

ESSENTIAL QUESTIONS

- Why is knowledge of characteristics of a chemical reaction, such as energetics and rate, important for its commercial use?
- How do reaction rates affect the amount of air pollution?

SUGGESTED BLOCKS FOR INSTRUCTION: 8

BIG IDEA II:

<table>
<tr><th colspan="2">KNOW</th><th>UNDERSTAND</th><th>DO</th></tr>
<tr><td colspan="2">Students will know that:</td><td>Students will understand that:</td><td>Students will be able to:</td></tr>
<tr><td></td><td>• Chemical kinetics is the study of the speed with which reactants are converted to products.
• Reaction rates are the change in concentration of a reactant or product per unit of time. (5.2.12.D.5)</td><td rowspan="3">• To be useful, reactions must occur at a reasonable rate.
• Chemical kinetics is an area of chemistry that concerns understanding the steps – reaction mechanism – by which a reaction takes place.
• A catalyst is a substance that speeds up a reaction without being consumed. A catalyst operates by providing a lower-energy pathway for the reaction in question.

<u>Sample Conceptual Understandings</u>

Reaction Rates
1. In the Haber process for the production of ammonia.

$N_2\,(g) + H_2\,(g) \rightarrow NH_3(g)$

what is the relationship between the rate of production of ammonia and the rate of consumption of hydrogen?

Rate Laws
1. The following data were obtained for the gas phase decomposition of dinitrogen pentoxide,

$2\,N_2O_5\,(g) \rightarrow 4\,NO_2\,(g) + O_2\,(g)$

$[N_2O_5]_0$ (mol/L) — Initial Rate (mol/L · s)
0.0750 — 8.90×10^{-4}
0.190 — 2.26×10^{-3}
0.275 — 3.26×10^{-3}
0.410 — 4.85×10^{-3}

Defining the rate as $-\Delta[N_2O_5]/\Delta t$, write the rate law and calculate the value of the rate constant.</td><td>• Write a mathematical expression for the rate of a chemical reaction.
• Interpret a graph of concentration vs. time to determine the rate of a reaction.</td></tr>
<tr><td></td><td>• There are various rate laws that express how the rate of reactions is dependent upon the concentration.
• The integrated rate law expresses how the concentration of a species changes over time. (5.2.12.D.5)</td><td>• Define the terms rate law, rate constant, and order.
• Distinguish between rate law and integrated rate law.
• Use concentration and rate data to determine the overall reaction order and the value of the rate constant.
• Given a set of concentration and time data, identify a reaction as first-order, second-order, or zero-order .</td></tr>
<tr><td></td><td>• Reaction mechanisms are a series of elementary steps whose sum of the elementary steps must give the overall balanced equation for the reaction. (5.2.12.D.5)</td><td>• Identify an intermediate species, given a sequence of reaction mechanisms.
• Identify the rate-determining step in a multistep reaction.
• Given the rate law, determine whether a proposed mechanism is acceptable.
• Propose alternative mechanisms for a given process.</td></tr>
</table>

BIG IDEA II:

KNOW		UNDERSTAND	DO
Students will know that:		***Students will understand that:***	***Students will be able to:***
	• Activation Energy (*Ea*) is the energy required to convert atoms or molecules into the activated complex (transition state) or the minimum energy required for an effective collision. (5.2.12.D.4)	**Catalysis** Using your knowledge of catalysis, design an animation (using iPad2 technology) that demonstrates the effect of a catalyst on the number of effective collisions.	• Define activation energy and explain its connection to the rate of reaction. • Calculate the activation energy (E_a) of a reaction given a set of data (rate constant, k, versus temperature).
	• A *catalyst* is a substance that speeds up a reaction without being consumed itself. • Catalysts lower activation energy but do not change ΔE • Catalysis results in a higher percentage of effective collisions. (5.2.12.D.4)		• Use diagrams to illustrate the effect of a catalyst on the number of effective collisions. • Identify the species that is a catalyst, given a reaction mechanism.

BIG IDEA II:

21st Century Skills		
Creativity and Innovation	***Critical Thinking and Problem Solving***	***Communication and Collaboration***
Information Literacy	***Media Literacy***	***ICT Literacy***
Life and Career Skills	***Technology Based Activities***	
http://www.p21.org/index.php?option=com_content&task=view&id=254&Itemid=119 http://www.iste.org/standards/nets-for-students.aspx		

Learning Activities	
Laboratory Activities: 1) "*Factors Affecting Reaction Rates*" kit from Flinn Scientific; 2) "*Kinetics of a Reaction*" kit from Flinn Scientific; 3) "*Introduction to Kinetics II*" kit from Flinn Scientific; 4) *"Rate of Chemical Reactions"* kit from Flinn Scientific;	
Performance Assessment Task Sample	*You are a university research scientist*. You are charged with investigating two chemical processes involving the production of NO_2 and O_2. One process involves the decomposition of N_2O_5, while the other involves NO reacting with O_3. You are given a set of data for each reaction. Concentration versus time at two temperatures. You will submit a report that includes: • Neat, accurate, and readable data tables • Calculation of Activation Energy and Rate Law <u>Teacher</u> Ask the students: • How does the rate of reaction differ between the two chemical processes? • What are the environmental implications of these two reactions? (Analysis, Synthesis, Evaluation)

Assessment Models

- **NOTE: The assessment models provided in this document are suggestions for the teacher. If the teacher chooses to develop his/her own model, *it must be of equal or better quality and at the same or higher cognitive levels (as noted in parentheses*).**
- **Depending upon the needs of the class, the assessment questions may be answered in the form of essays, quizzes, mobiles, PowerPoint, oral reports, booklets, or other formats of measurement used by the teacher.**

Diagnostic/Pre-Assessment:

- Chemical Reactions Pre-Assessment (content from Honors Chemistry)

Open-Ended (Formative) Assessment:

- Differentiated group and individual work is assigned daily, from various sources *(Synthesis, Analysis, and Evaluation).*
- Introductory and Closing Activities will be done every day to pre-assess student knowledge and assess understanding of topics *(Synthesis, Analysis, and Evaluation).*
- Homework will be assigned daily.

Summative Assessment:

- Assessment questions should be open-ended and should follow the general format illustrated in the Essential Questions/Sample Conceptual Understanding section. *(Synthesis, Analysis, Evaluation)*
- Assessment strategies will address a diverse array of learning modalities.
- Students will record laboratory data in laboratory notebook, a process that will be supplemented by the iPad2 technology.
- Students will write up formal lab reports when assigned.

(RST 1, 2, 3, 5, 6, 7, 10)(WHST 2, 4, 5, 6, 8, 10)

Additional Resources

Chemistry. 6th ed. Zumdahl & Zumdahl. (2006)
Chapter 12 (pp. 555 – 606)

Online Resources

http://chemed.chem.purdue.edu/genchem/topicreview/bp/ch22/react.html
http://www.youtube.com/watch?v=ObwnBoiyTQ0

BIG IDEA III:

BIG IDEA III: Systems

Curriculum Management System

COURSE NAME: Thermodynamics & Equilibrium Chemistry

OVERARCHING GOALS

1. All students will understand that science is both a body of knowledge and evidence-based, model-building enterprise that continually extends, refines, and revises knowledge.
2. Investigate, research, and synthesize data and information to understand meaningful real-world problems.

ESSENTIAL QUESTIONS

- How are acids & bases used to meet human needs?
- What are the implications of acid rain on an ecosystem?

SUGGESTED BLOCKS FOR INSTRUCTION: 8

BIG IDEA III:

KNOW	UNDERSTAND	DO
Students will know that:	***Students will understand that:***	***Students will be able to:***
• Titrations are controlled addition of a solution of known concentration (the titrant) in order to determine the concentration of a solution of unknown concentration. • The pH range is an important consideration when choosing an acid/base indicator. (5.2.12.A.6)	• Acids and bases are important in numerous chemical processes that occur around us, from industrial to biological processes, from the laboratory to the environment. • A large number of important reactions involve the transfer of either electrons or hydrogen ions between reacting ions, molecules, or atoms. In other chemical reactions, atoms interact with one another by sharing electrons to create a bond.	• Calculate the pH of a solution at various points of the titration, including: after a specified volume has been added, at the halfway point, at the equivalence point. • Use knowledge of the pH scale and indicator thresholds to choose appropriate indicators for a titration.
• The common ion effect means that when a salt provides an aqueous ion in solution that is already present due to an acid or base, the equilibrium will shift away from the added component.	**<u>Sample Conceptual Understandings</u>** **Titration** 1. Hydrogen cyanide gas (HCN), a powerful respiratory inhibitor, is highly toxic. It is a very weak acid (K_a = 6.2 x 10^{-10}) when dissolved in water. If a 50.0mL sample of 0.100M HCN is titrated with 0.100M NaOH, calculate the pH of the solution: a) After 8.00mL of 0.100MNaOH has been added. b) At the halfway point of the titration c) At the equivalence point of the titration.	• Calculate the initial concentration of ion from salt when calculating values for H+ and OH-. • Calculate the percent dissociation of an acid solution, given the K_a.
• A *buffered solution* is a solution that resists a change in pH when either hydroxide ions or protons are added. • Buffered solutions contain either a weak acid and its salt, or a weak base and its salt. • The capacity of a buffer is the amount of protons or hydroxide ions the buffer can absorb without a significant change in pH. (5.2.12.A.6)	**Buffers** 1. A buffered solution contains 0.25M NH_3 (K_b = 1.8 x 10^{-5}) and 0.40M NH_4Cl. Calculate the pH of this solution.	• Explain how a buffered solution works. • Calculate the pH of a buffered solution given the concentration and identity of its components. • Calculate the change in pH that occurs when a strong acid/base is added to a buffered solution. • Use the Hnderson-Hasselbalch equation to determine the pH of a buffered solution. • Calculate the buffering capacity.

BIG IDEA III:

KNOW	UNDERSTAND	DO
Students will know that:	***Students will understand that:***	***Students will be able to:***
• The solubility product (K_{sp}) can be used to describe the solubility of an ionic solid. (5.2.12.A.6)	**Solubility Product** 1. Calculate the solubility of solid CaF_2 ($K_{sp} = 4.0 \times 10^{-11}$) in a 0.025M NaF solution. **Extending the Concepts** 1. Research and report on serious acid rain effects over the past decade. Identify steps that have been taken, as well as steps that could be taken, to address this problem. 2. Construct models and draw electron dot structures of a water molecule and a hydronium ion. Diagram the process of the production of a hydronium ion from the water molecule.	• Given the solubility of an ionic solid, calculate the solubility product (K_{sp}). • Given the solubility product (K_{sp}) of an ionic solid, calculate the solubility of the species.

BIG IDEA III:

21st Century Skills		
Creativity and Innovation	***Critical Thinking and Problem Solving***	***Communication and Collaboration***
Information Literacy	***Media Literacy***	***ICT Literacy***
Life and Career Skills	***Technology Based Activities***	
http://www.p21.org/index.php?option=com_content&task=view&id=254&Itemid=119 http://www.iste.org/standards/nets-for-students.aspx		

Learning Activities

Laboratory Activities: 1) *"Acids, Bases, and Salts*" kit from Flinn Scientific; 2) "*Equilibrium Constant of an Ionic Compound*" kit from Flinn Scientific; 3) "*pH Properties of Buffer Solutions*" kit from Flinn Scientific; 4) *"Dissociation Constants of Weak Acids"* kit from Flinn Scientific;

Performance Assessment Task Sample	*You are a scientist for the Environmental Protection Agency*. You are charged with investigating the relationship between acid rain and the dissolved oxygen content in water. You will attempt to simulate the envinonment of a pond, and to determine the effects of acid rain on this aquatic environment. You will submit a report that includes: • Process and procedure for conducting the experiment. • Data & Results with appropriate analysis. • Implications for the future. <u>Teacher</u> Ask the students: • What are the effects of acid rain? • What are scientists doing to reduce acid rain? • What is the affect of acid rain as the rain water permeates soil? • How does acid rain affect the nutrient concentration of soil? (Analysis, Synthesis, Evaluation)

Assessment Models

- **NOTE: The assessment models provided in this document are suggestions for the teacher. If the teacher chooses to develop his/her own model, *it must be of equal or better quality and at the same or higher cognitive levels (as noted in parentheses*).**
- **Depending upon the needs of the class, the assessment questions may be answered in the form of essays, quizzes, mobiles, PowerPoint, oral reports, booklets, or other formats of measurement used by the teacher.**

Diagnostic/Pre-Assessment:

- Acid/Base Titration Mini-Lab
- Acid/Base KWL Chart

Open-Ended (Formative) Assessment:

- Group and individual work is assigned daily, from various sources *(Synthesis, Analysis, and Evaluation).*
- Introductory and Closing Activities will be done every day to pre-assess student knowledge and assess understanding of topics *(Synthesis, Analysis, and Evaluation).*

Summative Assessment:

- Assessment questions should be open-ended and should follow the general format illustrated in the Essential Questions/Sample Conceptual Understanding section. *(Synthesis, Analysis, Evaluation)*
- Assessment strategies will address a diverse array of learning modalities.
- Students will record laboratory data in laboratory notebook, a process that will be supplemented by the iPad2 technology.

(RST 1, 2, 3, 5, 7, 10)(WHST 2, 4, 5, 8, 10)

Additional Resources

Chemistry. 6th ed. Zumdahl & Zumdahl. (2006)
Chapter 15 (pp. 713 – 781)

Online Resources

http://epa.gov/acidrain/
http://www.cdphe.state.co.us/hm/hhw/howto/acidbase.htm

BIG IDEA IV:

BIG IDEA IV: Order

Curriculum Management System

COURSE NAME: Thermodynamics & Equilibrium Chemistry

OVERARCHING GOALS

1. All students will understand that science is both a body of knowledge and evidence-based, model-building enterprise that continually extends, refines, and revises knowledge.
2. Investigate, research, and synthesize data and information to understand meaningful real-world problems.

ESSENTIAL QUESTIONS

- In what ways does energy flowing into or out of a system impact the behavior of the system?
- How can "disorder" be positive?

SUGGESTED BLOCKS FOR INSTRUCTION: 8

BIG IDEA IV:

KNOW	UNDERSTAND	DO
Students will know that:	***Students will understand that:***	***Students will be able to:***
• Spontaneous processes are processes that occur without outside intervention. (5.2.12.C.1)	• There is a natural tendency for a system to move in the direction of disorder or entropy. • Nature proceeds toward the states that have the highest probabilities of existing.	• Identify a process as spontaneous or nonspontaneous. • Identify the driving force for a spontaneous process.
• Entropy (S) is a measure of randomness or disorder. • The driving force for a spontaneous process is an increase in the entropy of the universe. • Entropy is a thermodynamic function describing the number of arrangements that are available to a system. (5.2.12.C.1)	**Sample Conceptual Understandings** **Entropy Changes** 1. Predict the sign of the entropy change for each of the following processes: a) Solid sugar is added to water to form a solution. b) Iodine vapor condenses on a cold surface to form crystals. **Entropy of Surroundings**	• Distinguish between a substance with high positional entropy and low positional entropy. • Predict the sign of an entropy change for a given process.
• In any spontaneous process there is always an increase in the entropy of the universe. (5.2.12.C.1)	1. In the metallurgy of antimony, the pure metal is recovered via different reactions, depending on the composition of the ore. For example, iron is used to reduce the antimony in sulfide ores: Sb_2S_3 (s) + 3Fe (s) → 2Sb (s) + 3 FeS (s) $\Delta H = -125kJ$ Carbon is used as the reducing agent for oxide ores: Sb_4O_6 (s) + 6C (s) → 4Sb (s) + 6CO (g) $\Delta H = 778kJ$ Calculate ΔS_{surr} for each of these reactions at 25°C and 1 atm.	• Explain the 2nd Law of Thermodynamics. • Predict whether a process will be spontaneous, given the sign of ΔS_{univ}.
• Entropy changes in the surroundings are primarily determined by heat flow. (5.2.12.C.1)		• Calculate ΔS_{surr} for a given reaction, given conditions of temperature and pressure.

BIG IDEA IV:

KNOW	UNDERSTAND	DO
Students will know that:	***Students will understand that:***	***Students will be able to:***
• Reactions will always move in a direction that lowers their free energy (- ΔG). (5.2.12.D.5)	**Free Energy & Spontaneity** 1. At what temperatures is the following process spontaneous at 1 atm? Br_2 (l) → Br_2 (g) ΔH°= 31.0kJ/mol and ΔS°=93.0J/Kmol What is the normal boiling point of liquid Br_2? 2. Research the practical uses for bromine and discuss why the process above, with the indicated normal boiling point, contributes to its uses. What role does spontaneity play?	• Identify the temperatures at which a process is spontaneous, given the signs of ΔS and ΔH.
• The change in positional entropy is dominated by the relative numbers of molecules of gaseous reactants and products. (5.2.12.C.1)		• Predict the sign of ΔS° for a given reaction. • State the 3rd Law of Thermodynamics.
• ΔG° is the change in free energy that will occur if the reactants in their standard states are converted to the products in their standard states. • ΔG° cannot be measured directly. • The more negative the value for ΔG°, the farther to the right the reaction will proceed in order to achieve equilibrium. • Equilibrium point occurs at the lowest value of free energy available to the reaction system. (5.2.12.D.5)		• Calculate ΔH° , ΔS° , and ΔG° , using given enthalpies of formation and positional entropies. • Calculate ΔG° given free energies of formation for a reaction. • Identify the equilibrium point given free energy data. • Calculate the equilibrium constant, given enthalpy and entropy data.

BIG IDEA IV:

21st Century Skills		
Creativity and Innovation	***Critical Thinking and Problem Solving***	***Communication and Collaboration***
Information Literacy	***Media Literacy***	***ICT Literacy***
Life and Career Skills	***Technology Based Activities***	
http://www.p21.org/index.php?option=com_content&task=view&id=254&Itemid=119 http://www.iste.org/standards/nets-for-students.aspx		

Learning Activities	
Laboratory Activities: 1) "*Entropy Lab*" from Chemistry lab handouts;	
Performance Assessment Task Sample	*You are a chemist at a metal refinery*. You are charged investigating the process of impure nickel being refined by smelting sulfide ores in a blast furnace. You will attempt to provide the refinery with thermodynamic specifications with regard to entropy, enthalpy, and free energy. You will submit a report that includes: • The sign of the entropy change for the reaction. • Calculation of entropy and enthalpy for the reaction. • Calculation of the equilibrium constant. <u>Teacher</u> Ask the students: • What are the needs for this process? • Is the process spontaneous? • Why is the temperature increased for the second step of the process? (Analysis, Synthesis, Evaluation)

Assessment Models

- **NOTE: The assessment models provided in this document are suggestions for the teacher. If the teacher chooses to develop his/her own model, *it must be of equal or better quality and at the same or higher cognitive levels (as noted in parentheses*).**
- **Depending upon the needs of the class, the assessment questions may be answered in the form of essays, quizzes, mobiles, PowerPoint, oral reports, booklets, or other formats of measurement used by the teacher.**

Diagnostic/Pre-Assessment:

- Do Now: Review of Thermodynamic Concepts (State Functions)

Open-Ended (Formative) Assessment:

- Differentiated group and individual work is assigned daily, from various sources *(Synthesis, Analysis, and Evaluation).*
- Introductory and Closing Activities will be done every day to pre-assess student knowledge and assess understanding of topics *(Synthesis, Analysis, and Evaluation).*
- Homework assigned daily.

Summative Assessment:

- Assessment questions should be open-ended and should follow the general format illustrated in the Essential Questions/Sample Conceptual Understanding section. *(Synthesis, Analysis, Evaluation)*
- Assessment strategies will address a diverse array of learning modalities.
- Students will record laboratory data in laboratory notebook, a process that will be supplemented by the iPad2 technology.

(RST 2, 3, 5, 6, 7, 8, 10)(WHST 1, 2, 4, 5, 7, 8, 9, 10)

Additional Resources

Chemistry. 6th ed. Zumdahl & Zumdahl. (2006)
Chapter 16 (pp. 783 – 825)

Online Resources

http://entropysite.oxy.edu/wiki_entropy.html
http://chemed.chem.purdue.edu/genchem/topicreview/bp/ch21/gibbs.php

BIG IDEA V:

BIG IDEA V: Transfer

Curriculum Management System
COURSE NAME: Thermodynamics & Equilibrium

OVERARCHING GOALS

1. All students will understand that science is both a body of knowledge and evidence-based, model-building enterprise that continually extends, refines, and revises knowledge.
2. Investigate, research, and synthesize data and information to understand meaningful real-world problems.

ESSENTIAL QUESTIONS

- How are electrolytic processes influential in preparing industrial materials?
- How can electrochemistry be used to analyze trace amounts of pollutants in natural waters?

SUGGESTED BLOCKS FOR INSTRUCTION: 8

BIG IDEA V:

KNOW	UNDERSTAND	DO
Students will know that:	***Students will understand that:***	***Students will be able to:***
• Oxidation refers to a loss of electrons. • Reduction refers to a gain of electrons. • The species oxidized is the reducing agent. • The species reduced is the oxidizing agent. (5.2.12.B.2)	• A large number of important reactions involve the transfer of electrons between reacting ions, molecules, or atoms. • Electrochemistry is concerned with the generation of an electric current from a spontaneous chemical reaction and the opposite process, the use of a current to produce chemical change. **<u>Sample Conceptual Understandings</u>** **Galvanic Cells** 1. Consider a galvanic cell based on the reaction: Al^{3+} (aq) + Mg (s) → Al (s) + Mg^{2+}(aq) The half reactions are: $Al^{3+} + 3e^- \rightarrow Al$ E° = -1.66V $Mg^{2+} + 2e^- \rightarrow Mg$ E° = -2.37V Give the balanced cell reaction and calculate E° for the cell. 2. Using data of standard reduction potentials, calculate ΔG° for the reaction: Cu^{2+} (aq) + Fe (s) → Cu (s) + Fe^{2+} (aq)	• Define *oxidation* and *reduction*. • Given a redox reaction, identify the: o Substance being oxidized o Substance being reduced o Oxidizing agent o Reducing agent • Locate and identify applications of redox in industrial processes.
• A galvanic cell changes chemical energy to electrical energy. • Reduction occurs at the cathode, and oxidation at the anode. (5.2.12.B.2)		• Label the components of a galvanic cell. • Identify half reactions as processes of oxidation or reduction.
• Cell potential is the electromotive force on the electrons. (5.2.12.B.2)		• Use a voltmeter or potentiometer to measure the cell potential. • Calculate cell potentials given standard reduction potentials.
• Electromotive force can be converted to work. • Work leaving the system has a negative charge. • Electromotive force is not converted to work with 100% efficiency, as energy is always lost in the form of heat. (5.2.12.B.2)		• Explain the relationship between cell potential, work, and charge. • Calculate ΔG° for a cell reaction using half reactions and cell potentials.

BIG IDEA V:

KNOW	UNDERSTAND	DO
Students will know that:	***Students will understand that:***	***Students will be able to:***
• Cells spontaneously discharge until they achieve equilibrium, at which point they are considered "dead." (5.2.12.D.5)	**Equilibrium Constants from Cell Potentials** 1. For the oxidation-reduction reaction: $S_4O_6^{2-}(aq) + Cr^{2+}(aq) \rightarrow Cr^{3+}(aq) + S_2O_3^{2-}(aq)$ The appropriate half reactions are: $S_4O_6^{2-} + 2e^- \rightarrow S_2O_3^{2-}$ $E° = 0.17V$ $Cr^{3+} + e^- \rightarrow Cr^{2+}$ $E° = -0.50V$ Balance the redox, and calculate E° and K (at 25°C). **<u>Extending the Concepts</u>** 1. Why is aluminum metal more easily produced from recycled aluminum cans than from aluminum contained in clay, bauxite, or aluminum oxide ore? 2. Investigate the amount and composition of wastes in your community. Construct a graphical visual aid to convey this data. a) How does your community compare to the nation? b) What steps could be taken to reduce the quantity of discards in your community?	• Given a redox reaction, calculate the cell potential and the equilibrium constant. • Identify the value of ΔG when a cell is considered "dead."
• A battery is a galvanic cell, or group of galvanic cells, connected in series. (5.2.12.B.2)		• Identify common types of batteries o Lead Storage o Dry Cell Battery o Fuel Cell
• Corrosion refers to the oxidation of a metal. • Many metals develop a thin layer of metal oxide on the outside that prevents further oxidation. (5.2.12.B.2)		• Explain the process of corrosion. • Identify means for preventing corrosion for certain metals.
• Electrolysis is the forcing of a current through a cell to produce a negative cell potential. (5.2.12.B.2)		• Explain the concept of electrolysis and connect it to spontaneity. • Identify applications for the electrolysis of water to produce hydrogen and oxygen.
• Electroplating is a depositing of neutral metal atoms on the electrode by reducing metal ions in solution. • Metals that are more easily reduced are plated more readily. (5.2.12.B.2)		• Identify the amount of current needed to produce a given amount of metal. • Calculate how long a given current must be applied to produce a given amount of metal.

21st Century Skills		
Creativity and Innovation	***Critical Thinking and Problem Solving***	***Communication and Collaboration***
Information Literacy	***Media Literacy***	***ICT Literacy***
Life and Career Skills	***Technology Based Activities***	
http://www.p21.org/index.php?option=com_content&task=view&id=254&Itemid=119 http://www.iste.org/standards/nets-for-students.aspx		

Learning Activities

Laboratory Activities: 1) "*Electrochemical Cells*" kit from Flinn Scientific; 2) "*Intro to Oxidation-Reduction*" kit from Flinn Scientific; 3) "*Producing Metals with Electricity"* kit from Flinn Scientific;

Performance Assessment Task Sample

You are a research chemist for a prominent manufacturer of household batteries. You are charged with investigating different options for the contents of a newly designed battery. You will target three options for anode/cathode half reactions to design your battery. You will conduct an experiment to test the three options chosen, and will report back to your company.

You will submit a report that includes:

- Process and procedure for choosing battery options.
- Observations recorded.
- Voltages measured.
- Implications of results & recommendations

Teacher

Ask the students:

- What are the main issues in choosing an effective process for a battery?
- Is your choice a viable option for your manufacturer? Why or why not?

(Analysis, Synthesis, Evaluation)

Assessment Models

- **NOTE: The assessment models provided in this document are suggestions for the teacher. If the teacher chooses to develop his/her own model, *it must be of equal or better quality and at the same or higher cognitive levels (as noted in parentheses*).**
- **Depending upon the needs of the class, the assessment questions may be answered in the form of essays, quizzes, mobiles, PowerPoint, oral reports, booklets, or other formats of measurement used by the teacher.**

Diagnostic/Pre-Assessment:

- Do Now: How does a battery work?
- Redox Preassessment

Open-Ended (Formative) Assessment:

- Differentiated group and individual work is assigned daily, from various sources *(Synthesis, Analysis, and Evaluation).*
- Introductory and Closing Activities will be done every day to pre-assess student knowledge and assess understanding of topics *(Synthesis, Analysis, and Evaluation).*
- Homework assigned on a nightly basis.

Summative Assessment:

- Assessment questions should be open-ended and should follow the general format illustrated in the Essential Questions/Sample Conceptual Understanding section. *(Synthesis, Analysis, Evaluation)*
- Assessment strategies will address a diverse array of learning modalities.
- Students will record laboratory data in laboratory notebook, a process that will be supplemented by the iPad2 technology.

(RST 1, 2, 3, 5, 6, 7, 10)(WHST 1, 2, 4, 5, 8, 10)

Additional Resources

Chemistry. 6th ed. Zumdahl & Zumdahl. (2006)
Chapter 17 (pp. 828 – 875)

Online Resources
http://www.science.uwaterloo.ca/~cchieh/cact/c123/battery.html
http://hyperphysics.phy-astr.gsu.edu/hbase/electric/battery.html

BIG IDEA X:

BIG IDEA VI: Structure

Curriculum Management System

COURSE NAME: Thermodynamics & Equilibrium Chemistry

OVERARCHING GOALS

1. All students will understand that science is both a body of knowledge and evidence-based, model-building enterprise that continually extends, refines, and revises knowledge.
2. Investigate, research, and synthesize data and information to understand meaningful real-world problems.

ESSENTIAL QUESTIONS

- How do structures of biologically important molecules account for their functions?
- What is the role of carbon in the molecular diversity of life?

SUGGESTED BLOCKS FOR INSTRUCTION: 5

BIG IDEA X:

KNOW	UNDERSTAND	DO
Students will know that:	***Students will understand that:***	***Students will be able to:***
• Straight chained hydrocarbons are referred to as alkanes. (5.2.12.B.1)	• The structure and geometry of molecules affects both the properties they exhibit as well as their intermolecular interactions. • Organic molecules are the foundation for many processes and concepts related to human life. **<u>Sample Conceptual Understandings</u>** **Structural Isomerism & Nomenclature** 1. Draw the isomers of pentane. 2. Draw the structural isomers for the alkane C_6H_{14} and give the systematic name for each one. 3. Determine the structure for each of the following compounds: a) 4-ethyl-3,5-dimethylnonane b) 4-tert-butylheptane	• Write formulas for the alkanes containing 1-10 carbons. • Name the alkanes containing 1-10 carbons.
• Structural isomers contain the same formula, but have different structures (arrangements). • Structural isomers have different properties from one another. (5.2.12.B.1)		• Identify structural isomers for each alkane. • Predict property trends based on knowledge of isomers and bond order. • Name structural isomers that are branched-chain alkanes.
• Cycloalkanes are structures in which the carbon atoms are arranged in a ring. (5.2.12.B.1)		• Number the rings of cycloalkanes. • Name given cycloalkanes.
• Alkenes are hydrocarbons that contain a double bond. • Alkynes are hydrocarbons that contain a triple bond. (5.2.12.B.1)		• Draw structures for various alkanes and alkynes. • Write names for various alkanes and alkynes.

BIG IDEA X:

KNOW		UNDERSTAND	DO
Students will know that:		***Students will understand that:***	***Students will be able to:***
	• Geometric isomers are isomers in which the order of chemical bonding is the same, but the arrangement of atoms in space is different. • In some isomer pairs, one isomer is biologically active, while the other is not. (5.2.12.B.1)	**<u>Extending the Concepts</u>** 1. Investigate several different polyesters. How are they formed? What explains their differences in properties? Give two structural formulas for polyesters. List five everyday products made of polyester. 2. Research and write about one example in which substituting a different functional group in a drug's molecular structure has had a dramatic effect on its medicinal properties.	• Draw geometric isomers for compounds that have the same formula and bond order. • Name geometric isomers for compounds that have the same formula and bond order.
	• Aromatic hydrocarbons are hydrocarbons with six-membered carbon rings and delocalized rings. (5.2.12.B.1)		• Identify and name aromatic hydrocarbons.
	• Characteristic functional groups allow for classification of hydrocarbon derivatives. (5.2.12.B.1)		• Identify common functional groups seen in organic compounds. • Classify an organic structure based on functional groups present.

BIG IDEA X:

21st Century Skills		
Creativity and Innovation	***Critical Thinking and Problem Solving***	***Communication and Collaboration***
Information Literacy	***Media Literacy***	***ICT Literacy***
Life and Career Skills	***Technology Based Activities***	
http://www.p21.org/index.php?option=com_content&task=view&id=254&Itemid=119 http://www.iste.org/standards/nets-for-students.aspx		

Learning Activities	
Laboratory Activities: 1) "*Ester Formation*" kit from Flinn Scientific; 2) "*Organic Chemistry Kit*" kit from Flinn Scientific; 3) "*Polymers, Polymers, Polymers"* kit from Flinn Scientific;	
Performance Assessment Task Sample	*You are an organic chemist for a plastic manufacturer*. Your task is to investigate the polymer units in ABS plastic. You will target three monomer units in considering the polymer components of the plastic. You will collect information such as chemical formula, percent composition, and monomer mole ratios. You must determine if the composition of the plastic is optimal for its intended use. You will submit a report that includes: • Sketch of two repeating units of plastic assuming that the three monomer units react in a 1:1:1 mole ratio. • Percent by mass of acrylonitrile, butadiene, and styrene in the polymer sample. • Determination of the actualy mole ratio among the three monomer units. • Implications of results & statement about viability of plastic <u>Teacher</u> Ask the students: • Why is quality control of plastics important? • Can different monomer mole ratios be deemed acceptable depending on the plastic's intended use? (Analysis, Synthesis, Evaluation)

Assessment Models

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Diagnostic/Pre-Assessment:

- KWL Chart: Organic Chemistry
- Prewrite: Carbon-containing compounds

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Additional Resources

Chemistry. 6th ed. Zumdahl & Zumdahl. (2006)
Chapter 22 (pp. 1043 – 1102)

Online Resources
http://www.organic-chemistry.org/
http://www.livescience.com/3505-chemistry-life-human-body.html