Advanced Chemistry

[Implement start year (2013-2014)]

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Unit 3: Driving Forces of Chemical Reactions: *Students will be able to independently use their learning to predict the outcome of a chemical reaction based upon its kinetic and thermodynamic properties.*

Stage 1 – Desired Results

Established Goals	21st Century Themes
2009 NJCCC Standard(s), Strand(s)/CPI # (http://www.state.nj.us/education/cccs/) 5.1.12.A.1 Mathematical, physical, and computational tools are used to search for and explain core scientific concepts and principles. 5.1.12.A.2 Interpretation and manipulation of evidence-based models are used to build and critique arguments/explanations. 5.1.12.B.3 Empirical evidence is used to construct and defend arguments. 5.2.12.A.1 Electrons, protons, and neutrons are parts of the atom and have measurable properties, including mass and, in the case of protons and electrons, charge. The nuclei of atoms are composed of protons and neutrons. A kind of force that is only evident at nuclear distances holds the particles of the nucleus together against the electrical repulsion between the protons. 5.2.12.A.2 Differences in the physical properties of solids, liquids, and gases are explained by the ways in which the atoms, ions, or molecules of the substances are arranged, and by the strength of the forces of attraction between the atoms, ions, or molecules. 5.2.12.A.5 Solids, liquids, and gases may dissolve to form solutions. When combining a solute and solvent to prepare a solution, exceeding a particular	**(www.21stcenturyskills.org)** _X_ Global Awareness _X_Financial, Economic, Business and Entrepreneurial Literacy _X_Civic Literacy _X_Health Literacy _X_Environmental Literacy **21st Century Skills** *Learning and Innovation Skills:* _X_Creativity and Innovation _X_ Critical Thinking and Problem Solving _X_Communication and Collaboration *Information, Media and Technology Skills:* __X_Information Literacy __X_Media Literacy __X_ICT (Information, Communications and Technology) Literacy *Life and Career Skills:* __X_Flexibility and Adaptability __X_Initiative and Self-Direction __X_Social and Cross-Cultural Skills __X_Productivity and Accountability __X_Leadership and Responsibility

concentration of solute will lead to precipitation of the solute from the solution. Dynamic equilibrium occurs in saturated solutions. Concentration of solutions can be calculated in terms of molarity, molality, and percent by mass. 5.2.12.B.1 An atom's electron configuration, particularly of the outermost electrons, determines how the atom interacts with other atoms. Chemical bonds are the interactions between atoms that hold them together in molecules or between oppositely charged ions 5.2.12.C.1 Gas particles move independently and are far apart relative to each other. The behavior of gases can be explained by the kinetic molecular theory. The kinetic molecular theory can be used to explain the relationship between pressure and volume, volume and temperature, pressure and temperature, and the number of particles in a gas sample. There is a natural tendency for a system to move in the direction of disorder or entropy. 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. Heating a pure solid increases the vibrational energy of its atoms, molecules, or ions. When the vibrational energy of the molecules of a pure substance becomes great enough, the solid melts. 5.2.12.B.3 The conservation of atoms in chemical reactions leads to the ability to calculate the mass of products and reactants using the mole concept. **Common Core Curriculum Standards for Math and English** (http://www.corestandards.org/)	

Enduring Understandings:	**Essential Questions:**
Students will understand that . . . *EU1* Simple qualitative and quantitative models can be used to analyze and explain the rate of a chemical reaction. *EU2* The extent of completeness of chemical reactions can be predicted by simple qualitative and quantitative models. *EU3* The three laws of thermodynamics govern the spontaneity and completeness of a chemical reaction.	*EU 1* • Does the rate of a chemical reaction affect its usefulness? *EU 2* • When is a reaction finished and how can its outcome be controlled? *EU3* • To what extent do energy transformations govern chemical and physical processes?

Knowledge: *Students will know . . .*	**Skills:** *Students will be able to . . .*
EU1 • Collision theory • Activation energy • Energy profiles • Reaction Mechanisms. • Differential and Integrated rate laws. • Nuclear kinetics	*EU1* • Use the collision model to predict how various changes will affect the rate of a reaction. • Interpret an energy profile for a reaction. • Determine a rate law using experimental data, both graphically and mathematically. • Calculate the rate constant, including units, for a reaction. • Calculate instantaneous rates and concentrations from an experimentally determined rate law. • Analyze a mechanism to determine its feasibility.

EU2
• Law of Mass Action
• LeChatelier's Principle
• Reaction Quotent (Q)
• Acid-Base Equilibrium
    • Ka/Kb values
    • Titrations and pH curves
    • Interactions of strong and weak acids and bases
    • Buffered solutions
• Solubility Product constants and precipitation
	EU2
	• Calculations involving reactants and products and equilibrium and non-equilibrium conditions (ICE tables)
	• Calculate equilibrium constants and equilibrium concentrations.
	• Analyze a pH curve from a titration.
	• Calculate pH and concentration of an acid/base via titration
	• Given the nature of the acid/base combination, choose the proper indicator
	• Predict the impact on pH when adding additional acid or base to a buffered solution
	• Use K_{sp} to determine a substance's maximum solubility
	• Use the magnitude of the K value or Q value to determine status of a reaction

EU3
• Enthalpy
    • Hess' Law
    • Standard Enthalpies of Formation
    • Bond Enthalpies
• Entropy
• Gibbs Free Energy
• Equilibrium, thermodynamics, and kinetics and electromotive force are all interrelated
• Mathematical equations can help chemists interpret the interplay of all driving forces on a reaction
	EU3
	• Relate laboratory observations to thermodynamic changes
	• Calculate thermodynamic values from given data
	• Utilize mathematical relationships between the various driving forces of reactions to predict and rationalize the progression of a chemical reaction

Stage 2 – Assessment Evidence

Recommended Performance Tasks: *Each unit must have at least 1 Performance Task. Consider the GRASPS form.*

Describe your performance tasks here (in bulleted format if more than one).

- Students will determine the chemical process by which bleach removes color in order to find ways to maximize its effectiveness. Each student will be assigned the role as a Research Assistant for the Clorox® Corporation. Clorox® is looking to create a "New and Improved" bleach formulation in order to maximize the performance of the product. In order to accomplish this task, the president of the company tasks the Research and Development department to improve the process. The job of the student researcher is to support the R&D team by providing the most likely mechanistic pathway for the action of bleach on stains (using blue food coloring as the sample stain). To accomplish this goal, students must present and defend (in oral or written format) their mechanism choice using experimental evidence to support their argument. (EU 1)

- Students will take measurements on a miniature swimming pool (or will use a report of the measurements for a life-sized pool) and then recommend the appropriate amounts of four common pool chemicals in order to balance the pool water for pH, total alkalinity, hardness, and chlorine levels. These recommendations will be accompanied by an explanation including equilibrium equations and equilibrium calculations. Students could take on the role of a swimming pool owner seeking justification for the pool store's seemingly excessive recommended chemical amounts and prepare a written report to show to the store manager.

- As part of an ROTC science program, students have been tasked to evaluate the complaints of the soldiers in combat zones that the Meals Ready to Eat (MRE) are not cooking quickly enough. Using information about the thermodynamic properties of the food and the chemical reaction that produces the heat used to cook the meal, students will prepare a letter to the military food services official with their recommendations on how to change the MRE to be more efficiently cooked. (EU 3)

- Analysis, using kinetics and thermodynamics, of a chemical change. (EU 1, EU 2, EU 3) Possible student prompts:

    - Many jewelry stores advertise the sentiment that "Diamonds are forever". While watching TV with a friend, you see a commercial with the familiar phrase that "diamonds are forever". Your friend just learned in their chemistry class that, according to the Laws of Thermodynamics, diamonds should spontaneously turn into graphite. Using your knowledge of the driving forces of chemical reactions, defend or dispute the claim that "diamonds are forever", being sure to provide your rationale behind the chemistry of this reaction.
    - A friend approaches you and tells you he intends to buy an engagement ring and propose to his girlfriend of 5 days because she is "the one". He confides in you that he does not have a job and cannot afford a large diamond ring. He then tells you that he did some research online and found out that diamonds spontaneously decompose into graphite, so he was thinking about just buying her a graphite ring. He asks you if you think this is a good idea. Prepare 1-2 paragraphs that you could email your friend that (1) explains whether his research is correct and (2) provides your opinion about whether a diamond ring is a good investment (based on chemistry, not dating principles).

Other Recommended Evidence: *Tests, Quizzes, Prompts, Self-assessment, Observations, Dialogues, etc.*

- Quizzes on Rate Laws, mechanisms, half-lives, Le Chatelier's Principle, simple equilibrium constant calculations, pH, conjugate acids/bases, K_{sp}, Hess's Law, entropy, and Gibb's Free energy
- Tests on Kinetics, Equilibrium, Acid/ Base Equilibrium, and Thermodynamics
- Laboratory notebooks or reports will be used to assess lab skills and practical use of various content

Stage 3 – Learning Plan

Suggested Learning Activities to Include Differentiated Instruction and Interdisciplinary Connections: *Consider the WHERETO elements. Each learning activity listed must be accompanied by a learning goal of A= Acquiring basic knowledge and skills, M= Making meaning and/or a T= Transfer.*

- Simulation of a reaction using beans to model an aqueous reaction (set up as a race where different groups have different "initial concentrations") in order to introduce how rates are measured (M)
- Laboratory activity, demonstration, and/or discussion to investigate how changes in the various factors affect the rate of reactions (M/T)
- POGIL on the determination of rate laws (M)
- Guided practice in solving the various types of mathematical problems associated with rate laws (M/T)
- Laboratory experiment where rates and rate laws are determined from data collected by student (*e.g.* Iodine Clock Reaction Lab) (T)
- Demonstration: Set up two different funnel systems, where A is a single long-stem funnel and B is a long-stem funnel below a wide-stem funnel. Water is poured into each in the same way in order to model the "rate-determining" step. Since the thinner long-stem funnel is the rate-determining step, both finish at the same time. (M)
- POGIL on reaction mechanisms (M)
- Discuss mechanisms and model/discuss the various aspects involved in analyzing them. (A)
- Demonstration: Ping pong balls or "Switch-Pitch" balls to demonstrate molecularity and activation energy of a reaction step (M)
- Use various analogies to help the students understand the necessary aspects of a successful collision (M)
- Laboratory experiment or demonstration where activation energy is determined from lab data (T)
- Given experimental data and a proposed mechanism for a given reaction, students will determine the rate law and identify the rate-determining step in the mechanism. (T)
- POGIL – LeChatelier's Principle (A/M)
- Discussion with clarification of applying LeChatelier's Principle to changes in concentration, pressure and temperature (M)
- Teacher-led discussion of the equilibrium constant and Law of Mass Action (A)
- Guided practice in using the ICE chart (Initial – Change – Equilibrium) to solve mathematical problems associated with equilibrium (M)
- Spectrophotometric determination of an equilibrium constant (*e.g.* Formation of $Fe[SCN]^{2+}$) (T)
- Independent practice in solving mathematical problems associated with equilibrium (T)
- Discussion of similarities of all types of equilibrium problems (Kc, Ksp, Ka) (A/M)

- Independent practice in solving equilibrium problems involving precipitation and acid/base chemistry (T)
- Acid/Base Titration Lab (using indicators & pH probes, determining concentration of acid/pH, etc.) (M/T)
- Discussion of buffers in nature (M)
- Teacher modeling of solving buffer problems (A/M)
- Independent practice in solving buffer problems. (T)
- Demonstrations of spontaneous vs. non-spontaneous reactions; spontaneity not related to time ($KMnO_4$ + Glycerin) (A)
- Thermodynamics and Solubility Lab (M/T)
- Teacher-led discussion of practical applications of enthalpy changes (M)
- Review of enthalpy calculations (students learn parts of this in 1st year chemistry) (A)
- Teacher-directed modeling of Hess's Law (A)
- Independent practice in solving Hess's Law problems (T)
- Teacher-led discussion of entropy and Gibb's free energy (A)
- Independent practice in solving thermodynamics problems (T)
- Lab using baking soda and vinegar to calculate thermodynamic changes for a simple reaction. (T)
- Discussion about the relationship between kinetics, equilibrium, and thermodynamics- (A/M)
- Independent practice in solving problems involving more than one of the above concepts (T)

This resource manual has a variety of examples that may be used as a demo, activity or lab.
http://www.oakland.k12.mi.us/Portals/0/Learning/Themodynamics2.pdf