South Carolina Academic Standards and Performance Indicators for Science 2014

Instructional Units Resource

Chemistry

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As support for implementing the *South Carolina Academic Standards and Performance Indicators for Science 2014*, the standards for Chemistry have been grouped into possible units. In the Overview of Units below, the titles for those possible units are listed in columns. Refer to the Overview document to note these unit titles and how Standards, Conceptual Understandings, Performance Indicators, Science and Engineering Practices, and Crosscutting Concepts align. Following the Overview of Units, an Instructional Unit document is provided that delivers guidance and possible resources in teaching our new *South Carolina Academic Standards and Performance Indicators for Science 2014*. The purpose of this document is to provide guidance as to how all the standards in this grade may be grouped into units and how those units might look. Since this document is merely guidance, districts should implement the standards in a manner that addresses the district curriculum and the needs of students. This document is a living document and instructional leaders from around the state will continuously update and expand these resource documents. These documents will be released throughout the 2016-2017 school year with the intentionality of staying ahead of instruction. Teachers should also note that links to the Standards document, A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas, the SEP Support Document, and the Support Document 2.0 are embedded throughout the Instructional Unit format for reference.

Acknowledgments

Jean Baptiste Massieu, famous deaf educator, made a statement that is now considered a French proverb. “Gratitude is the memory of the heart. Indeed, appreciation comes when you feel grateful from the depths of your heart. The head keeps an account of all the benefits you received and gave. But the heart records the feelings of appreciation, humility, and generosity that one feels when someone showers you with kindness.” It is with sincere appreciation that we humbly acknowledge the dedication, hard work and generosity of time provided by teachers and instructional leaders across the state that have made and are continuing to make the Instructional Unit Resources possible.

Chemistry Overview of Units

Unit 1		Unit 2	Unit 3	Unit 4	Unit 5	Unit 6
ATOMIC STRUCTURE AND NUCLEAR PROCESSES		BONDING AND CHEMICAL FORMULAS	STATES OF MATTER	SOLUTIONS, ACIDS, AND BASES	CHEMICAL REACTIONS	THERMOCHEMISTRY AND CHEMICAL KINETICS
Standard		**Standard**	**Standard**	**Standard**	**Standard**	**Standard**
H.C.2		H.C.3	H.C.4	H.C.5	H.C.6	H.C.7
Conceptual Understanding		**Conceptual Understanding**	**Conceptual Understanding**	**Conceptual Understanding**	**Conceptual Understanding**	**Conceptual Understanding**
H.C.2A	H.C.2B	H.C.3A	H.C.4A	H.C.5A	H.C.6A	H.C.7A
Performance Indicators		**Performance Indicators**	**Performance Indicators**	**Performance Indicators**	**Performance Indicators**	**Performance Indicators**
H.C.2A.1 H.C.2A.2 H.C.2A.3	H.C.2B.1 H.C.2B.2 H.C.2B.3 H.C.2B.4	H.C.3A.1 H.C.3A.2 H.C.3A.3 H.C.3A.4 H.C.3A.5 H.C.3A.6 H.C.3A.7	H.C.4A.1 H.C.4A.2 H.C.4A.3	H.C.5A.1 H.C.5A.2 H.C.5A.3 H.C.5A.4	H.C.6A.1 H.C.6A.2 H.C.6A.3 H.C.6A.4	H.C.7A.1 H.C.7A.2 H.C.7A.3 H.C.7A.4
***Science and Engineering Practices**		***Science and Engineering Practices**	***Science and Engineering Practices**	***Science and Engineering Practices**	***Science and Engineering Practices**	***Science and Engineering Practices**
S.1A.2 S.1A.6 S.1A.4 S.1A.8 S.1A.5		S.1A.2 S.1A.6 S.1A.3 S.1A.4	S.1A.2 S.1A.3 S.1A.4	S.1A.4 S.1A.5 S.1A.8	S.1A.2 S.1A.3 S.1A.5	S.1A.2 S.1A.5 S.1A.3 S.1A.4
***Crosscutting Concepts**		***Crosscutting Concepts**	***Crosscutting Concepts**	***Crosscutting Concepts**	***Crosscutting Concepts**	***Crosscutting Concepts**
1, 2, 3, 4, 5, 6, 7		1, 4, 6	2, 4, 5	2, 3, 6	1, 2, 3, 4, 7	2, 3, 4, 6, 7

**Teachers have the discretion to enhance the selected SEP's and CCC's.*

Unit Title
Thermochemistry and Chemical Kinetics
Standard http://ed.sc.gov/scdoe/assets/file/agency/ccr/Standards-Learning/documents/South_Carolina_Academic_Standards_and_Performance_Indicators_for_Science_2014.pdf
H.C.7-The student will demonstrate an understanding of the conservation of energy and energy transfer.

Conceptual Understanding

H.C.7A The first law of thermodynamics states that the amount of energy in the universe is constant. An energy diagram is used to represent changes in the energy of the reactants and products in a chemical reaction. Enthalpy refers to the heat content that is present in an atom, ion, or compound. While some chemical reactions occur spontaneously, other reactions may require that activation energy be lowered in order for the reaction to occur.

New Academic Vocabulary

Some students may need extra support with the following academic vocabulary in order to understand what they are being asked to understand and do. Teaching these terms in an instructional context is recommended rather than teaching the words in isolation. A great time to deliver explicit instruction for the terms would be during the modeling process. Ultimately, the student should be able to use the academic vocabulary in conversation with peers and teachers. These terms are pulled from the essential knowledge portion of the Support Doc 2.0 (http://ed.sc.gov/instruction/standards-learning/science/support-documents-and-resources/) and further inquiry into the terms can be found there.

Law of conservation of energy	Enthalpy	Exothermic	Endothermic	Heat of reaction	Potential energy of reactants
Potential energy of products	Activation energy	Thermochemical equations	Molar enthalpies of reaction	Bond energy	Specific heat
Energy diagram	Enthalpy of combustion	Collision theory	Collisions	Surface area	Concentration
Catalyst	Favorable orientation of reactants	Activation pathway	Reaction pathway		

Performance Indicators
Text highlighted below in *orange* and *italicized/underlined* shows connections to SEP's.
H.C.7A.1 *Analyze and interpret data* from energy diagrams and investigations to support claims that the amount of energy released or absorbed during a chemical reaction depends on changes in total bond energy. H.C.7A.2 *Use mathematical and computational thinking* to write thermochemical equations and draw energy diagrams for the combustion of common hydrocarbon fuels and carbohydrates, given molar enthalpies of combustion. H.C.7A.3 *Plan and conduct controlled scientific investigations* to determine the effects of temperature, surface area, stirring, concentration of reactants, and the presence of various catalysts on the rate of chemical reactions. H.C.7A.4 *Develop and use models to explain* the relationships between collision frequency, the energy of collisions, the orientation of molecules, activation energy, and the rates of chemical reactions.
***Science and Engineering Practices** **Support for the guidance, overviews of grade level progressions, and explicit details of each SEP can found in the Science and Engineering Support Doc (http://ed.sc.gov/scdoe/assets/File/instruction/standards/Science/Support%20Documents/Complete_2014SEPsGuide_SupportDoc2_0.pdf). It is important that teachers realize that the nine science and engineering practices are not intended to be used in isolation. Even if a performance indicator for a given standard only lists one of the practices as a performance expectation, scientists and engineers do not use these practices in isolation, but rather as part of an overall sequence of practice. When educators design the learning for their students, it is important that they see how a given performance expectation fits into the broader context of the other science and engineering practices. This will allow teachers to provide comprehensive, authentic learning experiences through which students will develop and demonstrate a deep understanding of scientific concepts.**
H.C.1A.2 Develop and use models to (1) understand or represent phenomena, processes, and relationships; (2) test devices or solutions; or (3) communicate ideas to others. H.C.1A.3 Plan and conduct controlled scientific investigations to answer questions, test hypotheses, and develop explanations: (1) formulate scientific questions and testable hypotheses based on credible scientific information; (2) identify materials, procedures, and variables; (3) use appropriate laboratory equipment, technology, and techniques to collect qualitative and quantitative data; and (4) record and represent data in an appropriate form. Use appropriate safety procedures. H.C.1A.4 Analyze and interpret data from informational texts and data collected from investigations using a range of methods (such as tabulation, graphing, or statistical analysis) to (1) reveal patterns and construct meaning; (2) support or refute hypotheses, explanations, claims, or designs; or (3) evaluate the strength of conclusions. H.C.1A.5 Use mathematical and computational thinking to (1) use and manipulate appropriate metric units, (2) express relationships between variables for models and investigations, and (3) use grade-level appropriate statistics to analyze data.
***Cross Cutting Concepts (http://www.nap.edu/read/13165/chapter/8)** **The link above provides support from the Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (2012). The text in blue and *italicized/underlined* below provides a brief explanation of how the specific content ties to the CCC's.**

2. Cause and effect Mechanism and explanation: The National Research Council (2012) states that "events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts" (p. 84). *When temperature increases, then the number of collisions between molecules and reaction rates increase.*

3. Scale, proportion, and quantity: The National Research Council (2012) states that "in considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance" (p. 84). *For exothermic reactions, the heat of reaction is a negative value. For endothermic reactions, the heat of reaction is a positive value.*

4. Systems and systems models: The National Research Council (2012) states that "Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering" (p. 84). *The total energy within a system is called enthalpy.*

6. Structure and function: The National Research Council (2012) states that "the way in which an object or living thing is shaped and its substructure determine many of its properties and functions " (p. 84). *The structure of a salt crystal will correlate with the bond energies and the amount of energy released or absorbed.*

7. Stability and change: The National Research Council (2012) states that "For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study" (p. 84). *Increasing the reactant concentrations increases the number of collisions that can occur.*

**Teachers have the discretion to enhance the selected SEP's and CCC's.*

Prior Knowledge

- 3.P.2A. (Properties of Matter)
- 5.P.2B (Mixtures and Solutions)
- 6.P.3A (Conservation of Energy)
- 7.P.2B.4 (Chemical and Physical Changes)
- 7.P.2B.5 (Chemical Changes)

Subsequent Knowledge

- N/A

Possible Instructional Strategies/Lessons

Strategies and lessons that will enable students to master the standard and/or indicator.

- H.C.7A.1
  - Exothermic, Endothermic, and Chemical Change: In this introductory lab activity, students investigate temperature changes during two different chemical reactions. They collect, analyze, and interpret data to evaluate if a system absorbs or releases energy during a reaction. Following the lab investigation, students use their data to write thermochemical equations showing the net direction of energy flow and draw energy diagrams to depict this energy change. At the conclusion of the lesson, students use models of chemical reactions to explain how bond energy correlates with the net flow of energy. This lesson can be found using http://highschoolenergy.acs.org/content/hsef/en/how-can-energy-change/exothermic-endothermic-chemical-change.html#preparing_to_investigate.
  - Using Lewis Structures to Calculate the Heat of Reaction: In this lesson, students are given a table of bond energies and sample equations on cardstock. Students will model the reactions by drawing Lewis structures of the reactants and products that reflect the stoichiometry of the reaction. Students will use their drawings and provided bond energies to mathematically represent the energy changes in the reaction. At the conclusion of the activity, students will draw a potential energy diagram that reflects the patterns of the heat of reaction data. This activity is adapted from a lesson found at https://dashboard.dublinschools.net/lessons/?id=974dd49e72a6d1efeec372a463e2f25a&v=1.
  - Investigate Chemistry: Hand warmers: , In this lab activity, students investigate the structure and function of a hand warmer. They determine what specific chemistry-based mechanisms allow the hand warm to transfer thermal energy to the surroundings. Students also uncover the relationship between solubility and the enthalpy of solutions. At the conclusion of the activity, students design a hand warmer using sodium acetate. As an extension to the lab activity, students could design a hand warmer using a solid of their choice. The goal of the extension would be for students to use data to choose which solid provided the most exothermic temperature change upon dissolving. The lab activity can be found at http://www.rsc.org/learn-chemistry/resource/res00000789/hand-warmers?cmpid=CMP00000872.

- Specific Heat Experiment: This is a virtual lesson in which students can choose between three different materials and collect virtual data about mass and temperature change. Students will then calculate the specific heat of their chosen material based on the collected data. This activity can be extended to allow students to design and conduct their own experiment to determine the specific heat of a substance. This lesson can be found using http://www.chem.uiuc.edu/webfunchem/specificheat/brass3.htm.

- Soda Can Calorimeter: In this lab activity, students construct and use a soda can calorimeter to determine the energy content of different snack foods. This lab can be used to discuss the scale and proportion through the concepts of conservation of energy, heat transfer, bond energy and specific heat. This activity also lends itself to the discussion of system versus surroundings within the context of calorimetry. Please note that no peanuts or tree nuts should be used in this experiment. Examples of appropriate foods include marshmallow, cheese puffs, and onion rings. There is sample data provided in this activity for teacher use. There are videos and virtual lab simulations that teachers may use as an introduction to this activity. This lab can be found using https://www.flinnsci.com/media/510570/soda_can.pdf.

- Sub-Zero: In this project-based, unit-long lesson outline, students will explore the relationship between atomic arrangement, bond energies, chemical reactions, and heats (enthalpies) of reactions. Students will design and conduct experiments to measure temperature change in order to determine reaction enthalpies. Students will use their results to create models showing the change in bond energies of reactants and products. At the conclusion of these activities, students will compare their measured values to actual values and justify whether their reactions can be used safely and effectively used to construct ice packs and hand warmers. This project-based lesson can be found using http://www.nextgenscience.org/sites/default/files/HS-PS-Chem_Sub_Zero_Nov%202014.pdf.

- H.C.7A.2

  - Thermochemical Equations: This activity requires students to use mathematical thinking to calculate energy changes. Students are also required to classify the equations as endothermic and exothermic. This activity can be found at http://www.hcisd.org/cms/lib4/TX01001784/Centricity/Domain/1677/Thermochemical%20Equations%20-%20Student%20Pages%20Revised%20IN.pdf.

- Potential Energy Diagrams: Students will use mathematical and computational thinking to determine the values of potential energy of reactants and products. They will determine whether the reaction is endothermic or exothermic. This document can be found at https://www.delsearegional.us/Academic/Classes/highschool/science/chemistry/firstyear/Worksheets/07/PEdiagrams.pdf.

- Energy Diagram Practice: This practice website allows students to use mathematical and computational thinking to identify enthalpy, activation energy, heat of reaction, and reaction type for the example provided. This website is http://www.sciencegeek.net/Chemistry/taters/energydiagram.htm.

- H.C.7A.3
  - Chemical Reactions Rates-Inquiry on Affecting Factors: Students are able to plan and conduct investigations concerning the factors affecting chemical reaction rates. Students visit stations to explore temperature, surface areas, concentrations, and catalysts. These investigation activities can be found at http://www.cpalms.org/Public/PreviewResourceLesson/Preview/51001.

  - Reaction Rates-Why Do Changes in Temperature and Reactant Concentration Affect the Reaction Rate: In this lab-based investigation, students create a model to uncover the mechanisms by which temperature and concentration affect reaction rate. Given a list of available materials, students design and write an investigation to test their models. As a culminating assessment, students will craft an argument to defend their evidence for how temperature and concentration affect reaction rates. This activity can be found using https://www.nsta.org/publications/press/extras/files/adi-chem/Lab21StudentHandout-ReactionRates.pdf.

  - Investigating Chemical Reactions-Factors Which Influence the Rate of a Reaction: Students conduct this investigation to determine how surface area, concentration, and temperature affect chemical reaction rates. The extension questions provided in the handout are a wonderful source for students to use to develop a plan for a real-world investigation. This investigation can be found at http://serc.carleton.edu/sp/mnstep/activities/27817.html.

  - Reactions and Rates: In this PhET simulation, students alter the concentration, temperature, and types of reactant molecules to monitor the cause and effect of reaction rate factors. As part of this simulation, students can use graphs and charts to visualize the concentrations of reactant and product molecules. Students can also view potential energy diagrams for each reaction to determine when activation energy has been reached and when collisions result in the formation of products. As a formative assessment for this activity, students will write a summary that explains the shapes of potential energy profiles and the concentration graphs for reactants and products. This activity can be found using https://phet.colorado.edu/en/simulation/reactions-and-rates.

- H.C.7A.4
    - Collision Theory Modeling: Students will use two playdough colors to model the Collision Theory. They will make a ball of playdough in each color. Students will "roll" one ball towards the other. The balls do not stick, so there is no reaction. The second time students will use "activation energy" to make the two balls of playdough collide and become a part of each other. Students will complete a 2D word model making connections between activation energy, collision, reaction, no reaction, molecule orientation, and chemical reaction rates.
    - Rates of Reaction: Students will model the Collision Theory by mixing two solutions together. Students will record the time and observations. They are required to make a graph for each solution and the times. This activity can be found at https://www.cpet.ufl.edu/wp-content/uploads/2013/03/%E2%80%98Rates-of-Reaction%E2%80%99-Lab-Activity.pdf.
    - Plop, Plop, Fizz, Fizz Rate of Reactions Activity: Students conduct this lab experiment to determine how activation energy affects the rate of reaction. Students will model this process on paper and graph the effect of activation energy on reaction rate. This activity can be found at http://www.csun.edu/~cheteach/activities/RateofReactionActivity.pdf.

Resources

- Potential Energy Diagrams: This resource deconstructs the components of a potential energy diagram. Students practice reading, analyzing, and interpreting potential energy diagrams, including the activating energy and the heat of the reaction (endothermic vs. exothermic). At the conclusion of the lesson activity, students will assess their understanding using review questions. This resource can be found using http://www.ck12.org/book/Chemistry/section/23.3/.

- Bomb Calorimetry: Students are able to select the food, analyze it, and make observations from this Bomb Calorimetry simulation. The simulation calculates the amount of energy released from the reaction. This simulation can be found at https://highered.mheducation.com/sites/9834092339/student_view0/chapter48/bomb_calorimeter.html.

- Burning Foods to Measure Calories: This video provides a mini-lesson with an exothermic reaction for students. Students are able to make observations about the amount of energy released via a carbohydrate and a lipid. This video can be found at https://www.youtube.com/watch?v=nAOkh9dVSqE.

- Effects of Catalysts on Reaction Rates: Students can use this website as a resource in planning and conducting investigations to see the effects of catalysts on reaction rates. This resource breaks down the components of a chemical reaction and provides graphs as visuals for the students. This resource can be found at http://www.chemguide.co.uk/physical/basicrates/catalyst.html.

- Kinetics and Equilibrium: Students should use this resource to plan and conduct an investigation to see the effects of various factors on reaction rates. This resource provide excellent diagrams for each factor. This resource can be found at https://www.cdli.ca/sampleResources/chem3202/unit01_org01_ilo03/b_activity.html.

- Rules for Using Thermochemical Equations: This website provides rules for writing thermochemical equations. Students are able to use mathematical and computational thinking to work an example: What is the enthalpy change when 3.5 g of H_2 (g) reacts with Cl_2 (g) to form HCl (g)? The example takes you step-by-step through the problem. This website is https://www.chem.wisc.edu/deptfiles/genchem/netorial/modules/thermodynamics/chemical/chemical3.htm.

- Writing Thermochemical Equations with Enthalpy Changes Sample Problem 1: This video works through a mathematical example of a thermochemical equation. Students are able to follow the process including balancing the equations. This video can be found at https://www.youtube.com/watch?v=K9UUzNUPJOQ.

- How to Speed Up Chemical Reactions (and Get a Date): This video models effective collision factors and activation energy to build analogy between reaction kinetics and getting a date to a school dance. The video connects molecular concepts to real-life applicable concepts that students understand. It includes pre- and post-lesson questions that could be adapted for classroom use. This video can be found using http://ed.ted.com/lessons/how-to-speed-up-chemical-reactions-and-get-a-date.

- Collision Theory: This resource provides students with criteria needed for a collision to occur. Students may use this resource to develop models of the Collision Theory. This resource is found at https://www.boundless.com/chemistry/textbooks/boundless-chemistry-textbook/chemical-kinetics-13/activation-energy-and-temperature-dependence-100/the-collision-theory-422-7067/.

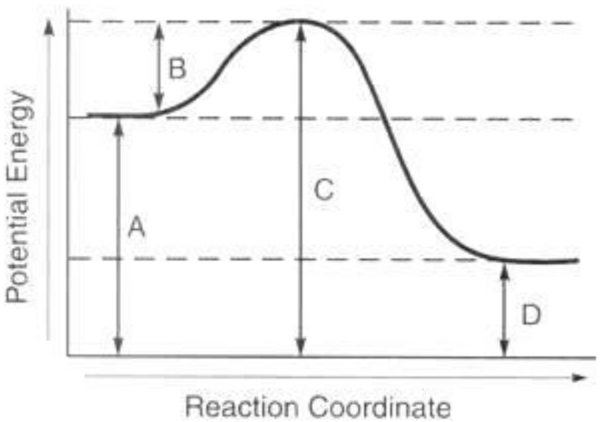
Sample Formative Assessment Tasks/Questions

Additional sample formative assessment tasks/questions for grade bands are located at the end of each of the SEP Support Doc.
(http://ed.sc.gov/scdoe/assets/File/instruction/standards/Science/Support%20Documents/Complete_2014SEPsGuide_SupportDoc2_0.pdf)

- Build a Hand Warmer: The learning goal of this assessment is for students design a hand warmer with the maximum exothermic temperature change and the minimum cost. This assessment is meant to dovetail with the hand warmer lab activity.

- Sub-Zero-High School Sample Classroom Assessment: This formative assessment should be used as a culminating assessment for the Sub-Zero lesson plan. The goal of this assessment is for students to justify a claim for the design of a hand warmer. This lesson and assessment can be found at http://www.nextgenscience.org/sites/default/files/HS-PS-Chem_Sub_Zero_Nov%202014.pdf.

- Label a Potential Energy Graph: Students will label each section of the potential energy graph A, B, C, and D and explain what is happening at each section. Teacher should make cards with specific values for heat of reactants, heat of products, and activation; or she can provide the heat of reaction (molar enthalpy) and either heat of reactants or heat of products. In their discussion, students will identify whether the graph is exothermic or endothermic, why, and cite examples of the different types of reactions. This graph is found at https://socratic.org/chemistry/chemical-kinetics/potential-energy-diagrams.



- Energy Profile for Combustion of a Hydrocarbon: Using the given reaction above, student label reactants and products specific to a combustion reaction. Students will calculate the molar enthalpy of reaction.

- Athlete Nutrition Plan: Students will research a sport to create a weekly meal plan that provides the athlete with the appropriate number of calories and nutrients. Students must justify why they have determined these foods provide the proper nutrition given the constraints of their sport.

- Graph from Chemical Reaction activities in H.C.7A.3: Students will illustrate the effects of various reaction rate variables by creating a graph to provide a visual of the lab data.

- Reaction Rates Role-Play: In small groups, students will act out the roles of reactant, transition state, and product molecules. Students can demonstrate through modeling how the physical and chemical structures of reactant molecules affect the rate of chemical reactions. Specifically, students will need to demonstrate in their skits the factors that affect reaction rates (concentration, surface area, agitation) and collision theory concepts (energy of reactants, activation energy, orientation of molecules).

- Reaction Rates Argument Driven Inquiry: This assessment should be used in conjunction with the Reaction Rates: Why Do Changes in Temperature and Reactant Concentration Affect the Rate of a Reaction? Students will provide evidence from experiments that temperature and concentration of reactants are driving factors in the kinetics of reactions. Students will justify their evidence by constructing written arguments that use specific lab data as supporting details. This assessment piece is found in https://www.nsta.org/publications/press/extras/files/adi-chem/Lab21StudentHandout-ReactionRates.pdf.

- Collision Theory Modeling: Students model collisions by walking around the room. Some students hold their arms parallel to the floor while other students hold their arms out like a bird. When they run into another student, a collision occurs and a new compound forms. This activity is found at http://fwjohnsoncollegiate.rbe.sk.ca/spoll_chemistry30.

- Modeling to Demonstrate Relationships: Students will create a 2D model on butcher paper that will explain the relationships between collision frequency, the energy of collisions, the orientation of molecules, activation energy, and the rates of chemical reactions.

- Writing Piece to Reactions and Rates PhET simulation: The teacher will provide screenshots of the graphs produced from the simulations. Students will justify why the potential energy graphs take the particular shape they do.

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