# Phoenixville Area School District Understanding by Design (UbD) Science Template

## Grade Level &/or HS Subject: 11/Chemistry  Unit Name: Thermochemistry and Thermodynamics

### Stage 1 Desired Results

**Overarching NGSS & PA Standards:**

HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate

HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy

PA. PS Chemical Reactions 2. Develop a model to illustrate that the release or absorption of energy from a

***Transfer***

*Students will be able to independently use their learning to:*

ask questions and/or define problems, develop and/or use models, plan and/or carry out investigations, analyze and interpret data using computational thinking, obtain, evaluate, and communicate information (supported by evidence), and construct explanations and design solutions

***Meaning-Making***

*Students will understand that…*

- There are certain laws that govern the flow of heat (i.e. laws of convection, heat always flows from a hotter object to a colder object) and these laws hold true in open and closed systems.
- Changes in states of matter are due to the weakening of intermolecular forces between materials, and conditions like pressure and temperature can change the strengths of these forces.
- In real-world applications, bond enthalpies may not be directly calculated since conditions (temperature, pressure, kinetics) are not practical; however, less complex chemical reactions may be carried out that fit our conditions and those reactions can be manipulated to give the same outcome.
- Not all chemical reactions are theoretically possible, due to matrix effects of kinetics (rates), equilibrium variables, and thermodynamic constraints.
- Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (ETS1.C)
- Conservation of energy means that total change of energy in any system is always equal to the total energy transferred into or out of a system. (PS3.B)
- Although energy cannot be destroyed, it can be converted into less useful forms—for example, to thermal energy in the surrounding environment. (PS3.D)
- Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (ETS1.A)

ESSENTIAL QUESTIONS
*Students will keep considering...*

How is the change in Earth's climate related to the heat capacity of the components of the Earth's environment?

What are some reasons why chemical reactions do not occur, while others spontaneously occur?

How is climate change and the greenhouse effect being driven by thermodynamic effects?

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| chemical reaction system depends upon the changes in total bond energy.<br><br>HS-PS3-4. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).<br><br>HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of esigned materials. | • Relationships between systems or components of a system may be modeled in such a way that predictions can be made about these relationships. (SEP: Developing and Using Models) | |
| | ***Knowledge and Skills Acquisition*** | |
| | UNDERSTANDINGS<br>*Students will know…*<br>• *That energy, work and heat are intimately related to each other*<br>• *That chemical processes can be classified as exothermic or endothermic*<br>• *Which units are used to measure heat transfer?*<br>• *How to use the process of calorimetry to measure heat flow*<br>• *How to solve for enthalpy changes in chemical reactions by using heats of reaction*<br>• *Enthalpy changes when a substance melts, freezes, boils, condenses or dissolves can be quantified and solved for*<br>• *The purpose of Hess's Law is to introduce useful manipulations of practical chemical reactions when certain chemical reactions are not practical under standard lab conditions, and how to use it in mathematical relationships*<br>• *That heats of formation can be used to solve for the enthalpy of a reaction*<br>• *Spontaneous reactions can be predicted from characteristics of reactions*<br>• *Chemical reactions are determined by factors of kinetics, equilibrium and entropy and enthalpy effects*<br>• *How to define and quantify the change in Gibbs' free energy* | *Students will be skilled at…*<br><br>• Developing models based on evidence to illustrate the relationships between systems or between components of a system (SEP: Developing and Using Models)<br>• Using models to predict the relationships between systems or components of a system (SEP: Developing and Using Models)<br>• Using mathematical representations of phenomena to support claims (SEP: Using Mathematical and Computational Thinking)<br>• Constructing and revising explanations based on valid and reliable evidence obtained from a variety of sources (Including students' own investigations, models, |
| | KEY VOCABULARY<br><br>Potential energy system/surroundings law of conservation of energy heat capacity<br>Specific heat exothermic/endothermic heating curves enthalpy<br>Hess's Law enthalpy of formation enthalpy of reaction free energy<br>Spontaneity entropy calorimetry Born-Haber cycle | |

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| **Which branch(es) of science apply:**<br>**LS PS E&SS** | | theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue in the future (SEP: Constructing Explanations and Designing Solutions)<br>• Abstract and quantitative reasoning (MP.2)<br>• Using units as a way to understand problems and guide the solution of multi-step problems; choosing/interpreting units consistently in formulas; choosing and interpreting the scale and the origin in graphs and displays (HSN-Q.A.1)<br>• Choosing a level of accuracy appropriate to limitations on measurement when reporting quantities (HSN-Q.A.3) |

| Stage 2 – Evidence | | |
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| **Evaluative Criteria** | ***Assessment Evidence*** | |
| Presentation/ report rubric<br><br>Lab report<br><br>Presentation/ report rubric | PERFORMANCE TASK(S):<br><br>Students can research the process of photosynthesis and prepare a report (presentation) explaining how it still occurs spontaneously in our environment. Students can relate the opposite process, cellular respiration, to photosynthesis and show how enthalpy, free energy and entropy factors work together.<br><br>Students can perform a calorimetry experiment comparing specific heats of different materials. These concepts can be related to materials we use in the home as conducting materials (low specific heats) and insulating materials (high specific heats).<br><br>Students can lead a debate about what materials would be best to create an ice pack, in terms of energy, cost, and availability of materials after researching and designing an investigation. This will help students realize the information needed to create and put to market a useful product. | Differentiation Considerations:<br><br>Presentation can be adapted to other forms, such as brochure, or illustration of the process, etc.<br><br>Adapted lab worksheet, with guided calculations<br><br>Different roles for certain group members, group modifications and selections of members |
| What criteria will be used in each assessment to evaluate attainment of the desired results?<br><br>Point proficiency scale<br><br>Teacher monitoring checks for understanding<br><br>Lab report/presentation rubric/point scale | | Differentiation Considerations:<br><br>Vocabulary prompts<br><br>Choice of number of problems, types of scenarios<br><br>Expanded scaffolding of class discussions (i.e., gifted/talented: Entropy decreases in the reaction of air, iron and water to form rust. Why is this reaction spontaneous? (*An ordered solid (Fe) and a less-ordered gas ($O_2$) release enough energy to balance the production of a more ordered solid ($Fe_2O_3$) in the presence of a catalyst ($H_2O$).)* |