**Subject area/course**: Science/Chemistry

**Grade level/band**: 9-12

**Task source**: Achieve

**Sub-Zero**

**TEACHER'S GUIDE**

1. **Task overview**:

Chemical reactions can be described as endothermic or exothermic depending on whether energy is used or given off during a reaction. Practically, these types of reactions can be used as instant hot or cold packs at times when we need them, such as in hand warmers. In this task, students will be assessed on their knowledge of chemical reactions and energy change during the reactions. They will use molecular models to diagram the change in the arrangement of atoms and number and types of bonds before and after reactions. Following experiments where they measure the change in temperature of the reactions, students create models showing the change in energy (bond energy and thermal energy) in addition to the changes in the chemical species and number and types of bonds. Finally, students compare theoretical values for the temperature change of the reaction (given different reactant amounts) with their measured values using graphs and equations for lines of best fit and make evidence-based claims for whether the reactions they tested would be useful in hand warmers given criteria related to safety and usability.

1. **Aligned standards:**
2. **Primary Common Core State Standards**

CCSS.Math.Practice.MP1 Make sense of problems and persevere in solving them.

CCSS.Math.Practice.MP2 Reason abstractly and quantitatively.

CCSS.Math.Practice.MP3 Construct viable arguments and critique the reasoning of others.

CCSS.Math.Practice.MP4 Model with mathematics.

CCSS.Math.Practice.MP6 Attend to precision.

CCSS.Math.Content.HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

CCSS.Math.Content.HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.

CCSS.Math.Content.HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

CCSS.Math.Content.HSA.CED.A.1 Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadratic functions, and simple rational and exponential functions.

CCSS.Math.Content.HSA.REI.B.3 Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.

CCSS.Math.Content.HSS.ID.B.6 Represent data on two quantitative variables on a scatter plot, and describe how the variables are related.

CCSS.Math.Content.HSS.ID.B.6.A Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Use given functions or choose a function suggested by the context. Emphasize linear, quadratic, and exponential models.

CCSS.Math.Content.HSS.ID.B.6.C Fit a linear function for a scatter plot that suggests a linear association.

CCSS.Math.Content.HSS.ID.C.7 Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data.

CCSS.ELA.Literacy.W.9-10.1 Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.

CCSS.ELA.Literacy.W.9-10.1.A Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among claim(s), counterclaims, reasons, and evidence.

CCSS.ELA.Literacy.W.9-10.1.B Develop claim(s) and counterclaims fairly, supplying evidence for each while pointing out the strengths and limitations of both in a manner that anticipates the audience's knowledge level and concerns.

CCSS.ELA.Literacy.W.9-10.1.C Use words, phrases, and clauses to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.

CCSS.ELA.Literacy.W.9-10.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

CCSS.ELA-Literacy.WHST.9-10.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

CCSS.ELA.Literacy.WHST.9-10.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

CCSS.ELA.Literacy.RST.9-10.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.

1. **Critical abilities**

**Analysis of Information:** Integrate and synthesize multiple sources of information (e.g., texts, experiments, simulations) presented in diverse formats and media (e.g., visually, quantitatively, orally) in order to address a question, make informed decisions, understand a process, phenomenon, or concept, and solve problems while evaluating the credibility and accuracy of each source and noting any discrepancies among the data.

**Communication in Many Forms:** Use oral and written communication skills to learn, evaluate, and express ideas for a range of tasks, purposes, and audiences. Develop and strengthen writing as needed by planning, revising, editing, and rewriting while considering the audience.

**Interpersonal Interaction and Collaboration:** Develop a range of interpersonal skills, including the ability to work with others, to participate effectively in a range of conversations and collaborations.

**Modeling, Design, and Problem Solving**: Use quantitative reasoning to solve problems arising in everyday life, society, and the workplace, e.g., to plan a school event or analyze a problem in the community, to solve a design problem or to examine relationships among quantities of interest. Plan solution pathways, monitoring and evaluating progress and changing course if necessary, and find relevant external resources, such as experimental and modeling tools, to solve problems. Interpret and evaluate results in the context of the situation and improve the model or design as needed.

1. **Next Generation Science Standards (NGSS)**

**HS-PS1-2**. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

**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.

**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).

1. **Time/schedule requirements:**

The entire task could take 4–9 class periods (45–50 minutes each) spread out over the course of an instructional unit, with the divisions listed below:

* Task Component A: up to 1 class period
* Task Component B: 1–2 class periods
* Task Components C and D: 1–2 class periods, depending on whether parts are done outside of class
* Task Components E, F, G and H: 2–4 class periods total, depending on whether parts are done outside of class

1. **Materials/resources:**

To do the experiments for Task Components B and C, students will need access to safety equipment, laboratory space, and reactants and calorimeters as laid out in Attachment 1.

1. **Prior knowledge:**

The instructor should have a secure understanding of calorimetry. Students must be able to construct a trendline and write equations to make predictions about data. Students must also be cognizant of patterns of the periodic table as related to the state of chemical substances and related chemical reactions in Attachment 5 and 6.

1. **Connection to curriculum:**

The full task can be accomplished over the course of an instructional unit on thermochemistry. Task Components A and B can be used as summative assessments, or Task Component A can be a summative assessment of chemical reactions with Task Component B as a formative assessment for use with calorimetry and the distribution of thermal energy in a system. Task Component C could be formative, and Task Component D could be either formative or summative depending on where they are administered relative to lessons on the enthalpy of bond formation and thermal heat transfer. Task components E through G could be used as either formative or summative assessments depending on the placement of lessons using engineering practices and overlap/integration with math courses or lessons. Material covered in this task may be new for students enrolled concurrently in Algebra I and would require coordination with the mathematics teacher. For these students, the task may act as a formative assessment during a coordinated unit between both content area teachers. For students who have previously taken Algebra I or if this science unit is covered after the associated math standards, parts of this task, such as Task Components E, F and G, can serve as summative assessments.

This task provides multiple interdisciplinary connections to ELA/Literacy in both research and writing argument and research. Students can be assessed either formatively or summatively on ELA/Literacy research standards in Task Components A, B, C, D, & G, and they can be assessed either formatively or summatively on writing argument on Task Components B, F, & H. This task has been aligned to the 9–10 grade band ELA/Literacy standards for research and writing argument. Teachers using this task in 11th or 12th grade should refer to the comparable CCSS for the 11–12 grade band.

1. **Teacher instructions**

**Carefully read student instructions before using these steps. Consult with a Special Education instructor for specific modifications appropriate to your class and particular students.**

Task component A: (~1 class period)

Ask students to carefully read all instructions. Provide chemical and safety materials. Explicitly brief students to avoid alkali metal and water reactions. If possible, provide or encourage both videography of the experiment and accurate temperature measurements. Encourage and monitor students’ recording of qualitative and quantitative data. Provide copies of Attachments 1 and 2 to each student.

Task component B: (1-2 class periods)

Ask students to carefully read all instructions. Provide materials as before with the addition of calorimeter materials as listed on student instructions. If possible, provide or encourage both videography of the experiment and accurate temperature measurements. Encourage and monitor students’ recording of qualitative and quantitative data. Provide copies of Attachment 3 to each student.

Task components C and D: (1-2 class periods)

Ask students to carefully read all instructions. If possible, ask students to review videography of the experiment and accurate temperature measurements. Encourage and monitor students’ recording of qualitative and quantitative data. Provide copies of Attachments 4 and 5 to each student. Encourage students to trust their data and refer to their graphs when explaining their results.

*Task components E,F,G and H:*

Ask students to carefully read all instructions. If possible, ask students to review videography of the experiment and accurate temperature measurements as well as any graphs previously created. Be ready to support and scaffold the creation of a claim and the support of that claim with direct evidence. If necessary, review the concept and process to determine a line of best fit. Encourage students to trust their data and refer to their graphs when explaining their results. Provide students with a copy of Attachments 6 and 7.

1. **Student support:**

None provided.

1. **Extensions or variations:**

None provided.

1. **Scoring:**

Student work can be scored using the SCALE Scientific Practices rubric.