**Unit Essential Question:** *How does energy and matter flow within natural and designed ecosystems?*

**Introduction**

Throughout this unit, students have seen heat being absorbed and released in the chemical reactions they observed. This was the case with chemical changes in Task 1, cellular respiration (ATP formation) in Task 2, photosynthesis (sunlight) in Task 3, and geoscience processes in the rock cycle in Task 4. In this task, students use their knowledge to approach a design problem: How can they heat a pool in the river environment so blue catfish are able to spawn? Students will use hot packs and cold packs in their initial investigations, testing which chemical reactions absorb or release heat. They will then use what they learned from these investigations to develop models of heat-regulation devices, which they will then build, test, and revise for their final product. Throughout this task, students are engaging in the complete engineering and design process, applying new knowledge and skills to the design of their aquaponics system. The device that students design in this task will be modified and used in their aquaponics system design.

**Alignment Table**

|  |  |  |  |
| --- | --- | --- | --- |
| **Performance Expectations** | **Science and Engineering Practices** | **Disciplinary Core Ideas** | **Crosscutting Concepts** |
| **MS-PS1-6.** **Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.\*** [Clarification Statement: Emphasis is on the design, controlling the transfer of energy to the environment, and modification of a device using factors such as type and concentration of a substance. Examples of designs could involve chemical reactions such as dissolving ammonium chloride or calcium chloride.] [Assessment Boundary: Assessment is limited to the criteria of amount, time, and temperature of substance in testing the device.] | **Designing Solutions**   * Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific criteria and constraints. | **PS1.B: Chemical Reactions**   * Some chemical reactions release energy, others store energy. | **Energy and Matter**   * The transfer of energy can be tracked as energy flows through a designed or natural system. |
| **MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.** | **Analyzing and Interpreting Data**   * Analyze and interpret data to determine similarities and differences in findings. | **ETS1.B: Developing Possible Solutions**   * There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. * Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors.   **ETS1.C: Optimizing the Design Solution**   * Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process – that is, some of the characteristics may be incorporated into the new design. | **N/A** |
| **MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.** | **Developing and Using Models**   * Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs. | **ETS1.B: Developing Possible Solutions**   * A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. * Models of all kinds are important for testing solutions.   **ETS1.C: Optimizing the Design Solution**   * The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. | **N/A** |
| **Supplementary Science and Engineering Practices**   * **Planning and Carrying Out Investigations**   + Conduct an investigation […] to produce data to serve as the basis for evidence that meets the goals of the investigation. | | | |
| **Equity and Groupwork**   * Work within group roles to conduct investigations and build and test prototypes. * Come to consensus on a design solution. | | | |
| **Language**   * Describe similarities and differences in data. * Describe an experiment using procedural language. | | | |

**Learning Goals**

This learning task asks students to build, design, test, and refine a device that releases heat through a chemical reaction. More specifically, the purpose is to:

* Engage prior knowledge of how a change in one part of an environment can lead to further changes in the environment.
* Investigate how hot packs and cold packs work, specifically which mixture of substances leads to a chemical reaction that absorbs or releases heat.
* Use evidence from investigations to design two heat-regulation devices, and to develop models to explain their operation.
* Build and test two possible heat-regulation device prototypes, and use all groups’ data to inform a final refined design that best meets the criteria and constraints of the problem.
* Draw, label, and explain a model of the final heat-regulation device to be used in their aquaponics system, including the data to support the design.

**Content Background for Teachers**

In this task, students use their prior knowledge of energy from earlier tasks to build, test, and modify a device that releases thermal energy. More specifically, students are designing heat-regulation devices that can keep river water warm enough for fish spawning, using hot and cold packs as inspiration.

Most commerical hot and cold packs contain dry chemicals and a sealed inner pouch of liquid (usually water). The hot or cold pack is activated by breaking the seal on the liquid pouch, and shaking the pack vigorously. The shaking mixes the liquid with the chemical substances, initating either an exothermic (heat-releasing) or endothermic (heat-absorbing) reaction.

Students investigate hot and cold packs during the *Explore* by testing five chemical reactions: sodium bicarbonate and water, potassium chloride and water, sodium bicarbonate and vinegar, sodium bicarbonate and calcium chloride and water, and calcium chloride and water. The first three reactions are endothermic, meaning they feel cold to the touch. This is because it takes more energy to break the bonds than will be given off when the new substances are formed. The fourth and fifth reactions are exothermic, meaning that they feel warm to the touch. This is because it takes less energy to break the bonds than is given off when the substances dissolve in liquid.

Once students have tested these five chemical reactions for heat absorption or heat release, they can select the best-suited chemical reactions for their heat-regulation device prototypes. By the end of this task, students will able to apply a version of this device to their aquaponics system.

**Academic Vocabulary**

* Spawn
* Heat
* Absorb
* Release
* Temperature
* Heat-Regulation
* Criteria
* Constraints
* Design Solution
* Prototype

**Time Needed (Based on 45-Minute Periods)**

5.5 – 6.5 Days

* Engage: 0.5 period
* Explore: 1 period
* Explain: 1 period
* Elaborate: 2-3 periods
* Evaluate and Reflection: 1 period

**Materials**

* Unit 3, Task 5 Student Version

Explore (Per Lab Group)

* Thermal Chemical Reactions Investigation Card (in sheet protector)
* Calcium chlo**r**ide (used to melt ice on d**r**i**v**eways in winte**r**)
* Potassium chlo**r**ide (e.g., Mo**r**ton **L**ite**™**)
* Sodium bica**r**bonate (baking soda)
* Vinegar
* Five sandwich**-**size zip**-**lock bags
* Tablespoon measu**r**ing spoons
* 100 ml graduated cylinder
* Water
* Sharpie
* Materials List from Designing Heat-Regulation Devices Resource Card

Elaborate (Per Lab Group)

* Designing Heat-Regulation Devices Resource Card (in sheet protector)
* Students pick substances from the following list: calcium chloride, potassium chloride, sodium bicarbonate, vinegar
* Cold water
* Hot water (We recommend preparing a class-size vat of hot water so groups can start with hot water and add cold water to bring down the temperature to 68 degrees)
* Tablespoon measu**r**ing spoons
* 100 ml graduated cylinder
* 2 500 ml beakers
* Ice
* 2 Thermometers
* 2 - 4 sandwich**-**size zip**-**lock bags (thick and thin options)
* Additional material choices for building and modification of prototypes (ie. plastic wrap, foil, tape, cloth, felt, containers of different materials and sizes)

Evaluate

* Project Organizer Handout

**Instructions**

**Engage**

1. Introduce Task 5: Throughout previous tasks, you have thought about how energy, like heat or sunlight, drives the cycling of all matter on Earth. For example, we saw that great amounts of energy, or heat from the Earth’s core, was required to change sedimentary rock into igneous rock. Before we move forward, think about what you were still wondering about at the end of the last task (look back if you need to). What questions do you still have?
   * Before you pass out their Student Guide, give students time to reflect individually or with a partner about the questions they recorded at the end of the last task. Share a few of these out as a class, using facilitating questions to guide students toward questions that relate to this task.
2. Transition to Task 5: Throughout this unit, you have seen that heat is either absorbed or released in the chemical reactions you have observed. In this task, you will investigate these kinds of chemical reactions, and use what you learn to help address a problem the river environment is facing today.

* Now pass out the Task 5 Student Guide.

1. Read the scenario on their Student Guides aloud: Blue catfish, as shown in the picture below, are very important to the river environment. However, in recent years the river environment has experienced climate changes, leaving the river water a few degrees colder than normal. It turns out that colder water interferes with fish spawning, which can only happen at a certain range in water temperature.
   * This introduction links back to prior tasks, and sets the context for the design challenge in this task.
   * Before moving on to the questions, take any questions that students have about the context of the design challenge.
     + We recommend explcitly defining the term spawn for students (ie. the process of laying eggs, reproduction, or making more fish).
2. In pairs or groups, have students think about the questions below the picture of the river environment. These questions are intended to motivate a need for their design solution as well as emphasize the core theme of interconnectedness in ecosystems. Below are some sample student responses.
   * Question 1: If fish are unable to reproduce, the population will die out over time.
   * Question 2: Anything that eats the fish will lose a food source and could also go extinct. This chain would continue. Also, whatever the fish eats will grow in population and could overtake other resources.

**Explore**

1. Now that students have an idea of why saving the Blue Catfish matters, they can begin to think about designing a device to keep the river water warm enough for fish spawning. Students will investigate hot packs and cold packs as inspiration to inform their design.

* Read the introduction on their Student Guide aloud so students know that most commercial instant hot packs and cold packs use chemical reactions that either absorb or release heat, a concept they are familiar with from prior tasks. Each hot and cold pack uses different substances that when combined cause a chemical reaction to occur.

1. You may choose to pass out the Investigation Card and all materials to each group, or to set this investigation up as rotating stations (1 chemical reaction per station).
2. Assign roles to each group. You may use whatever roles you prefer. We recommend the use of the Materials Manager, Facilitator, Harmonizer, and Recorder.
   * Ask the Facilitator to read the directions and to make sure everyone understands the investigations.
   * Ask the Materials Manager to handle any resources needed to complete the investigations.
   * Ask the Harmonizer to make sure that everyone contributes their ideas and that everyone’s voice is heard.
   * Ask the Recorder to make sure the group is recording their observations in their Student Guides.
3. Students use the materials provided and the Investigation Card provided to test each combination of substances they are given. Based on their observations, they then decide which ones lead to chemical reactions that release heat and which ones lead to chemical reactions that absorb heat.

* This emphasizes the crosscutting concept of **Energy and Matter** as students track how energy flows through these chemical reaction systems. This activity also gives students practice at the supplementary SEP of **Planning and Carrying Out Investigations** as students conduct investigations to gather evidence that chemical reactions can absorb or release heat.
* \***Safety note**: Remind students that gas may result from some of the chemical reactions, so they should be sure to let gas out of the bag as needed (or it will pop).

1. We recommend writing a data table on the board and conducting a class-wide debrief that elicits which combined substances released or absorbed heat. This will lay the foundation for their design later in the task. Again, the use of equity sticks is encouraged (See "How to Use This Curriculum” for more details).
2. Possible Investigation Extension – As students are generally excited by chemical reactions, and because this investigation does not have students investigate every possible combination of the reactants given, you might permit students to select one other combination they’d like to investigate based on the data collected thus far and using the materials provided. Ask students to briefly explain why they selected this extra investigation, and to predict what will happen based on data collected during the investigation. They should show you this before proceeding with their extra investigation.

**Explain**

1. In the *Explain*, students use what they have learned from the *Explore* to answer questions that will help them design a heat-regulation device.
   * Read the context aloud and take clarifying questions to ensure that all students understand the scenario: The Blue Catfish spawns in river water at 70-75 degrees Fahrenheit, but the pool where they spawn is currently at a temperature of 68 degrees Fahrenheit.
   * This *Explain* and subsequent *Elaborate* asks students to practice multiple elements of the engineering and design performance expectations. The *Explain* emphasizes the SEP of **Designing Solutions** as students undertake a design project, engaging in the design cycle, to construct a solution that addresses the fish-spawning problem.
   * We recommend assigning group roles for this section of the task, mixing up the assigned roles from the *Explore*.
2. First students engage in the practice of defining design criteria and constraints. This process is guided by facilitating questions. Sample student responses are below:
   * 1a: My device needs to warm up the water temperature of the river to at least 70 degrees, but no more than 75 degrees, so fish spawning can occur. I can measure the success of the device by testing the temperature of the water at the end.
   * 1b: The substances will need to be put in some sort of container and then put in the water, so chemicals don’t pollute the water.
3. Students then use the data they collected in the *Explore* to decide which combination of substances to use in order to best meet the criteria of the problem.

* This asks students to begin practicing the SEP of **Analyzing and Interpreting Data** as they interpret data for similarities and differences that they can use to categorize reactions as heat-releasing or heat-absorbing.
* The following two chemical reactions from the *Explore* produce heat: sodium bicarbonate and calcium chloride and water, and calcium chloride and water. Students should be able to select one of these substance combinations as the best option for their heat-regulation device.
* This response to Question #2 is a good opportunity for formative assessment. Review student work to identify trends in students’ ability to use understanding of criteria and data analysis to select the best chemical reactions. See “How to Use This Curriculum” for strategies on utilizing formative assessment data to provide feedback to students and inform classroom instruction.

1. Lastly, students use one of the above chemical reactions to develop models of two different designs for their heat-regulation device, which they will build and test in the *Elaborate*. Both models should use the same chemical reaction, but will vary in the structure and materials of the device.

* This asks students to engage in the SEP of **Developing and Using Models** to generate data to test ideas about designed systems. By identifying inputs and outputs in the models, they are also emphasizing the CCC of **Energy and Matter** as they track energy flow into and out of the designed system.
* Before groups design and draw their models, review a list of materials you plan to offer them during the building process. You may use the material list in the *Designing Heat-Regulation Devices Resource Card* and add to it as desired. Adding additional materials will lead to more variety in design solutions (ie. double-bagging vs. single-bagging, foil on the outside of a Tupperware vs. plain Tupperware, double-bagging vs. double-bagging with a layer of cloth between bags, etc.)

1. Collect these models, which provide a summative assessment of the Engineering and Design Performance Expectation MS-ETS1-4. A rubric is provided at the end of this teacher version.

* You may also wish to make this a checkpoint in which you give student groups feedback on their models, as necessary, before they can move forward to the testing process in the *Elaborate*. For groups who are struggling, encourage them to refer back to the criteria and constraints of the problem to make sure their design meets these.

**Elaborate**

1. Now that students have developed models of potential design solutions, they can test these devices to see which best satisfies the criteria for the catfish problem in the river environment.

* Here, students continue to engage in the engineering and design cycle as they practice the SEP of **Designing Solutions.**

1. Pass out Design Card to groups and make materials available so groups can use what they need to build their devices. Assign student roles, mixing up their assigned roles from the *Explore*.
2. Keeping the criteria and constraints of the problem in mind and using the Design Card to guide them, students draw what their experimental set-up will look like and describe how they set up their experiment.
   * In their experimental set-up, students should show two beakers with approximately the same amount of water and a thermometer in each. Labels should note that each of the beakers starts at 68 degrees. Each of the chemical reactions should be conducted in some kind of container to be put into the water. This avoids contaminating the water, thus meeting an important constraint of the problem.
   * We recommend checking students’ experimental set-up and providing feedback before they move on to the actual test. If necessary, remind students to label each device to differentiate between the two.
3. Once their experimental set-up is approved, they may run the tests.

* Remind students to record their data in the table provided on their Student Guides.
* Note: In their data table, everyone should have 68 degrees as their starting temperature. If students get stuck on this, refer them back to the initial context at the beginning of the *Explain*.
* Once the temperatures of both beakers seem to stabilize, they may record their ending temperature.

1. Once students have tested their two designs, they engage in the SEP of **Analyzing and Interpreting Data** as they interpret test data for similarities and differences that they can use to select best characteristics and improve their device.

* Students first compare data about their own two designs to decide which worked better to meet the criteria of the problem.
* Then, have groups share their best design with the class, including the data that supports it. We recommend using a document camera so each group can show their model and data. However, you may also have students draw on a whiteboard or share verbally. Make sure the rest of the class is recording features about designs they like, including the data to support them, in their student guides. They will use this information to revise their device and as evidence in the *Evaluate* section of this task.

1. Based on what they learn from other groups, students evaluate the data to identify best characteristics that they might combine with their design’s best characterstics. Groups decide what adjustments they would like to make (ie. types of materials, amount of substances used, structure, etc.) and draw a labeled model of their revised device.

* Encourage students to combine the best characteristics from their own design and others design. However, if students also feel they need to try testing a new combination of solutions, material, or structure, they may do so at this stage.
  + For example, using data from other designs, a group may choose to double-bag their prototype or reduce the amount of reactants if too much thermal energy is being transferred.
* Students then run the test again using their revised device and collect data to finalize a design solution.
* Student should also specify how they could continue to improve their design and justify the reason for those suggestions. Alternatively, if time and materials permit, they may continue to modify the device and re-test until it meets the criteria and constraints of the problem.

1. Return to the whole-class concept map from the Lift-Off Task.

* In small groups, have students brainstorm new concepts and new connections that they have learned in this task, as well as any new questions that have come up for them. Then have groups share these aloud in a class-wide discussion and add to the class concept map. The use of equity sticks is encouraged for more equitable participation in class-wide discussions (See “How To Use This Curriculum” for more details).
  + Some possible facilitating prompts to ask students are: What new ideas/concepts do you want to add to the map? What connections do you want to add or change? What is your reason for that addition/revision? What connections can we make between the questions/ideas already on the map? What new questions do you have about the phenomenon?
  + Draw circles around each question and boxes around each concept.
  + Write connector words to describe connections between the concept boxes.
  + For this task, students may begin to connect some of their previous question circles to concept boxes about the following: how chemical reactions can be used to design solutions for the regulation of temperature.
* Have students analyze the additions to the class concept map for as many examples of this task’s crosscutting concept as they can find. Once a student has identified the crosscutting concept, you can trace the circle in the corresponding color (decided on in the Lift-Off task). We recommend asking students to share key words that helped them identify the crosscutting concept for that concept or question. Some identifying words students might look for are:
  + **Energy and Matter**: These could be phrases such as, “is made by,” “is put into,” “is added to,” “is cycled within,” “is taken out by,” “is extracted for,” “is conserved,” “is changed into,” etc.
* Once again, the purpose of this concept map is to facilitate the generation of student questions, promote language development, and support understanding of the science content throughout the unit. Allowing students to ask their own questions and use their own words to make meaning of the concepts will not only help them make deep connections about science content, but will also help their oral and written language development.

**Evaluate: Connecting to the Culminating Project**

1. Students independently complete the Task 5 section of the Unit 3 Project Organizer in class. Revisions can be done for homework, depending upon student’s needs and/or class scheduling.
2. Students have been tasked with creating a sustainable aquaponics system that mimics the properties of the river environment and regulates the temperature of the fish tank. Their prompt is as follows: Now that you have designed a heat-regulation device to help maintain river water temperature, you can use this knowledge to design your own heating devices that will work to maintain the temperature of your aquaponics fish tank.

* Draw the final heat-regulation device.
  + Label the materials used and explain how it works.
* Describe how you combined best characteristics of different designs to create a device that best meets the criteria and constraints.
  + Cite the data that supported your decisions.

1. This section of the Project Organizer provides a summative assessment of the Engineering and Design Performance Expectation MS-ETS1-3. A rubric is provided at the end of this teacher version.

**Reflection**

1. At the end of the task, ask students to reflect on what they have learned over the course of this task by answering the following three questions in their student guide:

* At the beginning of this task, you were asked to consider the effects if fish can’t spawn in the river environment. After designing a heat-regulation device today, how will these effects be reduced? Use evidence from the task to back up your explanation.
* In this task, we focused on the crosscutting concept of **Energy and Matter**: The transfer of energy can be tracked as it flows through a system, is conserved, and drives the cycling of matter. Where did you see us looking at **Energy and Matter** in this task?
* Now that you have learned more about how we can use chemical reactions to regulate temperature, what questions do you still have?

1. There are no right answers, but encourage students to look back at their Student Guides and their class concept map. They should not change their initial responses, but rather use this reflection space to add to their ideas and questions based on what they have learned through this task. By generating more of their own questions, students continue to engage in sense-making of the phenomenon and gathering knowledge and skills for their final projects.

**Assessment**

1. Collect students’ Task 5 Student Versions and assess the *Explain* using Rubric 1 of the 3-Dimensional Task 5 Rubrics below.
2. Collect students’ Project Organizer and assess using Rubric 2 of the 3-Dimensional Task 5 Rubrics below.
3. You may also give students time to make revisions with one of the two options:

* Students may make changes to their Project Organizer according to your comments OR
* Ask students to exchange Project Organizers with a partner and give partners 5 minutes to give written feedback. Then allow students time to make changes to their work according to the feedback.

**Task 5 Rubric 1**: Student develops models for iterative testing of a proposed heat-regulation device, describing how they acknowledge constraints and use an exothermic reaction to meet the criteria.

* Use to assess student responses for Prompt #3 of Explain
* Dimensions Assessed: SEP – Developing and Using Models; DCI – ETS1.B: Developing Possible Solutions
* Note: The relevant exothermic reactions are sodium bicarbonate and calcium chloride and water, and calcium chloride and water.

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| **Emerging (1)** | **Developing (2)** | **Proficient (3)** | **Advanced (4)** |
| Student develops **irrelevant** models for iterative testing of a proposed heat-regulation device. | Student develops **partial** models for iterative testing of a proposed heat-regulation device, describing how they acknowledge constraints **OR** use an exothermic reaction to meet the criteria. | Student develops **complete** model for iterative testing of a proposed heat-regulation device, **partially** describing how they acknowledge constraints and use an exothermic reaction to meet the criteria. | Student develops **detailed** models for iterative testing of a proposed heat-regulation device, **completely** describing how they acknowledge constraints and use an exothermic reaction to meet the criteria. |
| **Look Fors:**   * Student’s heat-regulation device models are irrelevant because they show no understanding of criteria or constraints. For example, they choose an endothermic reaction and dump chemicals straight in the river. | **Look Fors:**   * Student’s heat-regulation device models show one, but not both of the following: 1) Meets the criteria of warming up the water by using a relevant exothermic chemical reaction from the *Explore*, and 2) Acknowledges constraint of minimizing pollution by containing the chemical reactions with some kind of material or structure (ie. plastic bag or container). | **Look Fors:**   * Student’s heat-regulation device models show both of the following: 1) Meets the criteria of warming up the water by using a relevant exothermic chemical reaction from the *Explore*, and 2) Acknowledges constraint of minimizing pollution by containing the chemical reactions with some kind of material or structure (ie. plastic bag or container). * The explanation of each model, in the form of labels and captions, is partial. For example, student labels the substances in the exothermic reaction and describes that it releases heat. However, while student shows the chemicals inside plastic bags, they don’t explicitly explain why. | **Look Fors:**   * Student’s heat-regulation device models show both of the following: 1) Meets the criteria of warming up the water by using a relevant exothermic chemical reaction from the *Explore*, and 2) Acknowledges constraint of minimizing pollution by containing the chemical reactions with some kind of material or structure (ie. plastic bag or container). * The explanation of each model, in the form of labels and captions, is complete. For example, student labels the substances in the exothermic reaction and describes that it releases heat. Student also shows the chemicals inside plastic bags, and explains that this prevents water pollution. |

**Task 5 Rubric 2**: Student redesigns a heat-regulation device to better meet the criteria for success, referencing the relevant test data of different devices to explain why they combine best characteristics.

* Use to assess Task 5 Section of Project Organizer
* Dimensions Assessed: SEP – Analyzing and Interpreting Data; DCI – ETS1.C: Optimizing the Design Solution

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| --- | --- | --- | --- |
| **Emerging (1)** | **Developing (2)** | **Proficient (3)** | **Advanced (4)** |
| Student redesigns a heat-regulation device to better meet the criteria for success, **but does not** explain why they combine best characteristics.  OR  Student redesigns a heat-regulation device **that does not** meet the criteria for success. | Student redesigns a heat-regulation device to better meet the criteria for success, **but does not reference** the relevant test data of different devices to explain why they combine best characteristics. | Student redesigns a heat-regulation device to better meet the criteria for success, **referencing some** of the relevant test data of different devices to explain why they combine best characteristics. | Student redesigns a heat-regulation device to better meet the criteria for success, **referencing all** of the relevant test data of different devices to explain why they combine best characteristics. |
| **Look Fors:**   * Student’s heat-regulation device shows clear improvement that combines best characteristics from different designs (from own and other groups). However, student provides no explanation of why it combined these design features.   OR   * Student’s heat-regulation device does not show any improvements or does not combine best characteristics from different designs. | **Look Fors:**   * Student’s heat-regulation device shows clear improvement that combines best characteristics from different designs (from own and other groups). * Student explains why they combined these design features, but does not reference any data. For example, “We used our original chemical reaction and wrapped it in foil, like another group did, because it warmed the water.” | **Look Fors:**   * Student’s heat-regulation device shows clear improvement that combines best characteristics from different designs (from own and other groups). * Student explains why they combined these design features, using one piece of data. For example, “We used our original chemical reaction because it warmed the water. We also wrapped it in foil because another group’s data showed that this led to a higher temperature. In the final test, data showed that this revised design works, resulting in a temperature of 73 degrees.” | **Look Fors:**   * Student’s heat-regulation device shows clear improvement that combines best characteristics from different designs (from own and other groups). * Student explains why they combined these design features, using multiple pieces of data. For example, “We used our original chemical reaction because it warmed water to 70 degrees. We also wrapped it in foil because another group’s data showed that this led to a higher temperature of 74 degrees. In the final test, data showed that this revised design works, resulting in a temperature of 73 degrees.” |