Module 1: Thermal Transfer
6th Grade

About the Instructions:

This document is intended for use by classroom teachers, SciTrek leads, and SciTrek volunteers. The document has been composed with input from teachers, leads, volunteers, and SciTrek staff to provide suggestions to future teachers/leads/volunteers. The instructions are not intended to be used as a direct script but were written to provide teachers/leads/volunteers with a guideline to present the information that has worked in the past. Teachers/leads/volunteers should feel free to deviate from the instructions to help students reach the learning objectives of the module. Some places in which you can be creative and mold the program to meet your individual teaching style, or to meet the needs of students in the class are: during class discussions, managing the groups/class, generating alternative examples, and asking students leading questions. However, while running the module make sure to cover all the material each day within the scheduled 60 minutes. In addition, no changes should be made to the academic language surrounding the Analysis Activity.

This 6th grade module has been designed to build upon the scientific practices taught in 5th grade SciTrek. The material, which focuses on conclusions and analyzing and interpreting data, relies heavily on the content that is developed and practiced in 5th grade SciTrek modules. As a result, the 6th grade SciTrek program is only available to classes that completed 5th grade SciTrek in the previous year.

Activity Schedule:
There are no scheduling restrictions for this module.

Day 1: Analysis Assessment/Observations/Variables (60 minutes)
Day 2: Question/Materials Page/Experimental Set-Up/Procedure/Results Table (60 minutes)
Day 3: Experiment/Analysis Activity (60 minutes)
Day 4: Conclusion/Technique/Analysis Activity (60 minutes)
Day 5: Analysis Activity/Discussion/Question/Materials Page/Experimental Set-Up/Procedure (60 minutes)
Day 6: Results Table/Experiment/Graph/Conclusion (60 minutes)
Day 7: Poster Making/Poster Presentations (60 minutes)
Day 8: Analysis Assessment/Tie to Standards (60 minutes)

The exact module dates and times are posted on the SciTrek website (http://www.chem.ucsb.edu/scitrek/elementary) under the school/teacher. The times on the website include transportation time to and from the SciTrek office (Chem 1105). Thirty minutes are allotted for transportation before and after the module, therefore, if a module was running from 10-11 then the module times on the website would be from 9:30-11:30.

Student Groups:

For the initial observation (Day 1) students work in three groups of ~ten students each. After Day 1 the groups of ~ten students are further subdivided into three subgroups, ~four students each, to perform their experiments. Students stay in these subgroups for the rest of the module. On Day 5, subgroups will join to form “teams” (~3 subgroups per team) based on the changing variable they choose to investigate. One volunteer is assigned to help each of the groups/teams. We find groups work best when they are mixed levels and mixed language abilities.
**NGSS Performance Expectation Addressed:**

**MS-PS3-4** Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.

**Learning Objectives:**

1. Students will know that energy can be transferred in a chemical reaction in the form of heat.
2. Students will know that they can only have one changing variable to draw a conclusion.
3. Students will be able to determine whether a conclusion is appropriate based on a given data set.
4. Students will be able to recognize and interpret trends in graphical data.
5. Students will be able to collaborate as a class to plan and carry out a focused experiment.
6. Students will be able to analyze data collected by multiple groups and use it to make predictions.
7. Students will be able to list at least two ways that they behaved like scientists.

**Classroom Teacher Responsibilities:**

In order for SciTrek to be sustainable, the program needs to work with teachers on developing their abilities to run student-centered inquiry-based science lessons on their own in their classrooms. As teachers take over the role of SciTrek lead, SciTrek will expand to additional classrooms. Even when teachers lead the modules in their own classrooms, SciTrek will continue to provide volunteers and all of the materials needed to run the module. Below is a sample timeline for teachers to take over the role as the SciTrek lead.

* Groups are made up of ~ten students and are subdivided into three subgroups (~four students), to perform experiments.

1. **Module 1 & 2 (year 1)**
   a. Classroom Teacher Leads a Group

2. **Module 3 & 4 (year 2)**
   a. Classroom Teacher **Co-Leads the Class** (an experienced SciTrek volunteer will be present to help out if needed)
      i. Classroom teacher will be responsible for leading entire class discussions (examples: conclusion activity, tie to standards, etc.).
      ii. Classroom teacher will be responsible for time management.
      iii. Classroom teacher will be responsible for overseeing volunteers and helping any groups that are struggling.
      iv. Classroom teacher will be responsible for all above activities, the SciTrek co-lead will only step in for emergencies.

3. **Any Additional Modules (year 3 and beyond)**
   a. Classroom Teacher **Leads the Class**
      i. Classroom teacher will be responsible for leading entire class discussions (examples: conclusion activity, tie to standards, etc.).
      ii. Classroom teacher will be responsible for time management.
      iii. Classroom teacher will be responsible for overseeing volunteers and helping any groups that are struggling.

SciTrek staff will be counting on teacher involvement. Teachers should notify the SciTrek staff if they will not be present on any day(s) of the module. Additional steps can be taken to become a SciTrek lead faster than the proposed schedule above. Contact **scitrekadmin@chem.ucsb.edu** to learn more.
In addition, teachers are required to come to UCSB for the module orientation, ~one week prior to the start of the module. Contact scitrekadmin@chem.ucsb.edu for exact times and dates, or see our website at http://www.chem.ucsb.edu/scitrek/elementary under your class’ module times. At the orientation teachers will go over module content, learn their responsibilities during the module, and meet the volunteers that will be helping in their classroom. If you are not able to come to the orientation at UCSB due to an emergency or extenuating circumstance, you must complete an online orientation. Failure to do an orientation for the module will result in loss of priority registration for next year.

**Prior to the Module (at least 1 week):**

1. Come to the SciTrek module orientation at UCSB.

**During the Module:**

If possible, have a document camera available to the SciTrek lead every day of the module. If you do not have a document camera, please tell the SciTrek staff at orientation.

**Day 1:**
Have the students’ desks/tables moved into three groups and cleared off. This ensures that each student has a desk during SciTrek activities and that students can begin the module as soon as SciTrek arrives.

**Day 2-7:**
Have the students’ desks/tables moved into nine groups and cleared off. This ensures that each student has a desk during SciTrek activities and that students can begin the module as soon as SciTrek arrives.

**Day 8:**
Have the students’ desks/tables cleared off. The desks/tables do not need to be moved into groups.

**Scheduling Alternatives:**

Some teachers have expressed interest in giving the students more time to work with the volunteers throughout the module. Below are options that will allow the students more time to work with the volunteers. If you plan to do any of the following options, please inform the SciTrek staff no later than your orientation date (~one week before your module, exact orientation times are found at: http://www.chem.ucsb.edu/scitrek/elementary). This will allow the SciTrek staff to provide you with all needed materials.

**Day 1:**
If you would like to have more time for your students to make observations and generate variables, you can do the analysis assessment before SciTrek arrives.

**Day 2:**
If you would like to have more time for your students to design their experiments, you can do the example question/experimental set-up that is outlined in the introduction before SciTrek arrives.

**Day 3:**
If you would like to have more time for your students to perform their experiments, you can finish the analysis activity after SciTrek leaves.

**Day 4:**
If you would like to have more time for your students to work on the technique activities, you can finish the analysis activity after SciTrek leaves.
Day 5:
If you would like to have more time for your students to collaborate and redesign their experiments, you can do finish the analysis activity before SciTrek arrives.

Day 7:
If you would like to have more time for your students to discuss their experiments during poster presentations, you may take more time for each presentation and finish the presentations after SciTrek leaves.

Day 8:
If you would like more time for the tie to standards activity, you may give the analysis assessment before SciTrek arrives.

Materials Used for this Module:

1. Polypropylene 4 oz. containers (Fisher part number: 14-828-321)
2. Scoopula stainless steel spatulas, labeled with substance to be used (Fisher part number: 14-357Q)
3. Magnetic stir plates (Fisher part number: 11-676-263)
4. Magnetic stir bars, 1 inch (Fisher part number: 14-512-126)
5. Nalgene graduated cylinders, 100 mL (Fisher part number: 08-572D)
6. Weighing dishes, hexagonal, polystyrene (Fisher part number: 02-202-101)
7. Beakers, 250 mL borosilicate glass (Fisher part number: FB100250)
8. Traceable Flip-Stick digital thermometers (Fisher part number: 14-648-45)
9. Scales (Amazon.com: American Weigh Scales Signature Series Black AWS-1KG-BLK Digital Pocket Scale, 1000 g x 0.01 g)
10. Droppers
11. Extension cords
12. Sip Thru plastic lids (Smart & Final, First Street brand for 8 oz. or 10 oz cups)
13. Leslie’s Hardness Plus (calcium chloride, CaCl$_2$) (Leslie’s Pool Supply Sku: 14420)
   a. IMPORTANT: Calcium chloride absorbs water from the air, which negatively affects this experiment. Thus, it is important to keep the lids on all calcium chloride containers.
   b. IMPORTANT: Calcium chloride has an expiration date, so it must always be tested prior to use in the classroom.
   c. To test CaCl$_2$ freshness, stir 6.0 g CaCl$_2$ into 50 mL tap water at room temperature, record the initial and maximum temperature, and subtract the initial temperature from the maximum temperature to find the temperature change. Repeat two more times and find the average temperature, which should be $\approx 14.0°C$.
   d. If the temperature change varies by >1.5°C, fresh CaCl$_2$ must be acquired.
14. Baking soda (sodium hydrogen carbonate, NaHCO$_3$)
15. Salt (sodium chloride, NaCl)
16. Water
17. Clear rulers (Amazon.com: eBoot clear plastic ruler, 12-inch/metric)
18. Paper towels
19. Ziploc sandwich bags
20. Plastic spoons, labeled to avoid use with food

Note: The chemical reaction investigated in this experiment generates calcium carbonate (CaCO$_3$), also known as chalk. All the products/materials used in this module are safe to wash down the drain. Calcium carbonate has been known to build up on beakers, thermometers, etc. over time, leaving a white residue. This residue can be easily cleaned off the equipment by rinsing with vinegar.

All printed materials used by SciTrek (student notebooks, materials pages, team plan page, lead picture packet, poster parts, instructions, and nametags) can be made available for use and/or editing by emailing scitrekadmin@chem.ucsb.edu.
Day 1: Analysis Assessment/Observations/Variables

Schedule:

- Introduction (SciTrek Lead) – 2 minutes
- Analysis Assessment (SciTrek Lead) – 15 minutes
- Observation Discussion (SciTrek Lead) – 5 minutes
- Observations (SciTrek Volunteers) – 19 minutes
- Variable Discussion (SciTrek Lead) – 5 minutes
- Variables (SciTrek Volunteers) – 12 minutes
- Wrap-Up (SciTrek Lead) – 2 minutes

Materials:

(3) Volunteer Boxes:
- Student nametags
- (12) Student notebooks
- Volunteer instructions
- Picture of experimental set-up
- Volunteer lab coat
- (2) Pencils
- (2) Wet erase markers
- (12) Clear rulers
- Paper towels
- Water (8 oz)
- Dropper
- Scale
- Thermometer
- 100 mL Graduated cylinder
- 250 mL beaker
- NaHCO₃ exact container (2.4 g)
- NaCl exact container (4.0 g)
- CaCl₂ exact container (6.0 g)
- Set of 4 labeled weigh boats (NaHCO₃, NaCl, CaCl₂, Mix)
- Plastic lid
- Magnetic stir bar

Other Supplies:
- (3) Large group notepads
- Bucket with lid
- (3) Trays

Lead Box:
- (3) Blank nametags
- (3) Extra student notebooks
- Lead instructions
- Thermal Transfer picture packet
- Picture of experimental set-up
- Lead lab coat
- (35) Analysis assessments
- Time card
- (2) Pencils
- (2) Wet erase markers
- (3) Markers (orange, green, blue)
- (5) Clear rulers
- Paper towels
- Water (8 oz)
- Dropper
- Scale
- Thermometer
- 100 mL Graduated cylinder
- 250 mL beaker
- NaHCO₃ exact container (2.4 g)
- NaCl exact container (4.0 g)
- CaCl₂ exact container (6.0 g)
- Set of 4 labeled weigh boats (NaHCO₃, NaCl, CaCl₂, Mix)
- (3) Plastic lids
- Container of 3 magnetic stir bars
**Notebook Pages and Notepad Pages:** (Note: Notebook pages are rectangular and filled out in black, and notepad pages are square and filled out in blue.)

### OBSERVATIONS

<table>
<thead>
<tr>
<th>Formula</th>
<th>Substance Name</th>
<th>Physical Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>NaHCO₃</td>
<td>Sodium hydrogen carbonate</td>
<td>white, powdery solid</td>
<td>2.4 g</td>
</tr>
<tr>
<td>NaCl</td>
<td>Sodium chloride</td>
<td>white, grainy solid</td>
<td>3.9 g</td>
</tr>
<tr>
<td>CaCl₂</td>
<td>Calcium chloride</td>
<td>white, solid, little raills</td>
<td>4.0 g</td>
</tr>
<tr>
<td>H₂O</td>
<td>water</td>
<td>clear, colorless liquid</td>
<td>50 mL</td>
</tr>
</tbody>
</table>

- Stir plate and stir bar
- Scale
- Plastic lid
- Thermometer
- Glass beaker
- 14 weigh boats
- Graduated cylinder

Describe what happened during the experiment:
- Pour all substances together and stir
- Beaker got warm and made a lot of bubbles
- Temp. Max = 39.0°C
- Temp Change = 28.8°C
- 19.2°C

Temp. change: 9.8°C

### VARIABLES

<table>
<thead>
<tr>
<th>Variable</th>
<th>How will changing this variable affect the temperature change of the reaction?</th>
</tr>
</thead>
<tbody>
<tr>
<td>water amount</td>
<td>The more water, the smaller the temperature change.</td>
</tr>
<tr>
<td>water temperature</td>
<td>The hotter the water, the bigger the temperature change.</td>
</tr>
<tr>
<td>NaCl amount</td>
<td>The more NaCl, the bigger the temperature change.</td>
</tr>
<tr>
<td>NaHCO₃ amount</td>
<td>The more NaHCO₃, the bigger the temperature change.</td>
</tr>
<tr>
<td>Container type</td>
<td>The thicker the material of the container, the smaller the temperature change.</td>
</tr>
</tbody>
</table>
Set-Up:

SciTrek Lead:

If the classroom has a document camera, ask the teacher to use it for the analysis assessment and the class question (front cover, student notebook) during the observation discussion. If the classroom does not have a document camera, then write the class question on the board during the observation discussion.

On the board, write the three group colors (orange, blue, and green) and the name(s) of the volunteer(s) that will be working with each group.

Place a graduated cylinder, beaker, scale, weigh boat, stir plate, and stir bar on a tray to show/demonstrate during the observation discussion.

Pass out initial assessments and clear rulers to each student.

SciTrek Volunteer:

Put your name, the teacher’s name, and your group color on the top of your group notepad.

As students are taking the analysis assessment, walk around the room and quietly place the students’ nametags, which are in your group box, on each student’s desk.

Once you have passed out the nametags, assemble the experimental set-up (shown in the picture below as well as in the experimental set-up picture in your group box) on a tray. Use the following steps to help you with the set-up:

1. Fill a 100 mL graduated cylinder with 50 mL of water and place it on the tray.
2. Place the scale, beaker, thermometer, 4 labeled weigh boats (1 NaHCO₃, 1 NaCl, 1 CaCl₂, 1 Mix), magnetic stir bar, plastic lid, and Exact containers of NaHCO₃, NaCl, and CaCl₂ on the tray.
3. Plug in the stir plate (use extension cord if needed) and place it next to the tray of materials.

Introduction:

(2 minutes – Full Class – SciTrek Lead)

“Hi, we are scientists from UCSB and we want to show you what we do as scientists. We will show you an experiment and then you can make observations, come up with a class question, and design your own experiment to help answer the class question. We want to show you that you can do science and have fun.”
If you are a teacher that is leading the class tell your students that they are going to start a long-term science investigation and you have asked some scientists from UCSB to come and help. Allow the UCSB volunteers to introduce themselves and share their majors.

**Analysis Assessment:**
*(15 minutes – Full Class – SciTrek Lead)*

As the students are taking the assessment, the volunteers should get the student nametags out of their group boxes and walk around the room locating their students. Have the volunteers quietly lay each student’s nametag on their desk. If students do not have their name on their paper remind them to do so. After volunteers have handed out the nametags, they should assemble the experimental set-up.

“Before we start with the module, we will determine how your ideas on analyzing and interpreting data are developing.” Pass-out the analysis assessment and clear rulers, and tell students to fill out their name, teacher’s name, and date at the top of the assessment. Remind the students that it is important that they fill out this assessment on their own.

For page 1, read the directions for annotating to the students. Then, have students annotate the first results table by underlining controls, circling changing variables, and boxing information about data collection. Read question 1b (Can this group make a conclusion?), and have students answer it. Have students annotate the possible conclusion. Finally, read question 1d (Is this a correct conclusion for the results table? If NO what is wrong with the conclusion?) and have students answer the question. Repeat this process for questions 2 and 3.

For question 4, show students how to annotate the graph. First, ask students what is on the x-axis (the horizontal). Students should say time. Tell students that the changing variable will always be found on the x-axis, so we should circle time. Ask students where else they see time on this graph. They should say in the title, and circle time in the graph title. Then ask students what is being measured on the y-axis (vertical). They should say distance traveled. Tell students that data (measurements/observations) will always be found on the y-axis, and box distance traveled. Then ask if they see distance traveled anywhere else on the graph. They should also notice the data in the graph title, and box “distance a ball travels.” Finally, point out the “amount of sand” is a special type of control that they will learn about later in the module. Underline amount of sand in the legend and ask if this appears anywhere else on the graph. Underline amount of sand in the graph title.

Students should answer the remaining questions on their own. Tell students to do their best to plot the remaining points on the graph using circles as markers. Then tell students to draw trend lines for each experiment on the graph. Read questions 4d-4f and give students time to answer each. Walk around to make sure students are filling out the questions. After reading the last question, tell students to raise their hands when they are finished so you can collect their assessments and clear rulers.

**Observation Discussion:**
*(5 minutes – Full Class – SciTrek Lead)*

Tell the students that scientists make many observations. Ask the class, “What is an observation? What are the types of things that you can record for observations?” If they have trouble, show them an object and let them make some observations. Turn these specific observations into general features of an observation. Examples of possible general observations are: color, texture, size, weight, temperature, material, etc. Lead students to understand that an observation is a description using your five senses.
Have volunteers pass-out a notebook to each student. Have students fill out their name, teacher’s name, group color (color of their name on their nametag: orange, blue, or green), and their volunteer’s name on the front cover of their notebooks. Students will leave the subgroup number, subgroup symbol, and class question blank.

“In this experiment we are going to make observations of chemicals before, during, and after a chemical reaction.” Ask the class to help you define what a chemical reaction is. Choose 2-3 students to share their ideas about chemical reactions. Use these ideas to help lead to the definition: a process where one or more substances are altered into one or more different substances. Tell students that we can tell a chemical reaction has happened if the temperature changes, a gas forms, or the color changes. Tell students that they can refer back to this definition on page 1 of their notebooks. Then, tell students that as a class we will investigate the question, “What variables affect the temperature change of a reaction?” Write the class question on the front cover of a class notebook under the document camera and have students copy it onto their notebooks.

Tell students that one of the scientific devices that we will be using is a scale. Put one of the scales under the document camera. The scale will be used to measure the amounts of substances we will be working with. Show students how to turn on the scale and wait for it to read 0.00 g. Then, place one of the weigh boats on the scale (it does not matter which weigh boat you choose). Have the students read the mass of the weigh boat out loud. Ask the students if they think the mass of the weigh boat should be included in the mass of the substance. Lead students to realize that it should not. Tell students that the way scientists get rid of the mass of the weigh boat is to rezero or “tare” the scale before they add the substance they want to measure. Show students where the tare button is. Push the button and then pour the appropriate substance from one of the exact containers in the lead box into the weigh boat. Tell students that they should record all mass measurements to the nearest tenth (0.1) of a gram.

Inform students that another scientific device that we will be using is a magnetic stir plate. Hold up a stir bar and tell students that these are magnetic, and they will be used to stir their reactions. Tell students that they should all set their stir plates to stir at the same speed by turning the dial to the black mark. Remind them that they should not play with the stir bar or stir plate. Tell students we will also be using digital thermometers. In our experiment, we will need to record the maximum temperature of the reaction. These thermometers can help us record the exact maximum temperature because they have a button that says “Max/Min.” Tell students that once the reaction has reached its maximum temperature (i.e. when the temperature starts to decrease again), they can take the thermometer out and press the “Max/Min” button to find out the maximum temperature. After recording the maximum temperature, students should close the thermometer to reset it before performing the next trial.

Tell the class they will now get in their groups and make observations. To determine their group, they will need to look at the color of their nametag (orange, blue, or green). Tell each colored group where to go and to bring their notebook and a pencil.

If a student does not have a nametag, identify the group with the least number of students in it and write the student’s name on one of the extra nametags that are in the lead box using that color of marker.

**Observations:**
(19 minutes – Groups – SciTrek Volunteers)

Once the students come over to your group, have them sit in boy/girl fashion. Verify the materials are set up as described in the set-up section. As a group, have the students fill out the table with descriptions and amounts (mass or volume) of water, sodium hydrogen carbonate (NaHCO₃), sodium chloride (NaCl), and calcium chloride (CaCl₂). You will need to give students the names of the substances. Do not tell students
the common names of the substances (baking soda, salt). Weigh each substance in the appropriately labeled weigh boat and record masses to the nearest tenth of a gram.

Observations should be recorded in the table on the group notepad and then copied into student notebooks. The table should take you no longer than 7 minutes to fill out. As a group, generate ~4 other observations about the experimental set-up (aside from the information in the table). Write these on the group notepad while students copy them into their notebooks. Then give students ~1 minute to generate a few other observations by themselves and write them in their notebooks. Have students share out for 1 minute. Make sure that students know the container holding the water is called a graduated cylinder and the empty container is called a beaker. If they are not already there, add “graduated cylinder” and “beaker,” along with sketches of each, to the group notepad. You do not need to put any other observations about the experimental set-up on the group notepad.

Pour the water from the graduated cylinder into the beaker and add the stir bar. Then, open the thermometer, place it through the hole in the lid, and put the lid on the beaker so the thermometer rests in the water. Begin stirring by turning the stir plate dial to the black mark and wait a few moments to allow the water temperature to stabilize. Then ask students what the temperature is and record it on the group notepad while students record it in their notebooks. A picture of this set-up is shown below.

Pour all of the weighed substances into the weigh boat labeled “Mix.” Tell students we are going to add the chemicals into the water, which might affect the temperature. Tell students that while the reaction is taking place, they can tell you what they observe and you will record it on the group notepad. Then after the reaction is complete, they will be able to copy it into their notebooks. Have students tell you what they are going to do (pour all substances together) and record it on the group notepad. Tell the students we will record the highest temperature, so they need to watch the thermometer until the temperature reaches a maximum and starts decreasing again. When the students are ready, carefully lift the lid so that the thermometer stays in the water while you pour the contents of the Mix weigh boat into the water. Have a student hold the beaker steady while the reaction is happening. (Note: The temperature may drop momentarily, but should start increasing somewhat rapidly.) Try to allow all students to “one-finger touch” the outside of the beaker to feel that the reaction caused the beaker to get warm. Once the reaction reaches its maximum temperature (starts decreasing again), record the temperature on the group notepad. Have students copy down what you wrote on the group notepad during the reaction. In addition, have them draw what happened during the reaction in the beaker.

Ask students how we can determine how much the temperature changed because of the reaction. Then guide students in subtracting the initial temperature from the maximum temperature to get the temperature change. Record this on the group notepad and have students copy it into their notebooks. Note: the temperature change should be ~9-10°C, which corresponds to a change of ~16-18°F. Do not tell this to students unless they specifically ask what the change in Fahrenheit temperature would be.
Ask the students, “Did a chemical reaction happen when the chemicals were poured into the water?” Call on a few students to share the evidence they observed to confirm that a chemical reaction occurred. Students should say that a gas formed and the temperature changed/increased.

If there is extra time, have students summarize what happened during the experiment. An example group notepad/student notebook is shown below. Feel free to deviate from the example.

**Variable Discussion:**
(5 minutes – Full Class – SciTrek Lead)

Have each group share one of their observations with the rest of the class.

Review with the class that the temperature increased and bubbles (gas) were formed. Make sure that by the end of the discussion, the students understand that a chemical reaction occurred.

Ask the class what the class questions is. They should respond “What variables affect the temperature change of the reaction?”

Ask the students the following questions:
- What does the word “variable” mean to a scientist? (variables are parts of the experiment that you can change)
- Do you think that there are multiple variables that will affect the temperature change? (multiple variables might affect the temperature change)
- Explain that this is why we will need to work as a class to answer the class question: “What variables affect the temperature change of the reaction?”
Tell the class that they are going to think about variables in the experiment that they could change to help us answer the class question. In addition to generating variables, they should think about how/why these variables might affect the outcome of the experiment. Ask the class to give you a variable that they think might affect the temperature change. Then, have them tell you how/why they think that variable would affect the experiment. Probe them on how they would design an experiment to test if this variable affected the temperature change. Finally, have the students make a prediction of the results for the experiment they proposed. Remind students that predictions can be wrong and we will not know the correct answers until we carry out the experiment.

Example:  
**Variable:** sodium chloride mass  
*Why might this variable affect the temperature change of the reaction?* Because it might allow the chemical reaction to go on longer.  
*How would you test this variable?* Add different amounts of sodium chloride to the reaction.  
*Prediction:* The more sodium chloride the greater the temperature change.

Tell the students they will generate more variables and analyze them in their groups.

**Variables:**  
*(12 minutes – Groups – SciTrek Volunteers)*

As a group, generate a variable and make a prediction about how it will affect the temperature change. Encourage and challenge students to explain why they think their prediction is correct and how this variable will affect the temperature change. Repeat this process two more times, record these ideas on the group notepad, and have students copy it into their notebooks. If students have different predictions, they can write their own predictions in their notebooks. Next, students will individually generate additional variables, make predictions about how different values of this variable will affect the temperature change, and record their ideas in their notebooks. Have students share these ideas with the group.

Prepare one student to share a variable and why they think it will affect the temperature change during the class discussion.
**Wrap-Up:**

*(2 minutes – Full Class – SciTrek Lead)*

Have one student from each group share a variable that they generated and how/why they think it will affect the temperature change. Make sure that students tell you their predictions about how different values of that variable will affect the temperature change. Challenge students to justify their thinking and explore with them how this might help them design an experiment to answer the class question. For example, if a student’s variable was sodium chloride amount and they predicted that more sodium chloride will make a bigger temperature change, ask the student why they predicted this. One possible answer could be: if there is more sodium chloride, then a bigger reaction will happen, possibly allowing the reaction to have a bigger temperature change. Probe the students deeper by asking them questions such as: if you designed an experiment to test this, do you think it would be easier or harder to see if this variable affected the temperature change if you have sodium chloride amounts that are similar? Students should respond that it would be harder to see the effects of the variable if they have sodium chloride amounts that are similar. Therefore, they should choose values that are spread out for their experiments.

Tell the students that the next time we meet they will design an experiment to answer a question that they have about this experiment, which will help them learn about the temperature change of the reaction.

**Clean-Up:**

Before you leave, have students attach their nametags to their notebooks and place them in the group box. Place the beaker (and all its contents) and weigh boats into the bucket. Wipe the thermometer with a paper towel, close it, and put it back into your group box, making sure the thermometer turns off. Put all of the other materials into your group box. Bring all materials back to UCSB. In addition, put your lab coat into your group box. If you would like to divide your group (~ten students) into three subgroups you can...
do this by writing a “1,” “2,” or “3” on the top of each student’s notebook to designate their subgroups. Make sure that the subgroups are made up of mixed gender and mixed ability students.

Day 2: Question/Materials Page/Experimental Set-Up/Procedure/Results Table

Schedule:

Introduction (SciTrek Lead) – 12 minutes
Question (SciTrek Volunteers) – 9 minutes
Materials Page (SciTrek Volunteers) – 7 minutes
Experimental Set-Up (SciTrek Volunteers) – 8 minutes
Procedure (SciTrek Volunteers) – 18 minutes
Results Table (SciTrek Volunteers) – 3 minutes
Wrap-Up (SciTrek Lead) – 3 minutes

Materials:

(3) Volunteer Boxes:
- □ Student nametags
- □ Student notebooks
- □ Volunteer instructions

- □ Volunteer lab coat
- □ (3) Experiment 1 materials pages (group color & number indicated)
- □ (2) Pencils
- □ (2) Red pens
- □ Notepad

Lead Box:
- □ (3) Blank nametags
- □ (3) Extra student notebooks
- □ Lead instructions
- □ Thermal Transfer Picture Packet
- □ Lead lab coat

- □ (3) Experiment 1 materials pages
- □ Time card
- □ (2) Pencils
- □ (2) Wet erase markers

- □ (2) Red pens
- □ (3) Markers (orange, green, blue)
- □ Notepad
- □ Scoopula

Notebook Pages:
Experimental Considerations:
1. You will only have access to the materials on the materials page.
2. See materials page for restrictions on experimental design.

Changing Variable(s) (Independent Variable(s))
You will get to perform two experiments. For your first experiment decide which variable(s) (max two) that you would like to test. For each changing variable that you select, discuss with your group why you think that variable will affect the temperature change.

Changing Variable 1: \( \text{NaHCO}_3 \text{ mass} \)
Discuss with your group how you think changing variable 1 will affect the temperature change.

Changing Variable 2 (optional): \( \text{NaCl} \text{ mass} \)
Discuss with your group how you think changing variable 2 will affect the temperature change.

**Question**
Your group will investigate:
- If we change the _____ of \( \text{NaHCO}_3 \) and \( \text{NaCl} \) what will happen to the _____ of the reaction?

Get a materials page from your SciTrek volunteer and fill it out before moving onto the experimental set-up.

---

**EXPERIMENTAL SET-UP**
Determine the values of your changing variable(s) (ex: NaCl mass) from the materials page and write the values (ex: 2.0 g) for your three trials underneath.

**Changing Variable(s):**
- \( \text{NaHCO}_3 \text{ mass} \): 0.0 g, 1.0 g, 2.3 g
- \( \text{NaCl} \text{ mass} \): 2.0 g, 0.3 g, 6.9 g

**Controls (variables you will hold constant):**
Determine the variables that you will hold constant and indicate the specific value you will use in all your trials.

<table>
<thead>
<tr>
<th>Container Type</th>
<th>Beaker</th>
<th>( \text{CaCl}_2 \text{ mass} )</th>
<th>( \text{water volume} )</th>
<th>( \text{stir speed} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Container Type</td>
<td>Beaker</td>
<td>( \text{CaCl}_2 \text{ mass} )</td>
<td>( \text{water volume} )</td>
<td>( \text{stir speed} )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.50 g</td>
<td>50 mL</td>
<td>medium</td>
</tr>
</tbody>
</table>

---

**RESULTS**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Trial A</th>
<th>Trial B</th>
<th>Trial C</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{CaCl}_2 \text{ mass} )</td>
<td>0.50 g</td>
<td>0.50 g</td>
<td>0.50 g</td>
</tr>
<tr>
<td>( \text{NaHCO}_3 \text{ mass} )</td>
<td>0.0 g</td>
<td>1.0 g</td>
<td>2.3 g</td>
</tr>
<tr>
<td>( \text{NaCl} \text{ mass} )</td>
<td>2.0 g</td>
<td>0.3 g</td>
<td>6.9 g</td>
</tr>
<tr>
<td>( \text{water volume} )</td>
<td>50 mL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \text{stir speed} )</td>
<td></td>
<td></td>
<td>medium</td>
</tr>
</tbody>
</table>

**Predictions**

- \( S \): The independent variable(s) (\( \text{CaCl}_2 \text{ mass} \)) the changing variable(s) and the dependent variable is the change in temperature and other.

---

**Set-Up:**
SciTrek Lead:
If the classroom has a document camera, ask the teacher to use it for the question (page 4, student notebook), experiment 1 materials page (lead box), experimental set-up (page 5, student notebook), and results table (page 7, student notebook). If the classroom does not have a document camera, then tape the example poster-size notebook pages to the front board.

SciTrek Volunteer:
Set out student notebooks to allow students within the same subgroup (same number on front of notebook) to work together.

- If students are not in the classroom before SciTrek starts, set out the notebooks where students should sit when they come into the classroom.
- If students are in the classroom before SciTrek starts, set out the notebooks where students should sit during the module, and they will move to these spots after the introduction.

Make sure you have three experiment 1 materials pages, each filled out with a subgroup number (1, 2, or 3) and your group’s color. These will be given to students after they complete their question.

Have a red pen available to approve students’ question, experimental set-up, and procedure (pages 4, 5 and 6).

Introduction:
(12 minutes – Full Class – SciTrek Lead)

If needed, while you are doing the introduction have volunteers set out the notebooks/nametags where they would like students to sit. Make sure that students in the same subgroup are sitting next to each other. Tell students that a notebook will be put on their desk which is not their notebook, and they should not move it.

Ask students what they did during the last meeting with SciTrek. They should reply that they mixed three chemicals in water and observed a chemical reaction, which resulted in a temperature change. Make sure that they remember the names of the chemicals: sodium chloride (NaCl), calcium chloride (CaCl₂), and sodium hydrogen carbonate (NaHCO₃). In addition, they generated variables that might affect the temperature change. Ask the class if they remember the class question they will investigate. They should reply, “What variables affect the temperature change of the reaction?”

Tell students that one way scientists answer questions is by performing experiments. Today they will design an experiment to help answer the class question. Ask the class if they think there are multiple variables that could affect the temperature change. They should respond that there probably are multiple variables. Therefore, each subgroup is going to generate a smaller question to investigate. Once we put all the subgroups’ research together, we should be able to answer the class question.

Groups will first generate a question based on the changing variable(s) that they plan to explore. They will then fill out their experiment 1 materials page, which will allow them to determine their experimental set-up. The experimental set-up will help them generate a procedure, or a set of steps to conduct their experiment. Tell students that they need to keep a few things in mind when they are going through this process.

Experimental Considerations:
1. You will only have access to the materials on the materials page.
2. See materials page for restrictions on experimental design.

Tell students we are now going to generate an example question/experimental set-up together and that you will write it in an example notebook so that they will be able to refer back to it when they are completing the process themselves. Make sure that students DO NOT fill out the example question/experimental set-up in their notebooks.

Tell students for this example experiment, the changing variable will be: pick any variable (example: CaCl₂ mass), then write down the changing variable on the example notebook (page 4, student notebook) under the document camera. Tell students when they are going through this process in their subgroups, they can select one or two changing variable(s).

Show students how to insert the changing variable(s) and what they plan to measure/observe into the question frame to find the question that will be investigated. For the example discussed above, the question would be: If we change the CaCl₂ mass, what will happen to the temperature change of the reaction? Explain to students that many times when there is a large question, like our class question, scientists break it down into smaller questions that individual scientists can investigate, and then they compile their work to answer the large question.

Tell students once they have determined their question and have approval, their SciTrek volunteer will give them an experiment 1 materials page to help determine the values of their changing variable(s) and controls. Ask students if they know how scientists define controls. Make sure that by the end of the conversation students understand that controls are variables that are held constant during an experiment. For example, if the water volume was 50 mL for all of the trials, then one of their controls would be water volume. These controls and control values can be different than the original experiment that they conducted on Day 1, but must remain constant throughout all the trials that they do for this experiment.
Show students the experiment 1 materials page and read the first step (For each bolded word, circle if it is a changing variable and underline if it is a control.) Go through the bolded words and have students identify if you should underline or circle them. Read steps 2-4 on the experiment 1 materials page (Record masses to the nearest tenth of a gram. For variables that are controls, choose 1 value and write it in the first blank. For variables that are changing variables, select three values and write the trial letter under each value (example: $\frac{2.0 \text{ g}}{A}$).) Read the general materials to students and ask them if they need each one and check the box when they say yes. When you get to “scoopula,” show them the scoopula that is in the lead box and tell them it will be used to scoop the chemicals so that they will not touch them.

Go through the remaining items on the experiment 1 materials page. If a variable is a control, then choose a value, such as the original value (example: 50 mL for water volume). For variables that are changing variables, allow students to select the values. Make sure students are following all restrictions listed (example: CaCl$_2$ mass may only be 3.0 g – 9.0 g). In addition, make sure they are giving your mass values to the nearest tenth of a gram. Ask students, “Do we want a narrow or wide range of values for the changing variable, and why?” Guide students through selecting a wide range of values for the changing variable. If they choose a value contrary to their experimental design, question them on their reasoning. For example, if they said they wanted to use a wide range of CaCl$_2$ masses and they picked 3.0 g, 3.2 g, and 3.7 g, ask them if these values would allow them to best answer their question. Then allow them to change their values if needed.

Tell students that once they have completed their experiment 1 materials page, they will fill out their experimental set-up. First, they will fill out the information on the changing variable(s). Ask students what the changing variable was for our example experiment and show them where to fill it in on the experimental set-up. Only fill in the values for trials A and B. Second, they will fill in information about the controls. Ask students for one of the controls for the example experiment. Show students how to record the control on the left side of the slash (example: water volume) and the value of that control on the right.
Have students tell you the controls and values until all of the blanks are filled.

Tell students that once they have their experimental set-up complete, they will have it approved by their SciTrek volunteer. Then they will write a procedure that they will be able to follow next time and fill out a results table that they will use to record their data during their experiment. When writing a procedure, they should write all the values of their changing variable(s) and controls as well as what data will be collected. Show students the example procedure step on page 6 of their notebook (Measure A) 2.0 g, B) 4.0 g, C) 6.0 g, and D) 8.0 g of NaCl).

If needed, tell students that they will get into subgroups and design their experiments. Above is an example of what should be filled out for the example materials page (left) and experimental set-up (right) during the introduction. Note that several sections are left blank.

**Question:**

(9 minutes – Subgroups – SciTrek Volunteers)

Have subgroups decide what changing variable(s) they want to explore for their first experiment. If they only have one changing variable do not encourage them to have more and if they have two changing variables, do not encourage them to have fewer (Note: Students will analyze their data and then perform an additional experiment to correct any mistakes that they made on their first experiment). Each subgroup should briefly discuss why/how they think each changing variable will affect the temperature change.

After subgroups have decided on their changing variable(s), have them fill out their question. When you sign off on their question, give them an experiment 1 materials page with their group color and number designated in the upper right-hand corner. An example notebook page is shown below.
Materials Page:
(7 minutes – Subgroups – SciTrek Volunteers)

Have subgroups underline their controls and circle their changing variable(s) on the experiment 1 materials page. Then have them use the experiment 1 materials page to determine the values for their changing variable(s) and controls. For the changing variable(s) values, have students write the trial letter under the value they select. Ask students to justify the values that they have chosen for their changing variable(s) and controls and if these values will make it easier or harder to answer their question.

Make sure that students have picked water volumes, NaHCO$_3$ masses, CaCl$_2$ masses, and NaCl masses that are **within the limitations** given on the experiment 1 materials page. An example filled out experiment 1 materials page is shown in the experimental set-up section below (left).

Experimental Set-Up:
(8 minutes – Subgroups – SciTrek Volunteers)

Have subgroups use their experiment 1 materials page to fill in their experimental set-ups on page 5 of their notebooks. For groups that have two changing variables there will be one control blank that will not come from the materials page, so students should come up with one more variable that will be held constant (example: stir speed/medium). One possible example for this blank is stirring/stir. When you sign off on their experimental set-up, collect the experiment 1 materials page and verify that it is filled out correctly and completely. Having the experiment 1 materials page filled out is essential for students to start their experiments during the next SciTrek visit. An example of an experimental set-up is shown below (right).

Procedure:
(18 minutes – Subgroups – SciTrek Volunteers)
After each subgroup has filled out their experimental set-up, they can start on their procedure (page 6, student notebook). Make sure that students within the same subgroup are collaborating to write the procedure. Keep procedures as brief as possible while still conveying the pertinent information about the experiment (control values, changing variable values, and what data they will collect). An example step if NaCl mass is a changing variable would be: “Measure A) 2.0 g, B) 4.5 g, C) 8.0 g of NaCl.” Some subgroups may struggle with writing a procedure. You can have these groups dictate each step while you transcribe them onto a notepad found in your group box. Give this sheet to the students to copy into their notebooks. Once the students have finished, they should raise their hand to get their procedure approved. An example procedure can be shown below (left).

Tell students that they will now fill out the results table.

**Results Table:**
(3 minutes – Subgroups – SciTrek Volunteers)

Have students underline the variables that are controls, circle the variables that are changing variables, and box the data collection. When writing the values, make sure that for controls, they only write the value of the control in trial A and then draw an arrow through the remaining trials; for changing variable(s), they write the value in each of the boxes.

When students have finished, have them make predictions about the temperature change. Have them write an “L” in the box of the trial they think will give the largest temperature change and an “S” in the box of the trial they think will give the smallest temperature change. They will leave two of the boxes empty. If they think all trials will give the same temperature change, have them write “same” over all of the boxes. Try to question each subgroup on their thought process behind their predicted temperature changes. See example notebook above (right).
Wrap-Up:
(3 minutes – Full Class – SciTrek Lead)

If there is time, have one student from each group share what question they will investigate. Tell students that on the next SciTrek visit they will start their experiments. Tell students that all of their experiments will help us answer the class question: What variables affect the temperature change of the reaction?

Clean-Up:

Before you leave, have students attach their nametags to their notebooks and place them in the group box. Place the materials pages on top of the notebooks in your group box. Bring all materials back to UCSB. In addition, put your lab coat into your group box.

Day 3: Experiment/Analysis Activity

Schedule:

Introduction (SciTrek Lead) – 2 minutes
Experiment (SciTrek Volunteers) – 28 minutes
Analysis Activity (SciTrek Lead) – 28 minutes
Wrap-Up (SciTrek Lead) – 2 minutes

Materials:

(3) Volunteer Boxes:

☐ Student nametags
☐ Student notebooks
☐ Volunteer instructions
(3) Ziploc Bags, each with the following:
☐ Wet erase marker
☐ Paper towels
☐ (2) Waters (8 oz)
☐ (2) Scales
☐ (2) Thermometers
☐ (2) Pencils
☐ (2) Red pens
☐ Set of 3 labeled scoopulas (NaHCO₃, NaCl, CaCl₂)
☐ NaHCO₃ container
☐ NaCl container
☐ CaCl₂ container
☐ (6) 100 mL Graduated cylinders
☐ Set of 9 labeled weigh boats (2 NaHCO₃, 2 NaCl, 2 CaCl₂, 3 Mix)
☐ (2) Plastic lids
☐ (3) Magnetic stir bars
☐ Filled out experiment 1 materials page

Other Supplies:

☐ (3) Boxes of beakers
☐ (3) Boxes with 6 stir plates and 3 extension cords
☐ (2) Buckets with lids

Lead Box:

☐ (3) Extra student notebooks
☐ Lead instructions
☐ Thermal Transfer Picture Packet
☐ Lead lab coat
☐ Time card
☐ (2) Pencils
☐ (2) White rags
☐ Paper towels
☐ (2) Waters (8 oz)
☐ Scale
☐ Thermometer
☐ (2) 100 mL Graduated cylinders
☐ NaHCO₃ container
☐ NaCl container
☐ CaCl₂ container
☐ Set of 9 labeled weigh boats (2 NaHCO₃, 2 NaCl, 2 CaCl₂, 3 Mix)
☐ (3) Plastic lids
☐ (2) Red pens
☐ (2) Wet erase markers
☐ Set of 3 labeled scoopulas (NaHCO₃, NaCl, CaCl₂)
☐ Container of 3 magnetic stir bars
### Results Table

<table>
<thead>
<tr>
<th>Variables</th>
<th>Trial A</th>
<th>Trial B</th>
<th>Trial C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Container Type</td>
<td>Beaker</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Volume</td>
<td>50 mL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCo Mass</td>
<td>4.0 g</td>
<td>4.0 g</td>
<td>2.5 g</td>
</tr>
<tr>
<td>NaCl Mass</td>
<td>2.0 g</td>
<td>2.0 g</td>
<td>2.0 g</td>
</tr>
<tr>
<td>Stir Speed</td>
<td>Medium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Predictions</td>
<td>S</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>Initial Measurements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change in Temperature</td>
<td>42.5°C</td>
<td>35.7°C</td>
<td>40.7°C</td>
</tr>
<tr>
<td>Initial Observations/Measurements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The independent variable(s) is/are the changing variable(s) and the dependent variable is the change in temperature and other.

### Scientific Practices

**Analyzing & Interpreting Data**

1. Directions: Fill in the missing definitions.
   - **Conclusion:** claim supported by data
   - **Claim:** A statement that can be tested. The exploration of the data, the first part of a conclusion.
   - **Example:** The temperature does not affect the speed at which it rolls down a ramp.
   - **In a scientific experiment, often includes the changing variable.**
   - **Data:** Evidence collected from experiment(s) (measurements or observations), the second part of a conclusion.
   - **In a scientific experiment, often includes measurements or observations.**
   - **Data statements also often include values of the changing variable.**

2. Directions: On the results tables and conclusions below, circle each changing variable(s). Underline each conclusion(s) and box information about data collection. Then, decide if the possible conclusion is correct or not.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Trial 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Container Type</td>
<td>Beaker</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substance A Mass</td>
<td>2.0 g</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substance B Mass</td>
<td>5.0 g</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stir Speed</td>
<td>Medium</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final Observations/Measurements</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Possible Conclusion: The greater the stirring speed, the higher the temperature change because when the stir rate is high, the temperature change is greater.

Is this a correct conclusion? **YES** No I DON'T KNOW

If NO, what is wrong with the conclusion? Incorrect claim

### Scientific Practices

**Analyzing & Interpreting Data**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Trial 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Container Type</td>
<td>Beaker</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substance A Mass</td>
<td>4.0 g</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substance B Mass</td>
<td>5.0 g</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stir Speed</td>
<td>Medium</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final Observations/Measurements</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Possible Conclusion: We observed that the reaction made foam. When there were more foam, the temperature change was higher.

Is this a correct conclusion? **YES** No I DON'T KNOW

If NO, what is wrong with the conclusion? Claim and data switched

### Scientific Practices

**Analyzing & Interpreting Data**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Trial 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Container Type</td>
<td>Beaker</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substance A Mass</td>
<td>3.0 g</td>
<td>4.0 g</td>
<td>2.0 g</td>
<td>5.0 g</td>
</tr>
<tr>
<td>Substance B Mass</td>
<td>5.0 g</td>
<td>4.0 g</td>
<td>2.0 g</td>
<td>5.0 g</td>
</tr>
<tr>
<td>Stir Speed</td>
<td>Fast</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final Observations/Measurements</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Possible Conclusion: The lower the stiring speed, the higher the temperature change because when the stir rate is low, the temperature change is lower.

Is this a correct conclusion? **YES** No I DON'T KNOW

If NO, what is wrong with the conclusion? Multiple changing variables

How many changing variables can you have to make a conclusion? 1
**Set-Up:**

**SciTrek Lead:**

If the classroom has a document camera, ask the teacher to use it for the analysis activity (pages 8, 9, and 10, student notebook). If the classroom does not have a document camera, then tape example poster-size notebook pages to the front board.

**SciTrek Volunteer:**

Set out student notebooks.

- If students are not in the classroom before SciTrek starts, set out the notebooks where students should sit when they come into the classroom.
- If students are in the classroom before SciTrek starts, set out the notebooks where students should sit during the module, and they will move to these spots after the introduction.

Have all supplies ready so that you can set them out as soon as your subgroups are ready to start.

**Introduction:**

*(2 minutes – Full Class – SciTrek Lead)*

If needed, while you are doing the introduction have volunteers set out the notebooks/nametags where they would like students to sit. Make sure that students in the same subgroup are sitting next to each other. Tell students that a notebook will be put on their desk, which is not their notebook and they should not move it.

Ask the class, “What is the class question that we are investigating?” The students should reply, “What variables affect the temperature change of the reaction?” Tell them that today they will start their experiments to answer this question. However, before they can start their experiments, they need to have their results tables completed (students should have completed this the previous SciTrek visit). Once this is finished, they can raise their hands and they will receive their experimental supplies from their volunteers.

Tell students that when they record their data, they will make two measurements: the initial temperature and the maximum temperature. To get the maximum temperature they will use the max button on the thermometer. Tell students that this function must be reset between each trial by closing and reopening the thermometer and show them how this is done. Ask students how they will determine the temperature change. Make sure they understand that they will determine this by subtracting the initial temperature from the maximum temperature. In addition, they will record any other observations, such as the amount of bubbles that are produced. Show students where they will record these four things on the results table.

Tell students that during the experiment they should label beakers, weigh boats, and/or graduated cylinders with A, B, and C using a wet erase marker. Show students what the pen looks like. Tell them that this is the only pen that they should be writing on the equipment with. Remind students that we will use “scoopulas” to weigh each of the substances. Tell students that they need to be careful not to contaminate materials. Therefore, they should use the appropriately labeled scoopula to add each substance to the corresponding weigh boat. Also, tell students that the calcium chloride (CaCl$_2$) takes on water if it is left uncapped so it is important that they keep the lid closed tightly when they are not using it. In addition, tell them that it is important for them to wipe off the thermometer with a paper towel after each trial. Remind students that they will need to put the weigh boat on the scale and tare it (zero it) by pushing the tare button. Tell them that we are recording measurements to the nearest tenth of a gram, so they should record all digits.
Experiment:
(28 minutes – Subgroups – SciTrek Volunteers)

Once you have verified that subgroups have finished their results tables, give them their requested materials. If students are missing any of their experimental materials, the lead box has extra materials. Make sure that students are keeping the cap to the CaCl₂ closed when they are not using it and closing/wiping off their thermometer with a paper towel after each trial. As soon as students are done with their reactions, remove the beakers and put them in the bucket (please do not put trash in the bucket). It is important to do this as soon as possible so students do not play with or spill their beakers. When the experiment is finished, have students wipe the thermometer with a paper towel, and close it, making sure it turns off. Place graduated cylinders, scales, and thermometers in the group box, and all other dishes in the bucket. If your subgroup has things under control, help other subgroups. Students should record the maximum temperature after each trial, but have students wait until they have finished the entire experiment to calculate the changes in temperature. An example of a properly filled out results table is shown below.

While you start on the analysis activity, have volunteers clean up. Have one volunteer walk around with a damp rag and wipe off all students’ desks.

Analysis Activity:
(28 minutes – Full Class – SciTrek Lead)

**Note:** It is important to start the analysis activity at least 25 minutes before the end of the session.

Tell the students to turn to page 8 in their notebooks. Put a blank notebook under the document camera and turn to page 8. Mention that before they analyze their results and draw a conclusion, it is important that they recognize and understand others’ conclusions.
Ask the class, “What is a conclusion?” After listening to the students’ answers, make sure that the students understand that a conclusion is a **claim supported by data**. Write this definition on page 8 of the example notebook for the students to copy.

Tell the students that in order to make a conclusion we need to make sure that we understand the difference between a claim and data. First, read the definition of a claim and the example. Tell the students that a claim is a statement that we can verify by testing. Have the class generate two examples of statements that are claims. After a student suggests a possible claim, ask the class if the possible claim can be verified by testing. Have students hold their thumb up if it is a claim and down if it is not. Then ask someone else in the class to propose how you would test this claim. Several examples are shown below.

**Examples:**
- **Claim:** the longer a pumpkin is on the vine, the heavier the pumpkin becomes
  - **Test:** weigh pumpkins over time

- **Claim:** there are more 5th grade teachers than 2nd grade teachers at this school
  - **Test:** count the number of 5th and 2nd grade teachers at this school

- **Claim:** animals that live in the snow have lighter colored fur than animals that live in the jungle
  - **Test:** observe the fur color of animals in both habitats

Read the example given, “The ball mass does not affect the speed at which it rolls down a ramp.” Ask someone in the class to propose how you would test this claim. Example, “Roll balls with different masses down a ramp and compare their speeds.” Then, ask someone else if they can identify what the changing variable would be in that experiment. Lead students to notice that the changing variable (ball mass) was included in the claim, and circle ball mass in the example. Read the sentence frame to students, “A claim in a scientific experiment often includes the ___________.” Ask students what we should write in the blank. They should reply “changing variable.”

Next, read the definition of data and the example. Note that the example data supports the example claim, therefore, a conclusion can be formed by combining the two statements. This conclusion would be: The ball mass does not affect the speed at which it rolls down a ramp, because when the ball mass was 360 g its speed was 1.2 \( \frac{m}{s} \) and when the ball mass was 100 g its speed was 1.1 \( \frac{m}{s} \). Tell students that data often contains a numerical measurement such as a height (5 m) or a weight (20 kg). Ask the students if all the numerical values in the data statement are data (no). Lead students to realize that the information about speed (1.2 \( \frac{m}{s} \) and 1.1 \( \frac{m}{s} \)) are data **measurements** and the information about ball mass (360 g and 100 g) are values of the **changing variable**. Have the students circle the values of the changing variable and box the measurements in the data statement. Then, ask the students if data has to contain a numerical measurement. Explain that data can also be in the form of observations (example, plants are observed to have greener leaves when in direct light than in indirect light). When you want to identify if a statement is data look for measurements or words such as **recorded or observed** that allow you to know that an experiment was performed. Read the first sentence frame to students, “Data in a scientific experiment includes ______________ or ___________.” Ask students what we should write in the blanks. They should reply measurements and observations. Read the second sentence frame to students. “Data statements also often include values of the ____________.” Ask students what we should write in the blank. They should reply “changing variable.”

Read the directions to part 2 aloud to the class (On the results tables and conclusions below, circle each changing variable(s), underline each controls(s), and box information about data collection. Then, decide if the possible conclusion is correct of not.) Call on individual students to tell you how each item in the results table should be annotated. Then, read the full conclusion to the students. Have students tell you if there is anything that should be underlined, circled, or boxed and annotate the conclusion appropriately.
For annotating, do parts a and b as a class, and then take the notebook off the document camera and have students try to do parts c, d, and e on their own while you fill them out. While students are working, have volunteers walk around and help them if needed. Then put the notebook back under the document camera for them to check their work.

Use the following question flow chart for each conclusion to help students understand if the conclusion is correct or not.

What type of statement is before the “because” and how do you know?
If the statement is data (contains a measurement or observation)
  o  Can this be a correct conclusion? (No)
  o  What type of statement is after the “because” and how do you know? (claim because it can be tested)
  o  What is wrong with the conclusion? (claim and data switched)
  o  Move onto next conclusion
If the statement is a claim (can be tested)
  o  What is the changing variable in this claim?
  o  Is this a changing variable in this experiment? (Yes)
  o  Is the claim consistent with the results table?
    If No
      o  Can this be a correct conclusion? (No)
      o  What is wrong with the conclusion? (incorrect claim)
      o  Move onto next conclusion
    If Yes and 1 changing variable
      o  What type of statement is after the “because” and how do you know? (Data because it contains a measurement or an observation)
      o  Is the data consistent with the results table? (Yes)
      o  Is this a correct conclusion? (Yes)
      o  Move onto next conclusion.
If Yes and 2 changing variables
  o  What type of statement is after the “because” and how do you know? (Data because it contains a measurement or an observation)
  o  Is the data consistent with the results table? (Yes)
  o  Is this a fair conclusion? (No because the change could be due to the other changing variable.)
  o  Is this a correct conclusion? (No)
  o  What is wrong with the conclusion? (multiple changing variables)
Below are the explanations and answers to part 2 letters a-e on pages 8, 9, and 10.

Letter a:

**Table Annotations:**
Underline: Container Type, Substance A Mass, Substance B Mass, Stirring Speed
Circle: Substance C Mass
Box: Change in Temperature, Other

**Conclusion Annotations:**

The greater the mass of Substance C, the higher the temperature change because when the Substance C mass was 5.0 g, the temperature change was 8.5°C and when the Substance C mass was 11.0 g, the temperature change was 22.7°C.

*What type of statement is before the “because” and how do you know?*

- Claim because it can be tested.

*What is the changing variable in the claim?*

- Mass of Substance C

*Is this a changing variable in this experiment?*

- Yes

*Is the claim consistent with the results table?*

- Yes

*What type of statement is after the “because” and how do you know?*

- Data because it contains measurements.

*Is the data consistent with the results table? (check table with students)*

- Yes

*Is this a correct conclusion?*

- Yes

**Letter b:**

**Table Annotations:**

- Underline: Container Type, Substance A Mass, Substance B Mass, Substance C Mass
- Circle: Stirring Speed
- Box: Change in Temperature, Other

**Conclusion Annotations:**

- The greater the stirring speed, the higher the temperature change because when the stirring speed was slow, the temperature change was 13.0°C and when the stirring speed was super-fast, the temperature change was 10.2°C

*What type of statement is before the “because” and how do you know?*

- Claim because it can be tested.

*What is the changing variable in the claim?*

- Stirring speed

*Is this a changing variable in this experiment?*

- Yes

*Is the claim consistent with the results table?*

- No

*What is wrong with the conclusion?*

- Incorrect claim

**Letter c:**

**Table Annotations:**

- Underline: Container Type, Substance B Mass, Substance C Mass, Stirring Speed
- Circle: Substance A Mass
- Box: Change in Temperature, Other

**Conclusion Annotations:**

- The more Substance A the less foam is produced because when the Substance A mass was 2.0 g, we observed the beaker overflowed with foam, but when the Substance A mass was 8.0 g, we observed that there was only a little bit of foam.

*Note:* Circle “more Substance A” and write “substance A mass” above, because “more” really refers to the mass of Substance A.

*What type of statement is before the “because” and how do you know?*
Claim because it can be tested.

**What is the changing variable in the claim?**
Substance A mass

**Is this a changing variable in this experiment?**
Yes

**Is the claim consistent with the results table?**
Yes

**What type of statement is after the “because” and how do you know?**
Data because it contains observations.

**Is the data consistent with the results table?**
Yes

**Is this a correct conclusion?**
Yes

**Letter d:**

**Table Annotations:**
- Underline: Container Type, Substance A Mass, Substance C Mass, Stirring Speed
- Circle: Substance B Mass
- Box: Change in Temperature, Other

**Conclusion Annotations:**
We observed that the reaction **overflowed with foam** when there were **16.0 g** of Substance B but only made a **little foam** when there were only **10.0 g** of Substance B because the grater the mass of Substance B the more foam is made.

**What type of statement is before the “because” and how do you know?**
Data because it contains observations.

**What type of statement is after the “because” and how do you know?**
Claim because it can be tested

**Is this a correct conclusion?**
No

**What is wrong with the conclusion?**
Claim and the data are switched

**Letter e:**

**Table Annotations:**
- Underline: Container Type, Substance B Mass, Stirring Speed
- Circle: Substance A Mass, Substance C Mass
- Box: Change in Temperature, Other

**Conclusion Annotations:**
The lower the **Substance A mass** the higher the temperature change because when the Substance A mass was **2.0 g** the temperature change was **13.3 °C** and when the Substance A mass was **5.0 g** the temperature change was **5.9 °C**

**What type of statement is before the “because” and how do you know?**
Claim because it can be tested.

**What is the changing variable in the claim?**
Substance A mass

**Is this a changing variable in this experiment?**
Yes

**Is the claim consistent with the results table?**
Yes

**What type of statement is after the “because” and how do you know?**
Data because it contains measurements.

**Is the data consistent with the results table?** (check table with students)
Yes  

Is this a fair conclusion?
No, there are multiple changing variables therefore, it could be the mass of Substance C that is changing the temperature and not the mass of Substance A.

Is this a correct conclusion?
No

What is wrong with the conclusion?
Multiple changing variables.

Wrap-Up:
(2 minutes – Full Class – SciTrek Lead)

Tell students that on the next SciTrek visit they will analyze their data to draw a conclusion. They will then discuss their findings as a class to determine if they need to make changes to their experiments to better answer the class question. After, they will work on developing techniques to help them analyze their data.

Clean-Up:

Before you leave, have students attach their nametag to their notebook and place them in the group box. Make sure that all of the liquids and dishes are in the bucket and the bucket’s lid is securely fastened. Bring all materials back to UCSB. In addition, put your lab coat into your group box.

Day 4: Conclusion/Technique/Analysis Activity

Schedule:

Introduction (SciTrek Lead) – 3 minutes  
Conclusion (SciTrek Volunteers) – 10 minutes  
Findings Discussion (SciTrek Lead) – 10 minutes  
Technique (SciTrek Lead) – 15 minutes  
Analysis Activity (SciTrek Lead) – 20 minutes  
Wrap-Up (SciTrek Lead) – 2 minutes

Materials:

(3) Volunteer Boxes:
☐ Student nametags  ☐ Volunteer lab coat  ☐ Notepad
☐ Student notebooks  ☐ (2) Pencils
☐ Volunteer instructions  ☐ (2) Red pens

Lead Box:
☐ (3) Extra student notebooks  ☐ Lead lab coat  ☐ (2) Wet erase markers
☐ Lead instructions  ☐ Time card
☐ Thermal Transfer picture packet  ☐ (2) Pencils
☐ (2) Red pens
☐ Notepad
☐ (5) Clear rulers
CONCLUSION
Making a Conclusion from Your Data

How many changing variables did you have in your experiment? 2

Can you make a conclusion from your data? ☐ YES ☐ NO

IF NO
Why? I cannot make a conclusion because my experiment had more than one changing variable.

IF YES
We can conclude: claim

because: data (measurement/observation)

TECHNIQUE
Trend Lines
Trend lines are used to find trends in data on graphs.

1. Directions: Annotate the graphs and draw trend lines for each experiment.

How to draw a trend line:
1. Put your ruler on the graph so it goes along with the direction of the points and places half the points above the ruler and half the points below it.
2. Make sure all points are as close as possible to the ruler, and then trace along the ruler with your pencil. Always extend trend lines to both edges of the graph.

Graph 1

Graph 2

How to interpret trend lines:
- If the line is increasing (↑) or decreasing (↓), there is a trend.
- If the line is flat ( ), there is no trend.

2. Directions: Answer the following questions using Graphs 1 and 2.

a) Which graph(s) represent a changing variable that affects the data?

2

b) Which changing variable affects the data?

As Substance A increases, the temperature change decreases.

3. Directions: Annotate Graph 3.

What is the challenge in drawing a trend line on this graph?

The points are too close together.

TECHNIQUE
Designing Experiments

Four USB scientists were studying a chemical reaction between Substances A, B, C, and water. They all picked Substance A as their changing variable. Two scientists worked independently, and they used different control variables for the amounts of B, C, and water (Graph 1). The other two scientists collaborated, and they picked the same control variables for the amounts of B and water (Graph 2).

4. Directions: Annotate the graphs and draw trend lines for each experiment.

Graph 1

Graph 2

a) Does Substance A affect the change in temperature of the reaction?

If YES, describe the trend by filling in the following sentence frame:

As Substance A increases, the temperature change decreases.

b) Can you predict what the temperature change would be if the scientists tested 5.0 g of A, 5.0 g of B, and 10.0 mL of water, and 6.0 g of C?

If YES, which graph is more useful to make your prediction?

Expected Temperature Change = 5 °C.

What does this mean for your experiments/design?

We need to collaborate with other groups.

TECHNIQUE
Scientific Practices
Analyzing & Interpreting Data

A large group of scientists studying the reaction between Substances A, B, C, and water collaborated by dividing into 3 teams. Each studied the effect of one of the substances on the temperature change. The 3 teams agreed to keep the water volume constant at 20 mL for all experiments/trials. Now, they need your help to analyze the data.

1. Directions: Annotate the graph, draw trend lines for each experiment, and label trend lines with subgroup control values.

Graph 1

Team 1 Graph

a) Does Substance A affect the change in temperature of the reaction?

If YES, describe the trend by filling in the following sentence frame:

As Substance A increases, the temperature change decreases.

b) What temperature change would you expect to measure if you mixed the following?

<table>
<thead>
<tr>
<th>Substance A</th>
<th>5.0 g</th>
<th>6.0 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substance B</td>
<td>5.0 g</td>
<td>6.0 g</td>
</tr>
<tr>
<td>Substance C</td>
<td>10.0 g</td>
<td>5.0 g</td>
</tr>
</tbody>
</table>

Expected Temperature Change:

What experiment(s) do you need to look at?

Do you need to look at experiment(s): 0

What temperature change would you expect to measure if you mixed the following?

<table>
<thead>
<tr>
<th>Substance A</th>
<th>5.0 g</th>
<th>6.0 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substance B</td>
<td>5.0 g</td>
<td>6.0 g</td>
</tr>
<tr>
<td>Substance C</td>
<td>10.0 g</td>
<td>5.0 g</td>
</tr>
</tbody>
</table>

Expected Temperature Change:

What experiment(s) do you need to look at?

Do you need to look at experiment(s): 0
Set-Up:

SciTrek Lead:
If the classroom has a document camera, ask the teacher to use it for the findings discussion (page 1, picture packet), technique (pages 12-13, student notebook), and analysis activity (pages 14-17, student notebook). If the classroom does not have a document camera, then tape example poster-size notebook pages to the front board.

SciTrek Volunteer:
Set out student notebooks.
- If students are not in the classroom before SciTrek starts, set out the notebooks where students should sit when they come into the classroom.
- If students are in the classroom before SciTrek starts, pass out notebooks to them, and they will move to their subgroup seats after the introduction.

Introduction:
(3 minutes – Full Class – SciTrek Lead)

If needed, while you are doing the introduction, have volunteers set out the notebooks/nametags where they would like students to sit. They will move into their subgroups after the introduction.

Ask students what they did during the last meeting with SciTrek. They should reply that they conducted experiments to answer the class question, “What variables affect the temperature change of the reaction?” They also evaluated others’ conclusions to learn how to make reasonable claims and support them with appropriate data.

Briefly review what we learned about conclusions last time.
What types of statements are needed to make a conclusion?
A claim and a supporting data statement

**Can the statements be in any order?**
No. The claim must come first, followed by the data that supports it

**What is a claim, and what does it usually include?**
A statement that can be verified by testing, which may include the changing variable

**What type of information can be used for data?**
Measurements or observations

**What else do we often see in a data statement?**
Values of the changing variable

**How many changing variables can we have to make a conclusion?**
One

**Why can we only change one variable?**
If we test more than one changing variable at the same time, there is no way of telling which variable affected the data

Inform students that today they are going to analyze their own data to see if they can draw a conclusion and then discuss their findings as a class. They will then work on developing techniques to help them redesign their first experiment.

**Conclusion:**
(10 minutes – Subgroups – SciTrek Volunteers)

Help subgroups fill out page 11 of their notebook. If a subgroup has more than one changing variable, they will not be able to draw a conclusion. An example of when the students cannot make a conclusion is shown below on the left.

If a subgroup has only one changing variable, they will be able to make a conclusion. Make sure that the students’ conclusions have both a claim and supporting data and that these statements are in the appropriately labeled sections. Claims must be statements that can be tested and data statements must include either observations or measurements. Conclusions are still valid and important if they show that the changing variable tested did not affect the temperature change. Even if their conclusion is contrary to what you think, have students make a claim based solely on their data. If you think that their data is flawed, it is okay to ask them what they think went wrong and encourage them to repeat their experiment. An example of when the students can make a conclusion is shown below on the right.
Findings Discussion:
(10 minutes – Full Class – SciTrek Lead)

Once students finish their conclusions, tell them that we need to discuss our results as a class to find out if we need to do more experiments to answer the class question. Place page 1 of the picture packet under the document camera. First ask the students, “Who could not make a conclusion?” For any subgroups that raise their hands, ask why they could not make a conclusion (more than one changing variable). Ask those subgroups what they would do differently in order to be able to make a conclusion next time. They should say that they will only choose one changing variable in their next experiment. Record this on the class findings list under “Experimental Design” (page 1, picture packet).

Next, go through each variable (CaCl₂ mass, NaHCO₃ mass, NaCl mass, water volume, other (example: stir rate)), and ask students to raise their hand if this was their changing variable and then have those subgroups read their conclusion. If multiple subgroups had the same changing variable, ask them if their results are in agreement. Record brief summaries for each variable that was tested on the class findings list under “Conclusion Summaries.” Record all findings about one changing variable before moving onto findings about other changing variables. If subgroups have conflicting conclusions about the same changing variable, record both and remind the students that we will be conducting more experiments to find out how the changing variable affects the temperature change. An example filled out class findings list is shown below. (Note: there may be only a few or even zero groups that are able to make conclusions at this point, so you may not be able to record many findings. However, the example below shows conclusion summaries for all possible changing variables.)
Have volunteers pass out a clear ruler to each student to use during the technique and analysis activities. Keep the picture packet close by, as you will need to record two more class findings during the technique activity.

**Technique:**

(15 minutes – Full Class – SciTrek Lead)

Tell the class they are now going to work on techniques to help them analyze their data and design new experiments during the next SciTrek meeting. Tell students we are going to learn about trends. Trends are when data changes in one general direction, either going up or going down. If the data points all line in a flat line, then there is no trend in the data. Tell students we are going to use trend lines to help us recognize trends in data. Open an example notebook to page 12 under the document camera, and have the students turn to page 12 of their notebooks.

First, tell the students that we are going to look at a graph of data collected from a chemical reaction between Substances A and B. Have students look at Graph 1. Tell students that the changing variable is always found on the x-axis (vertical), then ask students what the changing variable is in Graph 1 (Substance A Mass) and have them circle it. Tell students that the data collected is found on the y-axis (horizontal), then ask students what the data collected was (Change in Temperature) and have them box it. Ask students what we should do to the title. They should respond, “Circle Substance A Mass and box Change in Temperature.” Make sure students annotate the graphs in their notebooks along with you.

Read the directions for how to draw a trend line, and use a clear ruler to show students how to draw a trend line on Graph 1. Repeat the process for Graph 2. Read how to interpret trend lines to students and have them draw in the appropriate lines. (If the line is increasing (/) or decreasing (\) there is a trend. If the line is flat (——) there is no trend). Note: Use the word “flat” rather than “straight” when describing trend lines that show no trend, because all lines are straight. Explain to students that when a graph has a
trend the changing variable affects the data, and when a graph does not have a trend the changing variable does not affect the data.

Go over question 2 as a class. Ask the students if either of the graphs has a trend. They should respond that only Graph 1 has a trend. Therefore, only changing the mass of Substance A will affect the data. Then, ask the students what happens to the temperature change when the mass of Substance A increases. They should respond that as the mass of Substance A increases the temperature change decreases. Have the students fill this into the sentence frame in question 2b.

For question 3, annotate the graph as a class. Then tell students that you will draw a trend line onto the data. Put the ruler on the paper in the three ways shown in the pictures below. Ask students which placement is correct. Lead students to understand that it is impossible to tell which way is correct because the data points are too close together. Finally, ask the students what this means for their experiment. They should respond that they need to pick values for their changing variable that are spread out/not similar. Add this point to the class findings list under “Experimental Design” (page 1, picture packet) and fill in question 3. An example filled out page 12 is shown below.

Tell students we will now work on developing techniques to help design experiments as a class. Turn to page 13 on the example notebook, and have the students turn to page 13 in their notebooks. Explain that we are going to examine the results of four scientists who are studying the temperature change in a
reaction between Substances A, B, C and water. Have the students independently annotate the graphs and draw trend lines. While they are doing this, have volunteers walk around and help students. In addition, annotate the changing variable and data on the graphs (do not underline Substance C, Substance B, and Water Volume yet) and draw on trend lines in the class notebook. Once the majority of students are done, put the class notebook under the document camera for them to check their work.

Tell students that for Graph 1 you see Substance B, Substance C and water volume in the title and ask them if they should be underlined, circled, or boxed. If they do not know what to do, show them the table under Graph 1 that shows all of these as controls and then underline them. Tell students that for Graph 2 you see Substance C in the title, and ask them if it should be underlined, circled, or boxed. Then underline Substance C. Ask students why Graph 1 has all the substances in the title but Graph 2 only has Substance A and C in the title. Make sure by the end of the conversation that students understand that for Graph 2 all the substances had different control values, therefore, they all needed to be in the title. However, for Graph 2, the scientists had two common control values (substance B mass and water volume), so they did not need to put these in the title. Tell students when a team of scientists choose control values all together they are called “team controls” and when subgroups within a team choose control values independently that differ from each other they are called “subgroup controls.” Underneath the Graph 2 controls table have students tell you if each of the controls is a team control or a subgroup control and label them. Tell the students that when a team of scientists has only one subgroup control, they can label the trend lines with the subgroup control values to distinguish them. In the right margin of Graph 2, write C and label the two lines with the corresponding subgroup control values.

Ask the students if Substance A affects the temperature change of the reaction and how they know. They should respond yes, because all four trend lines show a downward trend. Students should fill out the sentence frame: As Substance _A_ increases, the temperature change _decreases_. Make sure students understand that both graphs are valid to show that Substance A has an effect on the temperature change.

Ask the students, “Would both of these graphs be equally useful to make predictions about future experiments?” For example, can we predict the temperature change if we mixed 6.0 g A, 6.0 g B, 70 mL of water, and 6.0 g C?” Allow students to share their thoughts. At this point they might not be able to tell you the answer. After students have shared their ideas point out that the mass of Substance B and volume of water are the same as in Graph 2. Tell students that you will now show them how to use Graph 2 to estimate the temperature change. Show students that 6.0 g is between 8.0 g and 5.0 g but closer to 5.0 g. Therefore, they can put dots on both vertical axes in the approximate location of the 6.0 g line and then use a ruler to draw a dashed line for where they estimate the 6.0 g line should lie. Now that they have a line with all of the values of the controls they can find the temperature change. By hand, show them how to draw a vertical dashed line up from 6 g on the x-axis to the new trend line. Then, show them how to draw a flat horizontal dashed line over to the y-axis. The location where they hit the y-axis will be the estimated temperature change (~5-6°C). Tell students that when we make a prediction these are approximate numbers, so if they are within 2°C of the number that you write in the example notebook, they should consider the temperature correct. Have students fill out question 4b. Ask students what the scientists did that made Graph 2 more useful and what does this mean for when they design experiments. Make sure that by the end of the conversation, students understand that they need to collaborate with groups with the same changing variable when they select their control values. Add this point to the class findings list under “Experimental Design” (page 1, picture packet). An example filled out page 13 (left) and complete findings list (right) are shown below.
Turn to page 14 in the example notebook under the document camera, and have students turn to page 14 in their notebooks. Tell students that we will continue discussing the scientists who studied the reaction of Substances A, B, C, and water. They collected data by dividing into three teams, each choosing one of the substances as their changing variable. In addition, they all choose to keep the water volume constant at 70 mL. Give students time to annotate the graph, draw on trend lines, and label the trend line with the subgroup control values on their own while you do the same in the class notebook. When the majority of students are done, put the class notebook under the document camera for them to check their work.

Ask students what was the changing variable that Team 1 tested (Substance A mass). Point out that Substance B was a team control and Substance C was a subgroup control. Ask the students, “Do you see a trend and if so what does this mean?” Students should say there is a trend and it means that Substance A affects the temperature. Then, ask the students what happens to the temperature change when the mass of Substance A increases. They should respond that the temperature change decreases.

Tell the students we are going to use Team 1’s data to predict the temperature change if we were to mix different amounts of each substance. Look at letter 1b and read the quantities that will be mixed from the chart. Ask the students if they need to consider Substance B. They should say no because the value to be mixed is 6.0 g, which was a team control value. Then, focus on Substance C. Tell students to look at the Substance C values that Team 1 tested (5.0 g, 8.0 g, and 12.0 g) and compare them with the amount of Substance C in this question (8.0 g). Ask students which experiment/trend line they will need to look at and why. They should respond, the white circles, because 8.0 g of Substance C were used in that experiment. Circle the white circles. Have students look at the trend line for the white circles. Ask students what is the mass of A that we are interested in (5.0 g). Find 5 g on the x-axis and draw a dotted
line straight up to the trend line for the white circles. Then, find the predicted temperature by drawing a second dotted line straight across to the y-axis. Show students that this will give you ~12°C. Remind them that they can be off by up to 2°C and they should consider their answer correct. Write this on the example notebook and have students copy it into their notebooks.

For letter c, follow the same process. Ask the students if they need to consider Substance B. They should say no because the value is the team control value. Tell students to compare the Substance C values that Team 1 tested (5.0 g, 8.0 g, and 12.0 g) with the amount of Substance C in this question (10.0 g). Ask the students what trials they think we need to look at. They should say white and black circles because 10.0 g is halfway between 8.0 g and 12.0 g. Tell students we will have to approximate where this trend line will be. Have students use the same technique as for the technique activity to draw the dashed estimated trend line. Ask the students what we should do next. Students should respond, find 3 g of A on the x-axis and draw a dotted line up to the dashed trend line. Have students do this while you do it in the example notebook. Ask students what we should do next. Students should tell you to draw a dotted line straight across to the y-axis and read the expected temperature change. Have students do this while you do it in the example notebook. Ask students what temperature change will happen in the solution. They should say ~18°C. Write this number in the notebook. An example filled out page 14 is shown below.

Turn to page 15 in the example notebook under the document camera, and have students turn to page 15 in their notebooks. Give students time to annotate the graph, draw on trend lines, and label the trend lines with subgroup control values for themselves while you do the same in the class notebook. When the majority of students are done, put the class notebook under the document camera for them to check their work.

Ask the students what was the changing variable that Team 2 tested (Substance B mass). Point out that Substance C is a team control and substance A is a subgroup control. Ask the students, “Do you see a trend and what does this mean?”. Students should say there is not a trend and this means that Substance
B does not affect the temperature change. Since there is no trend, the sentence frame does not need to be filled in. Circle No on section 2a and have students do so on their notebooks.

Give students time to fill out questions 2b and 2c on their own. While they are working on these have the volunteers walk around and help students. In addition, draw on the estimated trend line on the graph in the class notebook. Once the majority of students are done, put the class notebook under the document camera and go over the answers with students. An example filled out page 15 is seen below.

Note: You must finish through page 15 today, otherwise there will not be enough time on Day 5. If there is still time, continue working on the analysis activity on pages 16 and 17. This will make Day 5 easier. For detailed instructions of how to do this, see the analysis activity instructions on Day 5.

Wrap-Up:
(2 minutes – Full Class – SciTrek Lead)

Tell the students that during the next SciTrek visit they will redesign their experiments using the techniques they learned today.

Clean-Up:

Before you leave, have students attach their nametag to their notebook and place them in the group box. Bring all materials back to UCSB. In addition, put your lab coat into your group box.
Day 5: Analysis Activity/Discussion/Question/Materials Page/Experimental Set-Up/Procedure

Schedule:
Introduction (SciTrek Lead) – 2 minutes
Analysis Activity (SciTrek Lead) – 18 minutes
Discussion (SciTrek Lead/Volunteers) – 15 minutes
Question (SciTrek Volunteers) – 5 minutes
Materials Page (SciTrek Volunteers) – 2 minutes
Experimental Set-Up (SciTrek Volunteers) – 5 minutes
Procedure (SciTrek Volunteers) – 11 minutes
Wrap-Up (SciTrek Lead) – 2 minutes

Materials:

(3) Volunteer Boxes:
☐ Student nametags
☐ Student notebooks
☐ Volunteer instructions
☐ Volunteer lab coat
☐ Team plan page
☐ (3) Experiment 2 materials pages
☐ (2) Pencils
☐ (2) Red pens
☐ Highlighter
☐ Notepad
☐ (12) Clear rulers

Lead Box:
☐ (3) Extra student notebooks
☐ Lead instructions
☐ Thermal Transfer picture packet
☐ Lead lab coat
☐ (2) Team plan pages
☐ (3) Experiment 2 materials pages
☐ Time card
☐ (2) Pencils
☐ (2) Red pens
☐ (2) Wet erase markers
☐ Highlighter
☐ Notepad
☐ (5) Clear rulers
☐ Team fair sticks (in Ziploc)
SCIENTIFIC PRACTICES
Analyzing & Interpreting Data

3. Directions: Annotate the graph, draw trend lines for each experiment, and label trend lines with subgroup control values.

a) Does Substance C affect the change in temperature of the reaction? **NO**

If YES, describe the trend by filling in the following sentence frame:

• As Substance C increases, the temperature change **increases**.

b) What temperature change would you expect to measure if you mixed the following?

<table>
<thead>
<tr>
<th>Substance A</th>
<th>1.0 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substance B</td>
<td>3.0 g</td>
</tr>
<tr>
<td>Substance C</td>
<td>8.0 g</td>
</tr>
</tbody>
</table>

What experiment do you need to look at?

- Team 3

Expected Temperature Change: **+4 °C**

c) What temperature change would you expect to measure if you mixed the following?

<table>
<thead>
<tr>
<th>Substance A</th>
<th>5.0 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substance B</td>
<td>10.0 g</td>
</tr>
</tbody>
</table>

What experiment do you need to look at?

- Team 1

Expected Temperature Change: **+4 °C**

CLASS PLAN

Subgroups: The original people you worked with

Teams: Multiple subgroups that are investigating the same changing variable

Changing Variable: Each subgroup picks multiple values on their own

Subgroup Controls: Each subgroup picks one value on their own

Team Controls: The team picks one value together for all subgroups within the team

**Class Control**

A control in which the whole class picks one value together for all teams to use:

- Water Volume: 50 mL
- NaCl Mass: 5.0 g
- Stir Speed: Medium

<table>
<thead>
<tr>
<th>Team NaHCO₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orange 1</td>
</tr>
<tr>
<td>Blue 1</td>
</tr>
<tr>
<td>Green 1</td>
</tr>
<tr>
<td>Orange 2</td>
</tr>
<tr>
<td>Blue 2</td>
</tr>
<tr>
<td>Green 2</td>
</tr>
<tr>
<td>Orange 3</td>
</tr>
<tr>
<td>Blue 3</td>
</tr>
<tr>
<td>Green 3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Team CaCl₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orange 1</td>
</tr>
<tr>
<td>Blue 1</td>
</tr>
<tr>
<td>Green 1</td>
</tr>
<tr>
<td>Orange 2</td>
</tr>
<tr>
<td>Blue 2</td>
</tr>
<tr>
<td>Green 2</td>
</tr>
<tr>
<td>Orange 3</td>
</tr>
<tr>
<td>Blue 3</td>
</tr>
<tr>
<td>Green 3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Team NaCl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orange 1</td>
</tr>
<tr>
<td>Blue 1</td>
</tr>
<tr>
<td>Green 1</td>
</tr>
<tr>
<td>Orange 2</td>
</tr>
<tr>
<td>Blue 2</td>
</tr>
<tr>
<td>Green 2</td>
</tr>
<tr>
<td>Orange 3</td>
</tr>
<tr>
<td>Blue 3</td>
</tr>
<tr>
<td>Green 3</td>
</tr>
</tbody>
</table>

4. Directions: Annotate the graph, draw trend lines for each experiment, and label trend lines with subgroup control values.

a) Using both of the graphs above, what temperature change would you expect to measure if you mixed the following?

<table>
<thead>
<tr>
<th>Substance A</th>
<th>6.0 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substance B</td>
<td>1.0 g</td>
</tr>
</tbody>
</table>

Team 1 Prediction: **7 °C**

Team 3 Prediction: **8 °C**

What experiment do you need to look at?

- Team 3

Expected Temperature Change:

Team 1: **7 °C**

Team 3: **9 °C**

Changinhg Variable (Independent Variable(s))

For your second experiment decide which variable(s) (max two) that you would like to test.

Changing Variable 1: NaHCO₃ mass

Changing Variable 2 (optional): 

**QUESTION**

Question our group will investigate:

• If we change the **NaHCO₃ mass**

what will happen to the **temperature change of**

the reaction?

SciTrek Member Approval: [Signature]

Get a materials page from your SciTrek volunteer and fill it out before moving onto the experimental set up.
**Set-Up:**

**SciTrek Lead:**
If the classroom has a document camera, ask the teacher to use it for the analysis activity (pages 16-17, student notebook) and discussion (page 2, picture packet). If the classroom does not have a document camera, then tape up the poster-size notebook pages on the front board.

**SciTrek Volunteer:**

- Set out student notebooks.
- If students are not in the classroom before SciTrek starts, set out the notebooks where students should sit when they come into the classroom.
- If students are in the classroom before SciTrek starts, pass out notebooks to them. They will move to their subgroup seats after the analysis activity.

**Introduction:**

(2 minutes – Full Class – SciTrek Lead)

If needed have the SciTrek volunteers hand out the notebooks/nametags to students in their seats. They will move into their subgroups after the analysis activity.

Ask the class, “What is the class question that we have been investigating?” Students should tell you, “What variables affect the temperature change of the reaction?” Tell the students that today they are going to continue developing analysis techniques and use these skills to plan their next investigation as a class. They will then break into teams to design their experiments.

Tell students that we will continue discussing the scientists who studied the reaction of Substances A, B, C, and water. Remind students that the scientists collected data by dividing into three teams, each choosing one of the substances as their changing variable. Have students turn to page 15 in their
notebooks and have one student share what they found out about Substance B last time. Ask students if Substance B affects the temperature change and how they know. They should say no, because the trend line is flat.

**Analysis Activity:**
*(18 minutes – Full Class – SciTrek Lead)*

Turn to page 16 in the example notebook under the document camera, and have students turn to page 16 in their notebooks. Give students time to annotate the graph, draw on trend lines, and label the trend lines with the subgroup control values on their own while you do the same in the class notebook. When the majority of students are done, put the class notebook under the document camera for them to check their work.

Ask the students what was the changing variable that Team 3 tested (Substance C mass). Point out that Substance B is a team control and substance A is a subgroup control. Remind students water volume is also a team control, and all teams are using 70 mL as the team control value. Ask students if there is any information they do not need to worry about. If students are struggling, ask them what Team 2 discovered. Students should respond that Substance B does not affect the temperature change. Then ask students if Team 3 needs to worry about Substance B (no). Show students that they should cross off Substance B and its values in all three charts on this page. Point out that this is helpful because now we can focus on just one control, Substance A.

Ask the students, “Do you see a trend and what does this mean?”. Students should say there is a trend and it means that Substance C affects the temperature change. Then, ask the students what happens to the temperature change when the mass of Substance C increases. They should respond that the temperature change **increases**. Fill in the sentence frame under section 3a and have students do so in their notebooks.

Give students time to fill out questions 3b and 3c on their own. While they are working on these have the volunteers walk around and help students. In addition, draw on the estimated trend line on the graph in the class notebook. Once the majority of students are done, put the class notebook under the document camera and go over the answers with students. An example filled out page 16 is shown below.
Turn to page 17 in the example notebook under the document camera, and have students turn to page 17 in their notebooks. Tell students that the scientists are now interested in looking at all of the team’s data together to make predictions about temperature changes for different combinations of the substances. Tell students that you have copied the Team 1 and Team 3 graphs onto this page so that we can look at the data at the same time. Have the students annotate the graphs, draw trend lines, and label the trend lines with subgroup control values (copy from pg. 14 and 16).

Ask students why they think Team 2’s graph is not printed here. They should respond that Team 2 found out that Substance B did not affect the temperature change, so we do not need to worry about Team 2’s graph to predict temperature changes. Then, ask students if there is any irrelevant information that we can cross out in the charts on this page. The students should tell you to cross off Substance B and its values in the three charts. Cross off Substance B on the example notebook and have students do so in their notebooks.

Read the directions for letter 4a and read the quantities that will be mixed from the chart. Tell the students we are going to use Team 1’s data to predict the temperature change when mixing these quantities, and then we will use Team 3’s data to make a prediction about the same quantities. Then we will compare the two predictions to make a final prediction that takes all of the pertinent data into account.

Look at the Team 1 graph and read the quantities that will be mixed from the chart again. Tell students we should focus on Substance C first because it is a subgroup control for this team. Tell students to compare the Substance C values that Team 1 tested (5.0 g, 8.0 g, and 12.0 g) with the amount of Substance C in this question (6.0 g). Ask students which experiment(s)/trend line(s) they need to look at and why. They should say the white and gray circles, because 6.0 g is between 5.0 g and 8.0 g. Circle the gray and white dots. Ask the students where we need to draw a dashed line. They should respond that the dashed line should be between the lines for white and gray circles, but closer to the line for gray circles because 6.0 g is closer to 5.0 g than to 8.0 g. Have students use the same technique as for the technique activity to draw the dashed estimated trend line.
Ask the students what we should do next. Students should respond, find 4.0 g of A on the x-axis and draw a dotted line straight up to the dashed trend line. Have students do this while you do it in the example notebook. Ask students what we should do next. Students should tell you to draw a dotted line straight across to the y-axis and read the expected temperature change. Have students do this while you do it in the example notebook. Ask students what temperature change will happen in the solution. They should say ~7°C. Write this number in the notebook as the Team 1 prediction.

Tell the students we are now going to use Team 3’s data to make a prediction about the temperature change using the same quantities. Give students time to try this on their own. While they are working, have the volunteers walk around and help students. In addition, draw on the estimated trend line and predict the temperature change for Team 3 on the graph in the class notebook. Once the majority of students are done, put the class notebook under the document camera and go over the answers with students. The Team 3 prediction should be ~8°C.

Ask the students which team’s prediction we should use for our final expected temperature change. Lead students to understand that we want to use a combination of both team’s predictions to make our final prediction. Since Team 1 predicted a temperature change of 7°C and Team 3 predicted 8°C, we will take the approximate expected temperature change to be 7.5°C. Write this number in the notebook in the box for expected temperature change, and have the students write the temperature changes they predicted in their notebooks. An example filled out page 17 is shown below.

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**Class Plan Discussion:**

*(7 minutes – Full Class – SciTrek Lead)*

Place the class plan page (page 2, picture packet) under the document camera. Tell the class they are now going to begin planning their next investigation. Tell the class they will soon split up into teams to
collaborate and work on answering the class question, just like the scientists in the analysis activity did. Remind students that the groups they worked with on their first experiments were called “subgroups.” Tell students each subgroup will decide which changing variable they want to study in their next experiment. Then, subgroups interested in the same changing variable will join together to form a “team.”

Ask the students how many variables we are investigating. They should say four: water volume, NaCl mass, NaHCO₃ mass, and CaCl₂ mass. Ask the students if every subgroup should pick all their controls independently. They should respond no, and that the subgroups need to collaborate to pick controls together. If they are struggling with this concept, turn to page 13 of the example student notebook and review the graphs before and after the scientists collaborated.

Tell students that the scientists in the analysis activity chose to keep water volume the same for all experiments done by all three teams so they would be able to compare data between them. Ask students if they think we should do something like this too. Lead students to agree that this is a good idea. Tell students we will pick a control value for water volume that all teams will use, therefore, we will call this a “Class Control” since this team control value will be used by all teams in the class. Ask students if they think it is a good idea for us to pick a class control value for water volume too. Lead students to choose the water volume that the whole class will use in their experiments. They can choose any volume between 20 and 60 mL (Note: 40-50 mL is best). After the class has chosen a value, write the volume under “Class Controls” on the class plan page (page 2, picture packet) under the document camera. This is the volume that all subgroups must use in all trials of their next experiment.

Tell the students we should choose one more class control value. Tell the students, “Let’s choose a control value for NaCl mass that we will all use, except for the team that chooses NaCl as their changing variable” (Note: the second class control must be NaCl, not NaHCO₃ or CaCl₂). Have the class choose a value between 0.0 and 8.0 g, and record it on the class plan page under the document camera. Remember to record the mass to the nearest tenth. Make sure that students understand that they can still choose to investigate NaCl as their changing variable, but all other teams must use the class control value.

Tell the students they will now form teams to investigate the three variables. Tell students we need to study all three variables, so we will have one team for each variable. Tell students we also need to make sure we collect enough data to learn about each variable, so each team needs to have ~3 subgroups. Give subgroups 1-2 minutes to discuss which changing variable they want to investigate and rank their choice of variable (1-3). Then, randomly select subgroups to choose their teams (write subgroup colors/numbers on a set of notecards to draw from). Record teams by checking subgroup boxes on the class plan page. Make sure that subgroups are evenly distributed between teams. Leave the class plan page under the document camera until the end of the team plan discussion. An example filled out class plan page is shown below.
Team Plan Discussion:
(8 minutes – Teams – SciTrek Volunteers)

The SciTrek Lead will assign each volunteer to a team. Have subgroups find their teams and have the teams move to sit with their volunteer(s).

Help your team fill out the team plan page found in your group box. First, have each of the subgroups on your team choose one of the three symbols. Write the subgroup color and number next to the symbol they select. Have the students tell you what changing variable they are investigating, circle it, and then underline the rest of the variables which will be controls. Find the changing variable (which should be circled) and check the changing variable box. Subgroups will choose values of the changing variable when they fill out the experiment 2 materials page later today.

Next, ask your team if they would like CaCl₂ mass or NaHCO₃ mass to be their subgroup control. If needed, remind them the definition of subgroup control, which will be on the class plan page under the document camera for reference (Note: if either CaCl₂ mass or NaHCO₃ mass is the team’s changing variable, they will automatically use the other one as their subgroup control). Check the subgroup control box for the variable they chose, and have each subgroup choose a value. Encourage the whole team to work together so that subgroups pick values that are spread out. Write each subgroup’s control value on the line next to their symbol.

The remaining two variables will be team controls (again, refer to the class plan page for the definition of team control if needed). Check the team control box for the remaining two variables and have the team choose one value for each. For NaCl mass and water volume your team must use the class control values, which are listed on the class plan page under the document camera.

When your team is finished filling out the team plan, make sure that there is only one box checked for each variable and all mass values are recorded to the nearest tenth. Highlight each checked box to make it
easier to see which variables are team controls, subgroup control, and changing variable. Hold onto the team plan page to help the subgroups on your team fill out their experiment 2 materials pages later today. An example filled out team plan page is shown below.

**Question:**

*(5 minutes – Teams – SciTrek Volunteers)*

Have each student write their subgroup symbol on the front cover of their notebooks. Ask your team what changing variable they are investigating. Refer to your team plan page if needed. Then, ask your team what they will be measuring (temperature change). If they are struggling, ask students what question we are trying to answer as a class (What variables affect the temperature change of the reaction?) Your team should briefly discuss why/how they think their changing variable will affect the temperature change. After your team has recalled their changing variable and what they are measuring, have all students fill out their question in their notebooks (page 18). Make sure students only have one changing variable listed before you sign off on their question.

While students are working on their questions, fill out the top portion of your team’s experiment 2 materials pages (found in your group box) with each subgroup’s color, number, and symbol. Refer to the team plan page for subgroup symbols. Students will now split into their subgroups to design their own experiments. Give each subgroup their experiment 2 materials page after you sign off on their question. An example filled out notebook page 18 is shown below.
Materials Page:
(2 minutes – Subgroups – SciTrek Volunteers)

Have subgroups underline their controls and circle their changing variable on the experiment 2 materials page. Then have them use the experiment 2 materials page to determine the values for their changing variable. Each student in a subgroup will choose one changing variable value. Have students write the trial letter under the value they choose. Ask students to justify the values that they have chosen for their changing variable and if these values will make it easier or harder to answer their question. Encourage students to work together to choose values that are spread out from each other. Subgroups will refer to the team plan page for all of their control values.

Make sure that students have picked values that are within the limitations given on the experiment 2 materials page and that all control values are consistent with the team plan page. An example filled out experiment 2 materials page is shown in the experimental set-up section below.

Experimental Set-Up:
(5 minutes – Subgroups – SciTrek Volunteers)

Have subgroups use the materials page to fill in their experimental set-up on page 19 of the student notebook. Make sure there is only one changing variable and values are consistent with the experiment 2 materials page. When you sign off on their experimental set-up, collect the experiment 2 materials page and verify that it is filled out correctly and completely. Having the experiment 2 materials pages filled out is essential for students to start their experiments during the next SciTrek visit. An example of an experimental set-up and experiment 2 materials page are shown below.
Procedure:
(11 minutes – Subgroups – SciTrek Volunteers)

After each subgroup has filled out their experimental set-up, they can start on their procedure (page 20, student notebook). Make sure that students within the same subgroup are collaborating to write the procedure. Keep procedures as brief as possible while still conveying the pertinent information about the experiment (control values, changing variable values, and what data they will collect). An example step if NaCl mass is a changing variable would be: “Measure E) 2.0 g, F) 4.0 g, G) 6.0 g, H) 8.0 g of NaCl.” Some groups may struggle with writing a procedure. You can have these groups dictate each step while you transcribe them onto a notepad found in your group box. Give this sheet to the students to copy into their notebooks. Once the students have finished, they should raise their hand for you to approve their procedure. An example procedure can be seen below.
**Note:** If there is still time, have subgroups fill out their results table (page 21, student notebook). This will make Day 6 easier. For an explanation of how to do this, see the results table on Day 6.

**Wrap-Up:**

(2 minutes – Subgroups – SciTrek Lead)

Tell the students that during SciTrek’s next visit they will conduct their experiments, graph their data on a team graph, and analyze the data to draw conclusions.

**Clean-Up:**

Before you leave, have students attach their nametag to their notebook and place them in the group box. Place the materials pages and team plan page on top of the notebooks in your group box. Bring all materials back to UCSB. In addition, put your lab coat into your group box.
Day 6: Results Table/Experiment/Graph/Conclusion

Schedule:

- Introduction (SciTrek Lead) – 8 minutes
- Results Table (SciTrek Volunteers) – 3 minutes
- Experiment (SciTrek Volunteers) – 24 minutes
- Graph (SciTrek Volunteers) – 15 minutes
- Conclusion (SciTrek Volunteers) – 8 minutes
- Wrap-Up (SciTrek Lead) – 2 minutes

Materials:

(3) Volunteer Boxes:

- □ Student nametags
- □ Student notebooks
- □ Volunteer instructions
- □ Volunteer lab coat

(3) Ziploc Bags, each with the following:

- □ Wet erase marker
- □ Paper towels
- □ (2) Waters (8 oz)
- □ (2) Droppers
- □ (2) Scales
- □ (2) Thermometers

- □ (2) Pencils
- □ (2) Red pens
- □ (12) Clear rulers

- □ (6) 100 mL Graduated cylinder
- □ Filled out team plan page

- □ Set of 3 labeled scoopulas (NaHCO₃, NaCl, CaCl₂)
- □ NaHCO₃ container
- □ NaCl container
- □ CaCl₂ container

- □ Set of 10 labeled weigh boats (2 NaHCO₃, 2 NaCl, 2 CaCl₂, 4 Mix)
- □ (2) Plastic lids
- □ (4) Magnetic stir bars
- □ Filled out experiment 2 materials page

Other Supplies:

- □ (3) Boxes of beakers
- □ (3) Boxes with 6 stir plates and 3 extension cords
- □ (2) Buckets with lids

Lead Box:

- □ (3) Extra student notebooks
- □ Lead instructions
- □ Thermal Transfer Picture Packet
- □ Lead lab coat
- □ Time card
- □ (2) Pencils
- □ (2) Red pens
- □ (2) Wet erase markers

- □ (5) Clear rulers
- □ (2) White rags
- □ Paper towels
- □ Water (8 oz)
- □ Scale
- □ Thermometer
- □ Set of 3 labeled scoopulas (NaHCO₃, NaCl, CaCl₂)
- □ NaHCO₃ container
- □ NaCl container

- □ CaCl₂ container
- □ Set of 10 labeled weigh boats (2 NaHCO₃, 2 NaCl, 2 CaCl₂, 4 Mix)
- □ (2) 100 mL Graduated cylinders
- □ (3) Plastic lids
- □ Container of 3 magnetic stir bars
Picture Packet Pages and Notebook Pages:

**RESULTS Table**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Trial D</th>
<th>Trial E</th>
<th>Trial F</th>
<th>Trial G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Container Type</td>
<td>Beaker</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Volume</td>
<td>50 mL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NaHCO₃ Mass</td>
<td>0.0 g</td>
<td>1.8 g</td>
<td>3.2 g</td>
<td>4.0 g</td>
</tr>
</tbody>
</table>

**Results Graph**

1. Check off the steps as you complete them.
2. Label the x-axis (horizontal) with your changing variable, including units (example: CaCl₂ Mass (g)).
3. Label the y-axis (vertical) with what you measured in your experiment, including units.
4. Select your subgroup control by checking the appropriate box. Your subgroup control is used in your subgroup symbol.
5. Use your subgroup symbol next to your data.
6. Graph your data on the grid by plotting your data on the graph.

**Additional Observations/Measurements**

- Feit hot, boiling any bubbles
- Small amount of bubbles
- Medium amount of bubbles
- Lots of bubbles
- Feit hot, boiling any bubbles

**Effects of NaHCO₃ Mass and CaCl₂ Mass on the Change in Temperature**

- Water volume: 50 mL
- NaHCO₃ Mass: 0.0 g to 4.0 g
- CaCl₂ Mass: 0.0 g to 4.0 g

**RESULTS Table**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Trial D</th>
<th>Trial E</th>
<th>Trial F</th>
<th>Trial G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Container Type</td>
<td>Beaker</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Water Volume</td>
<td>50 mL</td>
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<td>0.0 g</td>
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</tbody>
</table>

**Results Graph**

1. Check off the steps as you complete them.
2. Label the x-axis (horizontal) with your changing variable, including units (example: NaHCO₃ Mass (g)).
3. Label the y-axis (vertical) with what you measured in your experiment, including units.
4. Select your subgroup control by checking the appropriate box. Your subgroup control is used in your subgroup symbol.
5. Use your subgroup symbol next to your data.
6. Graph your data on the grid by plotting your data on the graph.

**Additional Observations/Measurements**

- Feit hot, boiling any bubbles
- Small amount of bubbles
- Medium amount of bubbles
- Lots of bubbles
- Feit hot, boiling any bubbles

The independent variable is the changing variable and the dependent variable is the change in temperature and other.
Set-Up:

SciTrek Lead:
If the classroom has a document camera, ask the teacher to use it for the results table and graph (page 3 and 4, picture packet and pages 21 and 22, student notebook). If the classroom does not have a document camera, then tape example poster-size notebook pages to the front board.

SciTrek Volunteer:
Set out student notebooks.
- If students are not in the classroom before SciTrek starts, set out the notebooks where students should sit when they come into the classroom.
- If students are in the classroom before SciTrek starts, set out the notebooks where students should sit during the module. They will move to these spots after the introduction.

Have all supplies ready so that you can set them out as soon as your subgroups are ready to start.

Introduction:
(8 minutes – Full Class – SciTrek Lead)

If needed, while you are doing the introduction have the SciTrek volunteers set out the SciTrek notebooks/nametags where they would like students to sit. Make sure that students in the same subgroup are sitting together and subgroups in the same team are near each other. Tell students that a notebook will be put on their desk which is not their notebook, and they should not move it.
Ask the class, “What is the class question that we have been investigating?” Students should tell you, “What variables affect the temperature change of the reaction?” Inform the class that they will be conducting experiments to answer the class question today. Once the experiment is complete they will plot their data on a team graph and analyze it to determine what conclusions can be drawn from their results. Tell students that their conclusions will help answer the class question. Ask the class how scientists define a conclusion (a claim supported by data). Ask the class what a claim is (a statement that can be tested, the explanation of your results) as well as what can be used for data (measurements or observations).

Tell the students that once they have collected their data they will display their measurements on a graph (page 22). Show them how to make a graph using the class data but make sure they DO NOT copy this data into their notebooks; they will graph their own data. Take out the picture packet, turn to the example results table on page 3, and put it under the document camera. Also, have a blank student notebook open to page 22 to review the steps to graph their data and graph the class data. Tell the students that your question was, “If we change the NaHCO$_3$ mass, what will happen to the temperature change of the reaction?” Tell students that in order to make a graph, they will need to follow the checklist shown on page 22 of their notebook.

☐ Write the title for your graph by filling in the blanks.
Looking at the example results table, ask students what the changing variable was. Insert the changing variable (NaHCO$_3$ Mass) in the first blank of the graph title. In the second blank, fill in the subgroup control (CaCl$_2$ Mass), which is marked at the top of the results table. Then, ask students what we are all measuring in this experiment. They should respond, “change in temperature,” and this should go in the last blank of the graph title.

☐ Label the x-axis (horizontal) with your changing variable, including units (example: CaCl$_2$ Mass (g)).
Ask students what your changing variable was. They should say NaHCO$_3$ mass. Write NaHCO$_3$ mass on line below the x-axis. Remind students that the units they will use for mass are grams, and write the units in parentheses, (g).

☐ Label the y-axis (vertical) with what you measured in your experiment, including units.
Ask students what we are measuring in all of our experiments. They should say “the temperature change of the reaction.” Write change in temperature on the line beside the y-axis. Remind students that the units they will use for temperature are degrees Celsius, and write the units in parentheses, (°C).

☐ Select your subgroup control in the legend by checking the appropriate box. Then put your subgroup control value next to your subgroup control.
Show the students the legend. Show students on the results table that your subgroup control was CaCl$_2$ mass, and check the box for CaCl$_2$ mass. Refer back to the results table and ask students what your value for CaCl$_2$ mass was (10.0 g). Then tell students that you need to write the value next to your subgroup symbol (triangle). Write 10.0 g next to the triangle.

☐ List your two team controls below the graph.
Tell students the other two controls left on your results table are your team controls. Note: When the students are graphing, they should refer back to their experimental set-up page to confirm their team controls. Write your team controls/values below the graph (ex. NaCl mass / 5.0 g). Tell students we can now start plotting the data.
Plot your Data:

☐ On the x-axis, circle your 4 changing variable values. If a value is not there, write it in. Refer to the results table. Ask students what your smallest changing variable value is (0.0 g), and circle 0 on the x-axis. Show students that you will need to write in the next changing variable value, 1.8, between 1.5 and 2 on the axis and then circle it. Only demonstrate the first two points.

☐ Starting with the smallest changing variable value, determine the temperature change and put your subgroup symbol at the appropriate level. Write the temperature change next to the point. Demonstrate how to graph the data from the results table. Point out that when the NaHCO₃ mass was 0.0 g, the temperature change was 20.4°C. Locate 0 on the x-axis (which should be circled) and trace your finger up to 20.4°C on the y-axis. Plot the point with a small triangle, since that is the example subgroup symbol, and write 20.4°C next to the point. Only demonstrate the first two points.

☐ Once you have plotted all 4 points, draw a trend line that best fits your data. Use a clear ruler to draw a trend line to fit the data. Remind students that they should draw the line so that about half the points lie above the line and half lie below it. Additionally, remind students to draw the line so it goes all the way to both ends of the graph.

The example results table (page 3, picture packet) and example partially filled out graph are shown below.

Plot the data collected by the other subgroups in your team.

Tell students that once they finish graphing their own data, they will graph the data collected by the other subgroups in their team. As soon as they finish drawing their trend line, they should check it with their volunteer and then ask a member of another subgroup on their team to see their results table. They should then follow the last three steps on the graphing checklist to graph the other subgroups’ data.
In the end, every student should have either two or three trend lines on their graph, representing the number of subgroups on the team. Show students the appropriate completed graph on either page 4 or 4b of the picture packet (depending on if the class has 2 or 3 subgroups on each team). Point out that on the completed team graph, the legend is completely filled out and all data points are marked with the symbol of the group that collected the data. The two versions of the completed team graph (page 4 and 4b, picture packet) are shown below.

Tell students that once they finish graphing their team results, they should draw conclusions from their results. Ask students what a conclusion is. They should respond that a conclusion is a claim supported by data. Tell students to refer to their team graph to help generate their claim but refer to their subgroup’s specific data to support the claim. Referring to the completed team graph under the document camera, point to the x-axis and ask students what happens to the temperature change when the NaHCO₃ mass increases. A possible claim the students might come up with is, “Adding more NaHCO₃ lowers the temperature change.” Then tell students they should use at least two data points to support the claim.

Tell students that they must have their results table completed before they can start their experiment. Remind students to label their beakers D, E, F, and G with a wet erase marker. Remind them to put the weigh boat on the scale and tare it (zero it) by pushing the tare button before using the scoopula to add the appropriate amount of substance. Remind students to leave CaCl₂ capped when they are not using it, close the thermometer between trials to reset the max/min function, and wipe off the thermometer with a paper towel after each trial. If needed, tell students to get together with their subgroup and start working.

**Results Table:**
(3 minutes – Subgroups – SciTrek Volunteers)

Have students select their subgroup control by checking one of the boxes and write in their subgroup symbol. Then have students underline the variables that are controls, circle the changing variable, and box
the data collection. When writing the values, make sure that for controls, they only write the value of the control in trial E and then draw an arrow through the remaining trials; for the changing variable, they should write a different value in each box.

When students have finished, have them make predictions about the temperature change. Have them write an “L” in the box of the trial that they think will give the largest temperature change and an “S” in the box of the trial that they think will give the smallest temperature change. They will leave two boxes empty. If they think all trials will give the same temperature change, have them write “same” over all of the boxes. Try to question each subgroup on their thought process behind their predicted temperature changes. An example results table is shown below.

Experiment:
(24 minutes – Subgroups – SciTrek Volunteers)

Once you have verified that subgroups have finished setting up their results tables, give them their requested materials. If students are missing any of their experimental materials, the lead box has extra materials. Make sure that students are keeping the cap to the CaCl₂ closed when they are not using it, closing the thermometer between trials, and wiping off their thermometer with a paper towel after each trial. As soon as students are done with their reactions, remove the beakers and graduated cylinders, and put them in the bucket (please do not put trash in the bucket). It is important to do this as soon as possible so students do not play with or spill their beakers. When the experiment is finished, have students wipe the thermometer with a paper towel and close it to turn it off. If your subgroups have things under control, help other subgroups. Students should record the maximum temperature after each trial, but have students wait until they have finished the entire experiment to calculate the changes in temperature. An example of a properly filled out results table is shown below.
Graph:
(15 minutes – Subgroups/Teams – SciTrek Volunteers)

Help students fill out their graph by having them go through and complete the checklist on page 22. It is important that students follow the steps in order. Be sure that students write a title for their graph by filling in the blanks and label the y-axis with “Change in Temperature (°C)”, the x-axis with their changing variable (including units), and the legend with their subgroup control value. Additionally, make sure students circle their changing variable values on the x-axis (and write them in if they are not printed on the axis).
Conclusion:
(8 minutes – Subgroups – SciTrek Volunteers)

Have students summarize their findings by looking at their team graph. Challenge students to think about how their changing variable did or did not affect the temperature change of the reaction.

When writing their conclusion, make sure that students start with a claim about the trend or pattern in their data and then write “because” and use data to back up the claim. Make sure the students’ claim is a statement that can be tested. The data collected in this experiment is in the form of measurements, so make sure students are using their specific measurements (not trial letters) to support their claims.

If students are struggling, ask them what happens to the trend lines when their changing variable increases. If the trend lines are increasing or decreasing, the changing variable affects the data and there is a trend. If, on the other hand, the trend line is flat, the changing variable does not affect the data. Both scenarios are equally valid and important since the goal is to learn about what variables affect (and what variables do not affect) the temperature change.

Example claims that state how the changing variable did or did not affect the temperature change.

Claim 1: adding more [substance] decreases the temperature change
Claim 2: adding more [substance] does not affect the temperature change

Once they have discussed their ideas, have the students fill out the section labeled: “Generate a claim about how your changing variable affected your subgroup’s results” (page 23). Even if their conclusion is contrary to what you think, have students make a claim based solely on the data they collected.

Next, students should determine the data to support their claim. Have students look at their trend line on the team graph and describe the trend. They should first say whether there is a trend, and if there is, say whether it goes up or down. Tell students to choose the data points that best illustrate the trend they just
described. Then, students should use those data points to fill out the section labeled: “What data do you have to support your claim?”

Example data to support the two claims that were previously listed.
Data 1: when the [substance] mass was 0.0 g the temperature change was 22.5°C (biggest) and when the [substance] mass was 8.0 g the temperature change was 9.6°C (smallest).

Data 2: when the [substance] mass was 0.0 g the temperature change was 12.2°C and when the [substance] mass was 8.0 g the temperature change was 12.0°C

Next, have students fill in the sentence frame: “I acted like a scientist when_____.” Each student’s response should be unique and specific. They should NOT write, “When I did an experiment,” because this is general and applies to all of the students in the class. If students are having trouble with this sentence frame, ask them what they did during each SciTrek visit.

Once students have completed their conclusions and “I acted like a scientist when__” statements, have them analyze their team graph to make a prediction from each subgroup’s data. Students are asked to predict what the temperature change will be if they use 3.5 g of their changing variable. To get started, have students look at their own data on the graph first. They should find 3.5 g on the x-axis, draw a dotted line straight up to their trend line, and then find the predicted temperature by drawing a second dotted line straight across to the y-axis. Students should write their predicted temperature change next to their symbol in the chart on pg. 23. Have students repeat this process for each of the trend lines on their team graph. Note: all 3 values will likely be different.

An example filled out page 23 can be seen below.
**Wrap-Up:**
*(2 minutes – Full Class – SciTrek Lead)*

Ask the students the following questions:

- How did you act like a scientist during this project?
- What did you do that scientists do?

After having a discussion about how they acted like scientists and talking about how everyone does things that scientists do in their everyday lives, tell students that they will make posters and present their findings during the next SciTrek visit. Tell the students that you are looking forward to hearing about all of their experiments.

**Clean-Up:**

Before you leave, have students attach their nametag to their notebook and place them in the group box. Make sure that all of the liquids and dishes are in the bucket and the bucket’s lid is securely fastened. Bring all materials back to UCSB. In addition, put your lab coat into your group box.

**Day 7: Poster Making/Poster Presentations**

**Schedule:**

- Introduction (SciTrek Lead) – 2 minutes
- Poster Making (SciTrek Volunteers) – 25 minutes
- Practice Posters (SciTrek Volunteers) – 5 minutes
- Poster Presentations (SciTrek Lead/Volunteers) – 26 minutes
- Wrap-Up (SciTrek Lead) – 2 minutes

**Materials:**

- (3) Volunteer Boxes:
  - □ Student nametags
  - □ Student notebooks
  - □ Volunteer instructions
  - □ Volunteer lab coat
  - □ Poster diagram
  - □ (3) Stickers on how to present results table
  - Poster Parts Pack
  - □ Scientists’ names
  - □ Question
  - □ Experimental set-up
  - □ Procedure
  - □ (3) Results tables
  - □ Results graph
  - □ Conclusion
  - □ Ways We Acted Like Scientists
  - □ Sticker on how to present graph: specific
  - □ (2) Pencils
  - □ (9) Paperclips
  - □ Highlighter
  - □ Scissors
  - □ Stapler
  - □ (2) Glues
  - □ (2) Clear rulers
  - □ (12) Sharpened SciTrek pencils (all same color)

- Poster Parts Pack
  - □ Scientists’ names
  - □ Question
  - □ Experimental set-up
  - □ Procedure
  - □ (3) Results tables
  - □ Results graph
  - □ Conclusion
  - □ Ways We Acted Like Scientists
  - □ Sticker on how to present results table
  - □ Experimental Set-Up: Specific sheet (white)
  - □ Procedure sheet (white)
  - □ Graph: General sheet (white)

- Other Supplies:
  - □ Poster paper tube

- Lead Box:
  - □ (3) Extra student notebooks
  - □ Lead instructions
  - □ (3) Stickers on how to present results table
  - □ (2) Scissors
  - □ Stapler
Set-Up:

SciTrek Lead:

If the classroom has a document camera, ask the teacher to use it for the notes on presentations (page 5, picture packet). If the classroom does not have a document camera, then write the class question on the board, “What variables affect the temperature change of the reaction?” Leave enough room to record student findings under the question.

Organize the posters so that groups that had the same changing variable present back to back.

SciTrek Volunteer:

- If students are not in the classroom before SciTrek starts, set out the notebooks where students should sit when they come into the classroom.
- If students are in the classroom before SciTrek starts, set out the notebooks where students should sit during the module. They will move to these spots after the introduction.

Picture Packet Page and Notebook Page:
**Introduction:**
*(2 minutes – Full Class – SciTrek Lead)*

Tell students that today they will work with their teams to create a poster and present their findings to the class. Inform students that this is a common practice in science. Scientists go to conferences where they present posters about the experiments they conducted. At these presentations, other scientists give them feedback on their experiments, which allows them to return to the lab with new ideas for future experiments. Similarly, this presentation will be their chance to tell the class what their team has discovered about the class question. Tell students that they should write as neatly as possible on the poster parts so that the other class members can read their poster.

Tell the students that they will have 25 minutes to make the poster and then 5 minutes to practice presenting it with their group. Remind students to read from their notebooks when presenting. Tell students that after practicing, they will return to their normal classroom seats to take notes on the presentations.

**Poster Making:**
*(25 minutes – Subgroups – SciTrek Volunteers)*

Each team (9-11 students) will make one poster about the second experiment, so there will be three presentations total. Every student on the team will have both a writing and a speaking part in the presentation. Note: While presenting, students should call substances by their names (NaHCO$_3$ = sodium hydrogen carbonate, CaCl$_2$ = calcium chloride, and NaCl = sodium chloride). If needed, have students write these in their notebooks.

Pass-out the writing portions (general poster parts, presentation sheets, and “Ways We Acted Like Scientists”) and have students write their names on them and complete them. In addition, have each student write their name on the scientists' names part. Keep in mind, the students presenting Graph: specific and Conclusion must be from the same subgroup. Use the following guidelines to help assign poster parts:

<table>
<thead>
<tr>
<th>Number of Students in Team</th>
<th>Suggested Division of Written Parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Students should add to “Ways We Acted Like Scientists” after they finish their part(s).</td>
</tr>
<tr>
<td></td>
<td>1. Scientists’ Names and Question</td>
</tr>
<tr>
<td></td>
<td>2. Experimental Set-Up: General</td>
</tr>
<tr>
<td></td>
<td>3. Experimental Set-Up: Specific <em>(Staple presentation sheet into notebook, pg. 19)</em></td>
</tr>
<tr>
<td></td>
<td>4. Results Table ○ <em>(Sticker, pg. 21)</em></td>
</tr>
<tr>
<td></td>
<td>5. Results Table △ <em>(Sticker, pg. 21)</em></td>
</tr>
<tr>
<td></td>
<td>6. Results Table X <em>(Sticker, pg. 21)</em></td>
</tr>
<tr>
<td></td>
<td>7. Procedure <em>(Give instruction sheet to student and staple presentation piece into notebook, pg. 20)</em></td>
</tr>
<tr>
<td></td>
<td>8. Graph: General <em>(Staple presentation sheet into notebook, pg. 22)</em></td>
</tr>
<tr>
<td></td>
<td>9. Graph: Specific <em>(Sticker, pg. 22)</em></td>
</tr>
<tr>
<td></td>
<td>10. Conclusion</td>
</tr>
</tbody>
</table>

*Students highlighted in gray must be from the same subgroup (the subgroup with the most convincing data).*

*Give the Graph: Specific sticker to the student that is most confident in presenting.
Once all writing sections are completed, have students add to the “Ways We Acted Like Scientists” poster part. To do this, they can copy their “I acted like a scientist when…” statements from pg. 23 of their notebooks or come up with new ones.

In the students’ notebooks, highlight and number the section that they will present. The parts should be numbered as follows: 1) scientists’ names, 2) question, 3) experimental set-up: general, 4) experimental set-up: specific (staple sheet), 5a) results table O, 5b) results table Δ, 5c) results table X, 6) procedure (staple sheet), 7) graph: general (staple sheet), 8) graph: specific (sticker), and 9) conclusion (see example below). Students will NOT present the “Ways We Acted Like Scientists” from their poster. If a student is presenting multiple sections, use the paperclips in your group box to clip together the sections that they are reading so that when presenting, it will be easy to flip back and forth between pages. Example highlighted and numbered notebook pages are shown below.
EXPERIMENTAL SET-UP:

Determine the values of your changing variable(s) (ex: NaCl mass) from the materials page and write the values (ex: 3.0 g) for your four trials under each beaker.

#3b EXPERIMENTAL SET-UP SPECIFIC

(Once filled out, staple to notebook pg. 19)

If you are responsible for presenting your team's specific experimental set-up, fill in the following sentence frame with information from your Experimental Set-Up. This is what you will read when you present.

Our team's subgroup control is CacO3 mass. The values our team used were 3.0 g, 6.0 g, and 9.0 g. We picked these values because we spread out the values between the highest and lowest allowed masses.

Controls (variables you will hold constant): determine the variables that you will hold constant and indicate the specific value you will use in all your trials.

Team Controls:
- Container Type: Beaker
- Water Volume: 50 mL
- NaCl mass: 5.0 g

Subgroup Control:
- CacO3 mass: 3.0 g

SciTrek Member Approval: 20

#10 PROCEDURE

Procedure Note:
- Make sure to include all values of your changing variable(s) in the procedure. (For example, for a group that decided to change sodium chloride (NaCl) mass one step would be: Measure 3.0 g, 6.0 g, 4.0 g, and 8.0 g of NaCl.)

Step 1: Measure mass of NaHCO3.

Step 2: Measure mass of CacO3.

Step 3: Measure mass of NaCl.

4. Get 50 mL of water and measure the temperature.

5. Pour all substances into a beaker and stir.

6. Record the max temperature and subtract to find the temperature change.

SciTrek Member Approval: 20

RESULTS

Graph

#7c GRAPH GENERAL

(Once filled out, staple to notebook pg. 20)

If you are responsible for presenting your team's graph, fill in the following sentence frame. This is what you will read when you present.

All of our graphs showed a decreasing trend.

We think subgroup A had the most convincing data because the points were closest to the trend line.

![Graph Image]
Place the following sentence frame sticker on the top of the notebook page of each of the students that are completing results tables (page 21).

We are subgroup ________. Our changing variable is ________, and the values we used are ________ g, ________ g, ________ g, and ________ g.

Show the students how to fill out the blanks on the sticker from their results table. For example, the sticker for the first results table on the poster below would read: We are subgroup circle. Our changing variable is sodium hydrogen carbonate mass, and the values we used are 0.5 g, 4.0 g, 2.0 g, and 3.5 g.

Next, place the following sentence frame sticker on the top of the notebook page of the student presenting the results graph: specific (page 22).

When the _changing variable_ mass was _g_ the temperature change was _°C_.

Then practice reading the four sentences with that student. For the poster below, one sentence would be: When the sodium hydrogen carbonate mass was 0.0 g the temperature change was 20.4°C. Make sure you fill in the first blank (ex: calcium chloride) for the student in the sentence frame but leave the second and third blanks (“mass” and “temperature”) empty.

The students that are presenting experimental set-up: specific, procedure, and graph: general should all receive white presentation sheets that need to be stapled into their notebooks and highlighted. The experimental set-up: specific sheet will be stapled to pg. 19, the procedure sheet will be cut and stapled to pg. 20, and the graph: general sheet will be stapled to pg. 22. These sheets have instructions on them.
for how to fill them out, but show students how to complete them if needed. Examples of properly highlighted notebook pages, presentation sheets, and stickers are shown above.

As soon as students have completed some of their pieces, start gluing them onto the large poster paper in landscape orientation, exactly as they are arranged in the example below. Do not wait until students have completed all the pieces to start gluing them onto the poster.

Once the poster is complete, have students start practicing for the presentation. Make sure that students read from their notebooks instead of off the poster.

![Highlighted notebook pages, presentation sheets, and stickers](image)

Ask your team a few questions about their poster. Have them use their findings to predict what would happen to the temperature change for other related experiments that they did not perform. For instance, if the group’s conclusion was, “the greater the sodium hydrogen carbonate mass the smaller the temperature change,” ask the group to predict the temperature change if they added 5.0 g of sodium hydrogen carbonate. They should be able to make a prediction based on their team graph.

If there is additional time, tell students that the other students will ask them questions during their poster presentations. Tell them that they should think about what questions they will be asked and then think of the answers to those questions so that they will be prepared during their presentation.

**Practice Posters:**
*(5 minutes – Subgroups – SciTrek Volunteers)*

Organize the posters in the following order of changing variables: NaCl Mass, CaCl₂ Mass, NaHCO₃ Mass.

Have teams practice their poster presentations, making sure they are reading the poster parts in the correct order (scientists’ names, question, experimental set-up: general, experimental set-up: specific, results table O, results table Δ, results table X, procedure, graph: general, graph: specific, and conclusion). Make sure each student’s part is highlighted in their notebook. If students are reading from multiple pages, use a paperclip to clip these pages together to make it easier for them to flip back and forth. Remind students to read from their notebooks rather than from their posters. Do not let poster practice go over 5 minutes.
**Poster Presentations:**
(31 minutes – Full Class – SciTrek Volunteers/SciTrek Lead)

Have students return to their original class seats. Ask the class, “What is the question that we have been working on answering?” Students should tell you, “What variables affect the temperature change of the reaction?” Tell students that during the presentations they are going to take notes. Have them turn to page 24 in their notebooks while you turn to page 5 of the picture packet. Tell them that they need to record each group’s changing variable when the group says their question. Then, they will record the values of the changing variable and the measurements when the group presents their graph (specific).

After each presentation, students will be given the opportunity to ask scientific questions to the presenting group to help them determine if/how the variable investigated affected the temperature change. Every student needs to come up with at least one scientific question per presentation. After each presentation, give students ~1 minute to write down a scientific question in their notebooks. Tell them these questions are important because they will have to record a summary of what they learned from the group. Therefore, their questions should focus on helping them summarize the group’s findings. Tell students that they will receive a SciTrek pencil if they ask/write down a scientific question.

Student notebooks have room for notes and questions for 2 presentations. Students will not take notes on their own presentation.

Volunteers should make sure that students are quiet and respectful when other groups are presenting. When one of your groups is presenting, go to the front of the room with them. Prompt students if they do not know who talks next and remind them to read from their notebooks. Volunteers should keep track of students that ask/write down scientific questions. Wait until poster presentations are finished to pass out SciTrek pencils.

During the student question time, the SciTrek lead and/or volunteers should ask at least one question. Examples of possible questions are: “How do you know...?”, “Did your results match your predictions?”, or “Is there anything else you can do to get more information about your question?” Try to direct questions to specific students in the group so that questions are not all answered by the same student.

Below is an example of notes that the lead/students could have taken during the poster presentations.
After all poster presentations have been given, ask the class, “What did we learn about the temperature change of the reaction?” Have them summarize the class findings. The highlights from the experiments are shown below.

- The NaCl mass does not affect the temperature change.
- The greater the CaCl₂ mass, the greater the temperature change.
- The greater the NaHCO₃ mass, the smaller the temperature change.

When summarizing experiments, use students’ collected data and not what they should have found from the list above. Tell students you want to get the highest temperature change and that you need them to tell you what values of variables you should use.

- NaCl mass: Any amount.
- CaCl₂ mass: As much as possible.
- NaHCO₃ mass: As little as possible.

Tell students they have taught you a lot about the temperature change of the reaction. Give students who wrote down and/or asked scientific questions a SciTrek pencil.

*Note: Timing is tight on this day. It is possible that students will only get through two of the three presentations during the allotted time. In this case, the teacher will need to lead the third poster presentation and discuss findings during class before the next SciTrek visit.

Wrap-Up:
(2 minutes – Full Class – SciTrek Lead)

Tell the students that the volunteers that have been working with them are undergraduate and graduate students who volunteer their time so that they can do experiments. Have the students say thank you to the volunteers. This is the last day with their SciTrek volunteers, so they should say goodbye to them. Tell students that you will be back one more time.
Ask students to remove the paper part of their nametag from the plastic holder. Tell them that they can keep the paper nametag but they need to give the plastic holder back to their SciTrek volunteer.

**Clean-Up:**

Before you leave, collect the plastic nametag holders and put them in the group box. Students can keep the paper part of their nametag. Collect notebooks and place them in the group box. Leave student posters in the classroom. Bring all materials back to UCSB. Remove tape from the lid of your group box and place inside. In addition, remove all materials from lab coat pockets, remove your nametag, unroll lab coat sleeves, and put your lab coat into the dirty clothes bag at UCSB.

**Day 8: Analysis Assessment/Tie to Standards**

**Schedule:**

- Analysis Assessment (SciTrek Lead) – 10 minutes
- Tie to Standards (SciTrek Lead) – 50 minutes

**Materials:**

**Lead Box:**

- (3) Extra student notebooks
- Student notebooks
- Lead instructions
- Thermal Transfer picture packet
- Picture of experimental set-up
- Lead lab coat
- (35) Analysis assessments
- Time card
- (2) Pencils
- (2) Wet erase markers

- (35) Clear rulers
- Water (8 oz)
- Paper towels
- Thermometer
- Dropper
- Beaker
- NaCl exact container (4.0 g)
- CaCl$_2$ exact container (10.0 g)
- NaHCO$_3$ exact container (3.0 g)

- Experiment 1 sandwich bag (½ scoop NaCl, ½ scoop NaHCO$_3$, 1½ scoop CaCl$_2$)
- Experiment 2 sandwich bag (½ scoop NaCl, 1½ scoop NaHCO$_3$, ½ scoop CaCl$_2$)
- Mix weigh boat
- Plastic lid
- Stir plate
- Magnetic stir bar
- Extension cord

**Boxes, each with the following:**

- Bag of 5 Experiment 1 sandwich bags (½ scoop NaCl, ½ scoop NaHCO$_3$, 1½ scoop CaCl$_2$)
- Bag of 5 Experiment 2 sandwich bags (½ scoop NaCl, 1½ scoop NaHCO$_3$, ½ scoop CaCl$_2$)
- (5) Waters (8 oz)
- (5) 100 mL graduated cylinders
- Paper towels
- White rag

**Other Supplies:**

- Bucket with lid
- Tray
Notebook Pages and Picture Packet Pages:

7. What temperature change was measured when we mixed 4.0 g NaCl, 3.6 g NaHCO₃, 10.0 g CaCl₂, and 50 mL water?

<table>
<thead>
<tr>
<th>Initial Temperature</th>
<th>Maximum Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>19.0°C</td>
<td>35.7°C</td>
</tr>
</tbody>
</table>

Change in Temperature: 16.7°C

8. How far was the measured temperature change from the expected temperature change?

\[
\text{Expected Temperature Change} = \frac{17.3°C}{0.6°C} = 28.83°C
\]

9. Can we consider our expected temperature change correct? YES NO

10. Is the temperature change in the reaction predictable? YES NO

5. Annotate the graphs below, draw trend lines, label subgroup controls, and answer the questions:

Why has the graph for NaCl mass been left out? NaCl mass does not affect the temperature change.

Graph 1 Controls

<table>
<thead>
<tr>
<th>Experiment Symbol</th>
<th>NaCl Mass</th>
<th>Water Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>0 g NaCl</td>
<td>50 mL</td>
</tr>
<tr>
<td>△</td>
<td>5.0 g NaCl</td>
<td>50 mL</td>
</tr>
<tr>
<td>X</td>
<td>10.0 g NaCl</td>
<td>50 mL</td>
</tr>
</tbody>
</table>

Does this graph show a trend that is consistent with the class findings? YES NO

Graph 2 Controls

<table>
<thead>
<tr>
<th>Experiment Symbol</th>
<th>NaCl Mass</th>
<th>Water Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>0 g NaCl</td>
<td>50 mL</td>
</tr>
<tr>
<td>△</td>
<td>5.0 g NaCl</td>
<td>50 mL</td>
</tr>
<tr>
<td>X</td>
<td>10.0 g NaCl</td>
<td>50 mL</td>
</tr>
</tbody>
</table>

Does this graph show a trend that is consistent with the class findings? NO

6. Using data from the graphs, what temperature change would you expect to measure if you mixed 4.0 g NaCl, 3.6 g NaHCO₃, 10.0 g CaCl₂, and 50 mL water?

Which experiment(s) should you look at?

Graph 1: O △ YES Prediction: 18°C
Graph 2: O △ X NO Prediction: 16.5°C

TIE TO STANDARDS:

1. Review the class findings about each substance from poster presentations.

Does NaCl mass affect the temperature change? YES NO

If YES, describe the trend: The greater the NaCl mass, the _______ the temperature change.

Does NaHCO₃ mass affect the temperature change? YES NO

If YES, describe the trend: The greater the NaHCO₃ mass, the _______ the temperature change.

Does CaCl₂ mass affect the temperature change? YES NO

If YES, describe the trend: The greater the CaCl₂ mass, the _______ the temperature change.

2. When scientists conduct experiments, they often repeat each trial in the exact same way several times. Why? Results will not always be the same numbers. During multiple trials, tell us how much the results can vary from each other.

When running multiple trials in an experiment, scientists collect a series of data points. Then they use math tools called median and range to help analyze the data.

3. Determine the median and range for the data in the table below.

<table>
<thead>
<tr>
<th>Substance Masses</th>
<th>Temperature Change (°C)</th>
<th>Median</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0 g NaHCO₃</td>
<td>11.9, 11.5, 12.0, 11.6, 11.2</td>
<td></td>
<td>1.2°C</td>
</tr>
<tr>
<td>4.0 g NaHCO₃</td>
<td>11.9, 11.5, 12.0, 11.6, 11.2</td>
<td></td>
<td>1.2°C</td>
</tr>
<tr>
<td>5.0 g CaCl₂</td>
<td>11.9, 11.5, 12.0, 11.6, 11.2</td>
<td></td>
<td>1.2°C</td>
</tr>
</tbody>
</table>

4. What does this tell us? As long as our predictions are within 1.2°C of the actual data, we can consider them correct.

Why is the temperature change predictable?

11. Temperature is a measure of _______ which is the energy of motion.

12. In the boxes below, indicate the speeds of the particles using arrows (larger arrows = faster speeds). Then fill in the thermometers to represent their relative temperatures.

Kinetic Energy: Low
Particles are moving slow

Kinetic Energy: High
Particles are moving fast

13. What did we expect in our experiment? Fill out the table below with your observations of the starting materials.

<table>
<thead>
<tr>
<th>Starting Material</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>NaCl</td>
<td>white, grainy, clear square pieces, solid</td>
</tr>
<tr>
<td>NaHCO₃</td>
<td>white, powdery solid, different size pieces</td>
</tr>
<tr>
<td>CaCl₂</td>
<td>white, small solid balls</td>
</tr>
<tr>
<td>Water</td>
<td>clear liquid</td>
</tr>
</tbody>
</table>

14. What did we expect in our experiment? white, milky liquid, gas, bubbles puff up the bag, chalky solid settles out
15. Did a chemical reaction happen?  
Evidence: Gas formed, temperature changed  
Yes  
No

16. Can energy be created or destroyed?  
Yes  
No

17. When a chemical reaction goes warmer, energy has been released  
Yes  
No

18. Do all substances store the same amount of energy?  
Yes  
No  
Evidence: Adding the same amounts of different substances gives a different temperature change.

19. Summarize the effects of each substance on the temperature change and kinetic energy by circling the answer that best completes each statement.

<table>
<thead>
<tr>
<th>Substance</th>
<th>Increase</th>
<th>Decrease</th>
<th>Stay the Same</th>
</tr>
</thead>
<tbody>
<tr>
<td>NaCl Mass</td>
<td>As NaCl mass increases, the temperature change</td>
<td>Increases</td>
<td>Decreases</td>
</tr>
<tr>
<td></td>
<td>If we add more NaCl to the reaction, the kinetic energy</td>
<td>Increases</td>
<td>Decreases</td>
</tr>
<tr>
<td>CaCl₂ Mass</td>
<td>As CaCl₂ mass increases, the temperature change</td>
<td>Increases</td>
<td>Decreases</td>
</tr>
<tr>
<td></td>
<td>If we add more CaCl₂ to the reaction, the kinetic energy</td>
<td>Increases</td>
<td>Decreases</td>
</tr>
<tr>
<td>NaHCO₃ Mass</td>
<td>As NaHCO₃ mass increases, the temperature change</td>
<td>Increases</td>
<td>Decreases</td>
</tr>
<tr>
<td></td>
<td>If we add more NaHCO₃ to the reaction, the kinetic energy</td>
<td>Increases</td>
<td>Decreases</td>
</tr>
</tbody>
</table>
Set-Up:

SciTrek Lead:
If the classroom has a document camera, ask the teacher to use it for the tie to standards activity (pages 25-30, student notebook). If the classroom does not have a document camera, then tape the example poster-size notebook pages to the front board.

Pass out assessments and clear rulers where each student will sit.

Pass out notebooks to students. Set up the temperature change demonstration (just like day 1 experimental set-up). If you do not have time to get set-up before the start of the module, ask the teacher to pass out notebooks and set-up the demonstration during the analysis assessment.

Remind the teacher to give you their lab coat at the end of the day.

Analysis Assessment:
(10 minutes – Full Class – SciTrek Lead)

“Before we start our activity today we will determine how your ideas on analyzing and interpreting data are developing. One of the ways that we get program funding is by demonstrating the program effectiveness. Therefore, we need you to do your best on the assessment.” Pass-out the analysis assessment and tell students to fill out their name, teacher’s name, and date on the top of the assessment. Remind the students that it is important that they fill out this assessment on their own.

For page 1, read the directions for annotating to the students. Tell students that any time they are asked to annotate a statement or table, they should underline controls, circle changing variables, and box
information about data collection. For this assessment, do **NOT** demonstrate how to annotate results tables, possible conclusions, or graphs.

Give students ~30 seconds to annotate the results table. Walk around to make sure students are annotating. Then, have students answer question 1b) on their own. Then, tell students to annotate the possible conclusion. Remind them to underline controls, circle changing variables, and box information about data collection. Read question 1d) and have students answer it. Tell students if a conclusion is incorrect, they should write what is wrong with the conclusion on the line provided. Repeat this process for questions 2 and 3.

For question 4, tell students to annotate the graph. Students should answer the remaining questions on their own. Tell students to do their best to plot the provided points on the graph using circles as markers. Then tell students to draw trend lines for each experiment on the graph using the clear ruler. Read questions 4d-4f and give students time to answer each. Walk around to make sure students are filling out the questions. After reading the last question, tell students to raise their hands when they are finished so you can collect their assessments. Students should keep their clear rulers to use during the tie to standards activity.

**Tie to Standards:**
(50 minutes – Full Class – SciTrek Lead)

**Class Findings (3 minutes)**

Tell students you enjoyed hearing about their findings last time, and that we should quickly review what we found out as a class. Have students open to page 25 in their notebooks and place an example notebook under the document camera. Ask students what we found out about NaCl mass. Students should say that NaCl mass does not affect the temperature change, and circle no. Ask students how they knew this. Students should say that there was no trend in the data for NaCl mass. Next, ask students if NaHCO₃ mass affects the temperature change. They should say yes, and that the greater the NaHCO₃ mass the smaller the temperature change. Circle yes and fill in the sentence frame. Ask students if CaCl₂ affects the temperature change. They should say yes, and that the greater the CaCl₂ mass the larger the temperature change. Circle yes and fill in the sentence frame. If students have trouble remembering the class findings, refer back to their notes on presentations (pg. 5, picture packet and pg. 24, student notebook). An example filled out question 1 is shown below.

<table>
<thead>
<tr>
<th>TIE TO STANDARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Review the class findings about each substance from poster presentations.</td>
</tr>
<tr>
<td>Does NaCl mass affect the temperature change?</td>
</tr>
<tr>
<td>If YES, describe the trend: The greater the NaCl mass, the</td>
</tr>
<tr>
<td>Does NaHCO₃ mass affect the temperature change?</td>
</tr>
<tr>
<td>If YES, describe the trend: The greater the NaHCO₃ mass, the</td>
</tr>
<tr>
<td>Does CaCl₂ mass affect the temperature change?</td>
</tr>
<tr>
<td>If YES, describe the trend: The greater the CaCl₂ mass, the</td>
</tr>
</tbody>
</table>

**Variations in Data (6 minutes)**

Tell students that you collected some data for this experiment in your own lab, and you would like to analyze it as a class. However, they first need to understand variations in data. Tell students that it is common for scientists to perform each of their trials multiple times and then use math to choose one value to represent all the data. Ask students why scientists need to do this, and call on a few students to
share their ideas. Lead students to understand that oftentimes measured results will not always be the same between trials, and doing trials multiple times tells us how much the results can vary. Have students answer question 2, as shown below.

<table>
<thead>
<tr>
<th>Question</th>
<th>Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.</td>
<td>When scientists conduct experiments, they often repeat each trial in the exact same way several times. Why? Results will not always be the same numbers. Doing multiple trials tells us how much the results can vary from each other.</td>
</tr>
</tbody>
</table>

Tell students that when scientists perform a trial multiple times, they use math to help them interpret the variations in the data. One way of doing this is by taking a median. Show students how to take the median for the data given in the table on question 3. Tell students that they need to put the values in increasing order first. Then, the median is the value that is in the middle. Have students record the median in their notebooks.

Tell students it is also useful to find out how spread out the measurements are for a given trial. Tell them that scientists also use a math tool called the range to find out how far apart the biggest and smallest measurements are. Show students how to calculate the range for the data in the table by subtracting the smallest value from the largest value. Have students calculate the range in the table for question 3.

Tell students that the data in the table is actual data that you collected for one trial in our experiment. Given this knowledge, ask students what the values that we calculated for median and range tell us. Tell students to think about what happened in your experiment to collect the data in the table. Students should be able to tell you that you mixed 0.0 g NaHCO₃, 4.0 g NaCl, and 5.0 g CaCl₂ 5 times, and you measured approximately 11.8°C, with measurements that varied by 1.2°C. Lead students to understand that this means when we are making predictions about this experiment, we can consider predictions correct if they are within 1.2°C of the real data. Have students answer question 4.

4. | What does this tell us? As long as our predictions are within 1.2°C of the actual data, we can consider them correct. |

**Predicting Temperature Change (15 minutes)**

Tell students that you did several experiments similar to the ones they designed, but you performed each trial three times for every experiment. Tell students that you took the median for each trial and graphed the median points on “team graphs” grouped by the changing variable investigated. These graphs are shown on page 26 of the student notebook.
First, ask students why the graph for the effects of NaCl mass has been left out. Students should be able to tell you that NaCl mass does not affect the temperature change of the reaction. As a result, it is not as useful for making predictions. Have students answer question 5, as shown below.

Next, annotate Graph 1 as a class. Ask students what the changing variable was. They should say sodium hydrogen carbonate (NaHCO₃) mass, and circle it on the x-axis. Then, ask students what data was collected in this experiment. They should say “Change in Temperature (°C)”, and box it on the y-axis. Ask students where else this information appears on the graph. They should say the title. Circle the changing variable and box the data in the title. Ask students what other information appears in the title. They should say that one of the controls, CaCl₂ mass, is in the title, so we should underline it. Ask students what type of control CaCl₂ mass is. Remind students that CaCl₂ mass is the subgroup control because it is the control that has different values between each of the experiments. Next, draw trend lines for each experiment using a clear ruler, and have students do so along with you. Then remind students that we should label each trend line with the corresponding subgroup control value. Label the trend lines in the margin on the right, and have students do so in their notebooks. Ask students if NaHCO₃ mass affects the change in temperature. They should say yes, because all three lines are decreasing. Ask students if this is consistent with the class findings. Students should say yes, and circle yes for the question on Graph 1, as shown below.

Next, have students annotate Graph 2, draw trend lines, and label the trend lines with subgroup control values on their own. Fill out Graph 2 without showing the students. After ~2-3 minutes, show students the annotated graph and trend lines, and ask students if they did something similar. Give students a moment to make any changes. Ask students if CaCl₂ mass affects the change in temperature. They should say yes, because all three lines are increasing. Ask students if this is consistent with the class findings. Students should say yes, and circle yes for the question on Graph 2, as shown below.

Read question 6, and tell students we should use both graphs to make predictions. Tell students to look at Graph 1 first, and ask students which experiment or experiments will be most useful to predict the temperature change. Show students that the subgroup control that they labeled on Graph 1 is CaCl₂ mass, so they should focus on the value given for CaCl₂ mass, which is 10.0 g. Students should notice that Graph 1 has a trend line that corresponds with 10.0 g of CaCl₂, which is represented by the symbol X. Have
students circle “X” for Graph 1 on question 6. Then ask students where to find NaHCO₃ mass on Graph 1. Students should say “the x-axis” and find the value, 3.0 g, on the axis. Have the students make a dotted line from 3 on the x-axis up to trend line X and then make a dotted line from the intersection to the y-axis to predict the temperature change on Graph 1 (~18°C). Have students write the predicted temperature change for Graph 1 on question 6. Remind students that their predictions can vary up to 1.2°C.

Follow the same process to predict the temperature change from Graph 2. Show students that the subgroup control on Graph 2 is NaHCO₃ mass. Ask students which experiments we need to look at considering we are using 3.0 g of NaHCO₃. Students should say that we need to look at circles and triangles, since 3.0 g is between 0.0 and 4.0 g. Circle the circle and triangle for Graph 2 on question 6. Ask students if we should draw a dashed line halfway between the circle and triangle trend lines. Students should say that the dashed line should be closer to the triangles, since 3.0 g is closer to 4.0 g than to 0.0 g. Draw the dashed line and have students do so in their notebooks. Then ask students where to find CaCl₂ mass on Graph 2. They should say “the x-axis” and find the value, 10.0 g, on the axis. Have the students make a dotted line from 10 on the x-axis up to the dashed trend line and then make a dotted line from the intersection to the y-axis to predict the temperature change on Graph 2 (~17°C).

Have the students complete question 6 with their predictions from Graph 2. Then, combine the two predictions to make an overall temperature change prediction by finding the temperature change that is halfway in between the two predictions. Note: If students have one predicted temperature change that ends in “.5,” the math is more complicated. For example, if students predict 18°C from Graph 1 and 16.5°C from Graph 2, the overall expected temperature change will be 17.25°C. The simplest way to explain how to get to 17.25°C is to discuss an example with money (ex. Ask how many quarters we would need to get from $16.50 to $18.00, which would be 6 quarters. Divide this by 2 to get 3 quarters. Add three quarters to $16.50 to get to $17.25). No matter what the overall expected temperature change is, it is important to round it to the nearest tenth. Likewise, if the expected temperature change ends in “.25,” it would need to be rounded to “.3”. An example filled out question 6 is shown below.
Turn to page 27 in the notebook. Tell students we will now test to see if our predictions are correct. Pour 50 mL of water into the beaker with a magnetic stir bar. Start the stir plate to begin stirring and position the thermometer in the beaker with the plastic lid. Wait a moment for the temperature to stabilize. Tell students that you weighed each substance ahead of time, and pour each of the substances from the exact containers into the Mix weigh boat. Record the initial temperature in the table on question 7, and pour the Mix weigh boat into the beaker with the water. Have students call out observations as the reaction is occurring. Once the maximum temperature has been reached, turn off the stir plate, press the “Max/Min” button on the thermometer, and record the max temperature. Have students do subtraction with you to find the change in temperature on question 7.

As students how we can find out how far our measured temperature change was from our expected temperature change. Lead students to understand that they should use subtraction to find the difference. Start with whichever temperature change (expected or measured) was larger, and subtract the other from it. Perform the subtraction for question 8, and have students do so in their notebooks. Then, ask students what this tells us about our expected temperature change. If the difference calculated in question 8 is less than 1.2°C, that means that the prediction is within the acceptable range of variation that we determined on question 3. This means that we can consider our prediction correct. If so, have students circle yes for question 9. Then, ask students what this tells us about the temperature change of the reaction. Students should say that it is predictable, and circle yes for question 10.

**Why Temperature Changes (19 minutes)**

Tell students that now that we know the temperature change of the reaction is predictable, we will talk about why. Tell students that temperature is really a measure of something called “kinetic energy,” which is the energy of motion. Fill this in for the definition on question 11 (page 28, student notebook), and have students write this in their notebooks. Tell students that all matter is made up of particles, which are always moving. Tell students if a substance has low kinetic energy, that means the particles of the
substance are moving slowly, which means they have a low temperature. Show students how to represent this on the first diagram on question 12. Use short arrows from the particles to show that the particles are moving slowly, and draw a low temperature in the thermometer. Then, have students fill out the second diagram while you do so on the example notebook. Give students ~1 minute to work on this before showing the example.

Next, tell students that if we want to know why the temperature change is predictable in our reaction, we need to think about what we started and ended with. Place page 6 of the picture packet under the document camera to show students what sodium chloride looks like. Have a few students share observations of sodium chloride and record them in the table on page 28 of the example notebook. Repeat this process with pages 7 and 8 of the picture packet to record observations for sodium hydrogen carbonate (NaHCO₃) and calcium chloride (CaCl₂). While you are doing this, have a volunteer or the teacher pass out water bottles, graduated cylinders, and Experiment 1 bags to each ~3 students. Collect clear rulers from students as you give them experimental materials.
Tell students we are going to observe the reaction again and make observations about what happens during and after the reaction. Show students how to set up the reaction in the Experiment 1 bag. Tell students they will work in groups of 3. Pour 50 mL of water into a graduated cylinder and have 1 student in each group do the same. Then take the Experiment 1 bag and tilt it so all the substances are settled in one corner. Pinch the corner and twist the bag a few times so that all substances are contained on one
side. Have a different student in the group do this with you. Once students are ready with one student securely holding the substances in the bag, have a volunteer or the teacher pour the water into the other side of the example bag and close the zipper while you are still holding the substances separate. Tell students to do the same by having the third student in the group pour the water and close the bag. Once all bags are securely closed, tell students we will release the substances and shake the bag so that all substances mix with the water at the same time. Count down from 3 and shake the bags so that everyone can make observations at the same time. Students should observe that the bags will begin to puff up immediately as gas is produced, and they will get very warm.

Once reactions have completed, ask students what we end with after the reaction. Have students record their observations on question 14. While students are writing observations, have a volunteer or the teacher collect the bags from the students and place them in the bucket (open the bag to let the gas out and seal it again before placing it in the bucket). Leave the other materials with the students.

![Table 13: What did we start with in our experiment? Fill out the table below with your observations of the starting materials.](image)

<table>
<thead>
<tr>
<th>Starting Material</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>NaCl</td>
<td>white, grainy, clear square pieces, solid</td>
</tr>
<tr>
<td>NaHCO₃</td>
<td>white, powdery solid, different size pieces</td>
</tr>
<tr>
<td>CCl₂</td>
<td>white, small solid balls</td>
</tr>
<tr>
<td>Water</td>
<td>clear liquid</td>
</tr>
</tbody>
</table>

Have students turn to the next page in their notebooks while you do so under the document camera. Ask students if we just saw a chemical reaction happen. They should say yes, and circle yes for question 15. Ask students how they know. They should say that a gas formed, the temperature changed, etc. If students have trouble with identifying the evidence of a chemical reaction, refer back to the definition on page 1 of the notebook.

Ask students if energy can be created or destroyed. Have a few students share ideas. Then tell students that energy can never be created nor destroyed but can only be transferred, and tell them that this is called the Law of Conservation of Energy. Students should circle no for question 16.

Ask students to tell you about the temperature change they just observed. Students should say that the temperature got hotter. Ask students what this tells us about the kinetic energy of the particles in the bag. Students should say that if the temperature felt warmer, then the kinetic energy must have increased. Ask students, “If energy cannot be created, then where did the kinetic energy come from?” Lead students to understand that energy is stored in the substances, and some of that energy is released to the surroundings during the reaction, which makes the particles speed up, thus making the bag feel warmer. Have students answer question 17.

Ask students if all substances store the same amount of energy. Call on a few students to share ideas. Probe students further by asking, “If we added 4.0 g of NaCl or 4.0 g of CCl₂ or 4.0 g of NaHCO₃ to water, would you expect to observe the same temperature change for each substance?” Students should say no. Lead students to understand that all substances do not store the same amount of energy, because adding
the same amounts of different substances gives a different temperature change. Have students answer question 18.

Tell students that since all substances do not all store the same amount of energy, we should try to summarize how each of the substances in our reaction affects the kinetic energy during the reaction. Read each statement in the table on question 19 and have the students help you finish the sentence by circling the answer on the right. Students can refer back to the graphs on page 26 if they need help remembering the trends. For the first statement, students should tell you that “As NaCl mass increases, the temperature change stays the same.” Ask students, if the temperature change is not affected by the amount of NaCl, does the amount of NaCl affect the kinetic energy? Students should say no, since temperature is a measure of kinetic energy. Thus students should say, “If we add more NaCl to the reaction, the kinetic energy stays the same.” Go through and complete the rest of the statements. Make sure that by the end of the conversation, students understand the direct relationship between temperature and kinetic energy: if the temperature change increases, kinetic energy also increases.

Cold Reactions (7 minutes)

Ask students if it is possible to make our reaction feel cold. If students are unsure, ask students if any of the substances made the temperature change go down. Students should say that adding more NaHCO₃ made the temperature change decrease. Answer question 20 (pg. 30, student notebook).
Read question 21 to students. Begin predicting the temperature for this mixture on the graph provided. Show students that the subgroup control is CaCl$_2$ mass, so we should look at the trend line that matches the amount given. Since we are given 3.0 g of CaCl$_2$ we will look at the trend line marked by circles. Then, if we have 12.0 g of NaHCO$_3$ (found on the x-axis), we can draw a dotted line from 12 on the x-axis down to the trend line marked by circles. Ask if students notice anything different about the temperature change we would expect for this mixture of substances. Students should say that this temperature change is negative. Ask students what this means, or what we would expect to observe in this case. Lead students to understand that this means the temperature would go down, and thus we would expect to feel the reaction get colder. Have students answer question 21. Tell students we will perform one more test to see if this is true. While students are writing, have a volunteer or the teacher pass out Experiment 2 bags.

Have students follow the same procedure as last time. Again, walk the students through tilting the bag so all the substances are settled in one corner and pinching and twisting the corner with the substances. Once students are ready with one student in each group of ~3 securely holding the substances in the bag, have a volunteer or the teacher pour the water into the other side of the bag and close the zipper while you are still holding the substances separate. Tell students to do the same by having a different student in the group pour the water and close the bag. Once all bags are securely closed, release the substances and shake the bag so that all substances mix with the water. Have students do this at the same time, so everyone can make observations at the same time. Students should still observe the bag puff up with gas and a milky white liquid form, but this time the bag should get cold.

Remind students that when a reaction felt hot, energy was released to the surroundings so the kinetic energy increased. Ask students what happened to the kinetic energy this time, when the reaction felt cold. Students should say that the kinetic energy decreased. Remind students that energy cannot be created or destroyed, and ask students where the energy went. Lead students to understand that energy was absorbed from the surroundings by the reaction, which made the particles in the surroundings slow down, thus making the bag feel colder. Have students answer question 22.

Ask students what are the two ways we have seen chemical reactions transfer energy. Students should say that chemical reactions can release or absorb energy. Have students fill this out for question 23. Finally, ask students what two factors that we talked about today affect the energy transferred during a reaction. Lead students to understand that the energy change is affected by the type of substance and the mass, and fill out question 24.
Clean-Up:

Collect experiment bags, release the gas, reseal the bags, and place them in the bucket. Place all other materials in the boxes. Collect the teacher’s lab coat and bring all materials back to UCSB.

Extra Practice Solutions:
4. a) Annotate the following results table.

<table>
<thead>
<tr>
<th>Substance A Mass</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.5 g</td>
<td>2.3 g</td>
<td>3.2 g</td>
<td>4.1 g</td>
</tr>
</tbody>
</table>

| Substance B Mass | 15 g | 20 g | 30 g | 40 g |

<table>
<thead>
<tr>
<th>Data</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Temperature (°C)</td>
<td>20°C</td>
<td>15°C</td>
<td>10°C</td>
</tr>
<tr>
<td>Change in Temperature (°C)</td>
<td>5°C</td>
<td>10°C</td>
<td>15°C</td>
</tr>
<tr>
<td>Amount of foam</td>
<td>Small</td>
<td>Medium</td>
<td>Large</td>
</tr>
</tbody>
</table>

b) Can this group make a conclusion? YES NO IDON'T KNOW

c) Annotate the following possible conclusion.

Possible Conclusion: The greater the Substance A mass, the greater the temperature change, because when the Substance A mass was large, the temperature change was large as well.

d) Is this a correct conclusion for the results table? YES NO IDON'T KNOW

Directions: Some scientists wanted to know how changing the Substance A mass would affect the temperature change of the reaction. They did 3 experiments, using a different Substance A mass each time, and plotted most of their data on a graph. Answer question a using the graph below.

5. a) Annotate the graph.

b) Plot the data points from the chart below on the graph using circles (○) as markers.

<table>
<thead>
<tr>
<th>Substance A Mass</th>
<th>Change in Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 g</td>
<td>3 g</td>
</tr>
<tr>
<td>15 g</td>
<td>5 g</td>
</tr>
<tr>
<td>20 g</td>
<td>10 g</td>
</tr>
<tr>
<td>30 g</td>
<td>15 g</td>
</tr>
<tr>
<td>40 g</td>
<td>20 g</td>
</tr>
</tbody>
</table>

c) Draw trend lines on the graph for each data set.

d) In general, for Substance A Masses, what happens as the Substance A mass increases?

The change in temperature increases.

a) What will the temperature change be when 15 g of A and 35 g of C are mixed? 26°C

b) What will the temperature change be when 15 g of A and 55 g of C are mixed? 38°C

CROSSWORD PUZZLE

Directions: Fill in the following crossword puzzle using the clues below. The list of words used for the word search can be found on the vocabulary page of your notebook (pg. 3).

Across
1. A scientific practice in which data is examined critically to look for trends.
2. The energy of motion.
3. The measure of kinetic energy.
4. A piece of laboratory equipment used to hold chemicals and conduct chemical reactions.
5. A scale that is purposely kept the same throughout an experiment.

Down
1. A type of definition that can be tested.
2. A claim supported by data.
3. When data changes in one general direction, there is a __________.
4. Measurements and observations are the two types of __________.
5. The button you push to “zero” a scale.
6. What you expect to happen based off of previous data.

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