Module 2: Thermal Transfer

6th Grade

About the Instructions:

This document is intended for use by classroom teachers, SciTrek leads, and SciTrek mentors. The document has been composed with input from teachers, leads, mentors, and SciTrek staff to provide suggestions for future teachers/leads/mentors. The instructions are not intended to be used as a direct script, but were written to provide teachers/leads/mentors with a guideline to present the information that has worked in the past. Teachers/leads/mentors should feel free to deviate from the instructions to help students reach the learning objectives of the module. 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 practice taught in 5th grade SciTrek, which is conclusions. If students did not have 5th grade SciTrek, they should do the 6th grade module with conclusion as their highlighted scientific practice instead of analyzing and interpreting data.

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/Team Plan/Question/Experimental Set-Up/Procedure/Results Table (60 minutes)
Day 6: Experiment/Graph/Conclusion (60 minutes)
Day 7: Poster Making/Poster Presentations (60 minutes)
Day 8: Analysis Assessment/Draw a Scientist/Tie to Standards/Content Assessment (60 minutes)

The exact module dates and times are posted on the SciTrek website (scitrek.chem.ucsb.edu/elementary) under the school/teacher. The times on the website include transportation time to and from outside of Chem 1204. Thirty minutes are allotted for transportation before and after the module. Therefore, if a module was running from 10:00-11:00, 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 approximately ten students each. After Day 1, the groups of approximately ten students are further subdivided into two subgroups, approximately five students each, for the rest of the module. On Day 5, subgroups will join to form "teams" (two subgroups per team), based on the changing variable they choose to investigate. One mentor is assigned to help each group/team (which is made up of two subgroups). We find groups/subgroups 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 changes in temperature, color change, or state of matters can be evidence of a chemical reaction.
2. Students will know that energy can be transferred in a chemical reaction in the form of heat and is dependent on mass of reactant used.
3. Students will know that different substances are able to store different amounts of energy.
4. Students will know they must only have one changing variable in order to draw a conclusion.
5. Students will be able to determine whether a conclusion is appropriate based on a given data set.
6. Students will be able to recognize and interpret trends in graphical data and use that data to make predictions.
7. Students will be able to collaborate as a class to plan and carry out, a focused experiment.
8. Students, in small groups, will be able to select a question and make experiment decision that allows them to answer their question and present their findings to the class.
9. Students will be able to list at least two ways 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 mentors 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 approximately ten students and are subdivided into two subgroups (approximately five students each) after Day 1 of the module.

1. Year 1
    a. Classroom teacher <u>leads a group</u> (Role: Group Lead; this is referred to as a mentor in these instructions)
2. Year 2
    a. Classroom teacher <u>co-leads the modules</u> with a SciTrek staff member (Role: Co-Lead)
        i. Classroom teacher will be responsible for leading entire class discussions (Ex: analysis activity).
        ii. Classroom teacher will be responsible for time management.
        iii. Classroom teacher will be responsible for overseeing mentors and helping any groups who are struggling.
        iv. Classroom teacher will be responsible for all above activities. The SciTrek co-lead will only step in for emergencies.
        v. The SciTrek co-lead will run the tie to standards activity.
3. Year 3 and beyond
    a. Classroom teacher <u>leads the modules</u> (Role: Lead)
        i. Classroom teacher will be responsible for leading entire class discussions (Ex: analysis activity).
        ii. Classroom teacher will be responsible for time management.
        iii. Classroom teacher will be responsible for overseeing mentors and helping any groups who are struggling.

    iv. For year 3 a SciTrek staff member will co-lead the tie to standards activity with the classroom teacher, for subsequent years they will run the tie to standards independently.

SciTrek staff is 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 scitrekelementary@chem.ucsb.edu to learn more.

In addition, teachers are required to come to UCSB for the module orientation, approximately one week prior to the start of the module. Contact scitrekelementary@chem.ucsb.edu for exact times and dates, or see our website at scitrek.chem.ucsb.edu/elementary under the class's module times. At the orientation, teachers will go over module content, learn their responsibilities during the module, and meet the mentors who will be helping in their classroom. Failure to come to the module orientation might result in loss of priority registration for the following year.

Prior to the Module (at least 1 week):

1. Come to the SciTrek module orientation at UCSB.

Notes for Teachers 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 a SciTrek staff member at orientation.

Day 1:
Have students' desks/tables moved into three groups and cleared off. We will need to have access to three electrical plugs (one for each group).
Day 2-7:
Have students' desks/tables moved into six groups and cleared off.
Day 3 and 6:
We will need to have access to six electrical plugs (one for each subgroup).
Day 8:
Have 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 mentors throughout the module. Below are options that will allow the students more time to work with the mentors. If you plan to do any of the following options, please inform the SciTrek staff no later than your orientation date (approximately one week before your module, exact orientation times are found at: scitrek.chem.ucsb.edu/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 give the analysis assessment to your class, ***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, outlined in the Introduction with your class, ***before*** SciTrek arrives.

Day 3:

If you would like to have more time for your students to perform their experiments, you can finish the first portion of the analysis activity (notebook, pages 8-10) with your class, ***after*** SciTrek leaves.

Day 4:

If you would like to have more time for your students to work on the technique and analysis activities, you can finish the second portion of the analysis activity (notebook, pages 14-16) with your class, ***after*** SciTrek leaves.

Day 5:

If you would like to have more time for your students to collaborate and redesign their experiments, you can finish the analysis activity (notebook, page 17) with your class, ***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 with your class, ***after*** SciTrek leaves.

Day 8:

If you would like more time for the tie to standards activity, you may give the analysis assessment to your class, ***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: Series Digital Pocket Weight Scale Accurate Measurements 1kg x 0.1g, (Black), AWS-1KG-BLK - AMERICAN WEIGH SCALES)
10. Disposable pipets (droppers) (Fisher part number: 13-711-7M)
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. **<u>IMPORTANT</u>**: 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. **<u>IMPORTANT</u>**: 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 change, which should be **~14.0°C**.
    d. **If the temperature change varies by more than 1.5°C (from 14.0°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. Wet erase pens
19. Paper towels
20. Ziploc sandwich bags

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/wiping with vinegar.

All printed materials used by SciTrek (notebooks, materials page, team plan page, picture packet, poster parts, instructions, and nametags) can be made available for use and/or editing by emailing scitrekelementary@chem.ucsb.edu.

Types of Documents:

Notebook:

One given to every student and is filled out by the student. The lead will use a notebook to write in as an example for students. The notebook the lead uses is referred to as the class notebook in these instructions.

Notepad:

One given to every group and is filled out by the mentor. In these instructions, the examples are narrower and taller than the notebook pages.

Picture Packet:

One per class that, if needed, the lead fills out. In these instructions, the examples are the same size as the notebook pages, but they are labeled.

In these instructions, all other example documents are labeled.

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 Mentors) – 19 minutes
Variable Discussion (SciTrek Lead) – 5 minutes
Variables (SciTrek Mentors) – 12 minutes
Wrap-Up (SciTrek Lead) – 2 minutes

Materials:

(3) Mentor Boxes:

☐ Nametags
☐ (NS+1) Notebooks
☐ Mentor instructions
☐ (12) Clear rulers
☐ Paper towels
☐ Water (8 oz)
☐ Dropper
☐ $NaHCO_3$ exact container (2.4 g)
☐ $NaCl$ exact container (4.0 g)
☐ $CaCl_2$ exact container (6.0 g)

☐ Picture of experimental set-up
☐ Mentor lab coat
☐ (2) Pencils
☐ (2) Dry erase markers
☐ Scale
☐ Thermometer
☐ 100 mL Graduated cylinder
☐ 250 mL Beaker
☐ Magnetic stir bar
☐ Set of (4) labeled weigh boats ($NaHCO_3$, NaCl, $CaCl_2$, Mix)
☐ Plastic lid

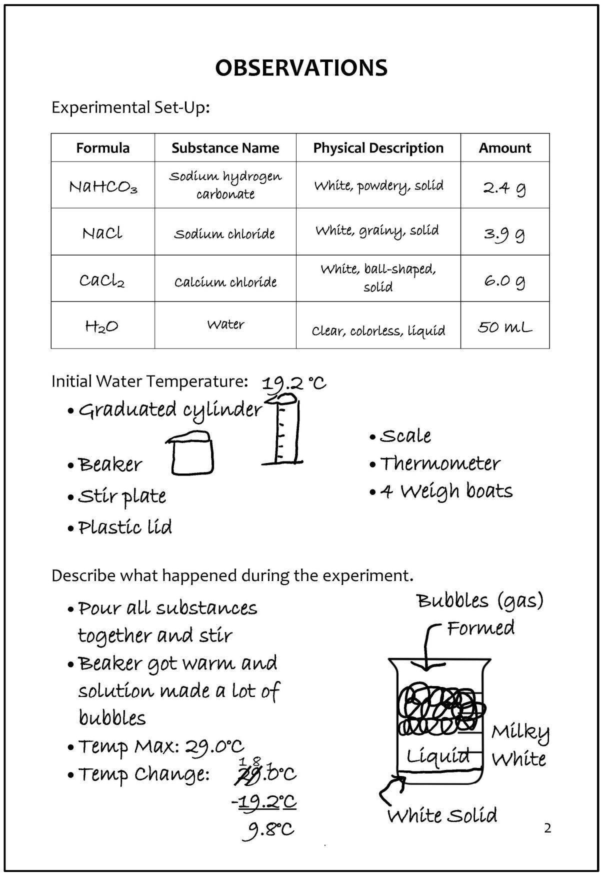
Other Supplies:

☐ (3) Notepads
☐ Bucket with lid
☐ (3) Trays
☐ Box with (6) stir plates and (3) extension cords

Lead Box:

☐ (3) Blank nametags
☐ (3) Extra 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
☐ (2) Black pens
☐ (3) Markers (orange, blue, green)
☐ (5) Clear rulers
☐ Paper towels
☐ Water (8 oz)
☐ Dropper
☐ Scale
☐ Thermometer
☐ 100 mL Graduated cylinder
☐ 250 mL Beaker
☐ $NaHCO_3$ exact container (2.4 g)
☐ NaCl exact container (4.0 g)
☐ $CaCl_2$ exact container (6.0 g)
☐ Container with (3) magnetic stir bars
☐ Set of (4) labeled weigh boats ($NaHCO_3$, NaCl, $CaCl_2$, Mix)
☐ (3) Plastic lids

Notepad and Notebook Pages:



OBSERVATIONS

Experimental Set-Up:

Formula	Substance Name	Physical Description	Amount
$NaHCO_3$	Sodium hydrogen carbonate	White, powdery, solid	2.4 g
NaCl	Sodium chloride	White, grainy, solid	3.9 g
$CaCl_2$	Calcium chloride	White, ball-shaped, solid	6.0 g
H_2O	Water	Clear, colorless, liquid	50 mL

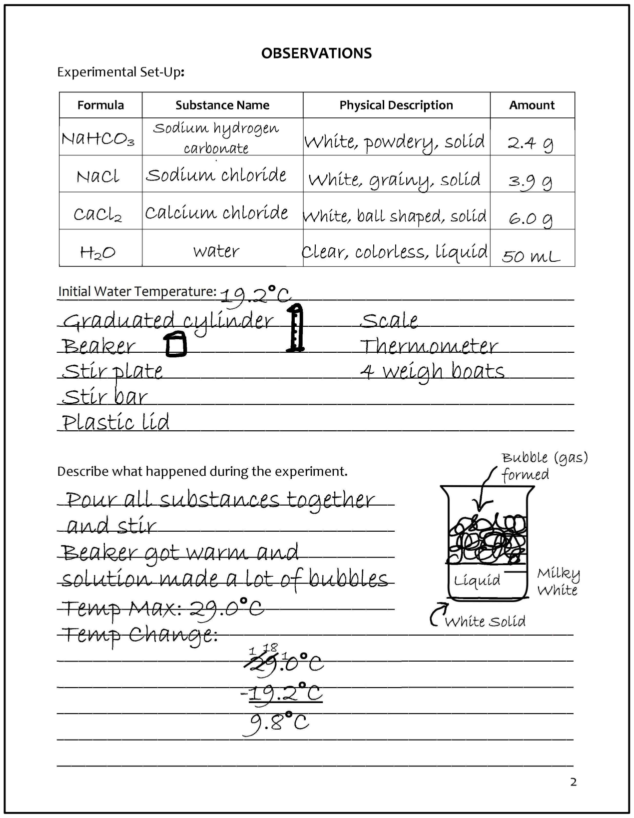
Initial Water Temperature: 19.2 °C

- Graduated cylinder
- Beaker
- Stir plate
- Plastic lid
- Scale
- Thermometer
- 4 Weigh boats

Describe what happened during the experiment.

- Pour all substances together and stir
- Beaker got warm and solution made a lot of bubbles
- Temp Max: 29.0°C
- Temp Change: $\overset{1\,8}{\cancel{29}}$.0°C
  -19.2°C
  9.8°C

2



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Initial Water Temperature: 19.2°C

Graduated cylinder
Beaker
Stir plate
Stir bar
Plastic lid
Scale
Thermometer
4 weigh boats

Describe what happened during the experiment.

Pour all substances together and stir
Beaker got warm and solution made a lot of bubbles
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Temp Change:
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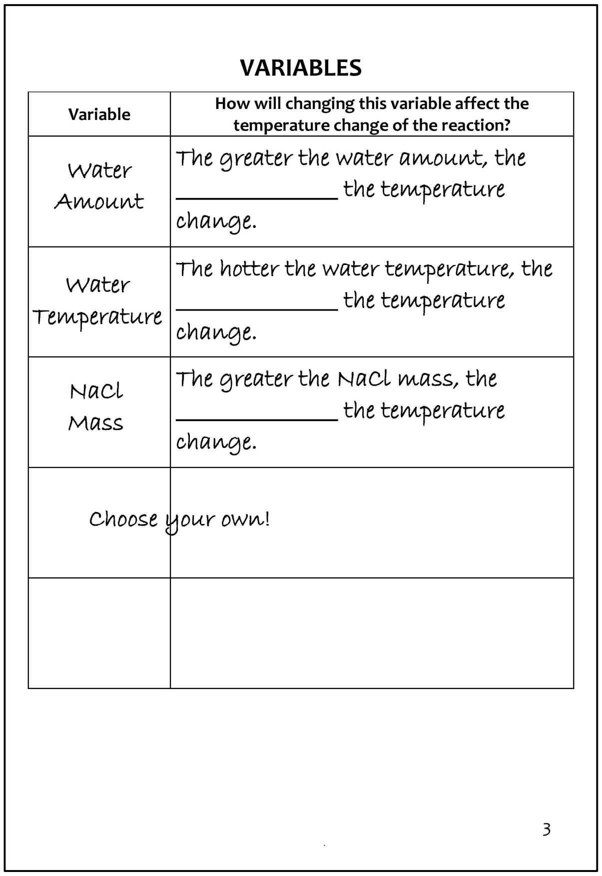
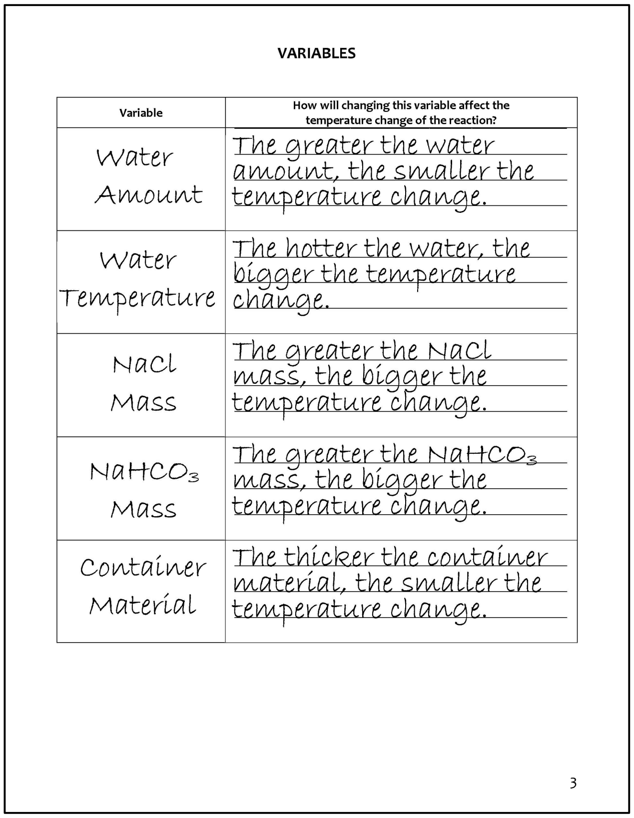
2



VARIABLES

Variable	How will changing this variable affect the temperature change of the reaction?
Water Amount	The greater the water amount, the ______________ the temperature change.
Water Temperature	The hotter the water temperature, the ______________ the temperature change.
NaCl Mass	The greater the NaCl mass, the ______________ the temperature change.
Choose your own!	

3



VARIABLES

Variable	How will changing this variable affect the temperature change of the reaction?
Water Amount	The greater the water amount, the smaller the temperature change.
Water Temperature	The hotter the water, the bigger the temperature change.
NaCl Mass	The greater the NaCl mass, the bigger the temperature change.
$NaHCO_3$ Mass	The greater the $NaHCO_3$ mass, the bigger the temperature change.
Container Material	The thicker the container material, the smaller the temperature change.

3

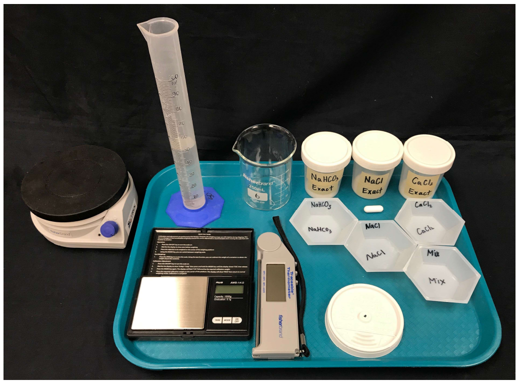
Preparation:

SciTrek Lead:

1. Make sure mentors are writing their name and group color on the whiteboard.
2. Make sure mentors are passing out nametags.
3. Make sure mentors are setting up for the initial observation.
4. Set up the document camera for the analysis assessment and class question (notebook, front cover).
5. Set the following out: scale, weigh boat, stir plate, stir bar, and thermometer to show during the observation discussion.
6. Pass out the analysis assessments.

SciTrek Mentors:

1. On the front whiteboard in the classroom, write your name and the color of the group (orange, blue, or green) you will be working with.
2. Pass out nametags.
    a. You may need to do this during the Introduction. Quietly set each student's nametag on their desk without talking to them. If names are not written on their desk, ask the classroom teacher or lead to help you when they are not talking with the class.
3. Have rulers and notebooks available to pass out.
4. Assemble the experimental set-up (shown in picture below as well as in color in the experimental set-up picture in your group box) on a tray.
    a. Fill a 100 mL graduated cylinder with 50 mL of water and place it on the tray.
    b. Place the scale, beaker, thermometer, 4 labeled weigh boats ($NaHCO_3$, NaCl, $CaCl_2$, Mix), magnetic stir bar, plastic lid, and exact containers of $NaHCO_3$, NaCl, and $CaCl_2$ on the tray.
    c. 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)

For UCSB Lead:
"Hi, we are scientists from UCSB and we want to show you what we do as scientists. We will show you a phenomenon which you can make observations about, come up with a class question, and design your own experiment to help answer the class question."

For Teacher Lead:
"I have asked some scientists from UCSB to come and help us with a long-term science investigation. We will make observations, come up with a class question, and you will design your own experiment to help answer the class question."

Allow the UCSB mentors to introduce themselves and share their majors.

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

Tell students, "Before we start with the module, we will determine how your ideas on analyzing and interpreting data are developing." Have students write their name, teacher's name, and date at the top of the assessment. Tell students, "When doing this assessment, you should work individually, so there should be no talking." As you are giving the assessment, walk around the room and verify students have written their names on their assessments.

For page 1, read the *Directions for annotating* to students. Then, have students annotate the first results table by underlining controls, circling changing variable(s), and boxing information about data collection (question *1a*). Read question *1b* (*Can this group make a conclusion?*) and have students circle *yes*, *no* or I do not *know*. Have students annotate the possible conclusion (question *1c*). 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 the process for questions *2* and *3* (page 2, top).

For page 2 (bottom), have mentors pass out rulers to students. Read the directions for question *4* to students. Then, have students annotate the graph by underlining controls, circling changing variables, and boxing information about data collection. Have students plot the remaining points on the graph using circles as markers. Then, tell students, "Draw trend lines for each experiment on the graph." Read questions *4d-4f* and give students time to answer each. When students are finished, collect the assessments and rulers as well as verify students' names are written on the top of the paper.

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

Have mentors 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 mentor's name, on the front cover of their notebooks. Students will leave the subgroup number, team/subgroup symbol, and class question blank. If a student does not have a nametag, only have them fill out their name and teacher's name on the cover of their notebook. They will be placed in a group when the class divides into groups for observations, and can fill out their group color, and mentor, at that point.

Tell students, "Scientists make many observations." Ask students, "What is an observation? What are the types of things you can record for an observation?" If they have trouble, show them an object and let them make observations. Turn these specific observations into general features of an observation. Examples of possible general observations are: color, texture, size, weight, temperature, etc. Lead students to understand an observation is a description using your five senses.

Tell students, "In this experiment, we are going to make observations of chemicals before, during, and after, a chemical reaction." Have a few students share what happens in a chemical reaction and make sure by the end of the discussion the class understands that during a chemical reaction one or more substances are altered into one or more different substances. Ask students, "What are some of the possible signs a chemical reaction has happened?" Make sure students generate the following: temperature changes, change of state, and color changes. Tell students, "As a class, we will investigate the question, 'What variables affect the temperature change of the chemical reaction?'" Write the class question on the front cover of the class notebook under the document camera, and have students copy it onto their notebooks.

Tell students, "We will need to use several pieces of scientific equipment to study a chemical reaction. One of these is a scale." Put a scale under the document camera. Tell students, "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 0.0 g. Then, place one of the weigh boats on the scale (it does not matter which weigh boat you choose). Have students read the mass of the weigh boat out loud. Ask students, "Do you think the mass of the weigh boat should be included in the mass of the substance we are weighing with it?" Lead students to realize it should not be included. Tell students, "Scientists get rid of the mass of the weigh boat by 'zeroing,' or 'taring' the scale, before they add the substance they want to measure." Show students the 'tare' button and push it to show them the mass goes back to 0.0 g. Tell students, "When recording masses, record them to the nearest tenth (0.1) of a gram."

Tell students, "Another scientific device we will be using is a magnetic stir plate." Show students the stir plate, then, hold up a stir bar. Tell students, "This is a magnetic stir bar and will be used to stir your reactions. You will set the stir plates speed by turning the dial. The most common speed we will use is 'level 2' which is marked with a black dot."

Tell students, "We will also be using digital thermometers, in our experiment, we will need to record the temperatures at the start and end of the reaction." Show students a thermometer. Tell students, "One nice feature of these thermometers is they will remember the maximum and minimum temperatures." Show students the 'Max/Min' button. Tell students, "You will record the temperature at the start of the reaction. Then after the reaction is over, meaning the temperature is no longer dropping or going up, push the Max/Min button and record that temperature."

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

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

Observations:
(19 minutes – Groups – SciTrek Mentors)

Once 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. Have students turn to page 2 of their notebooks.

As a group, have students fill out the table with descriptions and amounts (mass or volume), of water, sodium hydrogen carbonate ($NaHCO_3$), sodium chloride (NaCl), and calcium chloride ($CaCl_2$). You will need to give students the names of the substances. Do not tell students the common names of the substances (Ex: baking soda or 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 notepad under *Experimental Set-Up*, then copied by students into their notebooks. The table should take you no longer than 7 minutes to fill out.

As a group, generate approximately six observations about the experimental set-up (aside from the information in the table). Write these on the notepad, while students copy them into their notebooks. Make sure at least the following observations are included: graduated cylinder (with picture), 250 mL and beaker (with picture).

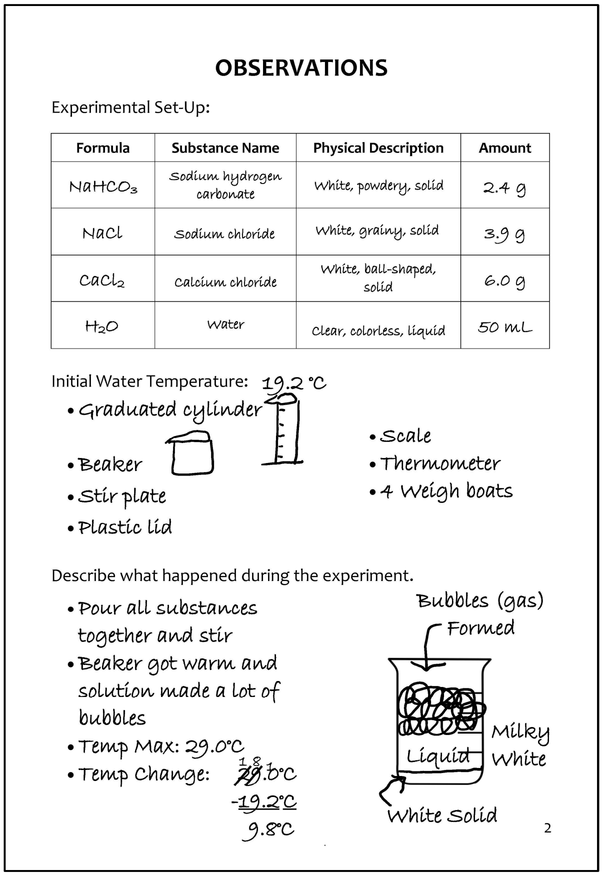
Pour the water from the graduated cylinder into the beaker, and add the stir bar. Then, open the thermometer, place it through the center of the lid, and put the lid on the beaker, so the thermometer rests in the water. Begin stirring by turning the stir plate dial to the black mark (level 2), and then wait a few moments to allow the water temperature to stabilize. Then, ask students, "What temperature should we record?" Record this temperature on the notepad while students record it in their notebooks. A picture of this set-up is shown to the right.

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. While the reaction is taking place, you can tell me what you observe, and I will record it on the notepad. After the reaction is complete, you will be able to copy the observations into your notebooks." Have students tell you what you are going to do (pour all substances together and stir), and record it on the notepad. Tell students, "If the temperature goes up, we will record the highest temperature and if the temperature goes down, we will record the lowest temperature, therefore, we need to watch the thermometer to see what happens and identify when the temperature starts to come back to room temperature." When the students are ready, carefully lift the lid so 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 after the solids are added, 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, and starts decreasing again, hit the Max/Min temperature button on the thermometer and record the maximum temperature on the notepad. Have students copy down what you wrote on the notepad during the reaction. In addition, have them draw what happened during the reaction, in the beaker.

Ask students, “How can we determine the temperature change caused by the reaction?” Guide students to understand, they can subtract the initial temperature, from the final (maximum) temperature. Do this math on the notepad, and have students copy it into their notebooks. **Note**: The temperature change should be ~10°C, which corresponds to a change of ~18°F. Do not tell this to students unless they specifically ask what the change in Fahrenheit temperature would be.

Ask students, “Did a chemical reaction happen when the substances were poured into the water and if so what evidence do you have that a reaction happened?” Call on a few students to share the evidence they observed to confirm a chemical reaction occurred. Possible student response: Yes, a chemical reaction happened because we saw a change in state (gas formed), color, and temperature.

If there is additional time, have students write a summary of what happened during the experiment. An example filled-out observations is shown below.



OBSERVATIONS

Experimental Set-Up:

Formula	Substance Name	Physical Description	Amount
$NaHCO_3$	Sodium hydrogen carbonate	White, powdery, solid	2.4 g
NaCl	Sodium chloride	White, grainy, solid	3.9 g
$CaCl_2$	Calcium chloride	White, ball-shaped, solid	6.0 g
H_2O	Water	Clear, colorless, liquid	50 mL

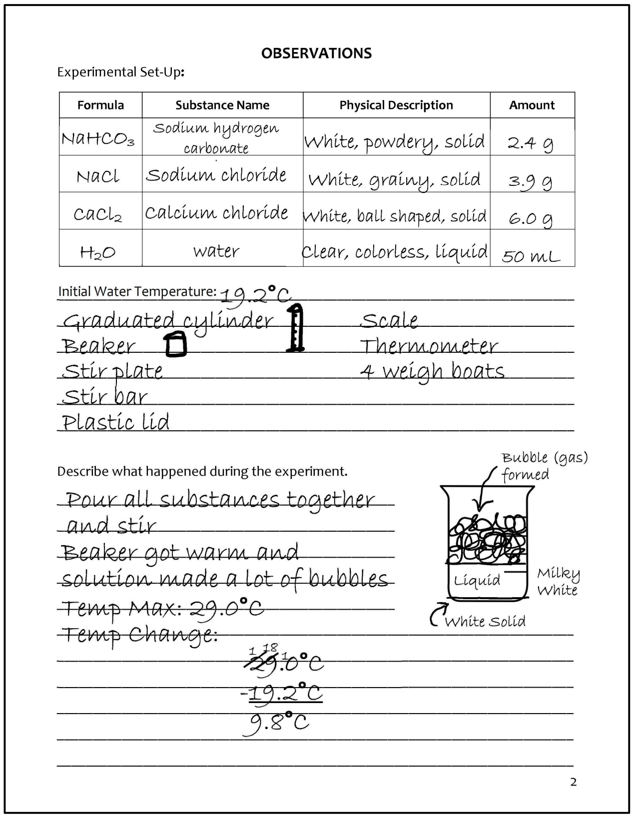
Initial Water Temperature: 19.2 °C

- Graduated cylinder
- Beaker
- Stir plate
- Plastic lid
- Scale
- Thermometer
- 4 Weigh boats

Describe what happened during the experiment.

- Pour all substances together and stir
- Beaker got warm and solution made a lot of bubbles
- Temp Max: 29.0°C
- Temp Change: $\overset{1\ 18}{\cancel{29}}.0^\circ C$ $-\underline{19.2^\circ C}$ $9.8^\circ C$

2



OBSERVATIONS

Experimental Set-Up:

Formula	Substance Name	Physical Description	Amount
$NaHCO_3$	Sodium hydrogen carbonate	White, powdery, solid	2.4 g
NaCl	Sodium chloride	White, grainy, solid	3.9 g
$CaCl_2$	Calcium chloride	White, ball shaped, solid	6.0 g
H_2O	water	Clear, colorless, liquid	50 mL

Initial Water Temperature: 19.2°C

Graduated cylinder
Beaker
Stir plate
Stir bar
Plastic lid
Scale
Thermometer
4 weigh boats

Describe what happened during the experiment.

Pour all substances together and stir
Beaker got warm and solution made a lot of bubbles
Temp Max: 29.0°C
Temp Change:
$\overset{1\ 18}{\cancel{29}}.0^\circ C$
$-\underline{19.2^\circ C}$
$9.8^\circ C$

2

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

Ask the class questions to review the experiment they carried out. Make sure by the end of the discussion, students have described the set-up and identified what happened when the substances were mixed together. Make sure students understand that a chemical reaction must have occurred, because they observed an increase in temperature, color change, and a change in state (formation of bubbles/gas).

Ask the class, “What is the class question?” They should reply, “What variables affect the temperature change of the chemical reaction?”

Lead students through the following questions, and explanations.

What does the word ‘variable’ mean to a scientist?

variables are the parts of the experiment you can change

Do you think there are multiple variables that will affect the temperature change of the chemical reaction?

multiple variables might affect the temperature change of the chemical reaction

Explain, this is why we will need to work as a class to answer the class question: “What variables affect the temperature change of the chemical reaction?”

Tell the class, “You are going to think about variables, in the experiment, you could change, in order to help us answer the class question. In addition to generating variables, you should think about how and/or why, these variables might affect the outcome of the experiment.” Ask the class, “What do you think is a variable that might affect the temperature change?” Then, have them tell you how and why they think that variable would affect the temperature change. Probe them on how they would design an experiment to test whether this variable affected the temperature change. Finally, have the students make a prediction of the results for the experiment they proposed. Remind students, “Predictions can be wrong, and we will not know the true answers until we carry out the experiment.”

Ex: *Variable:* sodium chloride mass

Why might this variable affect the temperature change of the reaction? 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.

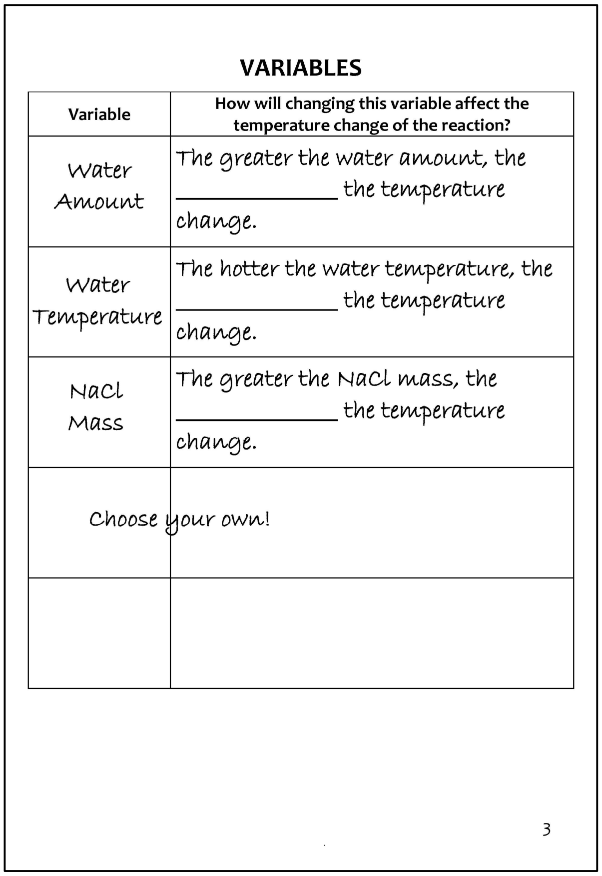
Tell students, “You will now generate more variables and analyze them, in your groups.”

Variables:

(12 minutes – Groups – SciTrek Mentors)

As a group, generate a variable and make a prediction about how it could affect the temperature change of the chemical reaction. The question focuses on this chemical reaction, therefore, do not allow students to propose adding new substance to the reaction. Encourage and challenge students to explain why they think their prediction is correct and how this variable could affect the temperature change of the reaction . If needed, you can write down a sentence frame for students to use. Repeat this process two more times, record these ideas on the notepad and have students copy them into their notebooks. Next, students will individually generate additional variables, make predictions about how different values of these variables will affect the temperature change, and record their ideas in their notebooks. Have students share these ideas with the group.

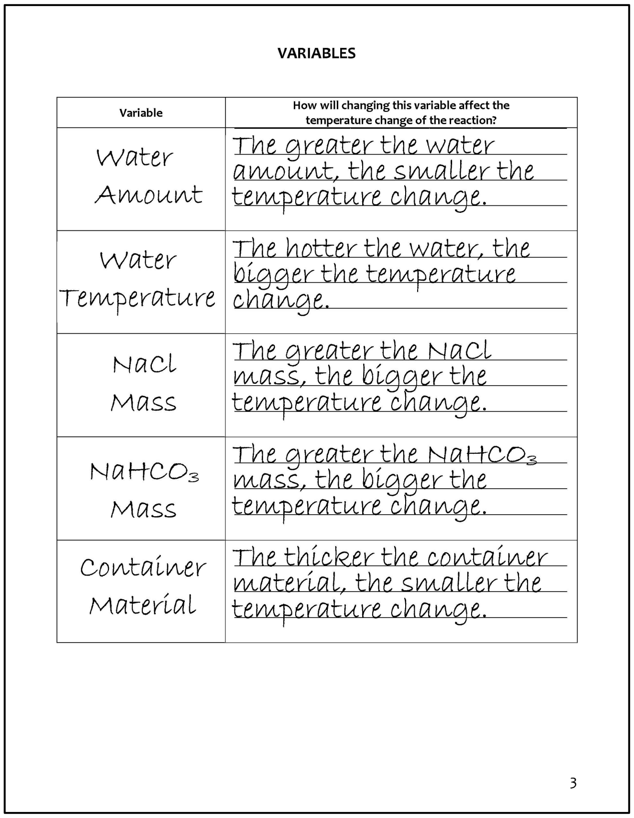
Prepare one student to share a variable and why they think it will affect the temperature change of the reaction, during the class discussion.



VARIABLES

Variable	How will changing this variable affect the temperature change of the reaction?
Water Amount	The greater the water amount, the ______________ the temperature change.
Water Temperature	The hotter the water temperature, the ______________ the temperature change.
NaCl Mass	The greater the NaCl mass, the ______________ the temperature change.
Choose your own!	

3



VARIABLES

Variable	How will changing this variable affect the temperature change of the reaction?
Water Amount	The greater the water amount, the smaller the temperature change.
Water Temperature	The hotter the water, the bigger the temperature change.
NaCl Mass	The greater the NaCl mass, the bigger the temperature change.
$NaHCO_3$ Mass	The greater the $NaHCO_3$ mass, the bigger the temperature change.
Container Material	The thicker the container material, the smaller the temperature change.

3

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

Have one student from each group share a variable they generated, as well as how and why they think it will affect the temperature change or the reaction. Make sure, students tell you their predictions about how different values of that variable will affect the temperature change of the reaction.

Tell students, "Next session, you will design an experiment to answer the class question: What variables affect the temperature change of the chemical reaction?"

Clean-Up:

1. Collect notebooks with attached nametags.
2. Put the beaker, stir bar, $CaCl_2$ weigh boat, and mix weigh boat (all other weigh boats should go in your group box) into the bucket.
3. Wipe the thermometer with a paper towel and close it, before you put it back into your group box.
4. Return the stir plates, plugs, and extension cords, to the stir plate box.
5. Place all other materials into your group box and bring them back to UCSB.

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

Schedule:

Introduction (SciTrek Lead) – 12 minutes
Question (SciTrek Mentors) – 9 minutes
Materials Page (SciTrek Mentors) – 7 minutes
Experimental Set-Up (SciTrek Mentors) – 8 minutes
Procedure (SciTrek Mentors) – 18 minutes
Results Table (SciTrek Mentors) – 3 minutes
Wrap-Up (SciTrek Lead) – 3 minutes
*If there is extra time, do the claim, data, and opinion extra practice (notebook, page 31).

Materials:

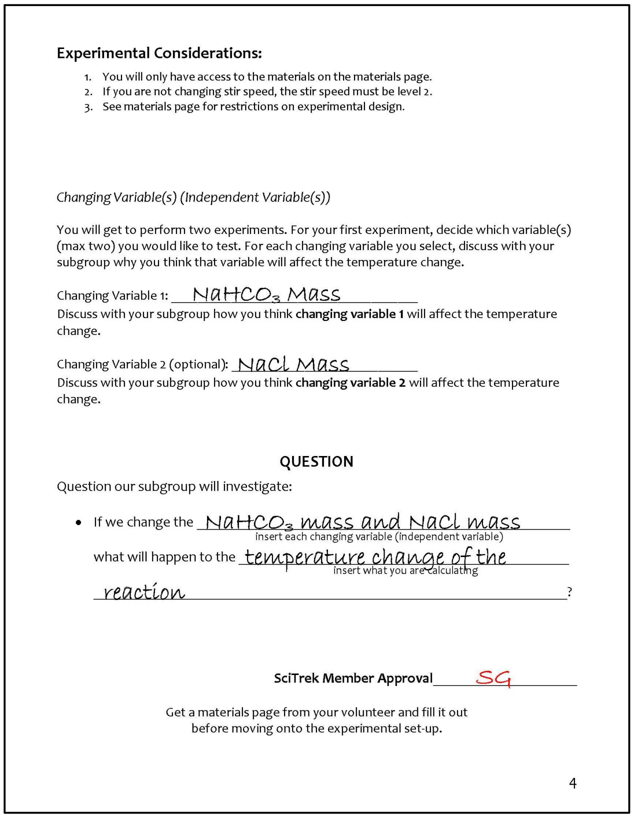
(3) Mentor Boxes:

☐ Nametags
☐ Notebooks
☐ Mentor instructions
☐ Mentor lab coat
☐ (2) Materials pages (subgroup color & number indicated)
☐ (2) Pencils
☐ (2) Red pens
☐ Paper notepad

Lead Box:

☐ (3) Blank nametags
☐ (3) Extra notebooks
☐ Lead instructions
☐ Thermal Transfer picture packet
☐ Lead lab coat
☐ (2) Materials pages
☐ Time card
☐ (2) Pencils
☐ (2) Red pens
☐ (2) Wet erase markers
☐ (2) Black pens
☐ (3) Markers (orange, blue, green)
☐ Paper notepad
☐ Scoopula

Notebook Pages:



Experimental Considerations:

1. You will only have access to the materials on the materials page.
2. If you are not changing stir speed, the stir speed must be level 2.
3. 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) you would like to test. For each changing variable you select, discuss with your subgroup why you think that variable will affect the temperature change.

Changing Variable 1: $NaHCO_3$ Mass

Discuss with your subgroup how you think **changing variable 1** will affect the temperature change.

Changing Variable 2 (optional): NaCl Mass

Discuss with your subgroup how you think **changing variable 2** will affect the temperature change.

QUESTION

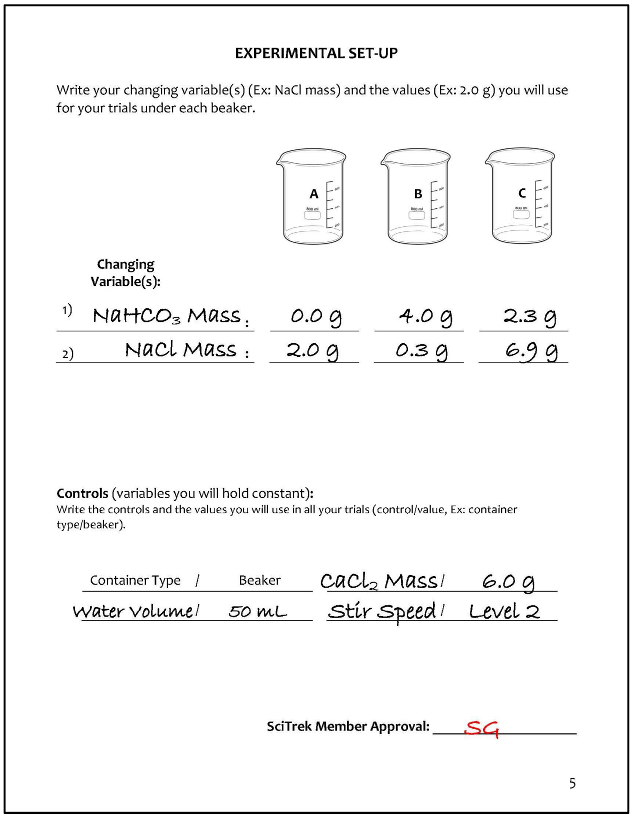
Question our subgroup will investigate:

- If we change the $NaHCO_3$ mass and NaCl mass
  insert each changing variable (independent variable)
  what will happen to the temperature change of the
  insert what you are calculating
  reaction?

SciTrek Member Approval SG

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

4



EXPERIMENTAL SET-UP

Write your changing variable(s) (Ex: NaCl mass) and the values (Ex: 2.0 g) you will use for your trials under each beaker.

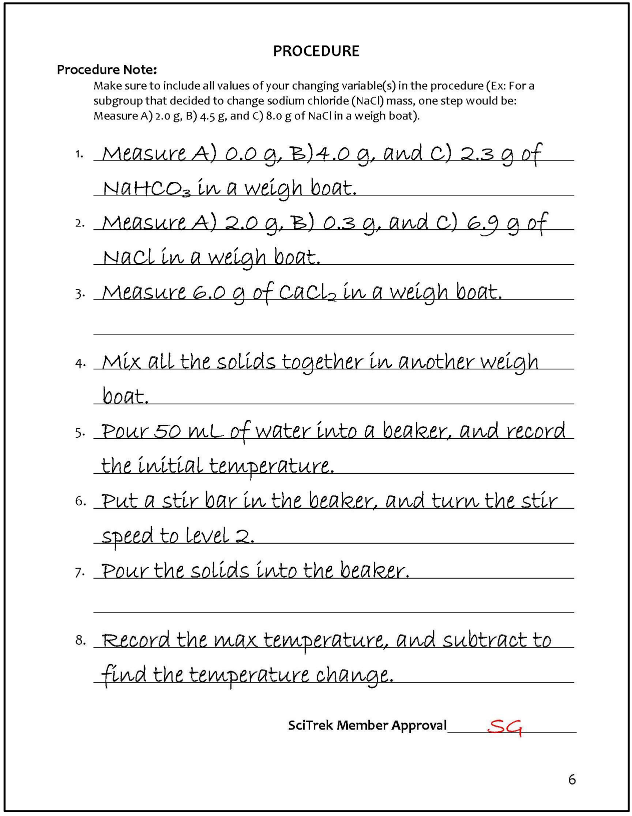
Changing Variable(s):	A	B	C
1) $NaHCO_3$ Mass :	0.0 g	4.0 g	2.3 g
2) NaCl Mass :	2.0 g	0.3 g	6.9 g

Controls (variables you will hold constant)**:**
Write the controls and the values you will use in all your trials (control/value, Ex: container type/beaker).

Container Type / Beaker
$CaCl_2$ Mass / 6.0 g
Water Volume / 50 mL
Stir Speed / Level 2

SciTrek Member Approval: SG

5



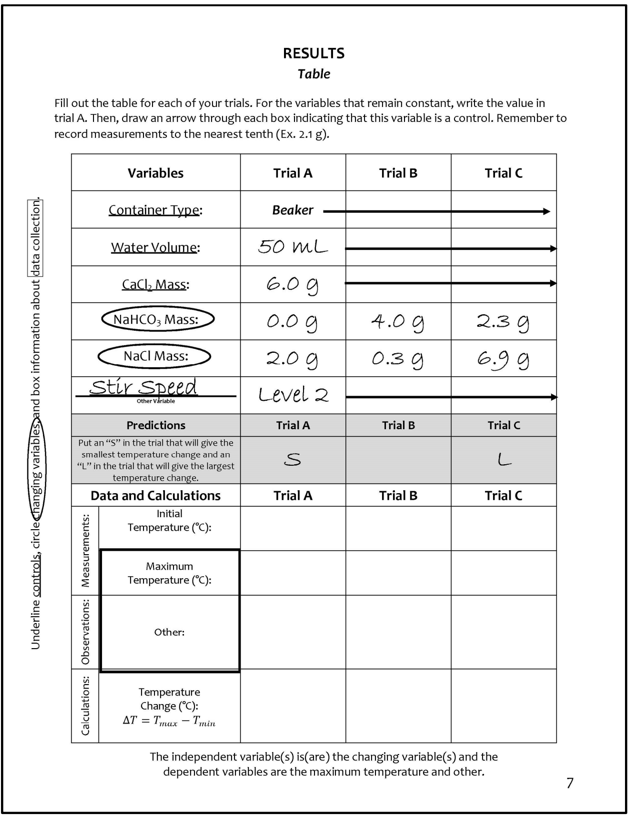
PROCEDURE

Procedure Note:
Make sure to include all values of your changing variable(s) in the procedure (Ex: For a subgroup that decided to change sodium chloride (NaCl) mass, one step would be: Measure A) 2.0 g, B) 4.5 g, and C) 8.0 g of NaCl in a weigh boat).

1. Measure A) 0.0 g, B) 4.0 g, and C) 2.3 g of $NaHCO_3$ in a weigh boat.
2. Measure A) 2.0 g, B) 0.3 g, and C) 6.9 g of NaCl in a weigh boat.
3. Measure 6.0 g of $CaCl_2$ in a weigh boat.
4. Mix all the solids together in another weigh boat.
5. Pour 50 mL of water into a beaker, and record the initial temperature.
6. Put a stir bar in the beaker, and turn the stir speed to level 2.
7. Pour the solids into the beaker.
8. Record the max temperature, and subtract to find the temperature change.

SciTrek Member Approval SG

6



RESULTS

Table

Fill out the table for each of your trials. For the variables that remain constant, write the value in trial A. Then, draw an arrow through each box indicating that this variable is a control. Remember to record measurements to the nearest tenth (Ex. 2.1 g).

Underline controls, circle changing variables, and box information about data collection.

Variables	Trial A	Trial B	Trial C
Container Type:	***Beaker*** →	→	→
Water Volume:	50 mL	→	→
$CaCl_2$ Mass:	6.0 g	→	→
$NaHCO_3$ Mass:	0.0 g	4.0 g	2.3 g
NaCl Mass:	2.0 g	0.3 g	6.9 g
Stir Speed Other Variable	Level 2	→	→
Predictions	**Trial A**	**Trial B**	**Trial C**
Put an "S" in the trial that will give the smallest temperature change and an "L" in the trial that will give the largest temperature change.	S		L
Data and Calculations	**Trial A**	**Trial B**	**Trial C**
Measurements: Initial Temperature (℃):			
Measurements: Maximum Temperature (℃):			
Observations: Other:			
Calculations: Temperature Change (℃): $\Delta T = T_{max} - T_{min}$			

The independent variable(s) is(are) the changing variable(s) and the dependent variables are the maximum temperature and other.

7

Preparation:

SciTrek Lead:

1. Make sure mentors are setting out notebooks in such a way that allows students within the same subgroup to work together.
2. Set up the document camera for the Introduction (notebook, pages 4-5; materials page; picture packet, page 1).

SciTrek Mentors:

1. Set out notebooks/nametags to allow students in the same subgroup (same number on the front of their notebook) to work together.
2. Make sure you have two materials pages, each filled out with a subgroup number (1 or 2) and your group's color, to give to subgroups after they complete their question.
3. Have a red pen available to approve subgroups' questions, experimental set-ups, and procedures (notebook, pages 4-6).

Note: Set notebooks where students will sit during the module, even if another student is currently at that desk. If needed, students will move to these spots after the Introduction.

Introduction:

(12 minutes – Full Class – SciTrek Lead)

If students are not in their subgroups, tell them, "A notebook will be put on your desk, which is not your notebook and you should not move it. You will move to your notebook after the Introduction."

Ask students, "What did we do and learn during our last session?" Possible student response: we mixed three chemicals in water and observed a chemical reaction, which resulted in a temperature change. We also generated variables that might affect the temperature change. Make sure they remember the names of the chemicals: sodium chloride ($NaCl$), calcium chloride ($CaCl_2$), and sodium hydrogen carbonate ($NaHCO_3$). Ask the class, "What is the class question we will be investigating?" Students should reply, "What variables affect the temperature change of the chemical reaction?"

Tell students, "One way scientists answer questions is by performing experiments. Today, you will design an experiment to help answer the class question." Ask the class, "Do you think there are multiple variables that could affect the temperature change?" Possible student response: there are probably multiple variables.

Explain to students, "Many times, when there is a broad question, like our class question, scientists break it down into smaller, more specific questions which small groups of scientists can investigate. The scientists then compile their work to answer the broader question. 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."

Subgroups will first generate a question based on the changing variable(s) they plan to explore. They will then fill out their 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 an experiment. Go over the experimental considerations (notebook, page 4) with students so they understand the limitations in the experiments they can design.

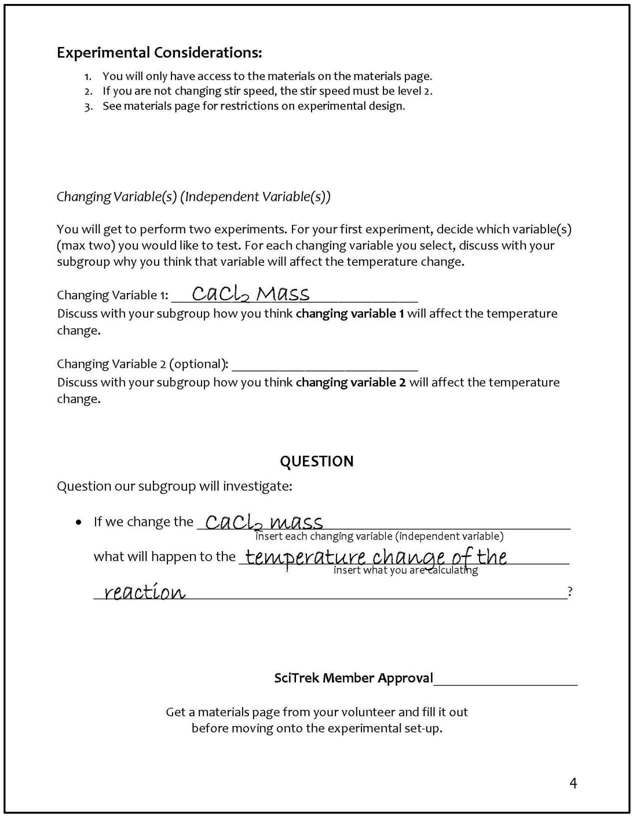
Experimental Considerations:

1. *You will only have access to the materials on the materials page.*
2. *If you are not changing stir sped, the stir speed must be level 2.*
3. *See materials page for restrictions on experimental design.*

Tell students, “We are now going to generate an example question/experimental set-up together. I will write it in the class notebook, so you will be able to refer back to it when you are completing the process yourselves.” Make sure students **do not** fill out the example question/experimental set-up in their notebooks, as they will be completing these pages for their own experiments in subgroups.

Tell students, “For the example experiment, the changing variable will be $CaCl_2$ mass.” **Note:** As an alternative, you can pick $NaHCO_3$ or NaCl as the changing variable. Then, write down the changing variable in the class notebook (notebook, page 4), under the document camera. Tell students, “When you are going through this process in your subgroups, you may select one or two changing variables.”

Show students how to insert the changing variable and what they plan to calculate, into the question frame to generate the question that will be investigated, “If we change the $\underline{CaCl_2\text{ mass,}}$ what will happen to the $\underline{\text{temperature change of the reaction}}$?”



Experimental Considerations:

1. You will only have access to the materials on the materials page.
2. If you are not changing stir speed, the stir speed must be level 2.
3. 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) you would like to test. For each changing variable you select, discuss with your subgroup why you think that variable will affect the temperature change.

Changing Variable 1: $CaCl_2$ Mass

Discuss with your subgroup how you think **changing variable 1** will affect the temperature change.

Changing Variable 2 (optional): ______________

Discuss with your subgroup how you think **changing variable 2** will affect the temperature change.

QUESTION

Question our subgroup will investigate:

- If we change the $CaCl_2$ mass
  insert each changing variable (independent variable)
  what will happen to the temperature change of the
  insert what you are calculating
  reaction?

SciTrek Member Approval______________

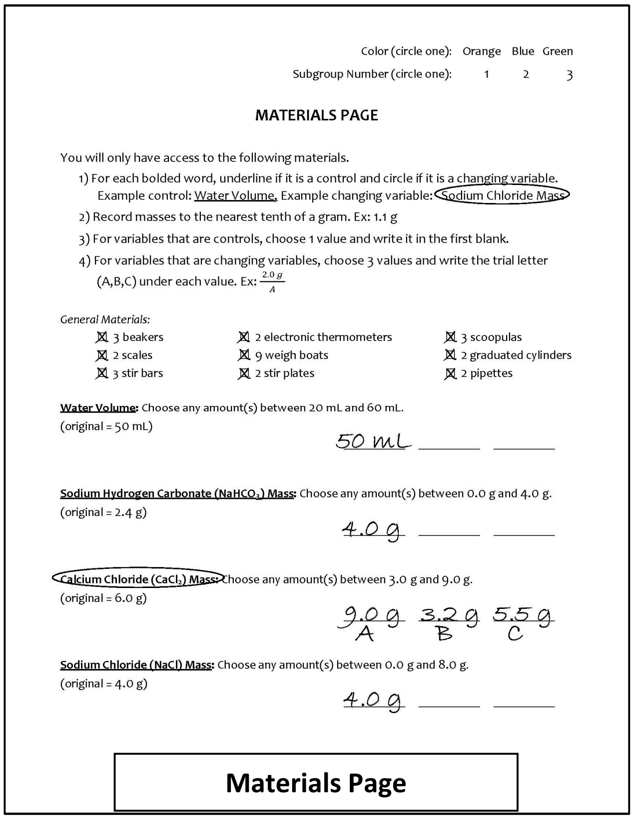
Get a materials page from your volunteer and fill it out
before moving onto the experimental set-up.

4

Tell students, “Once you have determined your question, and have approval, your mentor will give you a materials page for determining the values of your controls and changing variable(s).” Ask students, “What is a control?” Make sure, by the end of the conversation, students understand 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 control values, can be different from the original experiment they conducted on Day 1, but must remain constant throughout all the trials they do for this experiment.

Show students the materials page (lead box), and read the first step (*For each bolded word, underline if it is a control and circle if it is a changing variable*.). Then, have students tell you what to do for each bolded word. Read steps 2 through 4 on the 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, choose 3 values and write the trial letter (A, B, C) under each value.*). Read the general materials to students, ask them if they need each one, and check the box when they say yes. When you get to ‘scoopula,’ show them the scoopula in the lead box and tell them, “This will be used to scoop the chemicals.”

Go through the remaining items on the materials page. If a variable is a control, then choose (do not let students choose) a single value, such as the original value (Ex: 50 mL for water volume). Make sure to follow all restrictions listed (Ex: $NaHCO_3$ mass may only be between 0.0 g – 4.0 g). Assign each control value to a student, and tell them, “You are in charge of remembering this control, and its value, to help when filling out the experimental set-up.” For the variable that is the changing variable, allow students to select the values. Make sure students are giving you mass values to the nearest tenth of a gram. Make sure to follow all restrictions listed (Ex: $NaHCO_3$ masses may only be between 0.0 g and 4.0 g). Write the trial letter under each selected value. Ask students, “Do we want a narrow, or wide, range of changing variable values and why?” Guide students through selecting a wide range of values for the changing variable. If they choose a value contrary to their proposed 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, “Would the selected values allow us to best answer the question?” Allow them to change their values if needed. Assign the changing variable values to the students who chose them to remember for the experimental set-up.



Color (circle one): Orange Blue Green
Subgroup Number (circle one): 1 2 3

MATERIALS PAGE

You will only have access to the following materials.

1) For each bolded word, underline if it is a control and circle if it is a changing variable.
   Example control: Water Volume, Example changing variable: Sodium Chloride Mass
2) Record masses to the nearest tenth of a gram. Ex: 1.1 g
3) For variables that are controls, choose 1 value and write it in the first blank.
4) For variables that are changing variables, choose 3 values and write the trial letter (A,B,C) under each value. Ex: $\frac{2.0\ g}{A}$

General Materials:

☒ 3 beakers
☒ 2 scales
☒ 3 stir bars
☒ 2 electronic thermometers
☒ 9 weigh boats
☒ 2 stir plates
☒ 3 scoopulas
☒ 2 graduated cylinders
☒ 2 pipettes

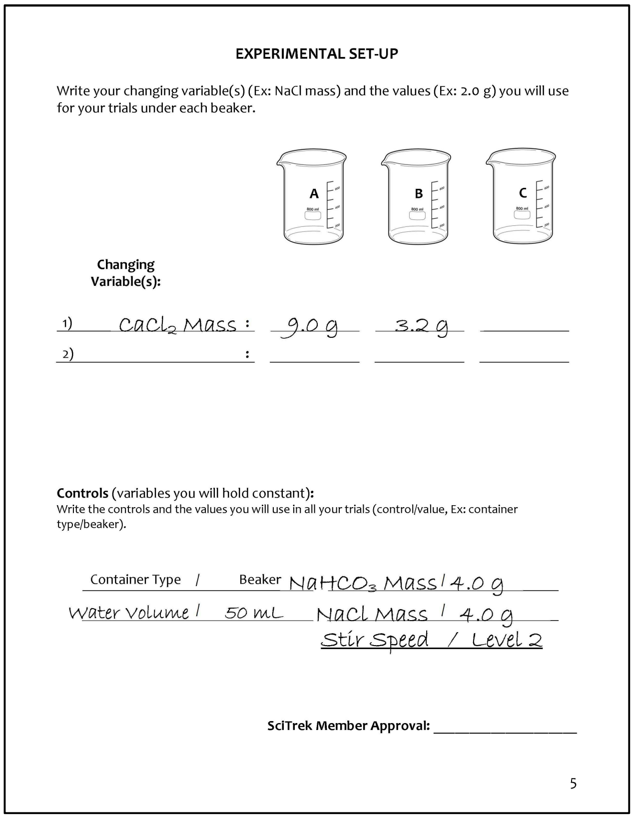
Water Volume: Choose any amount(s) between 20 mL and 60 mL.
(original = 50 mL)
50 mL ______ ______

Sodium Hydrogen Carbonate ($NaHCO_3$) Mass: Choose any amount(s) between 0.0 g and 4.0 g.
(original = 2.4 g)
4.0 g ______ ______

Calcium Chloride ($CaCl_2$) Mass: Choose any amount(s) between 3.0 g and 9.0 g.
(original = 6.0 g)
$\frac{9.0\ g}{A}$ $\frac{3.2\ g}{B}$ $\frac{5.5\ g}{C}$

Sodium Chloride (NaCl) Mass: Choose any amount(s) between 0.0 g and 8.0 g.
(original = 4.0 g)
4.0 g ______ ______

Materials Page



EXPERIMENTAL SET-UP

Write your changing variable(s) (Ex: NaCl mass) and the values (Ex: 2.0 g) you will use for your trials under each beaker.

Changing Variable(s):

1) $CaCl_2$ Mass : 9.0 g 3.2 g ______
2) ______ : ______ ______ ______

Controls (variables you will hold constant)**:**
Write the controls and the values you will use in all your trials (control/value, Ex: container type/beaker).

Container Type / Beaker
$NaHCO_3$ Mass / 4.0 g
Water Volume / 50 mL
NaCl Mass / 4.0 g
Stir Speed / Level 2

SciTrek Member Approval: ______________

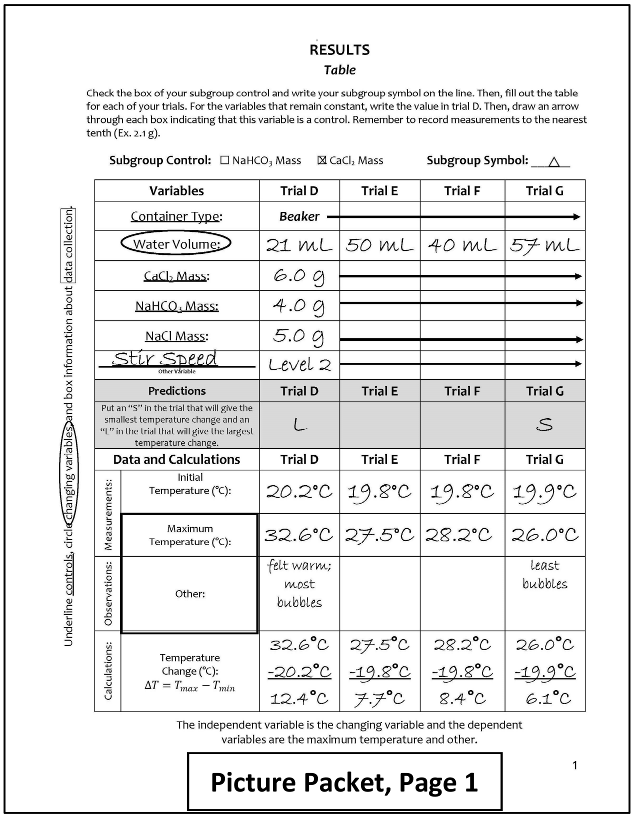
5

Tell students, “Once you have completed your materials page, you will fill out your experimental set-up. First, you will fill out the information on the changing variable(s).” Ask students, “What is the changing variable for the example experiment, and what values did we select?” Then, fill in the values, for trials A and B only. Tell students, “Second, you will fill in information about your controls.” Draw an additional control line under the existing control list. Ask students, “What is one of the controls, and its value, for the example experiment?" Show students how to record the control on the left side of the slash (Ex: water volume), and the value of that control on the right side of the slash (Ex: 50 mL) by doing so in the class notebook. There are four possible variables to choose from on the materials page. If a subgroup changes two variables, they will be left with one control blank empty after inserting in the information from the materials page. Since all control blanks must be filled out, tell students, "You may need to generate an additional control that does not come from the materials page." Lead students to realize this should be "stir speed/level 2."

Ask students, "Should everyone choose the same changing variable and why or why not?" Possible student response: no, because we will not learn as much about the class question. Tell students, "This means you should try to explore a changing variable you think few other subgroups are exploring. Once your subgroup has completed your experimental set-up, you should raise your hands and get it approved by your mentor." Above is an example of what should be filled out for the experimental set-up in the class notebook. Note that several sections are left blank by the lead, but students will fill these in for their own notebooks.

Tell students, "After you finish your experimental set-up, you will write a procedure for your experiment that you will be able to follow next session. When writing a procedure, you should include all values of your controls, and changing variable(s), as well as what data you will collect and what you will calculate." Show students the example procedure step on page 6 of their notebook (*Measure A) 2.0 g, B) 4.0 g, and D) 8.0 g of NaCl in a weigh boat*). Tell students, "Once your procedure is completed, you will get it approved by a mentor."

Tell students, "After you write your procedure you will fill out your results table." Put the filled-out results table (picture packet, page 1, below) under the document camera. **Note:** This is the results table for experiment 2, but it can be used to show students what to do with controls and changing variables. Tell students, "You should first underline controls, circle changing variables, and box information about data collection. For controls, you will write the control value in the *Trial A* box. Then, draw an arrow through the remaining trials' boxes. For the changing variable(s), you will write the changing variable value in each box." Show students both of these on the filled-out results table. Tell students, "Once you have filled out your results table, you will make predictions about which trial will produce the smallest and largest temperature changes. You will write an 'S' in the box of the trial you think will produce the smallest temperature change, and an 'L' in the box of the trial you think will produce the largest temperature change. If you think all trials will produce the same temperature change, you will write 'same' over all boxes."



RESULTS

Table

Check the box of your subgroup control and write your subgroup symbol on the line. Then, fill out the table for each of your trials. For the variables that remain constant, write the value in trial D. Then, draw an arrow through each box indicating that this variable is a control. Remember to record measurements to the nearest tenth (Ex. 2.1 g).

Subgroup Control: ☐ $NaHCO_3$ Mass ☒ $CaCl_2$ Mass **Subgroup Symbol:** △

Underline controls, circle changing variables, and box information about data collection.

Variables	Trial D	Trial E	Trial F	Trial G
Container Type:	**Beaker**	→	→	→
Water Volume:	21 mL	50 mL	40 mL	57 mL
$CaCl_2$ Mass:	6.0 g	→	→	→
$NaHCO_3$ Mass:	4.0 g	→	→	→
NaCl Mass:	5.0 g	→	→	→
Stir Speed Other Variable	Level 2	→	→	→

Predictions	Trial D	Trial E	Trial F	Trial G
Put an "S" in the trial that will give the smallest temperature change and an "L" in the trial that will give the largest temperature change.	L			S

Data and Calculations		Trial D	Trial E	Trial F	Trial G
Measurements:	Initial Temperature (℃):	20.2°C	19.8°C	19.8°C	19.9°C
	Maximum Temperature (℃):	32.6°C	27.5°C	28.2°C	26.0°C
Observations:	Other:	felt warm; most bubbles			least bubbles
Calculations:	Temperature Change (℃): $\Delta T = T_{max} - T_{min}$	32.6°C -20.2°C 12.4°C	27.5°C -19.8°C 7.7°C	28.2°C -19.8°C 8.4°C	26.0°C -19.9°C 6.1°C

The independent variable is the changing variable and the dependent variables are the maximum temperature and other.

1

Picture Packet, Page 1

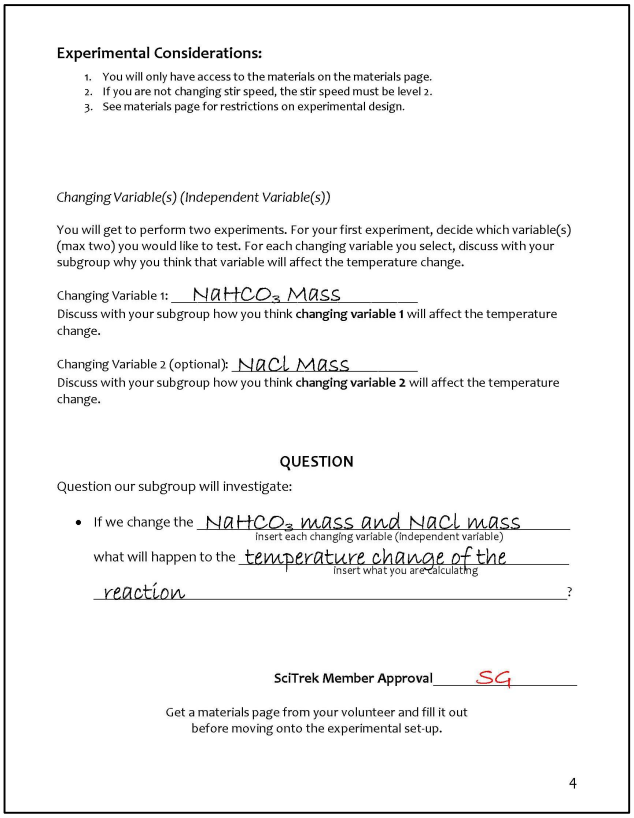
Have students start the design process. Place the example question (notebook, page 4) under the document camera so students may refer to it as they design their experiments. As subgroups move onto their experimental set-ups, put the example experimental set-up (notebook, page 5) under the document camera.

Question:

(9 minutes – Subgroups – SciTrek Mentors)

Have subgroups decide what changing variable(s) they want to explore for their first experiment. Do not try and sway students in any particular direction when choosing their number of changing variables. If they only have one changing variable, do not encourage them to have more. If they have two changing variables, do not encourage them to have fewer. Students will analyze their data, and then perform an additional experiment to correct any mistakes they made on their first experiment.

After subgroups have decided on their changing variable(s), have them fill out their question. When you sign off on their question, give them a materials page with their subgroup color and number designated in the upper right-hand corner. An example filled-out question is shown below.



Experimental Considerations:

1. You will only have access to the materials on the materials page.
2. If you are not changing stir speed, the stir speed must be level 2.
3. 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) you would like to test. For each changing variable you select, discuss with your subgroup why you think that variable will affect the temperature change.

Changing Variable 1: $NaHCO_3$ Mass

Discuss with your subgroup how you think **changing variable 1** will affect the temperature change.

Changing Variable 2 (optional): NaCl Mass

Discuss with your subgroup how you think **changing variable 2** will affect the temperature change.

QUESTION

Question our subgroup will investigate:

- If we change the $NaHCO_3$ mass and NaCl mass
  insert each changing variable (independent variable)
  what will happen to the temperature change of the
  insert what you are calculating
  reaction?

SciTrek Member Approval SG

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

4

Materials Page:

(7 minutes – Subgroups – SciTrek Mentors)

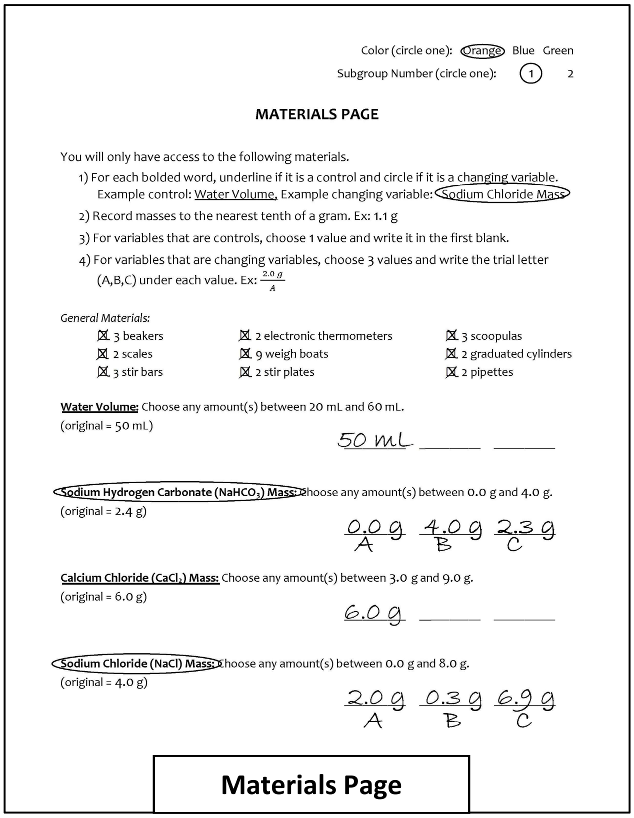
Have subgroups underline their controls and circle their changing variable(s) on the materials page. Then, have them use the materials page to choose the values for their controls and changing variable(s). For the changing variable(s) values, have students write the trial letter (A, B, or C) under the value they select. Ask students, “Why did you choose the values you did for your controls and changing variable(s)?, Will these values make it easier or harder to answer your question?”

Make sure students have picked water volumes, $NaHCO_3$ masses, $CaCl_2$ masses, and NaCl masses, that are **within the limitations** given on the materials page. An example filled-out materials page is shown in the Experimental Set-Up section below.

Experimental Set-Up:

(8 minutes – Subgroups – SciTrek Mentors)

Have subgroups use their materials page to fill in their experimental set-ups (notebook, page 5). For subgroups who have two changing variables, there will be one control blank that will not come from the materials page. For this control, students should write “stir speed/level 2.” When you sign off on their experimental set-ups, ensure all students within a subgroup have the same trial letters, corresponding to the same changing variable values; then, collect the materials page and verify that it is filled out correctly and completely. Filling out the materials page is essential for students to obtain the correct materials for their experiments on Day 3. An example filled-out experimental set-up is shown below (right).



Color (circle one): [✓ Orange] Blue Green
Subgroup Number (circle one): [✓ 1] 2

MATERIALS PAGE

You will only have access to the following materials.

1) For each bolded word, underline if it is a control and circle if it is a changing variable. Example control: Water Volume, Example changing variable: Sodium Chloride Mass
2) Record masses to the nearest tenth of a gram. Ex: 1.1 g
3) For variables that are controls, choose 1 value and write it in the first blank.
4) For variables that are changing variables, choose 3 values and write the trial letter (A,B,C) under each value. Ex: $\frac{2.0\ g}{A}$

General Materials:

- ☒ 3 beakers
- ☒ 2 scales
- ☒ 3 stir bars
- ☒ 2 electronic thermometers
- ☒ 9 weigh boats
- ☒ 2 stir plates
- ☒ 3 scoopulas
- ☒ 2 graduated cylinders
- ☒ 2 pipettes

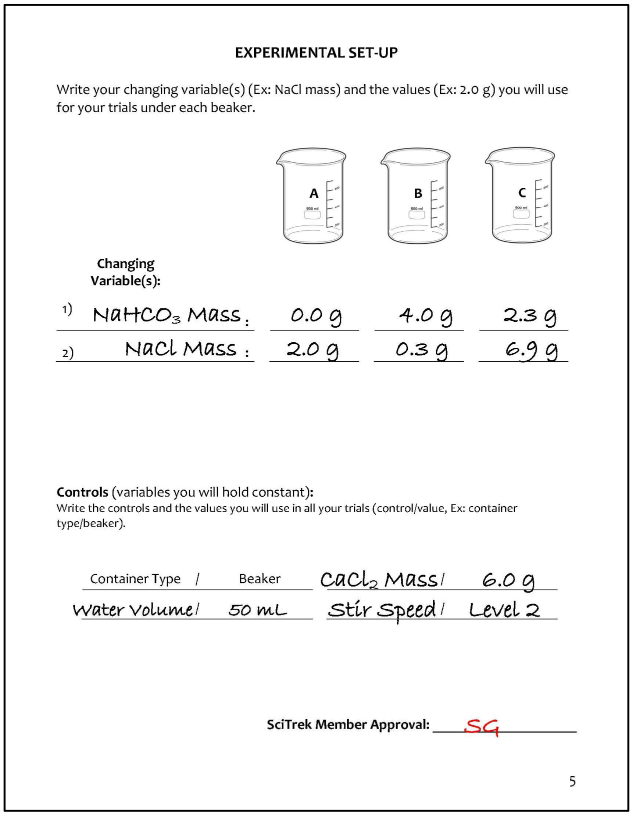
Water Volume: Choose any amount(s) between 20 mL and 60 mL.
(original = 50 mL)
50 mL ______ ______

Sodium Hydrogen Carbonate ($NaHCO_3$) Mass: Choose any amount(s) between 0.0 g and 4.0 g.
(original = 2.4 g)
$\frac{0.0\ g}{A}$ $\frac{4.0\ g}{B}$ $\frac{2.3\ g}{C}$

Calcium Chloride ($CaCl_2$) Mass: Choose any amount(s) between 3.0 g and 9.0 g.
(original = 6.0 g)
6.0 g ______ ______

Sodium Chloride (NaCl) Mass: Choose any amount(s) between 0.0 g and 8.0 g.
(original = 4.0 g)
$\frac{2.0\ g}{A}$ $\frac{0.3\ g}{B}$ $\frac{6.9\ g}{C}$

Materials Page



EXPERIMENTAL SET-UP

Write your changing variable(s) (Ex: NaCl mass) and the values (Ex: 2.0 g) you will use for your trials under each beaker.

Changing Variable(s):	A	B	C
1) $NaHCO_3$ Mass :	0.0 g	4.0 g	2.3 g
2) NaCl Mass :	2.0 g	0.3 g	6.9 g

Controls (variables you will hold constant)**:**
Write the controls and the values you will use in all your trials (control/value, Ex: container type/beaker).

Container Type / Beaker
$CaCl_2$ Mass / 6.0 g
Water Volume / 50 mL
Stir Speed / Level 2

SciTrek Member Approval: SG

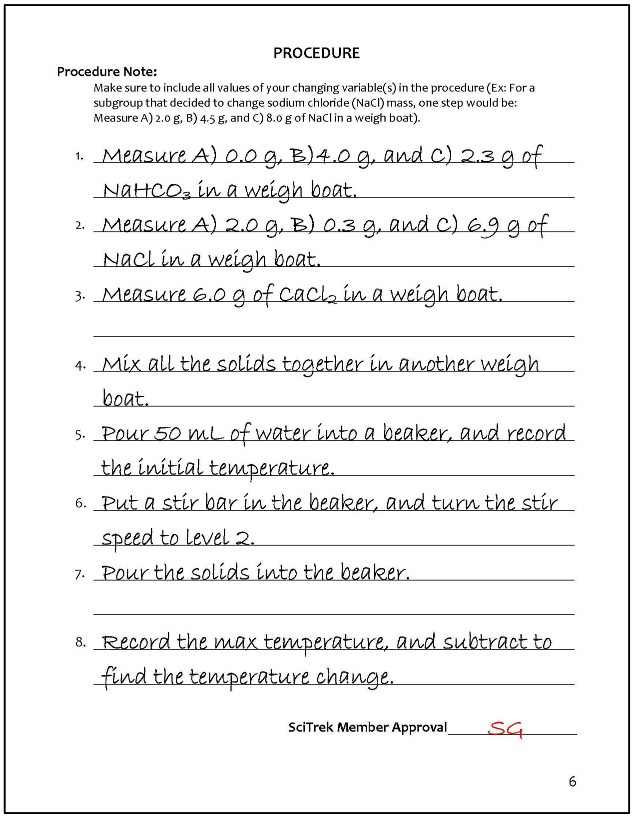
5

Procedure:

(18 minutes – Subgroups – SciTrek Mentors)

After each subgroup has filled out their experimental set-up, they can start on their procedure (notebook, page 6). Make sure students within the same subgroup are collaborating to write their procedure. Keep procedures as brief as possible, while still conveying the pertinent information (control values, changing variable values, the data they will collect, and what they will calculate) about the experiment. An example step for a subgroup who had NaCl mass as a changing variable would be, “Measure A) 2.0 g, B) 4.5 g, C) 8.0 g of NaCl in a weigh boat.” Some subgroups may struggle with writing procedures. You can have these subgroups dictate a step while you transcribe it onto a notepad found in your group box. Once they have dictated a step, give this sheet to students to copy into their notebooks before having them dictate the next step to you. Once students have finished, they should raise their hands and get their procedures approved by their mentor. An example filled-out procedure is shown below (left).

Note: 6th grade students are more independent, therefore, students in each subgroup may vary the wording in their procedures. This is fine, as long as the steps are in the same order, and the steps contain the same control(s) and/or changing variable(s).



PROCEDURE

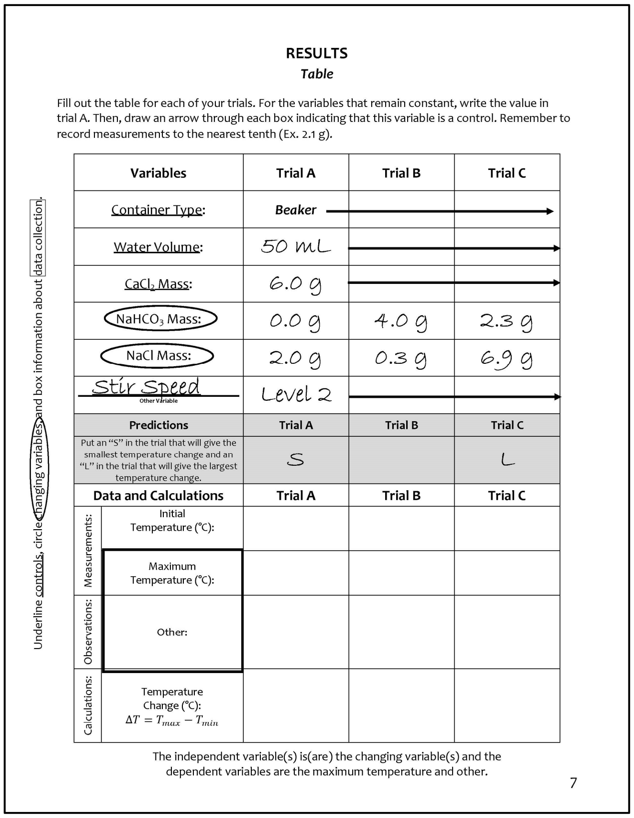
Procedure Note:

Make sure to include all values of your changing variable(s) in the procedure (Ex: For a subgroup that decided to change sodium chloride (NaCl) mass, one step would be: Measure A) 2.0 g, B) 4.5 g, and C) 8.0 g of NaCl in a weigh boat).

1. Measure A) 0.0 g, B)4.0 g, and C) 2.3 g of $NaHCO_3$ in a weigh boat.
2. Measure A) 2.0 g, B) 0.3 g, and C) 6.9 g of NaCl in a weigh boat.
3. Measure 6.0 g of $CaCl_2$ in a weigh boat.
4. Mix all the solids together in another weigh boat.
5. Pour 50 mL of water into a beaker, and record the initial temperature.
6. Put a stir bar in the beaker, and turn the stir speed to level 2.
7. Pour the solids into the beaker.
8. Record the max temperature, and subtract to find the temperature change.

SciTrek Member Approval SG

6



RESULTS

Table

Fill out the table for each of your trials. For the variables that remain constant, write the value in trial A. Then, draw an arrow through each box indicating that this variable is a control. Remember to record measurements to the nearest tenth (Ex. 2.1 g).

Underline controls, circle changing variables, and box information about data collection.

Variables	Trial A	Trial B	Trial C
Container Type:	**Beaker**	→	→
Water Volume:	50 mL	→	→
$CaCl_2$ Mass:	6.0 g	→	→
$NaHCO_3$ Mass:	0.0 g	4.0 g	2.3 g
NaCl Mass:	2.0 g	0.3 g	6.9 g
Stir Speed Other Variable	Level 2	→	→
Predictions	**Trial A**	**Trial B**	**Trial C**
Put an "S" in the trial that will give the smallest temperature change and an "L" in the trial that will give the largest temperature change.	S		L

	Data and Calculations	Trial A	Trial B	Trial C
Measurements:	Initial Temperature (°C):			
	Maximum Temperature (°C):			
Observations:	Other:			
Calculations:	Temperature Change (°C): $\Delta T = T_{max} - T_{min}$			

The independent variable(s) is(are) the changing variable(s) and the dependent variables are the maximum temperature and other.

7

Results Table:

(3 minutes – Subgroups – SciTrek Mentors)

Have students underline the variables that are controls, circle the variable(s) that is/are their changing variable(s), and box information about data collection. When writing the values make sure for controls, they only write the value of the control in the *Trial A* box, then, draw an arrow through the remaining trials' boxes. For the changing variable(s), they should write the values in each trial's corresponding box.

When students have finished, have them make predictions about the temperature change. Have them write an "S" in the box of the trial they think will produce the smallest temperature change and an "L" in the box of the trial they think will produce the largest temperature change. They will leave two of the boxes empty. If they think all trials will produce the same temperature change, have them write "same" over all of the boxes. It is okay if the students in a subgroup have different predictions. An example filled-out results table is shown above (right).

Wrap-Up:

(3 minutes – Full Class – SciTrek Lead)

Have one student from each subgroup share what question they will investigate.

Then, as a class complete the extra practice (notebook, page 31) where students determine if statements are claim, data, or opinion. Doing this extra practice will make it easier for students to write conclusions next session.

Tell students, "Next session, you will start your experiments. All of your experiments will help us answer the class question: What variables affect the temperature change of the chemical reaction?"

Clean-Up:

1. Collect notebooks with attached nametags.
2. Place materials into your group box and bring them back to UCSB.

Day 3: Experiment/Analysis Activity

Schedule:

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

Materials:

(3) Mentor Boxes:

☐ Nametags
☐ Notebooks
☐ Mentor instructions
☐ Mentor lab coat
☐ (2) Pencils

(2) Ziploc bags (gallon size), labeled (with subgroup number), each with the following:

☐ Filled-out materials page
☐ Wet erase marker
☐ Paper towels
☐ (2) Droppers
☐ (2) Scales
☐ (2) Thermometers
☐ Set of (3) labeled scoopulas ($NaHCO_3$, NaCl, $CaCl_2$)
☐ $NaHCO_3$ container
☐ NaCl container
☐ $CaCl_2$ container (1/3 filled)
☐ (3) Magnetic stir bars
☐ (variable) Labeled weigh boats ((2) of each [$NaHCO_3$, NaCl, $CaCl_2$] for non-changing variables and (3) of each for changing variable(s) and mix)
☐ (2) Plastic lids

Other Supplies:

☐ (2) Boxes of beakers
☐ Box with (14) 100 ml graduated cylinders
☐ Box with (14) 8 oz waters
☐ (2) Boxes with 6 stir plates and 3 extension cords
☐ Bucket with lids

Lead Box:

☐ (3) Extra notebooks
☐ Lead instructions
☐ Thermal Transfer picture packet
☐ Lead lab coat
☐ Time card
☐ (2) Pencils
☐ (2) Wet erase markers
☐ (2) Black pens
☐ (2) White rags
☐ Scale
☐ Thermometer
☐ $CaCl_2$ container (1/3 filled)
☐ Bag (paper towels, (2) droppers, set of (3) labeled scoopulas [$NaHCO_3$, NaCl, $CaCl_2$], $NaHCO_3$ container, NaCl container, set of 9 labeled weigh boats [(2) $NaHCO_3$, (2) NaCl, (2) $CaCl_2$, (3) Mix], (3) plastic lids, container of (3) magnetic stir bars)

Notebook Pages:

RESULTS

Table

Fill out the table for each of your trials. For the variables that remain constant, write the value in trial A. Then, draw an arrow through each box indicating that this variable is a control. Remember to record measurements to the nearest tenth (Ex. 2.1 g).

Underline controls, circle changing variables, and box information about data collection.

Variables		Trial A	Trial B	Trial C
Container Type:		Beaker	→	→
Water Volume:		50 mL	→	→
$CaCl_2$ Mass:		6.0 g	→	→
$NaHCO_3$ Mass:		0.0 g	4.0 g	2.3 g
NaCl Mass:		2.0 g	0.3 g	6.9 g
Stir Speed Other Variable		Level 2	→	→
Predictions		**Trial A**	**Trial B**	**Trial C**
Put an "S" in the trial that will give the smallest temperature change and an "L" in the trial that will give the largest temperature change.		S		L
Data and Calculations		**Trial A**	**Trial B**	**Trial C**
Measurements:	Initial Temperature (℃):	20.0°C	19.8°C	19.8°C
	Maximum Temperature (℃):	42.5°C	35.7°C	40.7°C
Observations:	Other:	felt hot	felt warm; lots of bubbles	felt warm; medium bubbles
Calculations:	Temperature Change (℃): $\Delta T = T_{max} - T_{min}$	42.5°C -20.0°C 22.5°C	2 14 1 ~~35~~.7°C -19.8°C 15.9°C	9 3 ~~10~~ 1 ~~40~~.7°C -19.8°C 20.9°C

The independent variable(s) is(are) the changing variable(s) and the dependent variables are the maximum temperature and other.

7

SCIENTIFIC PRACTICES

Analyzing & Interpreting Data

1. **Directions:** Fill in the missing definitions.
   - **Conclusion:** A claim supported by data
   - **Claim:** A statement that can be tested. The explanation of the data, the first part of a conclusion.
     - *Ex:* The ball mass does not affect the speed at which it rolls down a ramp.
     - A claim in a scientific experiment often includes the changing variable.
   - **Data:** Evidence collected from experiment(s) (measurements or observations), the second part of a conclusion.
     - *Ex:* When the ball mass was 60 g its speed was 1.2 $\frac{m}{s}$, and when the ball mass was 100 g, its speed was 1.1 $\frac{m}{s}$.
     - Data in a scientific experiment includes measurements or observations.
     - Data statements also often include values of the changing variable.
2. **Directions:** On the results tables and conclusions below, underline control(s), circle changing variable(s), and box information about data collection. Then, decide if the possible conclusion is correct or not.

a)

Variables		Trial A	Trial B	Trial C	Trial D
Container Type:		Beaker	→	→	→
Solid A Mass:		2.0 g	→	→	→
Solid B Mass:		6.0 g	→	→	→
Solid C Mass:		5.0 g	7.0 g	9.0 g	11.0 g
Stir Speed:		Medium	→	→	→
Data		**Trial A**	**Trial B**	**Trial C**	**Trial D**
Measurements/ Observations:	Temperature Change:	8.5℃	10.5℃	18.1℃	22.7℃
	Other:	Made a little foam	Made foam	Foam filled to the top	Overflowed with foam

Possible Conclusion: The greater the solid C mass, the higher the temperature change, because when the solid C mass was 5.0 g, the temperature change was 8.5℃, and when the solid C mass was 11.0 g, the temperature change was 22.7℃.

Is this a correct conclusion? [✓ YES] NO I DON'T KNOW

If NO, what is wrong with the conclusion? ____________.

8

SCIENTIFIC PRACTICES

Analyzing & Interpreting Data

b)

Variables		Trial A	Trial B	Trial C	Trial D
Container Type:		Beaker	→	→	→
Solid A Mass:		6.0 g	→	→	→
Solid B Mass:		10.0 g	→	→	→
Solid C Mass:		8.0 g	→	→	→
Stir Speed:		Slow	Medium	Fast	Super-Fast
Data		**Trial A**	**Trial B**	**Trial C**	**Trial D**
Measurements/ Observations:	Temperature Change:	13.0℃	12.1℃	11.3℃	10.2℃
	Other:	Made foam	Made a little foam	Made foam	Made a little foam

Possible Conclusion: The greater the stir speed, the higher the temperature change, because when the stir speed was slow, the temperature change was 13.0℃, and when the stir speed was super-fast, the temperature change was 10.2℃.

Is this a correct conclusion? YES [✓ NO] I DON'T KNOW

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

c)

Variables		Trial A	Trial B	Trial C	Trial D
Container Type:		Beaker	→	→	→
Solid A Mass:		2.0 g	4.0 g	6.0 g	8.0 g
Solid B Mass:		5.0 g	→	→	→
Solid C Mass:		5.0 g	→	→	→
Stir Speed:		Medium	→	→	→
Data		**Trial A**	**Trial B**	**Trial C**	**Trial D**
Measurements/ Observations:	Temperature Change:	7.1℃	5.8℃	3.7℃	2.9℃
	Other:	Overflowed with foam	Foam filled to the top	Made foam	Made a little foam

Possible Conclusion: The greater the solid A mass, the less foam is produced, because We observed when the solid A mass was 2.0 g, the beaker overflowed with foam, but when the solid A mass was 8.0 g the beaker had only a little bit of foam.

Is this a correct conclusion? [✓ YES] NO I DON'T KNOW

If NO, what is wrong with the conclusion? ____________.

9

SCIENTIFIC PRACTICES

Analyzing & Interpreting Data

d)

Variables		Trial A	Trial B	Trial C	Trial D
Container Type:		Beaker	→	→	→
Solid A Mass:		6.0 g	→	→	→
Solid B Mass:		10.0 g	12.0 g	14.0 g	16.0 g
Solid C Mass:		8.0 g	→	→	→
Stir Speed:		Medium	→	→	→
Data		**Trial A**	**Trial B**	**Trial C**	**Trial D**
Measurements/ Observations:	Temperature Change:	11.5℃	10.2℃	12.0℃	10.8℃
	Other:	Made a little foam	Made more foam	Foam filled to the top	Overflowed with foam

Possible Conclusion: We observed, when there were 16.0 g of solid B, the reaction overflowed with foam, and when there were 10.0 g of solid B, the reaction made a little foam, because the greater the solid B mass, the more foam is made.

Is this a correct conclusion? YES [✓ NO] I DON'T KNOW

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

e)

Variables		Trial A	Trial B	Trial C	Trial D
Container Type:		Beaker	→	→	→
Solid A Mass:		2.0 g	3.0 g	4.0 g	5.0 g
Solid B Mass:		5.0 g	→	→	→
Solid C Mass:		8.0 g	6.0 g	4.0 g	2.0 g
Stir Speed:		Fast	→	→	→
Data		**Trial A**	**Trial B**	**Trial C**	**Trial D**
Measurements/ Observations:	Temperature Change:	13.3℃	10.8℃	8.1℃	5.9℃
	Other:	Overflowed with foam	Foam filled to the top	Made foam	Made a little foam

Possible Conclusion: The smaller the solid A mass, the higher the temperature change, because when the solid A mass was 2.0 g, the temperature change was 13.3℃, and when the solid A mass was 5.0 g, the temperature change was 5.9℃.

Is this a correct conclusion? YES [✓ NO] I DON'T KNOW

If NO, what is wrong with the conclusion? More than 1 changing variable.

3. How many changing variables can you have in order to make a conclusion? 1

10

Preparation:

SciTrek Lead:

1. Make sure mentors are setting out notebooks.
2. Make sure mentors are setting up for the experiment.
3. Set up the document camera for the analysis activity (notebook, pages 8-10).

SciTrek Mentors:

1. Set out notebooks/nametags.
2. Plug in two stir plates for each subgroup and place them where they will work.
3. Put (2) waters, (2) graduated cylinders (if subgroups are changing water amount give them (3) graduated cylinders), (3) beakers, and a supplies bag (labeled with subgroup number), next to the stir plates.
4. With the wet erase pen, in the supplies bag, label the beakers, mix weigh boats, and changing variable weigh boats and/or graduated cylinder with an A, B, or C.

Note: Set notebooks where students will sit during the module, even if another student is currently at that desk. If needed, students will move to these spots after the Introduction.

Introduction:

(2 minutes – Full Class – SciTrek Lead)

If students are not in their subgroups, tell them, “A notebook will be put on your desk, which is not your notebook and you should not move it. You will move to your notebook after the Introduction.”

Ask the class, “What is the class question we are investigating?” Students should reply, “What variables affect the temperature change of the chemical reaction?” Tell students, “Today, you will conduct your experiments to answer this question. When you record your data, you will make two measurements: the initial temperature, and the maximum temperature. To get the maximum temperature, you will use the ‘max’ button on the thermometer. This function must be reset between each trial, by closing, and reopening, the thermometer.” Then, show them how this is done. Ask students, “How will you determine the temperature change?” Make sure they understand 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, “During the experiment, we will use several chemicals. It is important that you do not contaminate these. Therefore, only use the appropriately labeled ‘scoopula’ to add each substance to the corresponding weigh boat. Before you put the substance in the weigh boat, make sure you have tared (zeroed) the scale. The calcium chloride ($CaCl_2$) takes on water if it is left uncapped, so it is important that you keep the lid closed tightly when you are not using it. Between trials, you should wipe off the thermometer with a paper towel. You can now start your experiments.”

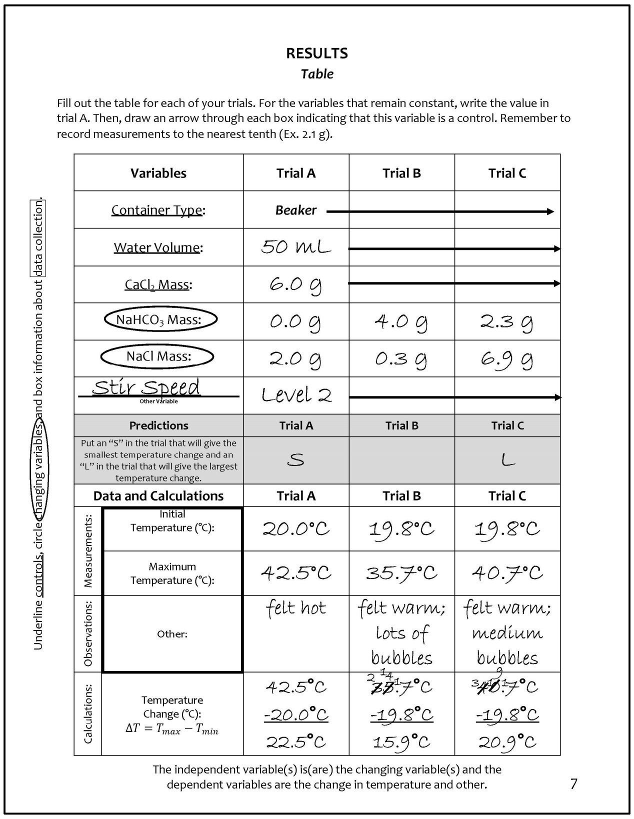
Experiment:

(28 minutes – Subgroups – SciTrek Mentors)

Give students their requested materials. If students are missing any of their experimental materials, the lead box has extra materials. Make sure students are keeping the cap to the $CaCl_2$ 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, stir bars, $CaCl_2$ weigh boats, graduated cylinders, and water bottles, and put them in the appropriate buckets/boxes. It is important to do this as soon as possible, so students do not play with or spill anything. When the experiment is finished, have students wipe the thermometer with a paper towel and close it, making sure it turns off. Place all other materials in your group box. Then, wipe off students' desks using a damp towel.

Students should record the maximum temperature after each trial, but have them wait until they have finished their entire experiment to calculate the temperature changes for each trial.

If your group has things under control, help other subgroups. An example filled-out results table is shown below.



RESULTS

Table

Fill out the table for each of your trials. For the variables that remain constant, write the value in trial A. Then, draw an arrow through each box indicating that this variable is a control. Remember to record measurements to the nearest tenth (Ex. 2.1 g).

Underline controls, circle changing variables, and box information about data collection.

Variables	Trial A	Trial B	Trial C
Container Type:	***Beaker*** →	→	→
Water Volume:	50 mL	→	→
$CaCl_2$ Mass:	6.0 g	→	→
$NaHCO_3$ Mass:	0.0 g	4.0 g	2.3 g
NaCl Mass:	2.0 g	0.3 g	6.9 g
Stir Speed Other Variable	Level 2	→	→
Predictions	**Trial A**	**Trial B**	**Trial C**
Put an "S" in the trial that will give the smallest temperature change and an "L" in the trial that will give the largest temperature change.	S		L
Data and Calculations	**Trial A**	**Trial B**	**Trial C**
Measurements: Initial Temperature (℃):	20.0°C	19.8°C	19.8°C
Measurements: Maximum Temperature (℃):	42.5°C	35.7°C	40.7°C
Observations: Other:	felt hot	felt warm; lots of bubbles	felt warm; medium bubbles
Calculations: Temperature Change (℃): $\Delta T = T_{max} - T_{min}$	42.5°C -20.0°C 22.5°C	2 14 1 ~~35~~.7°C -19.8°C 15.9°C	9 3 ~~40~~ 1 .7°C -19.8°C 20.9°C

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

7

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.

Have students turn to page 8 in their notebooks while you turn to page 8 in the class notebook, displaying it under the document camera. Tell students, "Before you analyze your results and draw a conclusion, it is important that you recognize and understand other scientists' conclusions."

Ask the class, "What is a conclusion?" After listening to the students' answers, make sure they understand a conclusion is a **claim supported by data**. Write this definition on page 8 of the class notebook for students to copy.

Tell students, "In order to make a conclusion, we need to make sure we understand the difference between a claim and data." Read the definition of a claim (*A statement that can be tested. The explanation of the data, the first part of a conclusion*).

Then, read the example, *The ball mass does not affect the speed at which it rolls down a ramp*. Ask a student, "How could you test this claim?" Possible student response: roll balls, with different masses, down a ramp, and compare their speeds. Then, ask another student, “Can you identify what the changing variable would be in that experiment?” Lead students to notice 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 should we write in the blank?” They should reply, “Changing variable.”

Next, read the definition of data (*Evidence collected from experiment(s) (measurements or observations), the second part of a conclusion*). Then, read the example, *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* $\frac{m}{s}$. **Note:** 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, “There are two forms of data collection, measurements and observations. If measurements were collected for data, then numerical values should be in the data statement. If observations were collected for data, then words such as ‘observed’ or ‘recorded’ should be in the data statement to 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 should we write in the blanks?” Students should reply, “Measurements and observations.” Ask students, “In our example data statement, what was the method of data collection and how do you know?” Possible student response: the method of data collection was measurements, because the statement contains numbers. Ask students, “Are all the numerical values, in the data statement, data?” Students should reply, “No.” Lead students to understand, 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 students circle the values of the changing variable, and box the measurements, in the data statement. Read the second sentence frame to students. *Data statements also often include values of the* ____________. Ask students, “What should we write in the blank?” Students should reply, “Changing variable.”

Read the directions to part 2 aloud to the class (*On the results tables and conclusions below, underline control(s), circle changing variable(s), and box information about data collection. Then, decide if the possible conclusion is correct or not.*).

For each question, first have student annotate the results table using the process below. Second, read the conclusion aloud to students and have them annotate the conclusion using the process below. Third use the flow chart below to analyze the conclusion as a class.

For annotating the tables, do parts *a* and *b* as a class; then, take the notebook out from under the document camera and have students try to do parts *c*, *d*, and *e* on their own, while you fill them out off to the side. After the students have finished working on it independently, have them check their work against yours.

For annotating the conclusions, do parts *a* and *b* as a class, then, give students approximately 30 seconds to annotate the conclusion on their own, before going over the answers as a class.

Use the following flow chart as a guide for leading students through analyzing each conclusion. Examples of how this flow chart was used for conclusions *a*-*e*, along with possible student answers, can be seen after the notebook pages 8-10 below.

Flow Chart for Analyzing Conclusions:

What type of statement is before the ‘because,’ and how do you know?

  If the statement is *data* (contains measurements or observations)

  - Is this a correct conclusion? (No)
  - What is wrong with the conclusion? (Claim and data switched)
  - Move onto next conclusion

If the statement is a *claim* (can be tested)

- What is the changing variable in this claim?
- Is this a changing variable in this experiment? (Yes)
- Is the claim consistent with the results table?

  If No

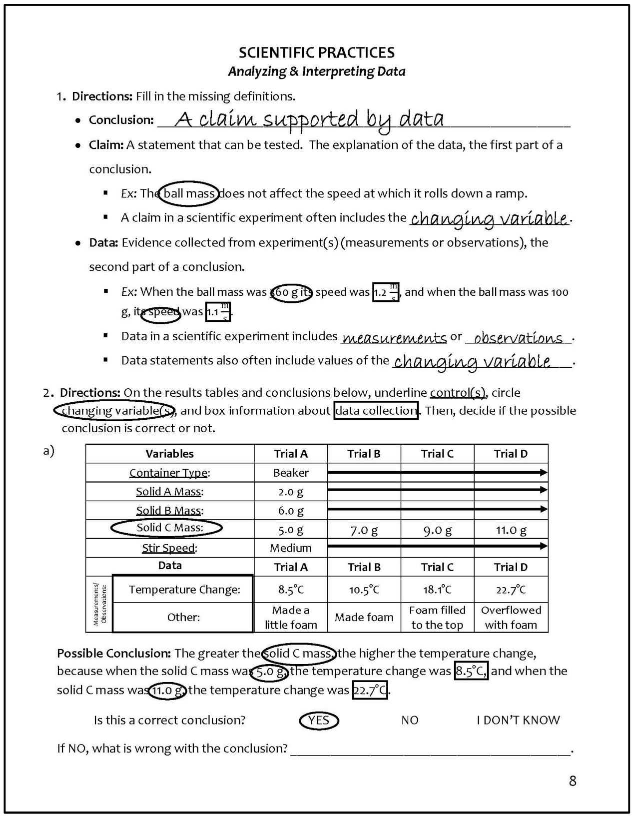
  - Is this a correct conclusion? (No)
  - What is wrong with the conclusion? (Incorrect claim)
  - Move onto next conclusion

  If Yes and *one changing variable*

  - What type of statement is after the 'because,' and how do you know? (Data, because it contains measurements or observations.)
  - Is the data consistent with the results table? (Yes)
  - Is this a correct conclusion? (Yes)
  - Move onto next conclusion.

  If Yes and *two changing variables*

  - What type of statement is after the 'because,' and how do you know? (Data, because it contains measurements or observations.)
  - Is the data consistent with the results table? (Yes)
  - Is this a fair conclusion? (No, because the change could be due to the other changing variable.)
  - Is this a correct conclusion? (No)
  - What is wrong with the conclusion? (More than one changing variable)



SCIENTIFIC PRACTICES

Analyzing & Interpreting Data

1. **Directions:** Fill in the missing definitions.
   - **Conclusion:** A claim supported by data
   - **Claim:** A statement that can be tested. The explanation of the data, the first part of a conclusion.
     - *Ex:* The ball mass does not affect the speed at which it rolls down a ramp.
     - A claim in a scientific experiment often includes the changing variable.
   - **Data:** Evidence collected from experiment(s) (measurements or observations), the second part of a conclusion.
     - *Ex:* When the ball mass was 60 g its speed was $1.2 \frac{m}{s}$, and when the ball mass was 100 g, its speed was $1.1 \frac{m}{s}$.
     - Data in a scientific experiment includes measurements or observations.
     - Data statements also often include values of the changing variable.
2. **Directions:** On the results tables and conclusions below, underline control(s), circle changing variable(s), and box information about data collection. Then, decide if the possible conclusion is correct or not.

a)

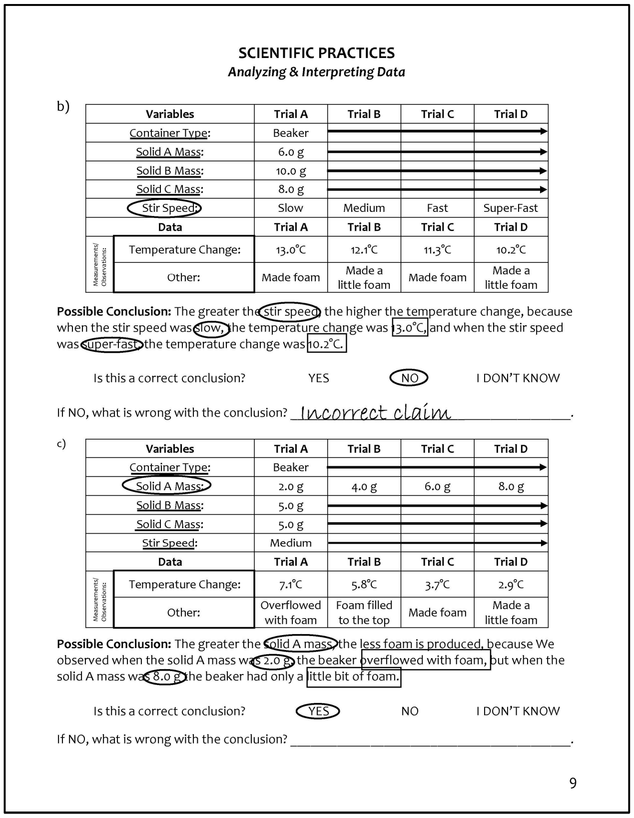
Variables		Trial A	Trial B	Trial C	Trial D
	Container Type:	Beaker	→	→	→
	Solid A Mass:	2.0 g	→	→	→
	Solid B Mass:	6.0 g	→	→	→
	Solid C Mass:	5.0 g	7.0 g	9.0 g	11.0 g
	Stir Speed:	Medium	→	→	→
	Data	Trial A	Trial B	Trial C	Trial D
Measurements/ Observations:	Temperature Change:	8.5°C	10.5°C	18.1°C	22.7°C
	Other:	Made a little foam	Made foam	Foam filled to the top	Overflowed with foam

Possible Conclusion: The greater the solid C mass, the higher the temperature change, because when the solid C mass was 5.0 g, the temperature change was 8.5°C, and when the solid C mass was 11.0 g, the temperature change was 22.7°C.

Is this a correct conclusion? [✓ YES] NO I DON'T KNOW

If NO, what is wrong with the conclusion? ________________.

8



SCIENTIFIC PRACTICES

Analyzing & Interpreting Data

b)

Variables		Trial A	Trial B	Trial C	Trial D
	Container Type:	Beaker	→	→	→
	Solid A Mass:	6.0 g	→	→	→
	Solid B Mass:	10.0 g	→	→	→
	Solid C Mass:	8.0 g	→	→	→
	Stir Speed:	Slow	Medium	Fast	Super-Fast
	Data	Trial A	Trial B	Trial C	Trial D
Measurements/ Observations:	Temperature Change:	13.0°C	12.1°C	11.3°C	10.2°C
	Other:	Made foam	Made a little foam	Made foam	Made a little foam

Possible Conclusion: The greater the stir speed, the higher the temperature change, because when the stir speed was slow, the temperature change was 13.0°C, and when the stir speed was super-fast, the temperature change was 10.2°C.

Is this a correct conclusion? YES [✓ NO] I DON'T KNOW

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

c)

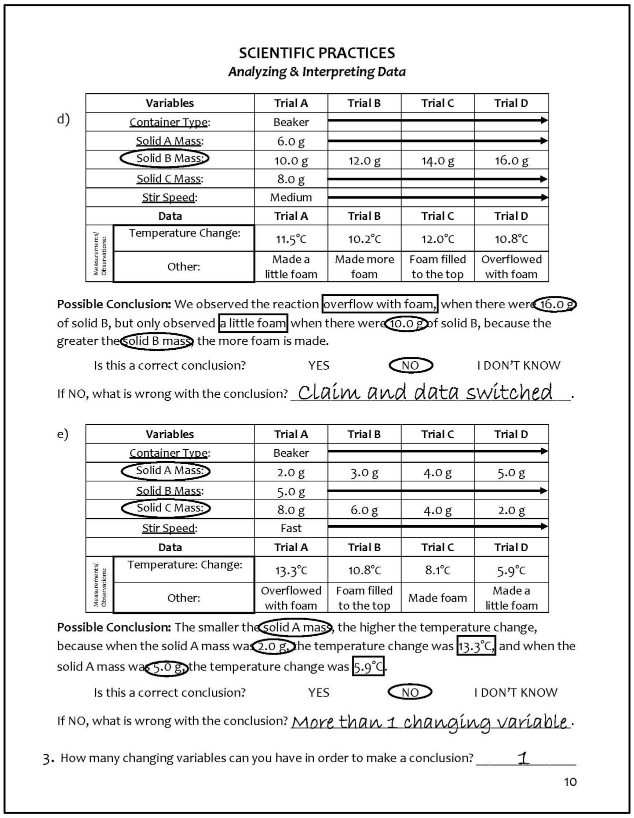
Variables		Trial A	Trial B	Trial C	Trial D
	Container Type:	Beaker	→	→	→
	Solid A Mass:	2.0 g	4.0 g	6.0 g	8.0 g
	Solid B Mass:	5.0 g	→	→	→
	Solid C Mass:	5.0 g	→	→	→
	Stir Speed:	Medium	→	→	→
	Data	Trial A	Trial B	Trial C	Trial D
Measurements/ Observations:	Temperature Change:	7.1°C	5.8°C	3.7°C	2.9°C
	Other:	Overflowed with foam	Foam filled to the top	Made foam	Made a little foam

Possible Conclusion: The greater the solid A mass, the less foam is produced, because We observed when the solid A mass was 2.0 g, the beaker overflowed with foam, but when the solid A mass was 8.0 g the beaker had only a little bit of foam.

Is this a correct conclusion? [✓ YES] NO I DON'T KNOW

If NO, what is wrong with the conclusion? ________________.

9



SCIENTIFIC PRACTICES

Analyzing & Interpreting Data

d)

Variables	Trial A	Trial B	Trial C	Trial D
Container Type:	Beaker	→		
Solid A Mass:	6.0 g	→		
Solid B Mass:	10.0 g	12.0 g	14.0 g	16.0 g
Solid C Mass:	8.0 g	→		
Stir Speed:	Medium	→		
Data	**Trial A**	**Trial B**	**Trial C**	**Trial D**
Measurements/ Observations: Temperature Change:	11.5°C	10.2°C	12.0°C	10.8°C
Other:	Made a little foam	Made more foam	Foam filled to the top	Overflowed with foam

Possible Conclusion: We observed the reaction overflow with foam, when there were 16.0 g of solid B, but only observed a little foam when there were 10.0 g of solid B, because the greater the solid B mass, the more foam is made.

Is this a correct conclusion? YES [✓ NO] I DON'T KNOW

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

e)

Variables	Trial A	Trial B	Trial C	Trial D
Container Type:	Beaker	→		
Solid A Mass:	2.0 g	3.0 g	4.0 g	5.0 g
Solid B Mass:	5.0 g	→		
Solid C Mass:	8.0 g	6.0 g	4.0 g	2.0 g
Stir Speed:	Fast	→		
Data	**Trial A**	**Trial B**	**Trial C**	**Trial D**
Measurements/ Observations: Temperature: Change:	13.3°C	10.8°C	8.1°C	5.9°C
Other:	Overflowed with foam	Foam filled to the top	Made foam	Made a little foam

Possible Conclusion: The smaller the solid A mass, the higher the temperature change, because when the solid A mass was 2.0 g, the temperature change was 13.3°C, and when the solid A mass was 5.0 g, the temperature change was 5.9°C.

Is this a correct conclusion? YES [✓ NO] I DON'T KNOW

If NO, what is wrong with the conclusion? More than 1 changing variable.

3. How many changing variables can you have in order to make a conclusion? 1

10

Below are the explanations and answers to part 2, letters *a-e*, on pages 8, 9, and 10.

As a class, annotate results table *a* by identifying and underlining the controls (*Container Type*, *Solid A Mass*, *Solid B Mass*, and *Stir Speed*), circling the changing variable (*Solid C Mass*), and boxing the information about the data collected (*Temperature Change*, and *Other*). Then, annotate the possible conclusion as a class.

a. *The greater the solid C mass, the higher the temperature change, because when the solid C mass was 5.0 g, the temperature change was 8.5°C, and when the solid 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 this claim?

Solid C mass

Is this a changing variable in this experiment?

Yes

Is the claim consistent with the results table? (check table with students)

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

As a class, annotate results table *b* by identifying and underlining the controls (*Container Type*, *Solid A Mass*, *Solid B Mass*, and *Solid C Mass*), circling the changing variable (*Stir Speed*), and boxing the information about the data collected (*Temperature Change* and *Other*). Then, annotate the possible conclusion as a class.

b. *The greater the stir speed, the higher the temperature change, because when the stir speed was slow, the temperature change was 13.0°C, and when the stir 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 this claim?
    - Stir speed
- Is this a changing variable in this experiment?
    - Yes
- Is the claim consistent with the results table? (check table with students)
    - No
- What is wrong with the conclusion?
    - Incorrect claim

Have students individually annotate results table *c* by identifying and underlining the controls (*Container Type*, *Solid B Mass*, *Solid C Mass*, and *Stir Speed*), circling the changing variable (*Solid A Mass*), and boxing the information about the data collected (*Temperature Change* and *Other*). Then, have students individually annotate the possible conclusion and share out their answers.

c. *The greater the solid A mass, the less foam is produced, because we observed when the solid A mass was 2.0 g, the beaker overflowed with foam, but when the solid A mass was 8.0 g, the beaker had only a little bit of foam.*

- 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 this claim?
    - Solid A mass
- Is this a changing variable in this experiment?
    - Yes
- Is the claim consistent with the results table? (check table with students)
    - 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? (check table with students)
    - Yes
- Is this a correct conclusion?
    - Yes

Have students individually annotate results table *d* by identifying, and underlining the controls (*Container Type*, *Solid A Mass*, *Solid C Mass*, and *Stir Speed*), circling the changing variable (*Solid B Mass*), and boxing the information about the data collected (*Temperature Change* and *Other*). Then, have students individually annotate the possible conclusion and share out their answers.

d. *We observed, when there were 16.0 g of solid B, the reaction overflowed with foam, and when there were 10.0 g of solid B, the reaction made a little foam, because the greater the solid B mass, the more foam is made.*

- What type of statement is before the 'because,' and how do you know?
    - Data, because it contains observations
- Is this a correct conclusion?
    - No

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

Have students individually annotate results table *e* by identifying and underlining the controls (*Container Type*, *Solid B Mass* and *Stir Speed*), circling the changing variables (*Solid A Mass* and *Solid C Mass*), and boxing the information about the data collected (*Temperature Change* and *Other*). Then, have students individually annotate the possible conclusion and share out their answers.

e. *The smaller the solid A mass, the higher the temperature change, because when the solid A mass was 2.0 g, the temperature change was 13.3°C, and when the solid 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 this claim?
  - Solid A mass
- Is this a changing variable in this experiment?
  - Yes
- Is the claim consistent with the results table? (check table with students)
  - 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 solid C mass which is changing the temperature, and not solid A mass.
- Is this a correct conclusion?
  - No
- What is wrong with the conclusion?
  - More than one changing variable

Ask students, “When designing an experiment, how many changing variables can you have in order to make a conclusion from your data?” Students should reply, “Only one.” Record this in the class notebook for number *3* on the bottom of page 10 while students do the same in their notebooks.

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

Tell students, “Next session, you will analyze your own data to see whether or not you can make a conclusion. We will then discuss each subgroups findings and determine how make changes to the experiments, in order to better answer the class question.”

Clean-Up:

1. Collect notebooks with attached nametags.
2. Put beakers, stir bars, $CaCl_2$ weigh boats, mix weigh boats (all other weigh boats should go in your group box), and any liquids, into the bucket.
3. Return the graduated cylinders to their box.
4. Return the water bottles to their box.
5. Return the stir plates, plugs, and extension cords, to their boxes.
6. Place all other materials into your group box and bring them back to UCSB.

Day 4: Conclusion/Technique/Analysis Activity

Schedule:

Introduction (SciTrek Lead) – 3 minutes
Conclusion (SciTrek Mentors) – 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) Mentor Boxes:

- ☐ Nametags
- ☐ Notebooks
- ☐ Mentor instructions
- ☐ Mentor lab coat
- ☐ (2) Pencils
- ☐ (2) Red pens
- ☐ Paper notepad
- ☐ (12) Clear rulers
- ☐ (NV) Copies of notebook pages 12-17

Lead Box:

- ☐ (3) Extra notebooks
- ☐ Lead instructions
- ☐ Thermal Transfer picture packet
- ☐ Lead lab coat
- ☐ Time card
- ☐ (2) Pencils
- ☐ (2) Red pens
- ☐ (2) Wet erase markers
- ☐ (2) Black pens
- ☐ Paper notepad
- ☐ (5) Clear rulers
- ☐ (2) Copies notebook pages 12-17

Notebook and Picture Packet Pages:

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? Because we had more than one changing variable.

IF YES

We can conclude ______________________
claim

because______________________
data (measurements/observations/calculations)

SciTrek Member Approval SG

11

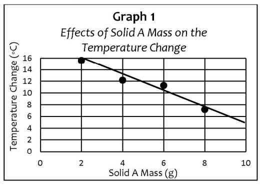
TECHNIQUE

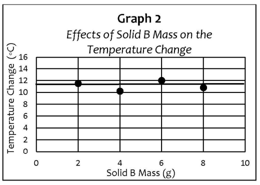
Trend Lines

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

How to draw a trend line:

1. Position 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 the ruler. When positioned correctly, all points should be as close as possible to the ruler.
2. Trace along the ruler with your pencil. Always extend trend lines to both edges of the graph.





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.

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

a) Which graph(s) represent a changing variable that affects the data? [✓ 1] 2

b) Which changing variable affects the data? [✓ A] B

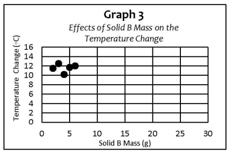
- Describe the trend by filling in the following sentence frame:

As solid A mass increases, the temperature change decreases.

2. Directions: *Answer the question using Graph 3.*

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

The points are too close together.



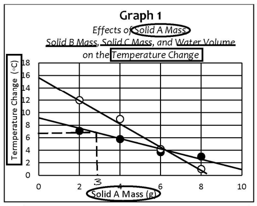
12

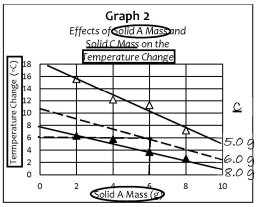
TECHNIQUE

Designing Experiments

Four UCSB scientists were studying the temperature change in a chemical reaction by examining solid A mass, solid B mass, solid C mass, and the water volume used. They all picked solid A mass as their changing variable. Two scientists worked independently, and they used different control values for solid B mass, solid C mass, and water volume (Graph 1). The other two scientists collaborated, and they picked the same control values for solid B mass and water volume (Graph 2).

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





Controls			
Scientist Symbol	Solid B Mass	Solid C Mass	Water Volume
●	6.0 g	5.0 g	60 mL
○	10.0 g	8.0 g	100 mL

Controls			
Scientist Symbol	Solid B Mass	Solid C Mass	Water Volume
▲	6.0 g	5.0 g	70 mL
△	6.0 g team control	8.0 g subgroup control	70 mL team control

a) Does solid A mass affect the temperature change of the reaction? YES [✓ NO]

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

- As solid A mass increases, the temperature change decreases.

b) What is the temperature change when the following are mixed: 3.0 g of A, 6.0 g of B, 5.0 g of C, and 60 mL of water? **Expected Temperature Change:** 7°C

- Why are trend lines important? They allow us to make predictions.

c) Can you predict what the temperature change would be if the scientists mixed 6.0 g of A, 6.0 g of B, 6.0 g of C, and 70 mL of water? [✓ YES] NO

- If YES, which graph is more useful to make your prediction? 1 [✓ 2]

Expected Temperature Change: 6°C

d) What does this mean for your experimental design? We should collaborate with other groups.

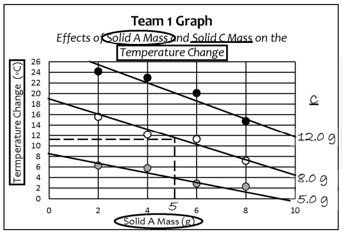
13

SCIENTIFIC PRACTICES

Analyzing & Interpreting Data

A large group of scientists collaborated by dividing into three teams to study the effects of solid A mass, solid B mass, solid C mass, and water volume on the temperature change in a chemical reaction. The three teams agreed to keep the water volume constant at 70 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.*



Controls		
Scientist Symbol	Solid B Mass	Solid C Mass
●	6.0 g	12.0 g
○	6.0 g	8.0 g
◍	6.0 g	5.0 g

a) Does solid A mass affect the temperature change of the reaction? [✓ YES] NO

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

- As solid A mass increases, the temperature change decreases.

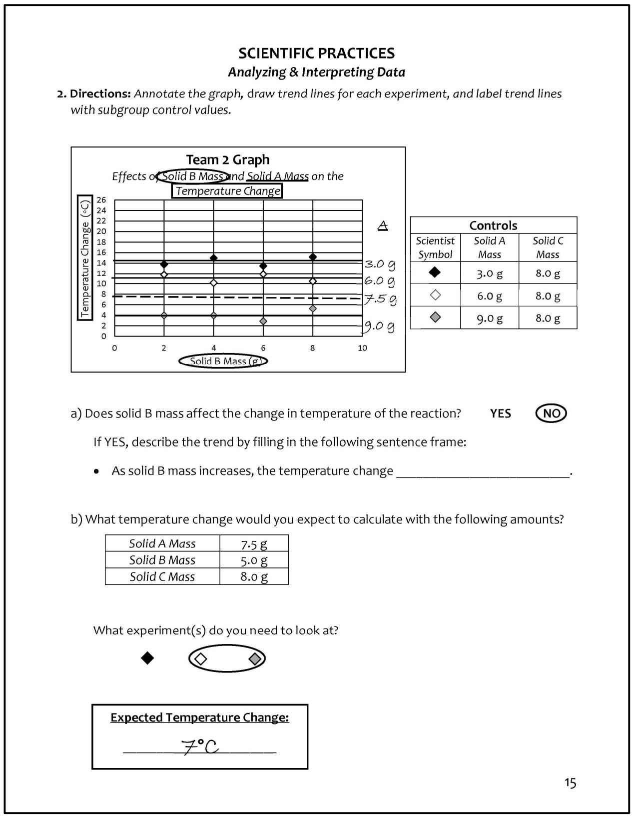
b) What temperature change would you expect to calculate with the following amounts?

Solid A Mass	5.0 g
Solid B Mass	6.0 g
Solid C Mass	8.0 g

What experiment(s) do you need to look at? ● [✓ ○] ◍

Expected Temperature Change: 11°C

14



SCIENTIFIC PRACTICES

Analyzing & Interpreting Data

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

Team 2 Graph

Effects of Solid B Mass and Solid A Mass on the Temperature Change

Controls		
Scientist Symbol	*Solid A Mass*	*Solid C Mass*
◆	3.0 g	8.0 g
◇	6.0 g	8.0 g
◈	9.0 g	8.0 g

a) Does solid B mass affect the change in temperature of the reaction? YES [✓ NO]

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

- As solid B mass increases, the temperature change __________________________.

b) What temperature change would you expect to calculate with the following amounts?

Solid A Mass	7.5 g
Solid B Mass	5.0 g
Solid C Mass	8.0 g

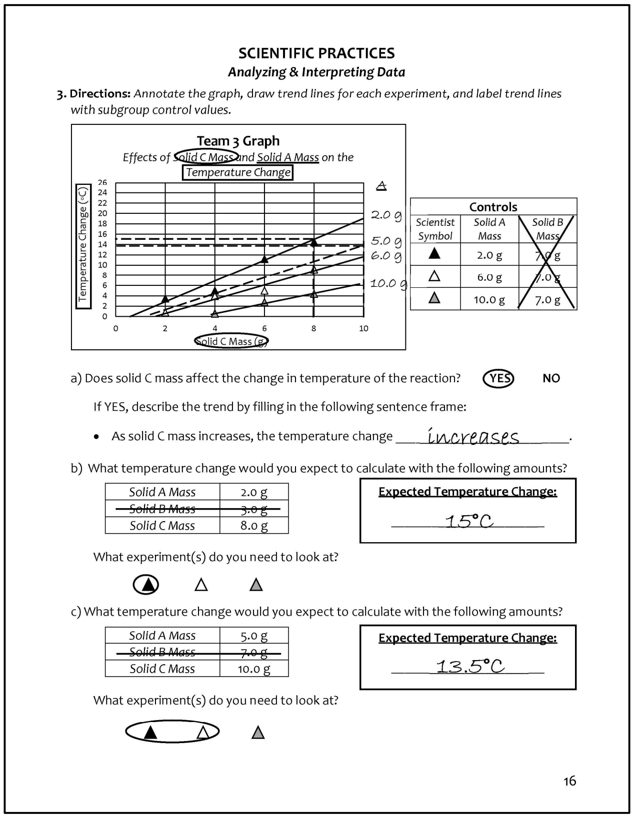
What experiment(s) do you need to look at?

◆ [✓ ◇ ◈]

Expected Temperature Change:

7°C

15



SCIENTIFIC PRACTICES

Analyzing & Interpreting Data

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

Team 3 Graph

Effects of Solid C Mass and Solid A Mass on the Temperature Change

Controls		
Scientist Symbol	*Solid A Mass*	~~*Solid B Mass*~~
▲	2.0 g	~~7.0 g~~
△	6.0 g	~~7.0 g~~
◬	10.0 g	~~7.0 g~~

a) Does solid C mass affect the change in temperature of the reaction? [✓ YES] NO

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

- As solid C mass increases, the temperature change increases.

b) What temperature change would you expect to calculate with the following amounts?

Solid A Mass	2.0 g
~~*Solid B Mass*~~	~~3.0 g~~
Solid C Mass	8.0 g

Expected Temperature Change:

15°C

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

[✓ ▲] △ ◬

c) What temperature change would you expect to calculate with the following amounts?

Solid A Mass	5.0 g
~~*Solid B Mass*~~	~~7.0 g~~
Solid C Mass	10.0 g

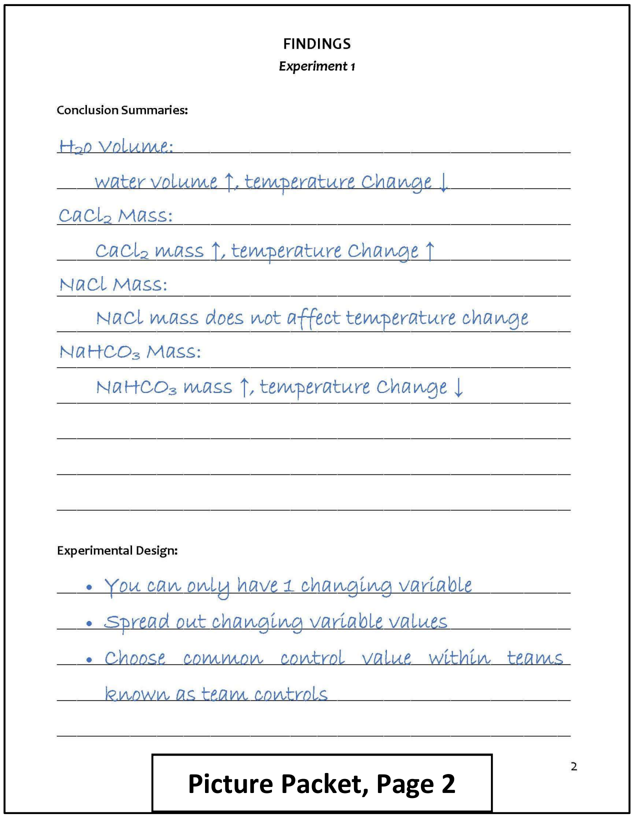
Expected Temperature Change:

13.5°C

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

[✓ ▲ △] ◬

16



FINDINGS

Experiment 1

Conclusion Summaries:

H_2O Volume:

water volume ↑, temperature Change ↓

$CaCl_2$ Mass:

$CaCl_2$ mass ↑, temperature Change ↑

NaCl Mass:

NaCl mass does not affect temperature change

$NaHCO_3$ Mass:

$NaHCO_3$ mass ↑, temperature Change ↓

Experimental Design:

- You can only have 1 changing variable
- Spread out changing variable values
- Choose common control value within teams known as team controls

2

Picture Packet, Page 2

Preparation:

SciTrek Lead:

1. Make sure mentors are setting out notebooks.

2. Set up the document camera for the findings discussion (picture packet, page 2), technique activities (notebook, pages 12-13), and analysis activity (notebook, pages 14-16).
3. Make sure mentors know they have copies of the notebook pages for the technique and analysis activities in their boxes and they know to fill them out with the class. Mentors should sit next to students that might need extra help.

SciTrek Mentors:

1. Set out notebooks/nametags.
2. Have a red pen available, to approve subgroups' conclusions (notebook, page 11).

Note: Set notebooks where students will sit during the module, even if another student is currently at that desk. If needed, students will move to these spots after the Introduction

Introduction:

(3 minutes – Full Class – SciTrek Lead)

If students are not in their subgroups, tell them, "A notebook will be put on your desk, which is not your notebook and you should not move it. You will move to your notebook after the Introduction."

Ask students, "What did you do, and learn, during the last session with SciTrek?" Possible student response: we conducted experiments to answer the class question, "What variables affect the temperature change of the chemical reaction?" We then looked at conclusions, in order to determine whether they were appropriate, for a given set of data.

Briefly review what they learned about conclusions last time.

- What is a conclusion?
  - Claim supported by data
- What is a claim, and what does it usually include?
  - 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
- Can the claim and data statements be in any order for the conclusion?
  - No, the claim must come first, followed by the data that supports it
- How many changing variables can we have, in order to make a conclusion and why?
  - One, if we test more than one changing variable at the same time, there is no way of telling which variable affected the data

Tell students, "Today, you are going to analyze your data, to see if you can draw a conclusion, then we will discuss your findings as a class. After, we will develop techniques to help you redesign your first experiment."

Conclusion:

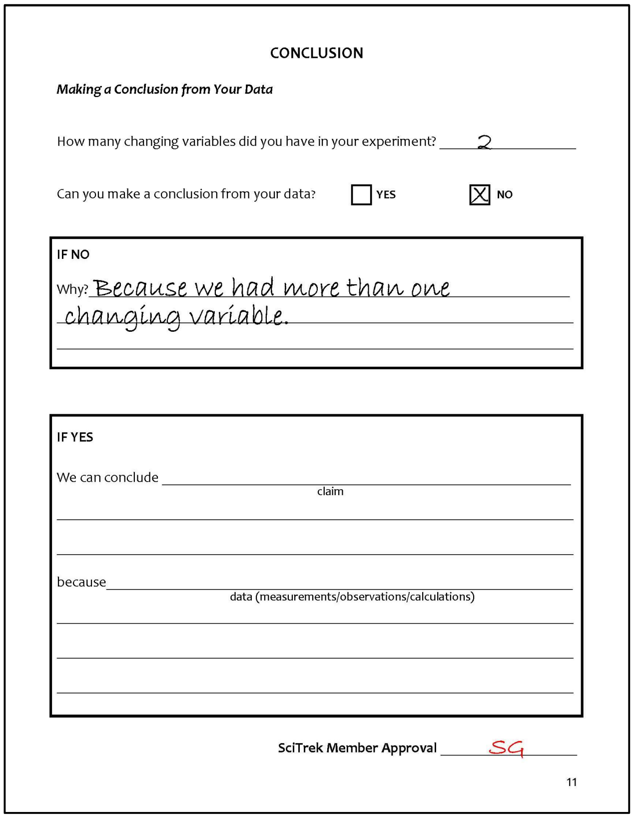
(10 minutes – Subgroups – SciTrek Mentors)

Help subgroups fill out page 11 of their notebooks. If the subgroup has more than one changing variable, they will not be able to draw a conclusion. An example of a scenario in which a subgroup cannot make a conclusion is shown below (left).

If the subgroup has only one changing variable, they will be able to make a conclusion. Make sure subgroups' conclusions have both a claim (statement that can be tested) and supporting data (measurements, observations, or calculations), and these statements are in the appropriately labeled sections. If the values of their changing variable have an order (Ex: 2.5 g → 3.2 g → 9.0 g) then that variable does have an effect on the temperature change. If, on the other hand, there was no order for their changing variable values (Ex: 5.5 g → 9.0 g →2.5 g) and/or the difference between the temperature change for each trial is small, then that variable does not have an effect on the temperature change. If possible, try to have subgroups generate a claim that allows them to make a prediction. An example of an appropriate claim could be: the greater the calcium chloride mass, the greater the temperature change. This is an appropriate claim, because it allows students to make a prediction about what would happen if new values of their changing variable were introduced.

After generating a claim about their experiment, subgroups will put their supporting data after the *because* in their conclusion sentence. Their supporting data should include at least two pieces of data, typically the minimum and maximum temperature changes. Make sure subgroups are using their changing variable values (not trial letters), and specific calculations to support their claims. The supporting data for the previously mentioned claim would be: when the $CaCl_2$ mass was 3.2 g, the temperature change was 3.4°C, and when the $CaCl_2$ mass was 9.0 g, the temperature change was 13.3°C.

Conclusions are still valid, and important, if they show the changing variable tested does not have an effect on the temperature change produced. Even if their conclusion is contrary to what you think, have subgroups make a claim based solely on their data. An example of a scenario in which a subgroup can make a conclusion, is shown below (right).



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? Because we had more than one changing variable.

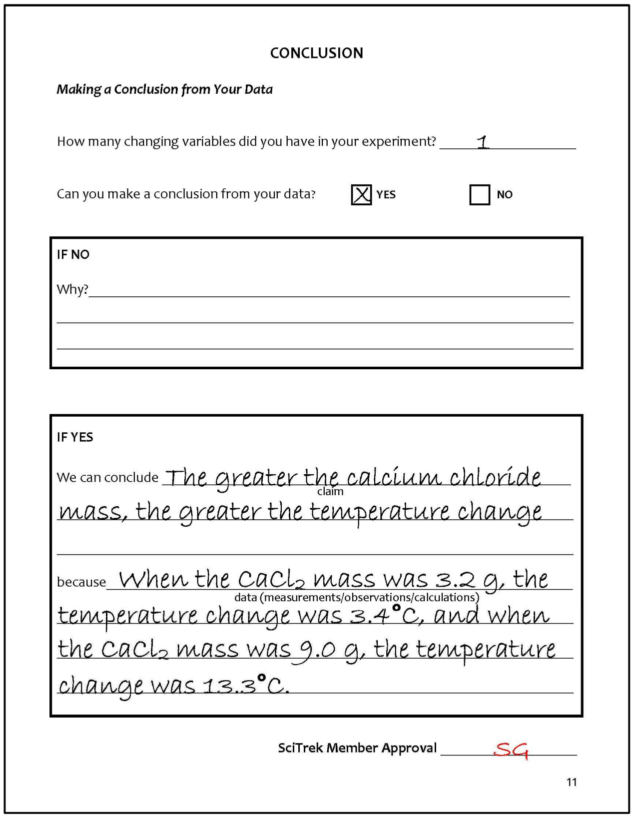
IF YES

We can conclude ____________ (claim)

because ____________ (data (measurements/observations/calculations))

SciTrek Member Approval SG

11



CONCLUSION

Making a Conclusion from Your Data

How many changing variables did you have in your experiment? 1

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

IF NO

Why? ____________

IF YES

We can conclude The greater the calcium chloride mass, the greater the temperature change (claim)

because When the $CaCl_2$ mass was 3.2 g, the temperature change was 3.4°C, and when the $CaCl_2$ mass was 9.0 g, the temperature change was 13.3°C. (data (measurements/observations/calculations))

SciTrek Member Approval SG

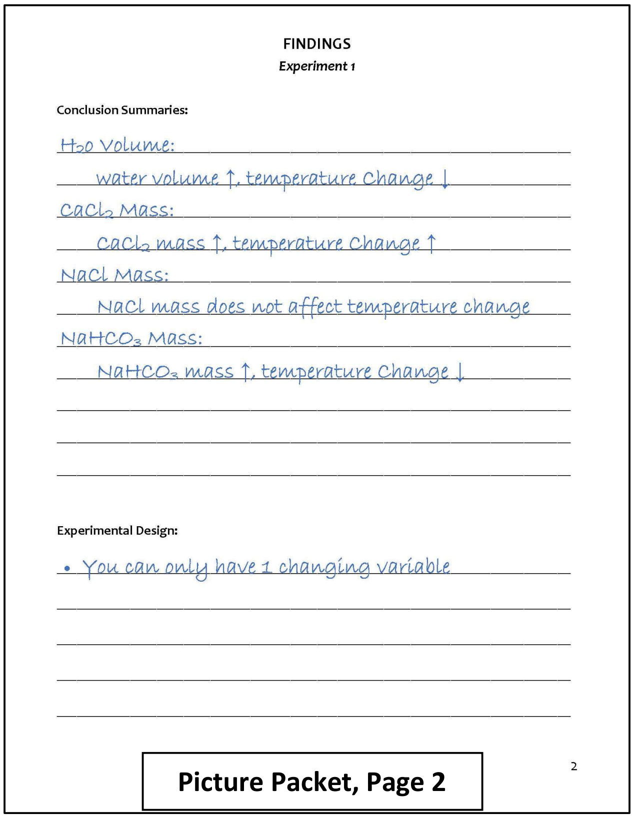
11

Findings Discussion:

(10 minutes – Full Class – SciTrek Lead)

Place page 2 of the picture packet under the document camera. First, ask students, “Who could not make a conclusion?” For any subgroups that raise their hands, ask them, “Why couldn’t you make a conclusion?” They should reply, “We had more than one changing variable.” Ask those subgroups, “What should you do differently, in order to be able to make a conclusion, next time?" They should reply, "We will only choose one changing variable in our next experiment." Record this on the class findings page, under *Experimental Design* (picture packet, page 2).

Next, go through each variable ($CaCl_2$ mass, $NaHCO_3$ mass, NaCl mass, water volume, other [Ex: stir speed]), and ask students, who were able to make a conclusion, to raise their hands if this was their changing variable. Have those subgroups read their conclusions. If multiple subgroups had the same changing variable, ask them whether their results agree. Record brief summaries for each variable that was tested on the class findings page 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 in order to find out how the changing variable affects the temperature change. An example filled out class findings page is shown below. **Note:** There may be only a few, or even zero, subgroups who are able to make conclusions at this point, so you may not be able to record many findings; however, the example below shows possible conclusion summaries for the most commonly chosen changing variables.



FINDINGS

Experiment 1

Conclusion Summaries:

H_2O Volume:

water volume ↑, temperature change ↓

$CaCl_2$ Mass:

$CaCl_2$ mass ↑, temperature change ↑

NaCl Mass:

NaCl mass does not affect temperature change

$NaHCO_3$ Mass:

$NaHCO_3$ mass ↑, temperature change ↓

Experimental Design:

- You can only have 1 changing variable

2

Picture Packet, Page 2

Technique:

(15 minutes – Full Class – SciTrek Lead)

It is helpful to have mentors sit between students and fill out the technique activity and the scientific practice activity along with students. This allows students to check their work easily. Mentors should have extra copies of these notebook pages in their boxes.

Tell the class, "You are now going to work on techniques to help you analyze your data, this will allow you to design a new, 'better' experiments during the next session." Have mentors pass out a clear ruler, to each student. Keep the picture packet close by, as you will need to record two more class findings during this technique activity.

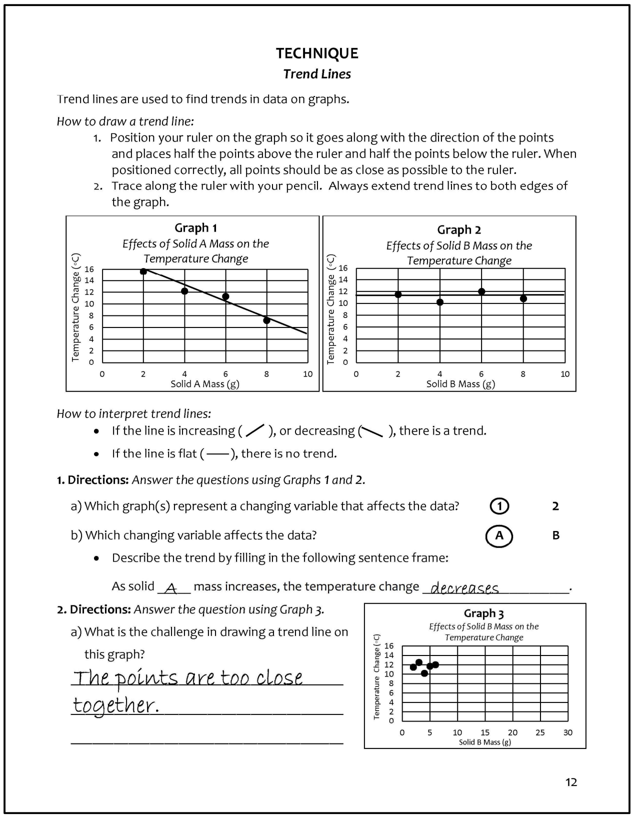
Tell students, “We are going to learn about trends. Trends are when data changes in one general direction, either going up or going down. If the data points all lie in a flat line, then there is no trend in the data. We are going to use trend lines to help us recognize patterns in data.” Open the class notebook to page 12, under the document camera, and have the students do the same in their notebooks.

Read the directions for how to draw a trend line (*1. Position 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 the ruler. When positioned correctly, all points should be as close as possible to the ruler. 2. Trace along the ruler with your pencil. Always extend trend lines to both edges of the graph.*). Then use a clear ruler to show students how to draw a trend line on Graph 1 and have them draw a trend line on Graph 1 in their notebooks. Repeat the process for Graph 2.

Read the directions on how to interpret trend lines to students (*If the line is increasing (/), or decreasing (\ ), there is a trend. If the line is flat (—), there is no trend.*). Have students draw in the appropriate lines. **Note:** Use the word ‘flat’ rather than ‘straight’ when describing trend lines showing no trend, because all lines are straight. Explain to students, “When a graph shows a trend, the changing variable affects the data. When a graph does not show a trend, the changing variable does not affect the data.”

Go over question *1* as a class. Ask students, “Which graph represents a changing variable that affects the data?” Students should reply, “Graph 1.” Circle *1* for question *1a* while students do the same in their notebooks. Tell students, “This means that Graph 1 has a trend which we are going to describe.” Ask students, “Which changing variable affects the temperature change?” Students should reply, “Solid A mass.” Circle *Solid A Mass* for question *1b* while students do the same in their notebooks. Then, ask students, “What happens to the temperature change when the solid A mass increases?” Possible student response: as solid A mass increases, the temperature change decreases. Fill these in for the sentence frame in question 1b while students do the same in their notebooks.

Then, tell students, “I will now draw a trend line onto the data in Graph 3.” 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 students, “What does this mean for your experiment?” Possible student response: we need to pick values for our changing variable that are spread out/not close. Add this point to the Findings under *Experimental Design* (picture packet, page 1) and fill in question *2*. An example filled-out page 12 is shown below.



TECHNIQUE

Trend Lines

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

How to draw a trend line:

1. Position 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 the ruler. When positioned correctly, all points should be as close as possible to the ruler.
2. Trace along the ruler with your pencil. Always extend trend lines to both edges of the graph.

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.

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

a) Which graph(s) represent a changing variable that affects the data? [✓ 1] 2

b) Which changing variable affects the data? [✓ A] B

- Describe the trend by filling in the following sentence frame:

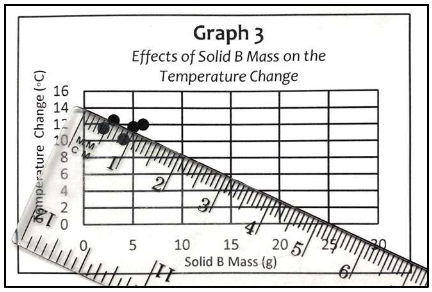
As solid A mass increases, the temperature change decreases.

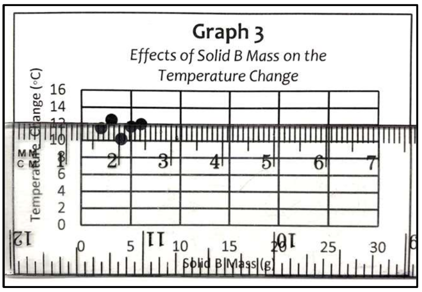
2. Directions: *Answer the question using Graph 3.*

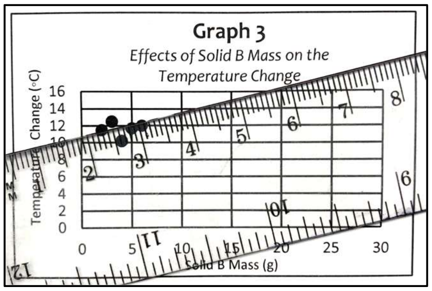
a) What is the challenge in drawing a trend line on this graph?

The points are too close together.

12







Turn to page 13 in the class notebook, and have students do the same in their notebooks. Tell students, “We will now work on developing techniques, in order to help design experiments as a class. To do this we are going to examine the results of four scientists, who are studying the temperature change in a chemical reaction. To help analyze the graph, we will annotate it by underlining controls, circling changing variables, and boxing information about data collection. The changing variable is always found on the x-axis (horizontal).” Ask students, “What is the changing variable in Graph 1 and what are the units?” They should reply, “Solid A mass, in grams.” Circle the x-axis title, *Solid A Mass (g)*, and have students do the same. Tell students, “The data collected is found on the y-axis (vertical).” Ask students, “What data was collected and what are the units?” They should reply, “Temperature change, in °C.” Box the y-axis title, *Temperature Change (°C)*, and have students do the same. Ask students, “Do you see the changing variable or the data anywhere else on the graph?” They should reply, “The title.” Ask students, “What should we do to the title?” They should reply, “Circle solid A mass, and box temperature change.” Tell students, “I also see solid B mass, solid C mass, and water volume, in the title.” Ask them, “What do you think that we should do with these?” If they do not know what to do, show them the table under Graph 1, which shows all of these as controls, then underline them.

Tell students, “We are now going to draw on the trend lines for graph 1.” Do this as a class. Once complete, repeat the process for Graph 2, making sure students underline solid C mass in the graph title.

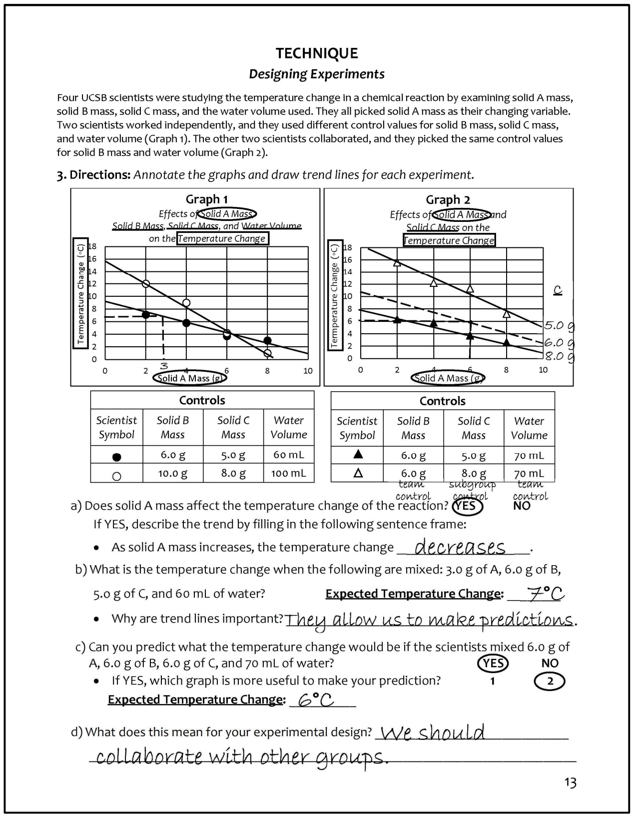
Ask students, “Why do you think Graph 1 has all the controls in the title, but Graph 2 only has one control?” Make sure, by the end of the conversation, students understand for Graph 1, all the controls had different values; therefore, they all needed to be in the title. However, for Graph 2, the scientists had two common control values (solid 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 that differ from each other, they are called ‘subgroup controls.’” Underneath the Graph 2 controls table, have students tell you whether each of the controls is a team control or a subgroup control, then label them. Tell students, “When a team of scientists has only one subgroup control, they can label the trend lines with the different 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 students, “Does the solid A mass affect the temperature change of the reaction and how do you know?” Possible student response: yes, because all four trend lines show a downward trend. Students should fill out the sentence frame for *3a*: *As solid A mass increases, the temperature change* decreases. Make sure students understand both graphs are valid, in order to show solid A mass has an effect on the temperature change.

Tell students, “Let’s see if we can predict the temperature change if we mix 3.0 g of A, 6.0 g of B, 5.0 g of C, and 60 mL of water. We do not have to be worried about the changing variable value, since the scale ranges from 0-10 g.” Walk students through each of the control values in question, and ask them, “Which trend line, on either graph, has the appropriate control values that match these?” Possible student response: the black circle and both of the triangle trend lines correspond to 6.0 g of B, but only the black circle trend line also has 5.0 g of C, and 60 mL of water as controls. Tell students, “We will use this trend line to estimate the temperature change.” Ask students, “Where does 3.0 g of A appear on the x-axis?” They should reply, “Halfway between 2.0 g and 4.0 g.” Put a small hash mark at 3.0 g and label it. Place your ruler vertically on the graph going from 3.0 g of A, up to the black circle trend line and draw a dashed line. Have students do the same. Next, lay your ruler horizontally starting at the intersection point of your dashed line and the black circle trend line. Draw another dashed line tracing back to the y-axis. Tell students, “The point where your dashed line touches on the y-axis is your expected temperature change.” Ask students, “What is the expected temperature change from mixing these amounts of substances?” Possible student response: 7°C. Write the value down for question *3b*. Tell students, “Because these are predictions, they are approximate numbers. As long as you are within 2°C of my estimated temperature change, you have drawn an acceptable trend line, and can consider your temperature change correct.” If any students do not get within 2°C of your estimated temperature change, have a mentor go and check their graph/trend line. Ask students, “Why are trend lines important?” Possible student response: we can use trend lines to make predictions from our graphs. Record this answer for question *3b*.

Read question *3c* to students (*Can you predict what the temperature change would be if the scientists mixed 6.0 g of A, 6.0 g of B, 6.0 g of C, and 70 mL of water?*). Walk students through each of the control values in the question and ask them, “Which trend line, on either graph, has the appropriate control values that match these?” Students should notice that neither graph has the exact control values. Ask students, “Since neither graph has exactly what we want, are any of the lines close to the values we want?” Students should notice the black triangles (5.0 g of C) and white triangles (8.0 g of C) have the correct mass of B (6.0 g) and water amount (70 mL). Tell students, “Since the lines do not cross and 6.0 g is between 5.0 g and 8.0 g we should be able to draw in an estimated trend line for 6.0 g and then predict the temperature change.” Have students circle Yes and 2 for question *3c*.

Tell students, “I will now show you how to draw on an estimated trend line in Graph 2.” Ask students, “Where does 6.0 g fall with relation to 5.0 g and 8.0 g?” Possible student response: it is closer to 5.0 g than to 8.0 g. Put dots on both vertical axes of Graph 2, in the approximate location of the 6.0 g trend line, then use a ruler to draw a dashed line between the two dots creating the estimated 6.0 g trend line. Then label the line in the graph margins as 6.0 g and have students do the same in their notebooks. Tell students, “Now, we have a line with all of the values of the controls in the question, therefore, we can estimate the temperature change.” Show students how to draw a vertical dashed line, up from 6.0 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, to find the estimated temperature change (6°C). Remind students, “These are approximate numbers, so if you are within 2°C of my estimated temperature change, you should consider your temperature change correct.” Have students fill out question *3c* with their predicted temperature change. Ask students, “What did the scientists do that made Graph 2 more useful and what does this mean for your experimental design?” Make sure, by the end of the conversation, students understand they need to collaborate with subgroups with the same changing variable, when they select their control values. Add this point to the class findings list under *Experimental Design* (picture packet, page 2). An example filled-out page 13 (left), and complete findings list (right), are shown below.



TECHNIQUE

Designing Experiments

Four UCSB scientists were studying the temperature change in a chemical reaction by examining solid A mass, solid B mass, solid C mass, and the water volume used. They all picked solid A mass as their changing variable. Two scientists worked independently, and they used different control values for solid B mass, solid C mass, and water volume (Graph 1). The other two scientists collaborated, and they picked the same control values for solid B mass and water volume (Graph 2).

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

Controls			
Scientist Symbol	Solid B Mass	Solid C Mass	Water Volume
●	6.0 g	5.0 g	60 mL
○	10.0 g	8.0 g	100 mL

Controls			
Scientist Symbol	Solid B Mass	Solid C Mass	Water Volume
▲	6.0 g	5.0 g	70 mL
△	6.0 g	8.0 g	70 mL
	team control	subgroup control	team control

a) Does solid A mass affect the temperature change of the reaction? [✓ YES] NO

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

- As solid A mass increases, the temperature change decreases.

b) What is the temperature change when the following are mixed: 3.0 g of A, 6.0 g of B, 5.0 g of C, and 60 mL of water? **Expected Temperature Change:** 7°C

- Why are trend lines important? They allow us to make predictions.

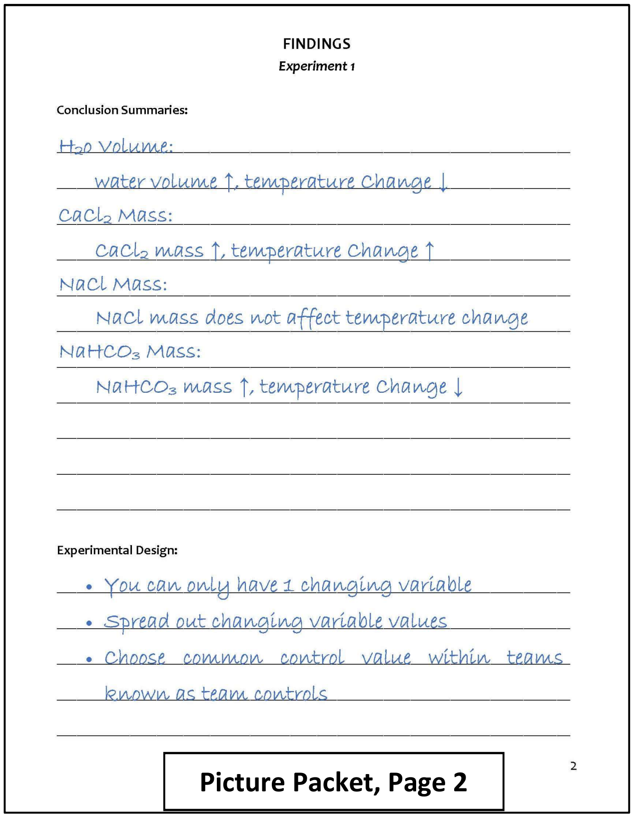
c) Can you predict what the temperature change would be if the scientists mixed 6.0 g of A, 6.0 g of B, 6.0 g of C, and 70 mL of water? [✓ YES] NO

- If YES, which graph is more useful to make your prediction? 1 [✓ 2]

Expected Temperature Change: 6°C

d) What does this mean for your experimental design? We should collaborate with other groups.

13



FINDINGS

Experiment 1

Conclusion Summaries:

H_2O Volume:

water volume ↑, temperature change ↓

$CaCl_2$ Mass:

$CaCl_2$ mass ↑, temperature change ↑

NaCl Mass:

NaCl mass does not affect temperature change

$NaHCO_3$ Mass:

$NaHCO_3$ mass ↑, temperature change ↓

Experimental Design:

- You can only have 1 changing variable
- Spread out changing variable values
- Choose common control value within teams known as team controls

2

Picture Packet, Page 2

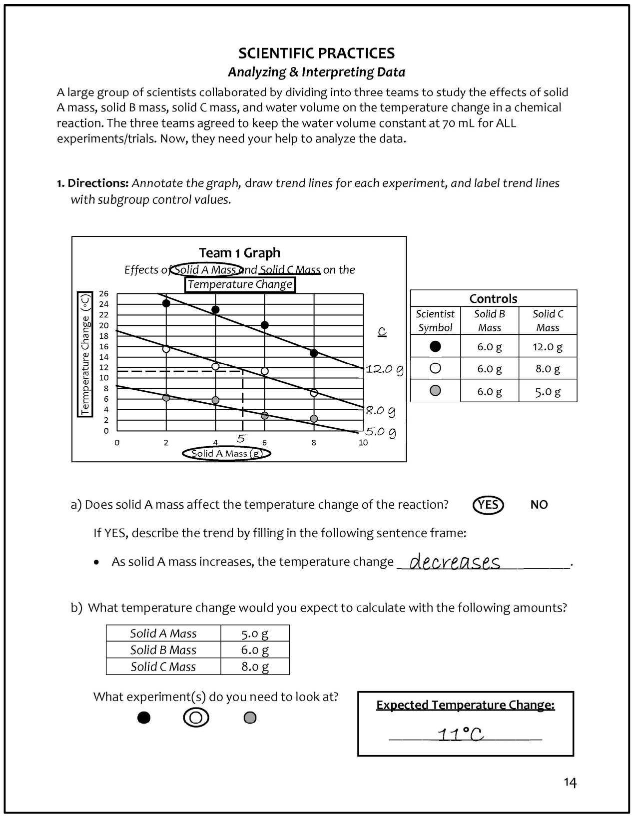
Analysis Activity:

(20 minutes – Full Class – SciTrek Lead)

Turn to page 14 in the class notebook under the document camera, and have students turn to page 14 in their notebooks. Tell students, “We will continue discussing the scientists who studied the reaction of A, B, C, and water, on the temperature change of the reaction. They collected data by dividing into three teams, each choosing one of the variables as their changing variable. In addition, they all chose to keep the water volume constant at 70 mL. We will start analyzing their data by annotating and labeling the graph.” 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 while it is not under the document camera. When the majority of students are done, put the class notebook under the document camera, for them to check their work.

Ask students, “What is the changing variable Team 1 tested?” They should reply, “Solid A mass.” Point out that solid B mass was a team control and solid C mass was a subgroup control. Ask students, “Do you see a trend, and, if so, what does this mean?" Possible student response: there is a trend, and it means that solid A mass affects the temperature change. Then, ask students, "What happens to the temperature change as solid A mass increases?" They should reply, "The temperature change decreases." Fill in the sentence frame under question *1a*, and have students do the same in their notebooks.

Tell students, "We are going to use Team 1's data to predict the temperature change if we were to mix 5.0 g of A, 6.0 g of B, and 8.0 g of C." Ask students, "Do we need to consider solid A mass and why?" Possible student response: no, because it is the changing variable and we can select the value we want. Ask students, "Do we need to consider solid B mass and why?" Possible student response: no, because the value to be mixed is 6.0 g, which is a team control value. Ask students, "Do we need to consider solid C mass and why?" Possible student response: yes, because the value to be mixed is 5.0 g and all lines have different values. Have students look at the solid C mass values that team 1 tested (5.0 g, 8.0 g, and 12.0 g), and compare them with the solid C mass in this question (8.0 g). Ask students, "Which experiment, or experiments, will we need to look at and why?" Possible student response: we should look at the white circles, because 8.0 g of solid C was used in that experiment. Circle the white circle for question *1b*. Have students look at the trend line for the white circles. Ask students, "What solid A mass are we interested in?" Students should reply, "5.0 g." Find 5.0 g on the x-axis and write it in. Use the ruler to draw a dashed line, straight up to the trend line for the white circles. Then, find the predicted temperature, by using the ruler to draw a second, horizontal dashed line straight across to the y-axis, which is roughly 11°C. Remind students, "Your predicted value can be off by up to 2°C, because these are estimates." Write "11°C" into the class notebook and have students write their estimated temperature change into their notebooks. An example fille-out page 14 is shown below (left).



SCIENTIFIC PRACTICES

Analyzing & Interpreting Data

A large group of scientists collaborated by dividing into three teams to study the effects of solid A mass, solid B mass, solid C mass, and water volume on the temperature change in a chemical reaction. The three teams agreed to keep the water volume constant at 70 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.*

Controls		
Scientist Symbol	*Solid B Mass*	*Solid C Mass*
●	6.0 g	12.0 g
○	6.0 g	8.0 g
◍	6.0 g	5.0 g

a) Does solid A mass affect the temperature change of the reaction? [✓ YES] NO

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

- As solid A mass increases, the temperature change decreases.

b) What temperature change would you expect to calculate with the following amounts?

Solid A Mass	5.0 g
Solid B Mass	6.0 g
Solid C Mass	8.0 g

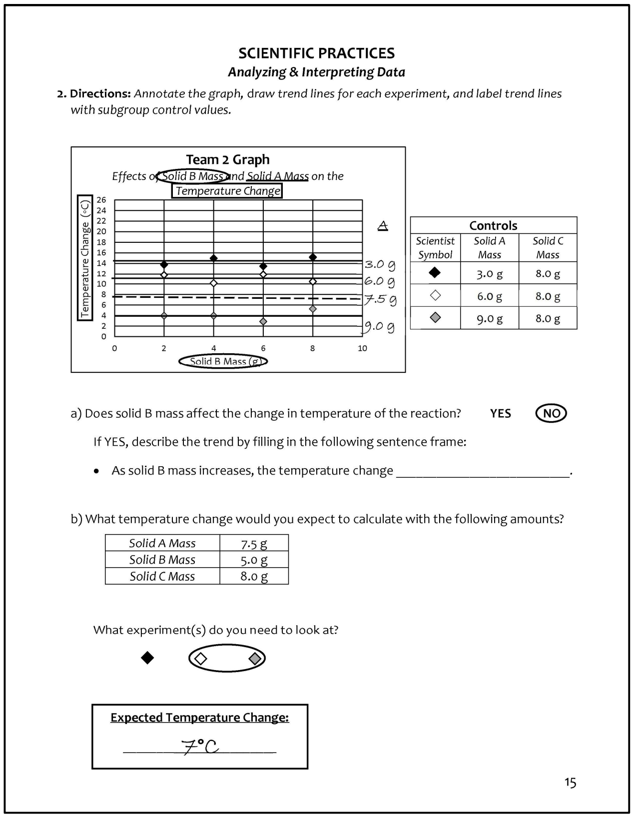
What experiment(s) do you need to look at?

● [✓ ○] ◍

Expected Temperature Change:

11°C

14



SCIENTIFIC PRACTICES

Analyzing & Interpreting Data

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

Controls		
Scientist Symbol	*Solid A Mass*	*Solid C Mass*
◆	3.0 g	8.0 g
◇	6.0 g	8.0 g
◈	9.0 g	8.0 g

a) Does solid B mass affect the change in temperature of the reaction? YES [✓ NO]

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

- As solid B mass increases, the temperature change ________________________.

b) What temperature change would you expect to calculate with the following amounts?

Solid A Mass	7.5 g
Solid B Mass	5.0 g
Solid C Mass	8.0 g

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

◆ [✓ ◇ ◈]

Expected Temperature Change:

7°C

15

Have students turn to page 15 in their notebooks and give students time to annotate the graph, draw on trend lines, and label the trend lines with the subgroup control values, on their own. Do the same in the class notebook off to the side of the document camera. When the majority of students are done, put the class notebook under the document camera for students to check their work.

Ask students, “What was the changing variable that team 2 tested?” They should reply, “Solid B mass.” Point out that solid C mass was a team control and solid A mass was a subgroup control. Ask students, “Do you see a trend and what does this mean?” Possible student response: there is not a trend and this means that solid B mass does not affect the temperature change of the reaction. Circle *NO* on question *2a* and have students do the same in their notebooks. Since there is no trend, the sentence frame in *2a* does not need to be filled in.

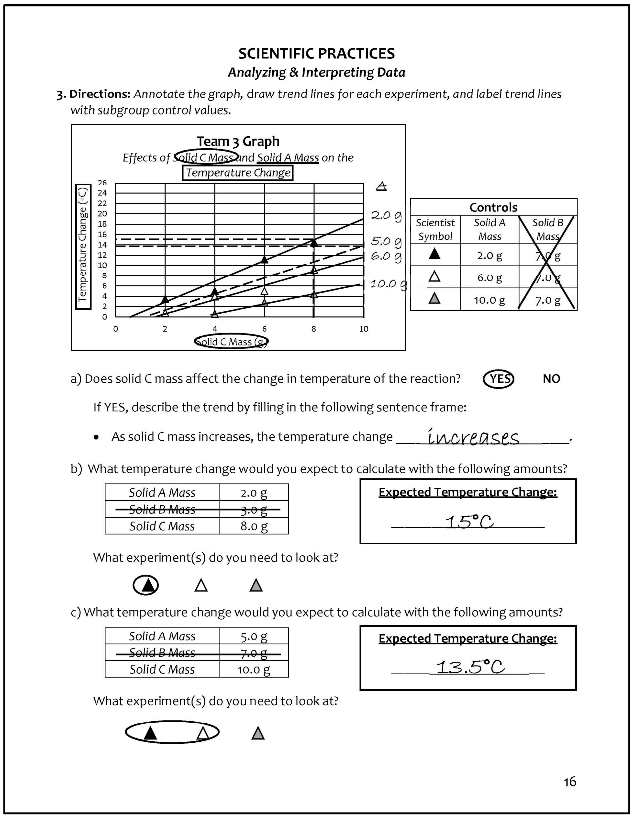
Tell students, “We are going to use team 2’s data to predict the temperature change if we were to mix 7.5 g of A, 5.0 g of B, and 8.0 g of C.” Ask students, “Do we need to consider solid B mass and why?” Possible student response: no, because it is the changing variable and we can select the value we want. Ask students, “Do we need to consider solid C mass and why?” Possible student response: no, because the value to be mixed is 8.0 g, which is a team control value. Ask students, “Do we need to consider solid A mass and why?” Possible student response: yes, because the value to be mixed is 7.5 g and all lines have different values. Have students look at the solid A mass values that team 2 tested (3.0 g, 6.0 g, and 9.0 g), and compare them with the solid A mass in this question (7.5 g). Ask students, “Which experiment, or experiments, will we need to look at and why?” Possible student response: we should look at the white and gray diamonds, because 7.5 g of solid C was used which is between 6.0 g and 9.0 g. Circle the white and gray diamonds for question *2b*. Tell students, “Because the 7.5 g trend line is not already on the graph we will need to estimate where it is.” Ask students, “Where does 7.5 g fall, with relation to 6.0 g and 9.0 g?” Possible student response: it is directly between 6.0 g and 9.0 g. Put dots on both vertical axes of team 2 graph, in the approximate location of the 7.5 g trend line, then use a ruler to draw a dashed line between the dots creating the estimated 7.5 g trend line. Then label the line in the graph margins as 7.5 g. Tell students, “Because solid B mass does not affect the change in temperature, we do not need to label the solid B amount that we are interested in on the x axis because all values will give the same temperature change. We can just look at where our estimated trend line hits the y axis.” Have students find their estimated temperature change, which is roughly 7°C. Remind students, “Your predicted value can be off by up to 2°C, because these are estimates.” Write “7°C” into the class notebook and have students write their estimated temperature change into their notebooks. An example filled-out page 15 is shown above (right).

Have students turn to page 16 in their notebooks and give students time to annotate the graph, draw on trend lines, and label the trend lines with the subgroup control values, on their own. Do the same in the class notebook off to the side of the document camera. When the majority of students are done, put the class notebook under the document camera for students to check their work.

Ask students, “What was the changing variable team 3 tested?” They should reply, “Solid C mass.” Point out that solid B mass was a team control, and solid A mass was a subgroup control. Ask students, “Do you see a trend, and, if so, what does this mean?” Possible student response: there is a trend and it means solid C mass affects the temperature change. Then, ask students, “What happens to the temperature change as solid C mass increases?” They should reply, “The temperature change increases.” Fill in the sentence frame under question *3a* and have students do the same in their notebooks.

Tell students, “We are going to use team 3’s data to predict the temperature change if we were to mix 2.0 g of A, 3.0 g of B, and 8.0 g of C.” Ask students, “Is there any irrelevant information or information that we do not need to worry about and why?” If students are struggling, ask them what team 2 discovered. Possible student response: we do not need to worry about solid B mass because it does not affect the temperature change. Tell students, “You should cross off solid B mass and its values, on the control charts on this page, to remind us that we do not need to worry about this variable. This is helpful because now we can focus on just one control, solid A mass.”

Give students time to fill out questions *3b* and *3c* on their own. While they are working on these draw the estimated trend line on the graph in the class notebook while it is not under the document camera. 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.



SCIENTIFIC PRACTICES

Analyzing & Interpreting Data

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

Controls		
Scientist Symbol	*Solid A Mass*	~~*Solid B Mass*~~
▲	2.0 g	~~7.0 g~~
△	6.0 g	~~7.0 g~~
◭	10.0 g	~~7.0 g~~

a) Does solid C mass affect the change in temperature of the reaction? [✓ YES] NO

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

- As solid C mass increases, the temperature change increases.

b) What temperature change would you expect to calculate with the following amounts?

Solid A Mass	2.0 g
~~*Solid B Mass*~~	~~3.0 g~~
Solid C Mass	8.0 g

Expected Temperature Change:

15°C

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

[✓ ▲] △ ◭

c) What temperature change would you expect to calculate with the following amounts?

Solid A Mass	5.0 g
~~*Solid B Mass*~~	~~7.0 g~~
Solid C Mass	10.0 g

Expected Temperature Change:

13.5°C

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

[✓ ▲ △] ◭

16

Note: You must finish through page 16 today, otherwise there will not be enough time on Day 5. If there is still time on Day 4, continue working on the analysis activity on pages 17. This will make Day 5 easier. For detailed instructions on how to do this, see the analysis activity section under Day 5. In the instruction for Day 5 it has students determine the predicted temperature changes as a class for team 1 and individually for team 2. If page 16 is being done on Day 4 then students can individually predict the temperature change for both teams.

Wrap-Up:

(2 minutes – Full Class – SciTrek Lead)

Tell students, "During the next session, you will design new experiments, using the techniques you learned today."

Clean-Up:

1. Collect notebooks with attached nametags.
2. Place materials into your group box and bring them back to UCSB.

Day 5: Analysis Activity/Question/Experimental Set-Up/Procedure/Results Table

Schedule:

Introduction (SciTrek Lead) – 2 minutes
Analysis Activity (SciTrek Lead) – 10 minutes
Class Plan Discussion (SciTrek Lead/Mentors) – 10 minutes
Team Plan Discussion (SciTrek Mentors) – 7 minutes
Question (SciTrek Mentors) – 5 minutes
Experimental Set-Up (SciTrek Mentors) – 5 minutes
Procedure (SciTrek Mentors) – 14 minutes
Results Table (SciTrek Mentors) – 5 minutes
Wrap-Up (SciTrek Lead) – 2 minutes

Materials:

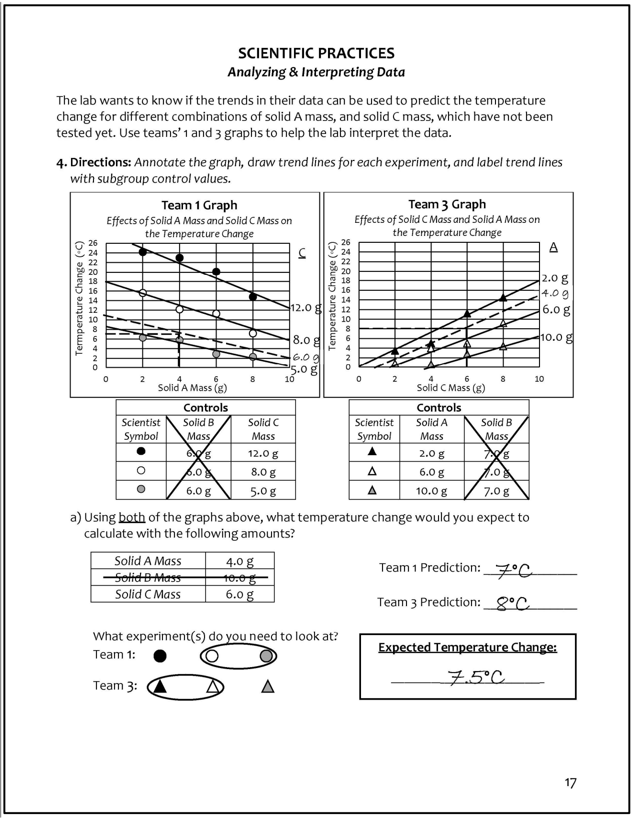
(3) Mentor Boxes:

- ☐ Nametags
- ☐ Notebooks
- ☐ Mentor instructions
- ☐ Mentor lab coat
- ☐ (2) Pencils
- ☐ (2) Red pens
- ☐ Paper notepad
- ☐ (12) Clear rulers
- ☐ (NV) Copies of notebook pages 12-17

Lead Box:

- ☐ (3) Extra notebooks
- ☐ Lead instructions
- ☐ Thermal Transfer picture packet
- ☐ Lead lab coat
- ☐ (2) Sets of team plans
- ☐ Time card
- ☐ (2) Pencils
- ☐ (2) Red pens
- ☐ (2) Wet erase markers
- ☐ (2) Black pens
- ☐ Paper notepad
- ☐ (5) Clear rulers
- ☐ Subgroup fair sticks (in Ziploc)
- ☐ (2) Copies of notebook pages 12-17

Notebook and Picture Packet Pages:



SCIENTIFIC PRACTICES

Analyzing & Interpreting Data

The lab wants to know if the trends in their data can be used to predict the temperature change for different combinations of solid A mass, and solid C mass, which have not been tested yet. Use teams' 1 and 3 graphs to help the lab interpret the data.

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

Controls		
Scientist Symbol	~~Solid B Mass~~	Solid C Mass
●	~~6.0 g~~	12.0 g
○	~~6.0 g~~	8.0 g
◍	~~6.0 g~~	5.0 g

Controls		
Scientist Symbol	Solid A Mass	~~Solid B Mass~~
▲	2.0 g	~~7.0 g~~
△	6.0 g	~~7.0 g~~
◭	10.0 g	~~7.0 g~~

a) Using both of the graphs above, what temperature change would you expect to calculate with the following amounts?

Solid A Mass	4.0 g
~~*Solid B Mass*~~	~~10.0 g~~
Solid C Mass	6.0 g

Team 1 Prediction: 7°C

Team 3 Prediction: 8°C

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

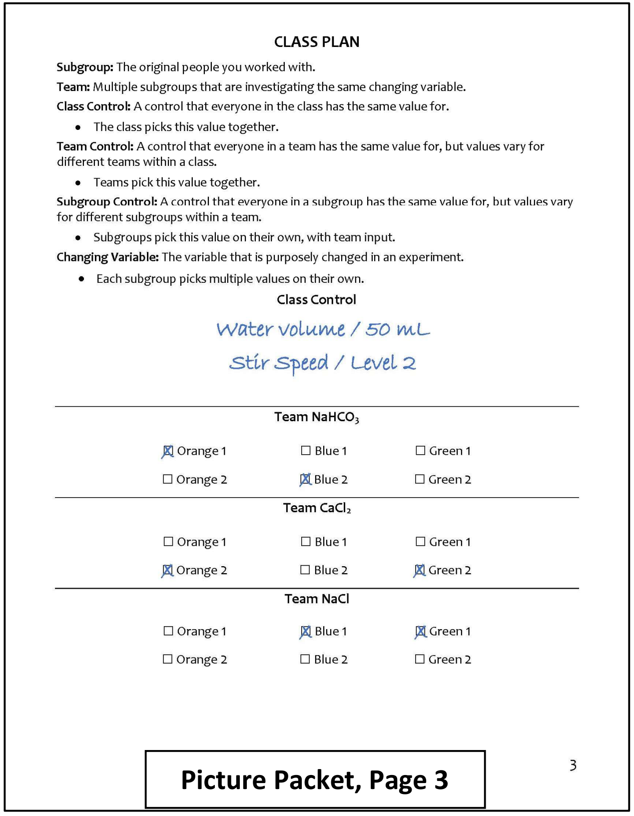
Team 1: ● [✓ ○ ◍]

Team 3: [✓ ▲ △] ◭

Expected Temperature Change:

7.5°C

17



CLASS PLAN

Subgroup: The original people you worked with.

Team: Multiple subgroups that are investigating the same changing variable.

Class Control: A control that everyone in the class has the same value for.

- The class picks this value together.

Team Control: A control that everyone in a team has the same value for, but values vary for different teams within a class.

- Teams pick this value together.

Subgroup Control: A control that everyone in a subgroup has the same value for, but values vary for different subgroups within a team.

- Subgroups pick this value on their own, with team input.

Changing Variable: The variable that is purposely changed in an experiment.

- Each subgroup picks multiple values on their own.

Class Control

Water volume / 50 mL

Stir Speed / Level 2

Team $NaHCO_3$

☒ Orange 1 ☐ Blue 1 ☐ Green 1
☐ Orange 2 ☒ Blue 2 ☐ Green 2

Team $CaCl_2$

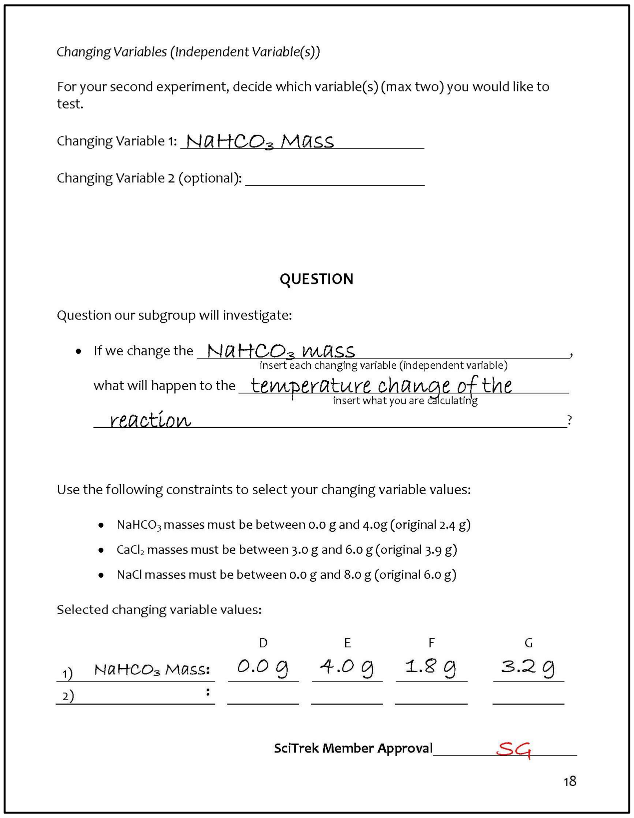
☐ Orange 1 ☐ Blue 1 ☐ Green 1
☒ Orange 2 ☐ Blue 2 ☒ Green 2

Team NaCl

☐ Orange 1 ☒ Blue 1 ☒ Green 1
☐ Orange 2 ☐ Blue 2 ☐ Green 2

Picture Packet, Page 3

3



Changing Variables (Independent Variable(s))

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

Changing Variable 1: $NaHCO_3$ Mass

Changing Variable 2 (optional): ____________

QUESTION

Question our subgroup will investigate:

- If we change the $NaHCO_3$ mass (insert each changing variable (independent variable)), what will happen to the temperature change of the reaction (insert what you are calculating)?

Use the following constraints to select your changing variable values:

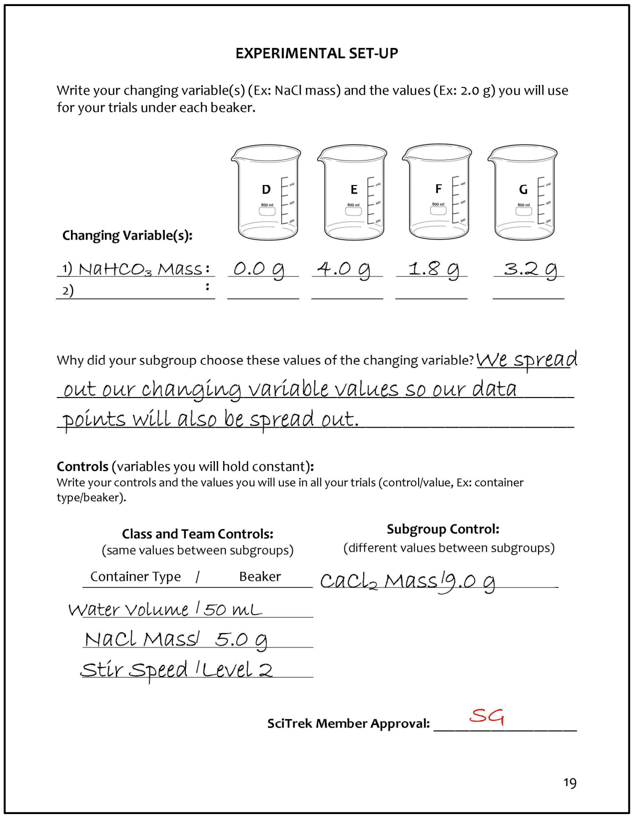
- $NaHCO_3$ masses must be between 0.0 g and 4.0g (original 2.4 g)
- $CaCl_2$ masses must be between 3.0 g and 6.0 g (original 3.9 g)
- NaCl masses must be between 0.0 g and 8.0 g (original 6.0 g)

Selected changing variable values:

	D	E	F	G
1) $NaHCO_3$ Mass:	0.0 g	4.0 g	1.8 g	3.2 g
2) ________:				

SciTrek Member Approval SG

18



EXPERIMENTAL SET-UP

Write your changing variable(s) (Ex: NaCl mass) and the values (Ex: 2.0 g) you will use for your trials under each beaker.

Changing Variable(s):

	D	E	F	G
1) $NaHCO_3$ Mass:	0.0 g	4.0 g	1.8 g	3.2 g
2) :				

Why did your subgroup choose these values of the changing variable? We spread out our changing variable values so our data points will also be spread out.

Controls (variables you will hold constant):
Write your controls and the values you will use in all your trials (control/value, Ex: container type/beaker).

Class and Team Controls:
(same values between subgroups)

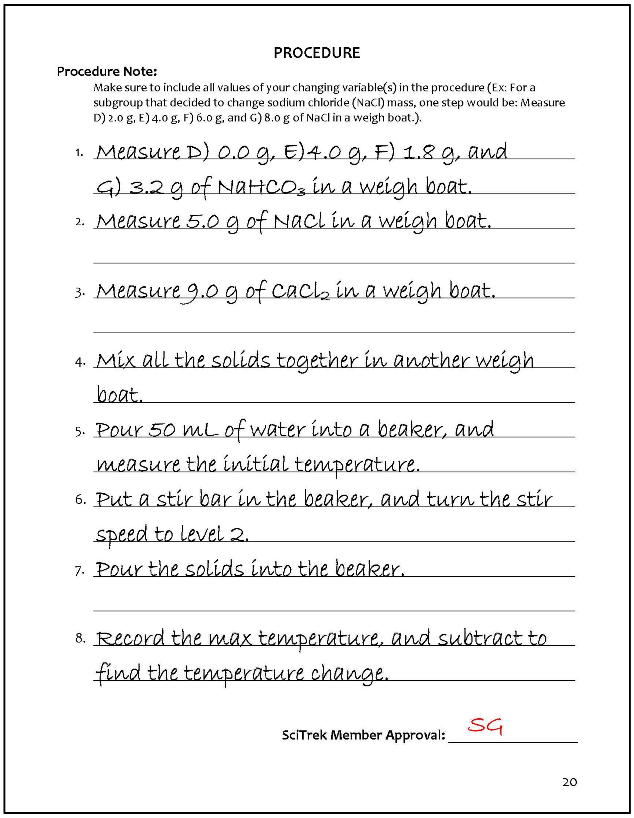
Container Type / Beaker
Water Volume / 50 mL
NaCl Mass/ 5.0 g
Stir Speed / Level 2

Subgroup Control:
(different values between subgroups)

$CaCl_2$ Mass / 9.0 g

SciTrek Member Approval: SG

19



PROCEDURE

Procedure Note:
Make sure to include all values of your changing variable(s) in the procedure (Ex: For a subgroup that decided to change sodium chloride (NaCl) mass, one step would be: Measure D) 2.0 g, E) 4.0 g, F) 6.0 g, and G) 8.0 g of NaCl in a weigh boat.).

1. Measure D) 0.0 g, E) 4.0 g, F) 1.8 g, and G) 3.2 g of $NaHCO_3$ in a weigh boat.
2. Measure 5.0 g of NaCl in a weigh boat.
3. Measure 9.0 g of $CaCl_2$ in a weigh boat.
4. Mix all the solids together in another weigh boat.
5. Pour 50 mL of water into a beaker, and measure the initial temperature.
6. Put a stir bar in the beaker, and turn the stir speed to level 2.
7. Pour the solids into the beaker.
8. Record the max temperature, and subtract to find the temperature change.

SciTrek Member Approval: SG

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Preparation:

SciTrek Lead:

1. Make sure mentors know what team they will work with once students form teams.
2. Make sure mentors are passing out notebooks and rulers.
3. Set up the document camera for the analysis activity (notebook, pages 17) and class plan discussion (picture packet, page 3).
4. Make sure mentors know they have copies of the notebook pages for the analysis activities in their boxes and they know to fill them out with the class. Mentors should sit next to students that might need extra help.

SciTrek Mentors:

1. Pass out notebooks/nametags and rulers.
2. Have a red pen available to approve subgroups' changing variable values, experimental set-ups, and procedures (notebook, pages 18-20).

Note: Pass out notebooks to students. If needed, students will move to their subgroups after the analysis activity.

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

If students are not in their subgroups, tell students, "You will move to your subgroups after the analysis activity."

Ask the class, "What is the class question that we have been investigating?" Students should reply, "What variables affect the temperature change of the chemical reaction?" Tell students, "Today, you are going to continue developing analysis techniques and use these skills to plan your next investigation as a class. You will then break into teams, in order to design your experiments."

Tell students, "We will continue discussing the scientists who studied the effects of solids A, B, and C, as well as water, on temperature change of the reaction. Remember, the scientists collected data by dividing into three teams, each choosing one of the solid masses as their changing variable." Ask students, "Did solid A mass affect the temperature change, and how do you know?" If needed, have students turn to page 14. Possible student response: yes, the more solid A mass, the smaller the temperature change and we know this because the trend line went down. Ask students, "Did solid B mass affect the temperature change, and how do you know?" If needed, have students turn to page 15. Possible student response: no, because the trend lines are flat. Ask students, "Did solid C mass affect the temperature change, and how do you know?" If needed, have students turn to page 16. Possible student response: yes, the more solid C mass, the larger the temperature change and we know this because the trend line went up.

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

Turn to page 17 in the class notebook, under the document camera, and have students turn to page 17 in their notebooks. Tell students, "The scientists are now interested in looking at all of the teams' data together, in order to make predictions about the temperature changes for different combinations of the substances. I have copied the team 1 and team 3 graphs onto this page, so we can look at the data at the same time." Do not have students annotate the graphs on page 17 because they have already done this on the previous pages.

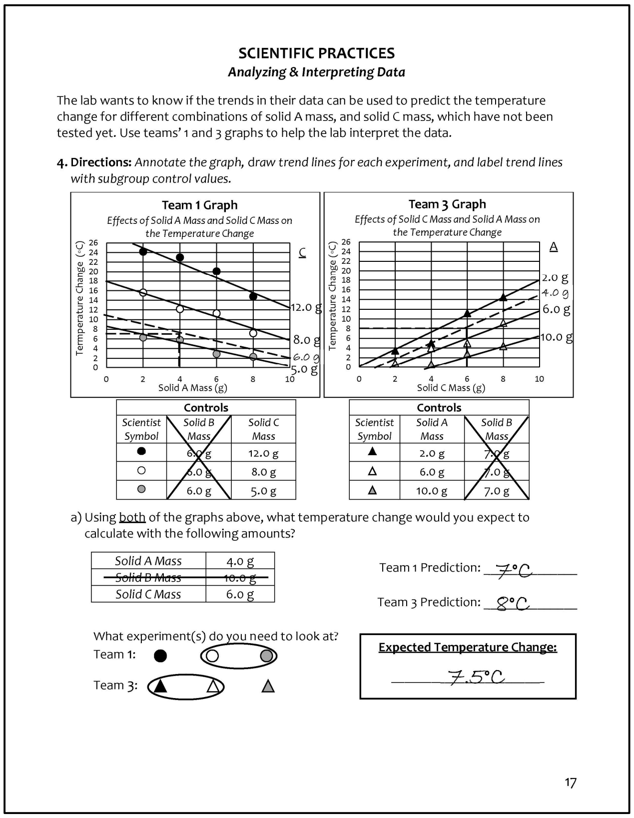
Ask students, "Why do you think team 2's graph is not printed here?" Possible student response: Team 2 found out that solid B mass did not affect the temperature change, so we do not need to worry about team 2's graph when predicting temperature changes. Then, ask students, "Is there any irrelevant information, that we could cross out, on this page and why?" Possible student response: we could cross off solid B mass, because this did not affect the temperature change. Cross off solid B mass in the class notebook, and have students do the same in their notebooks.

Read the directions for question *4a* (*Using both of the graphs above, what temperature change would you expect to calculate with the following amounts?*); then read the amounts of each solid that will be mixed, from the table. Tell students, "We are going to use team 1's data to predict the temperature change using the amounts provided. Then, we will use team 3's data to make a prediction about the same provided amounts. We will then be able to 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 amounts that will be mixed from the table again. Tell students, "We should focus on solid C mass first, because it is a subgroup control for this team." Have students compare solid C mass values that team 1 tested (5.0 g, 8.0 g, and 12.0 g), with solid C mass in this question (6.0 g). Ask students, "Which experiment(s)/trend line(s) will we need to look at and why?" Possible student response: the white and gray circles, because 6.0 g is between 5.0 g, and 8.0 g. Circle the gray and white circles for team 1 on question *4a*. Ask students, "Where do we need to draw the estimated trend line?" Possible student response: the estimated trend line should be between the lines for the white and gray circles, but closer to the line for the gray circles, because 6.0 g is closer to 5.0 g, than to 8.0 g. Have students use the technique they learned to draw the dashed, estimated trend line. Ask students, "What should we do next?" Possible student response: find 4.0 g of A on the x-axis, and draw a dashed line straight up to the dashed trend line. Have students do this while you do it in the class notebook. Ask students, "What should we do next?" Possible student response: draw a dashed line straight across to the y-axis and read the expected temperature change. Have students do this while you do it in the class notebook. Ask students, “What temperature change will the reaction cause, based on these amounts?” They should reply, “7°C.” Write this number in the class notebook as the *Team 1 Prediction*.

Tell students, “We are now going to use team 3’s data to make a prediction about the temperature change using the same amounts.” Give students time to try this on their own. While they are working on this, 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 approximately 8°C.

Ask students, “Which team’s prediction should we 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, the predicted power should be between those values at 7.5°C. Write this number in the class notebook, in the box for expected temperature change, and have the students write the temperature changes they predicted in their notebooks. Remind students, “Your predictions can differ from the one in the class notebook by up to 2°C.” An example filled-out page 17 is shown below.



SCIENTIFIC PRACTICES

Analyzing & Interpreting Data

The lab wants to know if the trends in their data can be used to predict the temperature change for different combinations of solid A mass, and solid C mass, which have not been tested yet. Use teams’ 1 and 3 graphs to help the lab interpret the data.

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

Controls		
Scientist Symbol	~~*Solid B Mass*~~	*Solid C Mass*
●	~~6.0 g~~	12.0 g
○	~~6.0 g~~	8.0 g
◍	~~6.0 g~~	5.0 g

Controls		
Scientist Symbol	*Solid A Mass*	~~*Solid B Mass*~~
▲	2.0 g	~~7.0 g~~
△	6.0 g	~~7.0 g~~
◮	10.0 g	~~7.0 g~~

a) Using both of the graphs above, what temperature change would you expect to calculate with the following amounts?

Solid A Mass	4.0 g
~~*Solid B Mass*~~	~~10.0 g~~
Solid C Mass	6.0 g

Team 1 Prediction: 7°C

Team 3 Prediction: 8°C

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

Team 1: ● [✓ ○ ◍]

Team 3: [✓ ▲ △] ◮

Expected Temperature Change:

7.5°C

17

Class Plan Discussion:

(10 minutes – Full Class – SciTrek Lead)

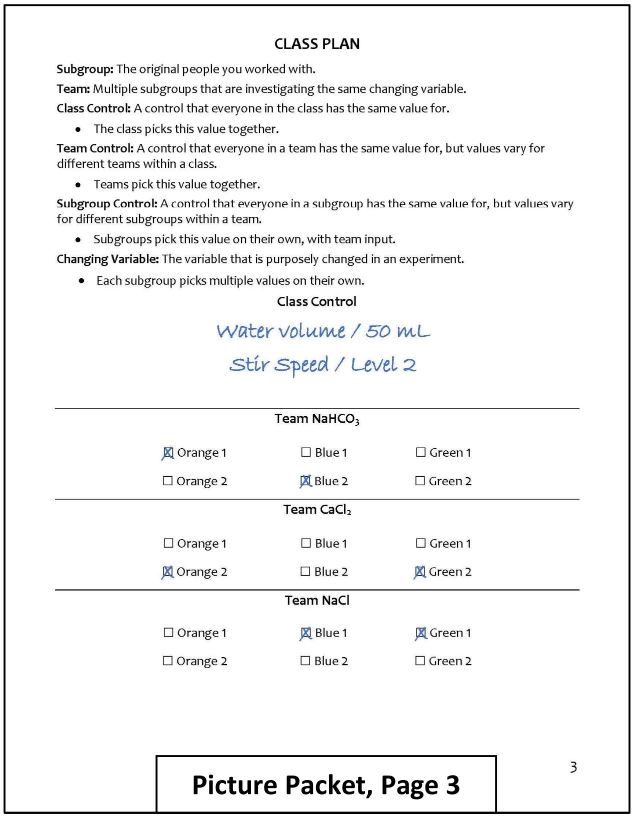
If students are not already in their subgroups, have them move to be next to their subgroup members.

Place the *Findings* page (picture packet, page 2) under the document camera. Review with students the *Experimental Design* findings: only have one changing variable, spread out changing variable values, and choose common control values. Ask students, “When we design our next experiment, what do we need to do?” Possible student response: we need to work together as a class and between subgroups to choose common control values.

Tell the class, “You are now going to begin planning your next investigation. You will soon split up into teams to collaborate and work on answering the class question, just like the scientists in the analysis activity. Remember, the groups you worked with on your first experiments were called ‘subgroups.’ 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 students, “Should subgroups on the same team pick their controls independently and why?” Possible student response: no, because subgroups that are investigating the same changing variable need to collaborate, so that we can get more information from the data. If they are struggling with this concept, turn to page 13 of the class notebook and review the graphs before and after the engineers collaborated.

Ask students, “What are the changing variables we are investigating?” They should reply, “Water volume, NaCl mass, $NaHCO_3$ mass, $CaCl_2$ mass, and stir speed.” Tell students, “Since we only have six subgroups, and we need to have at least two subgroups work together per team, we will have NaCl Mass, $NaHCO_3$ mass, and $CaCl_2$ mass as our changing variables and set all other variables as class controls (controls that have the same value for the entire class).” Put the *Class Plan* (picture packet, page 3) under the document camera. Tell students, “We will now determine the values for our class controls.” Have students choose the water volume the whole class will use in their experiments. They can choose any volume between 20 and 60 mL (**Note:** 40-50 mL is best). The stir speed control value must be the original value of level 2. After the class has chosen the values, write the controls, and their values, under *Class Controls* on the *Class Plan* (picture packet, page 3).

Tell students, “We will now form teams to investigate the other variables. Within your subgroup, rank the changing variables from most interested in investigating to least interested in investigating.” Give subgroups approximately 2 minutes to rank their choice of variable. Then, use the fair sticks (in the lead box) to select subgroups to choose the team they will join. Record which subgroups will be in which teams by checking each subgroup’s box on the *Class Plan* as they select their teams. Make sure subgroups are evenly distributed between teams. An example filled-out *Class Plan* is shown below.



CLASS PLAN

Subgroup: The original people you worked with.

Team: Multiple subgroups that are investigating the same changing variable.

Class Control: A control that everyone in the class has the same value for.

- The class picks this value together.

Team Control: A control that everyone in a team has the same value for, but values vary for different teams within a class.

- Teams pick this value together.

Subgroup Control: A control that everyone in a subgroup has the same value for, but values vary for different subgroups within a team.

- Subgroups pick this value on their own, with team input.

Changing Variable: The variable that is purposely changed in an experiment.

- Each subgroup picks multiple values on their own.

Class Control

Water volume / 50 mL

Stir Speed / Level 2

Team $NaHCO_3$

☒ Orange 1 ☐ Blue 1 ☐ Green 1

☐ Orange 2 ☒ Blue 2 ☐ Green 2

Team $CaCl_2$

☐ Orange 1 ☐ Blue 1 ☐ Green 1

☒ Orange 2 ☐ Blue 2 ☒ Green 2

Team NaCl

☐ Orange 1 ☒ Blue 1 ☒ Green 1

☐ Orange 2 ☐ Blue 2 ☐ Green 2

3

Picture Packet, Page 3

Team Plan Discussion:

(7 minutes – Teams – SciTrek Mentors)

Have subgroups find their teams and sit with them and their mentor(s). Give each team their team plan.

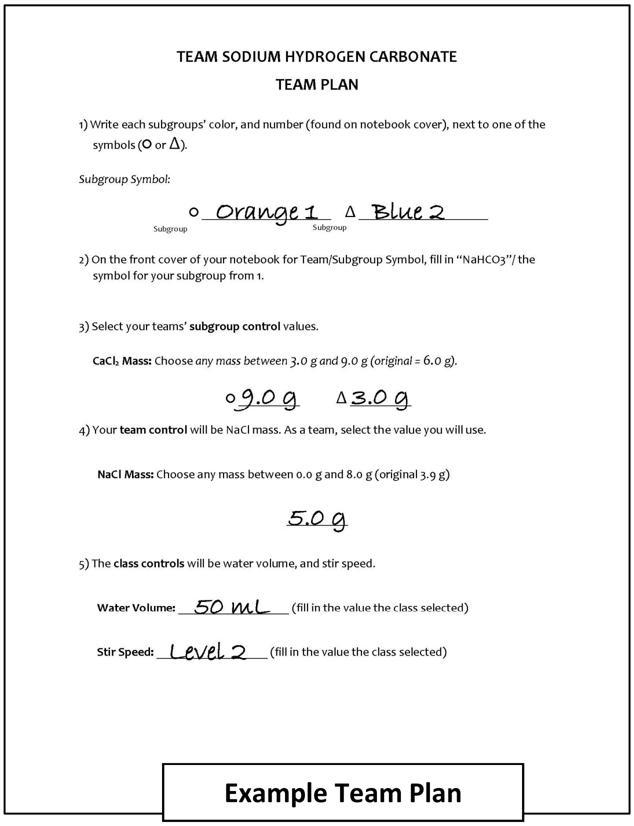
Help your team fill out the team plan, given to you by the lead. First, have each of the subgroups on your team choose one of the two symbols. Write the subgroup color and number next to the symbol they select (Ex: **O** _Orange 1_). Then have student write their team and symbol on the front cover of their notebook.

Tell students, "Subgroup controls are controls that are different for each subgroup. Therefore, each subgroup will now get to choose their subgroup control value." Ask students, "Should our subgroup control values be close to, or far apart from, each other and why?" Possible student response: they should be spread out, which will help us see how changing the subgroup control affects the temperature change of the reaction." Have each subgroup select their subgroup control values, and write the value next to the symbol.

Tell students, "Team controls are controls that are the same for the team. Therefore, we will need to agree on a value for these." Then have teams select a value for their team control.

Tell students, "Class controls are controls that we selected values for as a class." Have students tell you the values that the class selected for the water volume and stir speed, and record them on the team plan.

Hold onto the team plan to help the subgroups on your team fill out their experimental set ups later today. An example filled-out team plan is shown below. Each team has a slightly different team plan; examples of all team plans are shown below.



TEAM SODIUM HYDROGEN CARBONATE

TEAM PLAN

1) Write each subgroups' color, and number (found on notebook cover), next to one of the symbols (O or Δ).

Subgroup Symbol:

○ Orange 1 (Subgroup) Δ Blue 2 (Subgroup)

2) On the front cover of your notebook for Team/Subgroup Symbol, fill in "NaHCO3"/ the symbol for your subgroup from 1.

3) Select your teams' **subgroup control** values.

$CaCl_2$ Mass: Choose *any mass between 3.0 g and 9.0 g (original = 6.0 g).*

○ 9.0 g Δ 3.0 g

4) Your **team control** will be NaCl mass. As a team, select the value you will use.

NaCl Mass: Choose any mass between 0.0 g and 8.0 g (original 3.9 g)

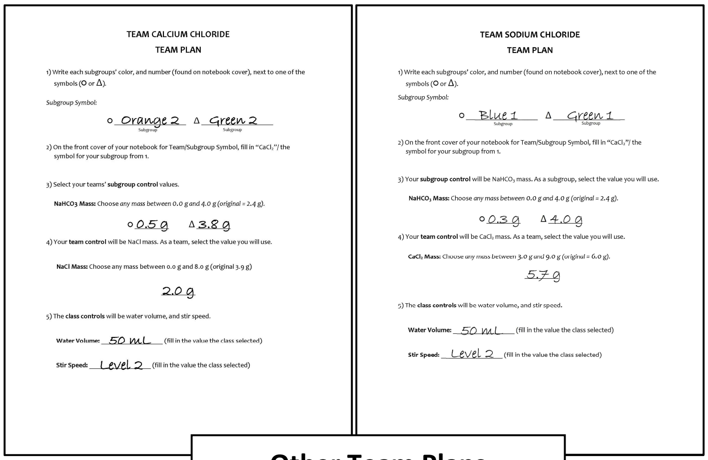
5.0 g

5) The **class controls** will be water volume, and stir speed.

Water Volume: 50 mL (fill in the value the class selected)

Stir Speed: Level 2 (fill in the value the class selected)

Example Team Plan



TEAM CALCIUM CHLORIDE

TEAM PLAN

1) Write each subgroups' color, and number (found on notebook cover), next to one of the symbols (O or Δ).

Subgroup Symbol:

○ Orange 2 (Subgroup) Δ Green 2 (Subgroup)

2) On the front cover of your notebook for Team/Subgroup Symbol, fill in "$CaCl_2$"/ the symbol for your subgroup from 1.

3) Select your teams' **subgroup control** values.

NaHCO3 Mass: Choose *any mass between 0.0 g and 4.0 g (original = 2.4 g).*

○ 0.5 g Δ 3.8 g

4) Your **team control** will be NaCl mass. As a team, select the value you will use.

NaCl Mass: Choose any mass between 0.0 g and 8.0 g (original 3.9 g)

2.0 g

5) The **class controls** will be water volume, and stir speed.

Water Volume: 50 mL (fill in the value the class selected)

Stir Speed: Level 2 (fill in the value the class selected)

TEAM SODIUM CHLORIDE

TEAM PLAN

1) Write each subgroups' color, and number (found on notebook cover), next to one of the symbols (O or Δ).

Subgroup Symbol:

○ Blue 1 (Subgroup) Δ Green 1 (Subgroup)

2) On the front cover of your notebook for Team/Subgroup Symbol, fill in "$CaCl_2$"/ the symbol for your subgroup from 1.

3) Your **subgroup control** will be $NaHCO_3$ mass. As a subgroup, select the value you will use.

$NaHCO_3$ Mass: Choose *any mass between 0.0 g and 4.0 g (original = 2.4 g).*

○ 0.3 g Δ 4.0 g

4) Your **team control** will be $CaCl_2$ mass. As a team, select the value you will use.

$CaCl_2$ Mass: Choose *any mass between 3.0 g and 9.0 g (original = 6.0 g).*

5.7 g

5) The **class controls** will be water volume, and stir speed.

Water Volume: 50 mL (fill in the value the class selected)

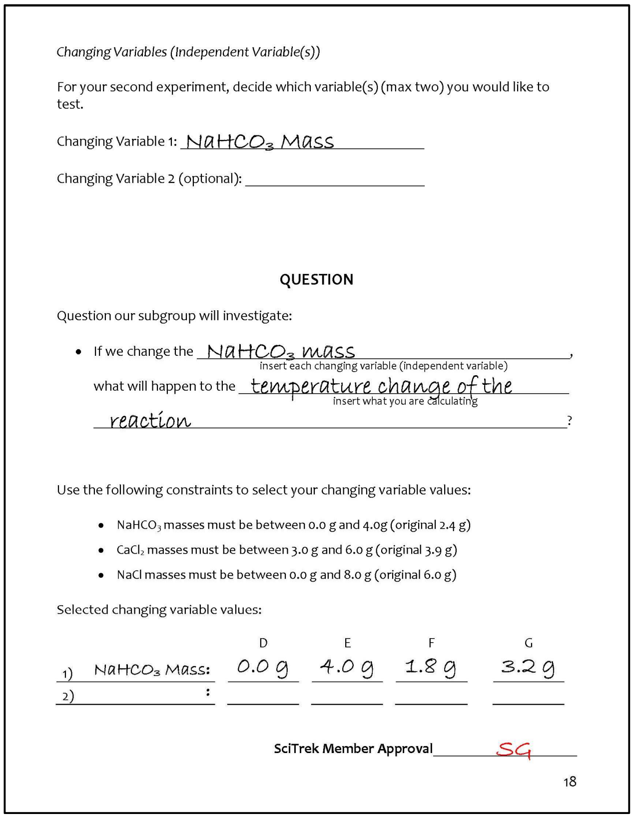
Stir Speed: Level 2 (fill in the value the class selected)

Other Team Plans

Question:
(5 minutes – Teams – SciTrek Mentors)

Have subgroups write their changing variable for *Changing Variable 1*. Ask students, “Why do we only have one changing variable?” Possible student response: if we had two changing variables, we would not be able to make a conclusion. Then, have subgroups fill out their questions. Questions will be the same for all members of a team.

Tell subgroups, “We have decided on all the values of our controls, but, within your subgroups, you need to select your changing variable values.” Make sure to point to the range of values your team’s changing variable can have. Have each individual subgroup select values for their trials, and record them in their notebooks. Then, sign off on their questions and changing variable values. An example notebook is shown below (left).



Changing Variables (Independent Variable(s))

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

Changing Variable 1: $NaHCO_3$ Mass

Changing Variable 2 (optional): ________

QUESTION

Question our subgroup will investigate:

- If we change the $NaHCO_3$ mass,
  insert each changing variable (independent variable)
  what will happen to the temperature change of the
  insert what you are calculating
  reaction?

Use the following constraints to select your changing variable values:

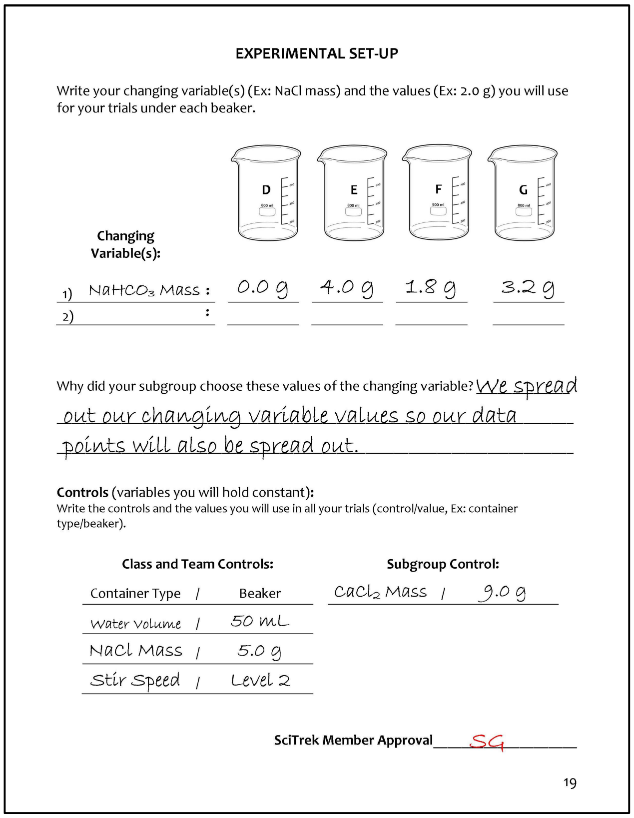
- $NaHCO_3$ masses must be between 0.0 g and 4.0g (original 2.4 g)
- $CaCl_2$ masses must be between 3.0 g and 6.0 g (original 3.9 g)
- NaCl masses must be between 0.0 g and 8.0 g (original 6.0 g)

Selected changing variable values:

	D	E	F	G
1) $NaHCO_3$ Mass:	0.0 g	4.0 g	1.8 g	3.2 g
2) :				

SciTrek Member Approval SG

18



EXPERIMENTAL SET-UP

Write your changing variable(s) (Ex: NaCl mass) and the values (Ex: 2.0 g) you will use for your trials under each beaker.

Changing Variable(s):	D	E	F	G
1) $NaHCO_3$ Mass :	0.0 g	4.0 g	1.8 g	3.2 g
2) :				

Why did your subgroup choose these values of the changing variable? We spread out our changing variable values so our data points will also be spread out.

Controls (variables you will hold constant):
Write the controls and the values you will use in all your trials (control/value, Ex: container type/beaker).

Class and Team Controls:

Container Type / Beaker
Water Volume / 50 mL
NaCl Mass / 5.0 g
Stir Speed / Level 2

Subgroup Control:

$CaCl_2$ Mass / 9.0 g

SciTrek Member Approval SG

19

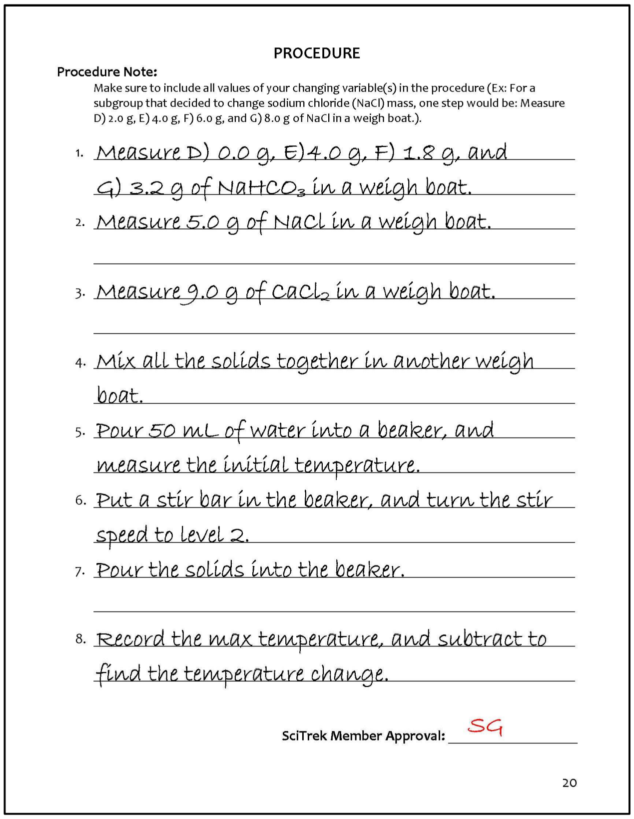
Experimental Set-Up:
(5 minutes – Subgroups – SciTrek Mentors)

Have subgroups fill in their experimental set-ups (notebook, page 19). If needed, you can let them look at page 18 of their notebook and the team plan. When you sign off on their experimental set-up, ensure all students within a subgroup have the same trial letters, corresponding to the same changing variable values. An example filled-out experimental set-up is seen above (right).

Procedure:
(14 minutes – Subgroups – SciTrek Mentors)

After each subgroup has filled out their experimental set-up, they can start on their procedure (notebook, page 20). Make sure students within the same subgroup are collaborating to write their procedure. Keep procedures as brief as possible, while still conveying the pertinent information (control values, changing variable values, the data they will collect, and what they will calculate) about the experiment. An example step for a subgroup who had NaCl mass as a changing variable would be, “Measure D) 2.0 g, E) 4.0 g, F) 6.0 g, G) 8.0 g of NaCl in a weigh boat.” Some subgroups may struggle with writing a procedure. If they are struggling, tell them to look back at their initial procedure on page 6 of their notebooks. If they are still having trouble, you can have these subgroups dictate a step while you transcribe it onto a notepad found in your group box. Once they have dictated a step, give this sheet to the students to copy into their notebooks before having them dictate the next step to you. Once students have finished, they should raise their hands and get their procedures approved by their mentor. An example filled-out procedure is shown below (left).

Note: 6th grade students are more independent, therefore, students in each subgroup may vary the wording in their procedures. This is fine, as long as the steps are in the same order, and steps contain the same control(s) and/or changing variable.



PROCEDURE

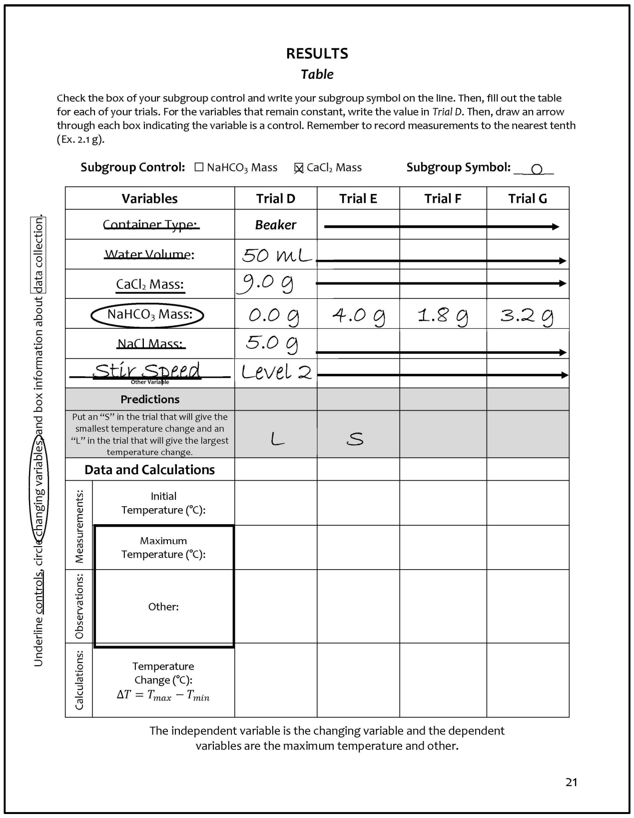
Procedure Note:

Make sure to include all values of your changing variable(s) in the procedure (Ex: For a subgroup that decided to change sodium chloride (NaCl) mass, one step would be: Measure D) 2.0 g, E) 4.0 g, F) 6.0 g, and G) 8.0 g of NaCl in a weigh boat.).

1. Measure D) 0.0 g, E) 4.0 g, F) 1.8 g, and G) 3.2 g of $NaHCO_3$ in a weigh boat.
2. Measure 5.0 g of NaCl in a weigh boat.
3. Measure 9.0 g of $CaCl_2$ in a weigh boat.
4. Mix all the solids together in another weigh boat.
5. Pour 50 mL of water into a beaker, and measure the initial temperature.
6. Put a stir bar in the beaker, and turn the stir speed to level 2.
7. Pour the solids into the beaker.
8. Record the max temperature, and subtract to find the temperature change.

SciTrek Member Approval: SG

20



RESULTS

Table

Check the box of your subgroup control and write your subgroup symbol on the line. Then, fill out the table for each of your trials. For the variables that remain constant, write the value in *Trial D*. Then, draw an arrow through each box indicating the variable is a control. Remember to record measurements to the nearest tenth (Ex. 2.1 g).

Subgroup Control: ☐ $NaHCO_3$ Mass ☒ $CaCl_2$ Mass **Subgroup Symbol:** ○

Underline controls, circle changing variables, and box information about data collection.

Variables	**Trial D**	**Trial E**	**Trial F**	**Trial G**
Container Type:	***Beaker***	→	→	→
Water Volume:	50 mL	→	→	→
$CaCl_2$ Mass:	9.0 g	→	→	→
$NaHCO_3$ Mass:	0.0 g	4.0 g	1.8 g	3.2 g
NaCl Mass:	5.0 g	→	→	→
Stir Speed Other Variable	Level 2	→	→	→
Predictions				
Put an “S” in the trial that will give the smallest temperature change and an “L” in the trial that will give the largest temperature change.	L	S		
Data and Calculations				
Measurements: Initial Temperature (℃):				
Measurements: Maximum Temperature (℃):				
Observations: Other:				
Calculations: Temperature Change (℃): $\Delta T = T_{max} - T_{min}$				

The independent variable is the changing variable and the dependent variables are the maximum temperature and other.

21

Results Table:

(3 minutes – Subgroups – SciTrek Mentors)

Have students select their subgroup control by checking one of the boxes and writing in their subgroup symbol on the line at the top of page 21. Then, have students underline the variables that are controls, circle the variable that is their changing variable, and box information about data collection. When writing the values make sure for controls, they only write the value of the control in the *Trial D* box, then, draw an arrow through the remaining trials’ boxes. For the changing variable, they should write the values in each trial’s corresponding box.

When students have finished, have them make predictions about the temperature change. Have them write an “S” in the box of the trial they think will produce the smallest temperature change and an “L” in the box of the trial they think will produce the largest temperature change. They will leave two of the boxes empty. If they think all trials will produce the same temperature change, have them write “same” over all of the boxes. It is okay if the students in a subgroup have different predictions. An example filled-out results table is shown above (right).

Wrap-Up:
(2 minutes – Subgroups – SciTrek Lead)

Tell students, "Next session, you will carry out the experiments you designed today, graph your data on a team graph, and analyze the data to draw conclusions."

Clean-Up:

1. Collect notebooks with attached nametags.
2. Place materials into your group box and bring them back to UCSB.

Day 6: Experiment/Graph/Conclusion

Schedule:

Introduction (SciTrek Lead) – 8 minutes
Experiment (SciTrek Mentors) – 24 minutes
Graph (SciTrek Mentors) – 18 minutes
Conclusion (SciTrek Mentors) – 8 minutes
Wrap-Up (SciTrek Lead) – 2 minutes

Materials:

(3) Mentor Boxes:

☐ Nametags
☐ Notebooks
☐ Mentor instructions
☐ Mentor lab coat
☐ (2) Pencils
☐ (2) Red pens
☐ (12) Clear rulers
☐ Filled-out team plan
☐ Paper notepad

(2) Ziploc bags (gallon size), labeled (with subgroup number), with the following:

☐ Wet erase marker
☐ Paper towels
☐ (2) Droppers
☐ (2) Scales
☐ (2) Thermometers
☐ Set of 3 labeled scoopulas ($NaHCO_3$, $NaCl$, $CaCl_2$)
☐ $NaHCO_3$ container
☐ $NaCl$ container
☐ Fresh $CaCl_2$ container (1/3 filled)
☐ Set of 12 labeled weigh boats (4 mix, 2 for each control substances and 4 for the changing substance)
☐ (2) Plastic lids
☐ (4) Magnetic stir bars

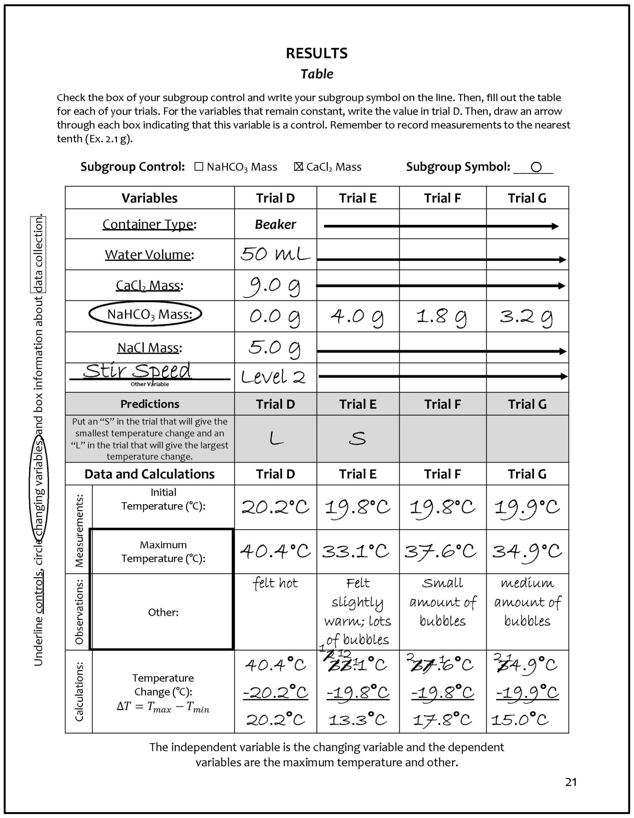
Other Supplies:

☐ (3) Boxes of beakers
☐ Box with (14) 100 ml graduated cylinders
☐ Box with (14) 8 oz waters
☐ (2) Boxes with 6 stir plates and 3 extension cords
☐ (2) Buckets with lids

Lead Box:

- ☐ (3) Extra notebooks
- ☐ Lead instructions
- ☐ Thermal Transfer picture packet
- ☐ Lead lab coat
- ☐ Time card
- ☐ (2) Pencils
- ☐ (2) Red pens
- ☐ (2) Wet erase markers
- ☐ (2) Black pens
- ☐ (5) Clear rulers
- ☐ (2) White rags
- ☐ Scale
- ☐ Thermometer
- ☐ Fresh $CaCl_2$ container (1/3 filled)
- ☐ Bag (paper towels, (2) droppers, set of 3 labeled scoopulas ($NaHCO_3$, NaCl, $CaCl_2$), $NaHCO_3$ container, NaCl container, set of 9 labeled weigh boats (2 $NaHCO_3$, 2 NaCl, 2 $CaCl_2$, 3 Mix), (3) plastic lids, container of 3 magnetic stir bars)

Notebook Pages:



RESULTS

Table

Check the box of your subgroup control and write your subgroup symbol on the line. Then, fill out the table for each of your trials. For the variables that remain constant, write the value in trial D. Then, draw an arrow through each box indicating that this variable is a control. Remember to record measurements to the nearest tenth (Ex. 2.1 g).

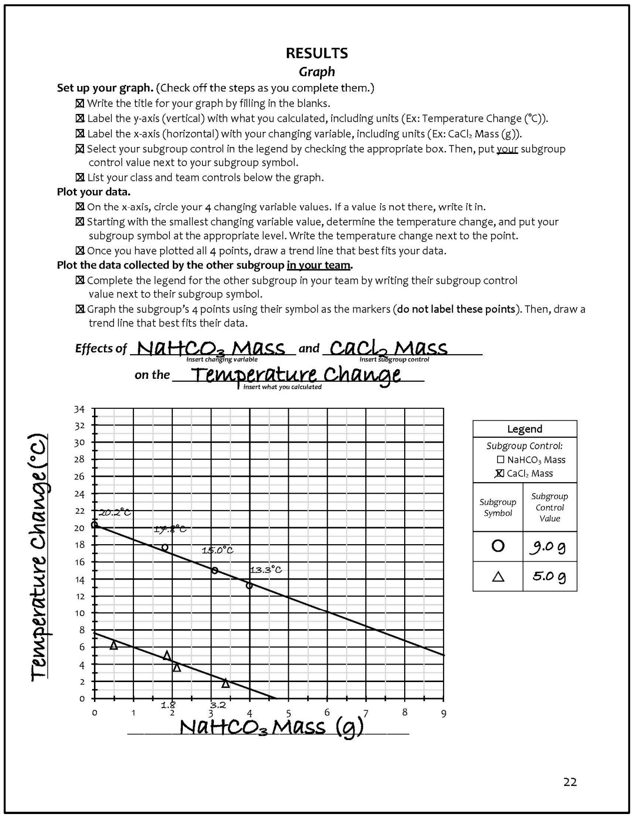
Subgroup Control: ☐ $NaHCO_3$ Mass ☒ $CaCl_2$ Mass **Subgroup Symbol:** ○

Underline controls, circle changing variables, and box information about data collection.

	Variables	Trial D	Trial E	Trial F	Trial G
	Container Type:	**Beaker**	→	→	→
	Water Volume:	50 mL	→	→	→
	$CaCl_2$ Mass:	9.0 g	→	→	→
	$NaHCO_3$ Mass:	0.0 g	4.0 g	1.8 g	3.2 g
	NaCl Mass:	5.0 g	→	→	→
	Stir Speed Other Variable	Level 2	→	→	→
	Predictions	**Trial D**	**Trial E**	**Trial F**	**Trial G**
	Put an "S" in the trial that will give the smallest temperature change and an "L" in the trial that will give the largest temperature change.	L	S		
	Data and Calculations	**Trial D**	**Trial E**	**Trial F**	**Trial G**
Measurements:	Initial Temperature (℃):	20.2°C	19.8°C	19.8°C	19.9°C
	Maximum Temperature (℃):	40.4°C	33.1°C	37.6°C	34.9°C
Observations:	Other:	felt hot	Felt slightly warm; lots of bubbles	Small amount of bubbles	medium amount of bubbles
Calculations:	Temperature Change (℃): $\Delta T = T_{max} - T_{min}$	40.4°C -20.2°C 20.2°C	1 2 12 ~~33~~.~~1~~1°C -19.8°C 13.3°C	2 1 ~~37~~.~~6~~6°C -19.8°C 17.8°C	2 1 ~~34~~.9°C -19.9°C 15.0°C

The independent variable is the changing variable and the dependent variables are the maximum temperature and other.

21



RESULTS

Graph

Set up your graph. (Check off the steps as you complete them.)

- ☒ Write the title for your graph by filling in the blanks.
- ☒ Label the y-axis (vertical) with what you calculated, including units (Ex: Temperature Change (℃)).
- ☒ Label the x-axis (horizontal) with your changing variable, including units (Ex: $CaCl_2$ Mass (g)).
- ☒ Select your subgroup control in the legend by checking the appropriate box. Then, put your subgroup control value next to your subgroup symbol.
- ☒ List your class and team controls below the graph.

Plot your data.

- ☒ On the x-axis, circle your 4 changing variable values. If a value is not there, write it in.
- ☒ 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.
- ☒ Once you have plotted all 4 points, draw a trend line that best fits your data.

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

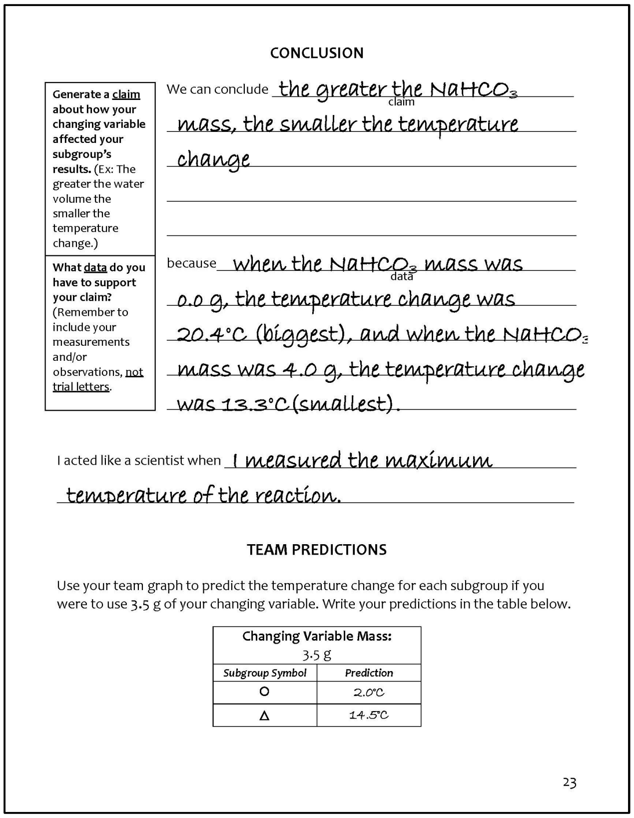
- ☒ Complete the legend for the other subgroup in your team by writing their subgroup control value next to their subgroup symbol.
- ☒ Graph the subgroup's 4 points using their symbol as the markers (**do not label these points**). Then, draw a trend line that best fits their data.

Effects of $NaHCO_3$ Mass **and** $CaCl_2$ Mass
insert changing variable / insert subgroup control

on the Temperature Change
insert what you calculated

Legend	
Subgroup Control: ☐ $NaHCO_3$ Mass ☒ $CaCl_2$ Mass	
Subgroup Symbol	*Subgroup Control Value*
○	9.0 g
△	5.0 g

22



CONCLUSION

Generate a <u>claim</u> about how your changing variable affected your subgroup's results. (Ex: The greater the water volume the smaller the temperature change.)	We can conclude the greater the $NaHCO_3$ mass, the smaller the temperature change claim
What <u>data</u> do you have to support your claim? (Remember to include your measurements and/or observations, <u>not trial letters</u>.	because when the $NaHCO_3$ mass was 0.0 g, the temperature change was 20.4°C (biggest), and when the $NaHCO_3$ mass was 4.0 g, the temperature change was 13.3°C(smallest). data

I acted like a scientist when I measured the maximum temperature of the reaction.

TEAM PREDICTIONS

Use your team graph to predict the temperature change for each subgroup if you were to use 3.5 g of your changing variable. Write your predictions in the table below.

Changing Variable Mass: 3.5 g	
Subgroup Symbol	***Prediction***
○	2.0°C
△	14.5°C

23

Preparation:

SciTrek Lead:

1. Make sure mentors are setting out notebooks.
2. Make sure mentors are setting up for the experiment.
3. Set up the document camera for the Introduction (picture packet, pages 1, 4, and 5; notebook, page 23).

SciTrek Mentors:

1. Set out notebooks/nametags.
2. Plug in two stir plates for each subgroup and place them where they will work.
3. Put (2) waters, (2) graduated cylinders, (4) beakers, and a bag with supplies, next to the stir plates.
4. With the wet erase pen, in the supplies bag, label the beakers, mix weigh boats, and changing variable weigh boats with a D, E, F, or G.

Note: Set notebooks where students will sit during the module, even if another student is currently at that desk. If needed, students will move to these spots after the Introduction.

Introduction:

(8 minutes – Full Class – SciTrek Lead)

If students are not in their subgroups, tell them, "A notebook will be put on your desk, which is not your notebook and you should not move it. You will move to your notebook after the Introduction."

Ask the class, "What is the class question we have been investigating?" Students should reply, "What variables affect the temperature change of the chemical reaction?" Tell students, "Today you are going to perform your second experiment. Once the experiment is complete, you will plot your data on a team graph and analyze it, in order to determine what conclusions can be drawn from your results. Your conclusions will help answer the class question."

Tell students, "Once you have collected your data, you will display your measurements on a graph." Show them how to make a graph using the example data. Display the example results table (picture packet, page 1; shown below [left]), on the document camera. Tell students, "For this example experiment, the question was, 'If we change the water volume, what will happen to the temperature change of the reaction?'" Switch to page 4 of the picture packet, and point to the checklist at the top (also on page 22 of the notebooks). Tell students, "In order to make a graph, you will need to follow the checklist shown on this page."

Go through the checklist and use the results table in the picture packet to show the students how to set up the graph as well as how the data points were graphed.

Set up your graph. (Check off the steps as you complete them.)

Tell students, "First, before we can plot the data, we need to set up the graph."

☐ *Write the title for your graph by filling in the blanks.*

Looking at the example results table (picture packet, page 1), ask students, "What was the changing variable?" They should reply, "Water volume." Tell them, "This is why they put water volume in the first blank of the graph title."

Tell students, "In the second blank, we need to fill in the subgroup control. Looking at the top of the results table, what is checked as the subgroup control, for this experiment?" Students should reply, "$CaCl_2$ Mass." Tell them, "This is why they put $CaCl_2$ mass in the second blank of the graph title."

Tell students, "In the third blank, we need to fill in what was calculated. Then, ask students, "What are we calculating in the experiment?" They should reply, "Temperature change." Tell them, "This is why they put temperature change in the third blank of the graph title."

☐ *Label the y-axis (vertical) with what you calculated, including units (Ex: Temperature Change (°C)).*

Show students where this was done on the graph.

☐ *Label the x-axis (horizontal) with your changing variable, including units (Ex: $CaCl_2$ Mass (g)).*

Show students where this was done on the graph.

☐ *Select your subgroup control in the legend by checking the appropriate box. Then, put your subgroup control value next to your subgroup symbol.*

Direct students' attention to the legend. Remind students the example's subgroup control was $CaCl_2$ mass, and show them where they checked the box for $CaCl_2$ mass. Tell students, "Your subgroup symbol should be on the results table (picture packet, page 1), and on the front of your notebook. For this subgroup, their symbol was triangle. Refer to the results table, and ask students, "What value for $CaCl_2$ mass did this subgroup use?" Students should reply, "6.0 g." Then, show students where this information was recorded in the legend.

Plot your Data:

Tell students, "Once your graph is set up, you will be able to plot the data."

☐ *On the x-axis, circle your 4 changing variable values. If a value is not there, write it in.*

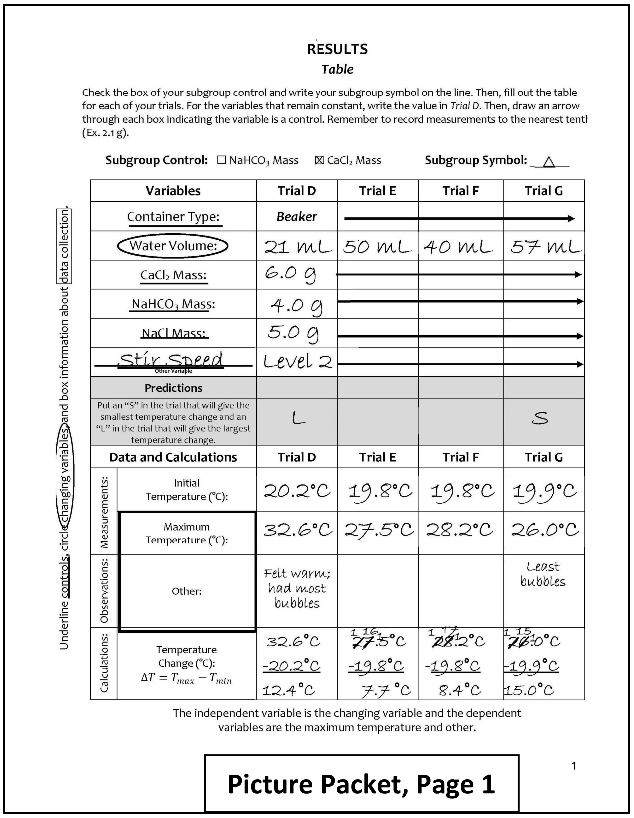
Refer to the results table. Ask students, “What is the first changing variable value?” Students should reply, “21 mL.” Show students where this was written in and circled on the graph. Ask students, “What is the second changing variable value?” Students should reply, “50 mL.” Show students where it was circled on the graph.

☐ *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.*

Ask students, “What was the temperature change when the water volume was 21 mL?” Students should reply, “12.4°C.” Show students how 12.4°C was graphed, using the subgroup symbol, and that the value was written next to it.

☐ *Once you have plotted all 4 points, draw a trend line that best fits your data.*

Tell students, “When you draw a trend line, you will use the clear rulers and you should extend your trend line to both sides of the graph, as is shown in this example.



RESULTS

Table

Check the box of your subgroup control and write your subgroup symbol on the line. Then, fill out the table for each of your trials. For the variables that remain constant, write the value in *Trial D*. Then, draw an arrow through each box indicating the variable is a control. Remember to record measurements to the nearest tenth (Ex. 2.1 g).

Subgroup Control: ☐ $NaHCO_3$ Mass ☒ $CaCl_2$ Mass **Subgroup Symbol:** △

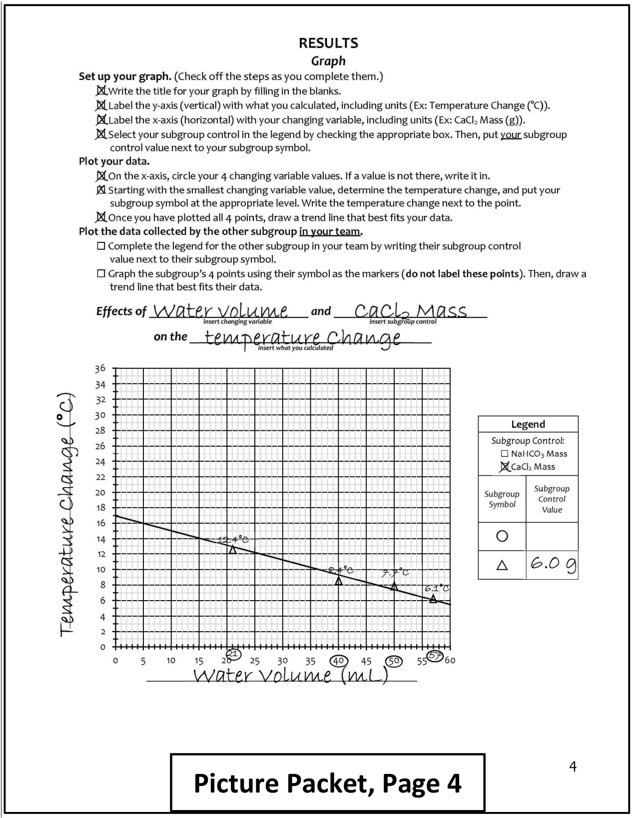
Underline controls, circle changing variables, and box information about data collection.

Variables	**Trial D**	**Trial E**	**Trial F**	**Trial G**
Container Type:	***Beaker***	→		
Water Volume:	21 mL	50 mL	40 mL	57 mL
$CaCl_2$ Mass:	6.0 g	→		
$NaHCO_3$ Mass:	4.0 g	→		
NaCl Mass:	5.0 g	→		
Stir Speed Other Variable	Level 2	→		
Predictions				
Put an “S” in the trial that will give the smallest temperature change and an “L” in the trial that will give the largest temperature change.	L			S
Data and Calculations	**Trial D**	**Trial E**	**Trial F**	**Trial G**
Measurements: Initial Temperature (℃):	20.2°C	19.8°C	19.8°C	19.9°C
Measurements: Maximum Temperature (℃):	32.6°C	27.5°C	28.2°C	26.0°C
Observations: Other:	Felt warm; had most bubbles			Least bubbles
Calculations: Temperature Change (℃): $\Delta T = T_{max} - T_{min}$	32.6°C -20.2°C 12.4°C	1 16 ~~27~~.5°C -19.8°C 7.7 °C	1 17 ~~28~~.2°C -19.8°C 8.4°C	1 15 ~~26~~.0°C -19.9°C 15.0°C

The independent variable is the changing variable and the dependent variables are the maximum temperature and other.

1

Picture Packet, Page 1



RESULTS

Graph

Set up your graph. (Check off the steps as you complete them.)

- ☒ Write the title for your graph by filling in the blanks.
- ☒ Label the y-axis (vertical) with what you calculated, including units (Ex: Temperature Change (℃)).
- ☒ Label the x-axis (horizontal) with your changing variable, including units (Ex: $CaCl_2$ Mass (g)).
- ☒ Select your subgroup control in the legend by checking the appropriate box. Then, put your subgroup control value next to your subgroup symbol.

Plot your data.

- ☒ On the x-axis, circle your 4 changing variable values. If a value is not there, write it in.
- ☒ 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.
- ☒ Once you have plotted all 4 points, draw a trend line that best fits your data.

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

- ☐ Complete the legend for the other subgroup in your team by writing their subgroup control value next to their subgroup symbol.
- ☐ Graph the subgroup’s 4 points using their symbol as the markers (**do not label these points**). Then, draw a trend line that best fits their data.

Effects of Water volume (insert changing variable) ***and*** $CaCl_2$ Mass (insert subgroup control)

on the temperature Change (insert what you calculated)

Legend	
Subgroup Control: ☐ $NaHCO_3$ Mass ☒ $CaCl_2$ Mass	
Subgroup Symbol	Subgroup Control Value
○	
△	6.0 g

4

Picture Packet, Page 4

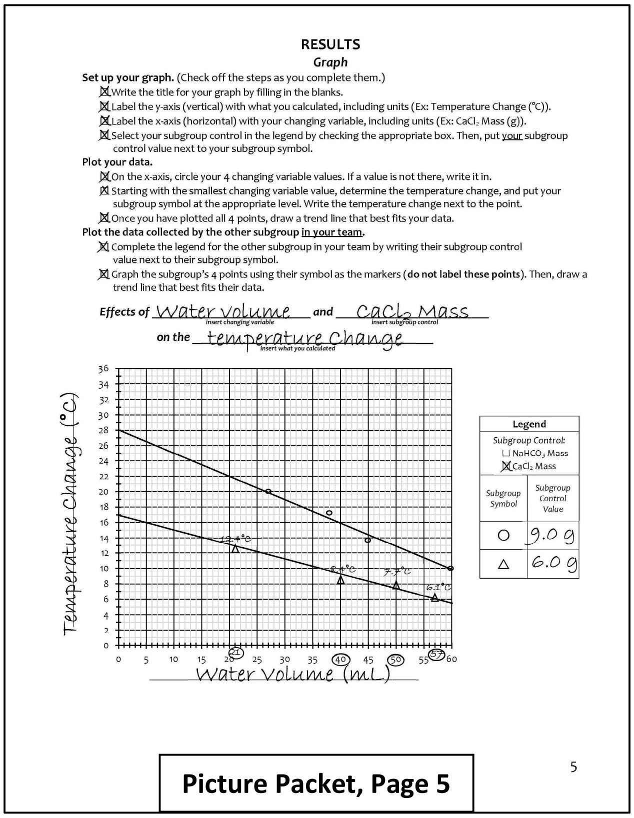
Plot the data collected by the other subgroups in your team.

Tell students, “Once you finish graphing your own data, you should have it checked by a mentor. After, you will ask the other subgroup on your team for their data, and graph it using the following steps.”

☐ *Complete the legend for the other subgroup in your team by writing their subgroup control value next to their subgroup symbol.*

☐ *Graph the other subgroup’s 4 points using their symbol as the markers (**do not label these points**). Then, draw a trend line that best fits their data.*

Once students have finished their graphs, they should have two trend lines on their graph, showing the data for both subgroups on their team. Show students the completed team graph (picture packet, page 5). 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.



RESULTS

Graph

Set up your graph. (Check off the steps as you complete them.)

- ☒ Write the title for your graph by filling in the blanks.
- ☒ Label the y-axis (vertical) with what you calculated, including units (Ex: Temperature Change (°C)).
- ☒ Label the x-axis (horizontal) with your changing variable, including units (Ex: $CaCl_2$ Mass (g)).
- ☒ Select your subgroup control in the legend by checking the appropriate box. Then, put <u>your</u> subgroup control value next to your subgroup symbol.

Plot your data.

- ☒ On the x-axis, circle your 4 changing variable values. If a value is not there, write it in.
- ☒ 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.
- ☒ Once you have plotted all 4 points, draw a trend line that best fits your data.

Plot the data collected by the other subgroup <u>in your team</u>.

- ☒ Complete the legend for the other subgroup in your team by writing their subgroup control value next to their subgroup symbol.
- ☒ Graph the subgroup's 4 points using their symbol as the markers (**do not label these points**). Then, draw a trend line that best fits their data.

Effects of Water volume (*insert changing variable*) ***and*** $CaCl_2$ Mass (*insert subgroup control*)

on the temperature change (*insert what you calculated*)

Legend

Subgroup Control:
☐ $NaHCO_3$ Mass
☒ $CaCl_2$ Mass

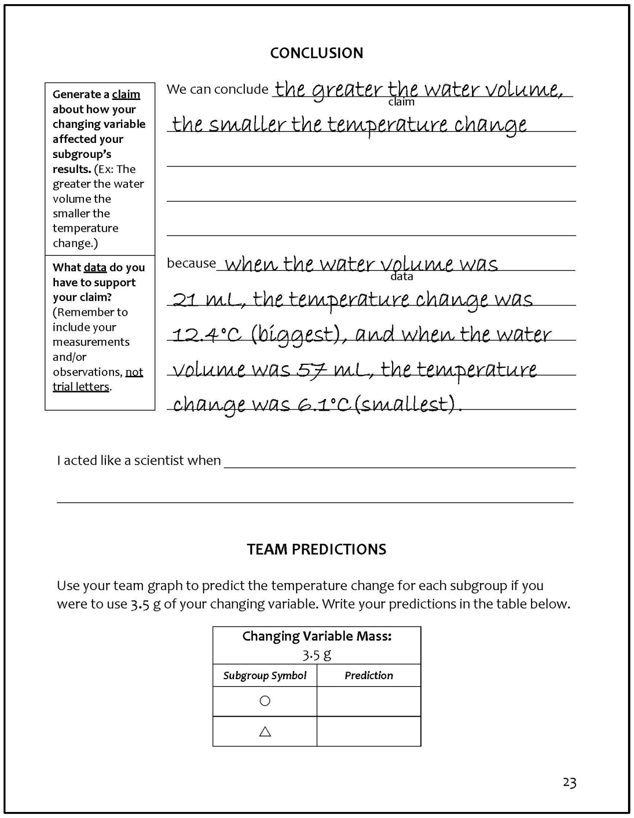
Subgroup Symbol	*Subgroup Control Value*
○	9.0 g
△	6.0 g

5

Picture Packet, Page 5

Tell students, "Once you finish graphing your team results, you should draw conclusions from your results." Ask students, "How do scientists define a conclusion?" Students should reply, "A claim supported by data." Ask students, "What is a claim?" Students should reply, "A statement that can be tested." Ask students, "What can be used for data?" Students should reply, "Measurements, observations, or calculations."

Tell students, "You need to refer to your entire team graph, for the claim, to verify the trend was the same for both subgroups. When coming up with the supporting data for your claim, refer only to your specific subgroup's data for values." Put the completed team graph, under the document camera (picture packet, page 5; shown above). Ask students, "Based on this team's data, what happens to the temperature change, when the water volume increases?" Possible student response: the greater the water volume, the smaller the temperature change. Write this claim into the class notebook in the claim section of the conclusions on page 23. Tell students, "You should use two data points to support your claim." Ask students, "Which two data points are the most convincing for this claim?" Possible student response: the smallest and largest values of the temperature change. Ask students, "What should our e data statement be?" Possible student response: when the water volume was 21 mL, the temperature change was 12.4°C (biggest), and when the water volume was 57 mL, the temperature change was 6.1°C (smallest). Write this data statement in the class notebook, under the data section of the conclusions on page 23. An example is shown below.



CONCLUSION

Generate a claim about how your changing variable affected your subgroup's results. (Ex: The greater the water volume the smaller the temperature change.)	We can conclude the greater the water volume, the smaller the temperature change claim
What data do you have to support your claim? (Remember to include your measurements and/or observations, not trial letters.)	because when the water volume was 21 mL, the temperature change was 12.4°C (biggest), and when the water volume was 57 mL, the temperature change was 6.1°C (smallest). data

I acted like a scientist when ______________________

TEAM PREDICTIONS

Use your team graph to predict the temperature change for each subgroup if you were to use 3.5 g of your changing variable. Write your predictions in the table below.

Changing Variable Mass: 3.5 g	
Subgroup Symbol	*Prediction*
○	
△	

23

Remind students of the following things before allowing them to start their experiments.

- 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.
- Leave $CaCl_2$ capped when not using it.
- Close the thermometer between trials, to reset the max/min function.
- Wipe off the thermometer with a paper towel, after each trial.

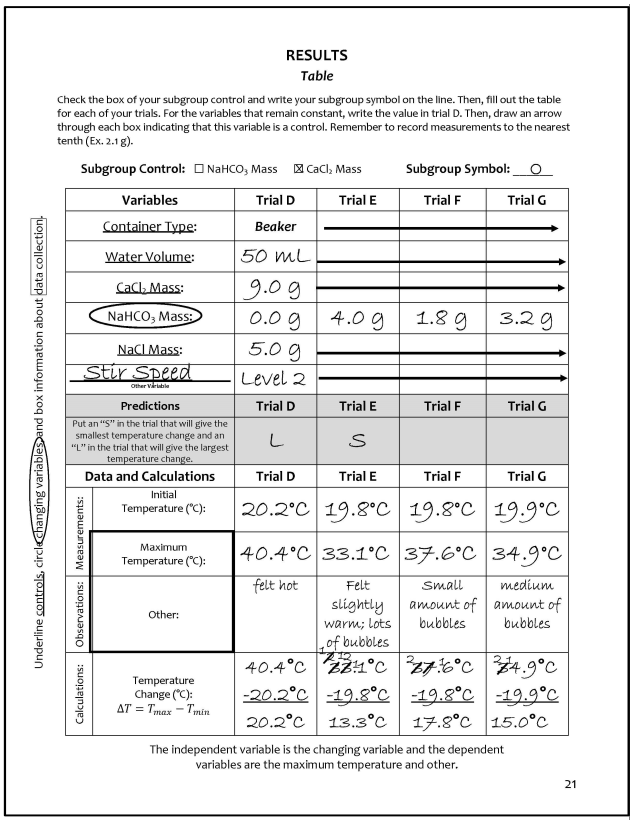
When students are starting their experiments, flip the picture packet to page 1 to show them the properly filled-out results table. When students are ready to start their graphs, flip the picture packet to page 5 to show them a properly filled-out graph.

Experiment:
(24 minutes – Subgroups – SciTrek Mentors)

If students are missing any of their experimental materials, the lead box has extra materials. Make sure students are keeping the cap to the $CaCl_2$ 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, stir bars, $CaCl_2$ weigh boats, graduated cylinders, and water bottles, and put them in the appropriate buckets/boxes. It is important to do this as soon as possible, so students do not play with or spill anything. When the experiment is finished, have students wipe the thermometer with a paper towel and close it, making sure it turns off. Place all other materials in your group box. Then, wipe off students' desks using a damp towel.

Students should record the maximum temperature after each trial, but have students wait until they have finished the entire experiment to calculate the temperature changes.

If your subgroups have things under control, help other subgroups. An example filled-out results table is shown below (left).



RESULTS

Table

Check the box of your subgroup control and write your subgroup symbol on the line. Then, fill out the table for each of your trials. For the variables that remain constant, write the value in trial D. Then, draw an arrow through each box indicating that this variable is a control. Remember to record measurements to the nearest tenth (Ex. 2.1 g).

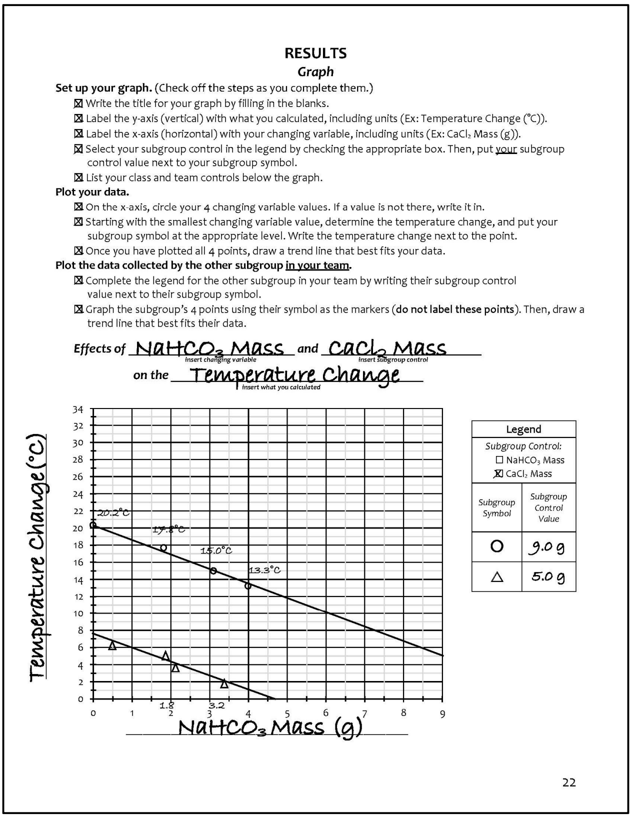
Subgroup Control: ☐ $NaHCO_3$ Mass ☒ $CaCl_2$ Mass **Subgroup Symbol:** ○

Underline controls, circle changing variables, and box information about data collection.

Variables	**Trial D**	**Trial E**	**Trial F**	**Trial G**
Container Type:	***Beaker***	⟶		
Water Volume:	50 mL	⟶		
$CaCl_2$ Mass:	9.0 g	⟶		
$NaHCO_3$ Mass:	0.0 g	4.0 g	1.8 g	3.2 g
NaCl Mass:	5.0 g	⟶		
Stir Speed Other Variable	Level 2	⟶		
Predictions	**Trial D**	**Trial E**	**Trial F**	**Trial G**
Put an "S" in the trial that will give the smallest temperature change and an "L" in the trial that will give the largest temperature change.	L	S		
Data and Calculations	**Trial D**	**Trial E**	**Trial F**	**Trial G**
Measurements: Initial Temperature (°C):	20.2°C	19.8°C	19.8°C	19.9°C
Measurements: Maximum Temperature (°C):	40.4°C	33.1°C	37.6°C	34.9°C
Observations: Other:	felt hot	Felt slightly warm; lots of bubbles	Small amount of bubbles	medium amount of bubbles
Calculations: Temperature Change (°C): $\Delta T = T_{max} - T_{min}$	40.4°C -20.2°C 20.2°C	1 12 ~~33~~.1°C -19.8°C 13.3°C	2 1 ~~37~~.6°C -19.8°C 17.8°C	2 1 ~~34~~.9°C -19.9°C 15.0°C

The independent variable is the changing variable and the dependent variables are the maximum temperature and other.

21



RESULTS

Graph

Set up your graph. (Check off the steps as you complete them.)

- ☒ Write the title for your graph by filling in the blanks.
- ☒ Label the y-axis (vertical) with what you calculated, including units (Ex: Temperature Change (°C)).
- ☒ Label the x-axis (horizontal) with your changing variable, including units (Ex: $CaCl_2$ Mass (g)).
- ☒ Select your subgroup control in the legend by checking the appropriate box. Then, put your subgroup control value next to your subgroup symbol.
- ☒ List your class and team controls below the graph.

Plot your data.

- ☒ On the x-axis, circle your 4 changing variable values. If a value is not there, write it in.
- ☒ 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.
- ☒ Once you have plotted all 4 points, draw a trend line that best fits your data.

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

- ☒ Complete the legend for the other subgroup in your team by writing their subgroup control value next to their subgroup symbol.
- ☒ Graph the subgroup's 4 points using their symbol as the markers (**do not label these points**). Then, draw a trend line that best fits their data.

Effects of $NaHCO_3$ Mass ***and*** $CaCl_2$ Mass
insert changing variable / insert subgroup control

on the Temperature Change
insert what you calculated

Legend

Subgroup Control:
☐ $NaHCO_3$ Mass
☒ $CaCl_2$ Mass

Subgroup Symbol	*Subgroup Control Value*
○	9.0 g
△	5.0 g

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Graph:

(18 minutes – Subgroups/Teams – SciTrek Mentors)

Pass out a clear ruler to students who are ready to make their graph. Help subgroups fill out their graphs by having them go through and complete the checklist on page 22. Be sure students write a title for their graph (by filling in the blanks), label the y-axis with "Temperature Change (°C)," label the x-axis with their changing variable (including units), and write their subgroup control value into the legend. Additionally, make sure students circle their changing variable values on the x-axis (as well as write them in if they are not already printed on the axis). Once students have their data plotted, they should draw in a trend line.

Once students have graphed their subgroup's data, help them graph the data from the other subgroup in their team.

If there is one mentor per **subgroup** or if one subgroup finishes before the other

Take a picture (using your cell phone or a tablet) of the other subgroups results table. If you are not helping the other subgroup, read off the data points, while students plot them.

If there is one mentor per **team** and subgroups finish at about the same time

Call both subgroups in the team together. Have one subgroup read off their data points, while the other subgroup plots them. Repeat this process, so both subgroups have all of the data plotted on their graphs.

Make sure when students are plotting the other subgroup's data they **do not** write the number values of the temperature change on top of their points, or circle the changing variable values. An example filled-out graph is shown above (right).

Conclusion:
(8 minutes – Subgroups – SciTrek Mentors)

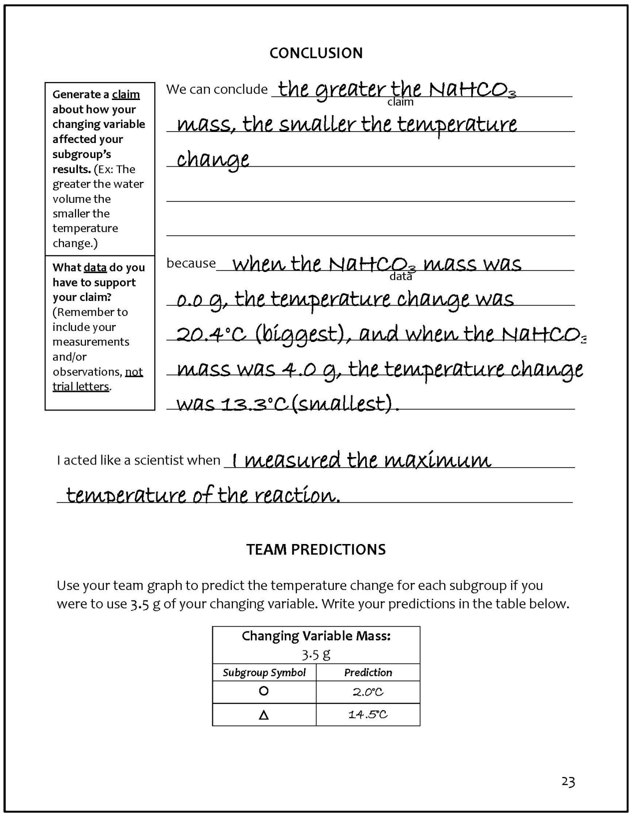
Have subgroups use their graphs to look for trends in their data. Challenge subgroups to think about how their changing variable did, or did not, affect the temperature change of the reaction.

When writing their conclusions (notebook, page 23), make sure subgroups begin the statement with a claim (statement that can be tested) about the trend or pattern in their data. If their graph shows an increasing or decreasing trend, then that variable affects the temperature change. If, on the other hand, their graph showed no trend (a flat line), then that variable did not affect the temperature change. An example of an appropriate claim could be: the greater the $NaHCO_3$ mass, the smaller the temperature change. This is an appropriate claim because it allows the students to make a prediction about what would happen if new values of their changing variable were introduced.

After generating a claim about their experiment, subgroups will put their supporting data after the *because* in their conclusion sentence. Their supporting data should include at least two pieces of data, typically the minimum and maximum temperature changes, as well as the corresponding changing variable values. Make sure subgroups are using their changing variable values (not trial letters) and specific calculations, to support their claims. The supporting data for the previously mentioned claim would be: when the $NaHCO_3$ mass was 0.0 g, the temperature change was 20.2°C (biggest), and when the $NaHCO_3$ mass was 4.0 g, the temperature change was 13.3°C (smallest).

Conclusions are still valid, and important, if they show the changing variable tested does not affect the temperature change.

An example filled-out conclusion is shown below.



CONCLUSION

Generate a <u>claim</u> about how your changing variable affected your subgroup's results. (Ex: The greater the water volume the smaller the temperature change.)	We can conclude the greater the $NaHCO_3$ mass, the smaller the temperature change claim
What <u>data</u> do you have to support your claim? (Remember to include your measurements and/or observations, <u>not trial letters</u>.	because when the $NaHCO_3$ mass was 0.0 g, the temperature change was 20.4°C (biggest), and when the $NaHCO_3$ mass was 4.0 g, the temperature change was 13.3°C (smallest). data

I acted like a scientist when I measured the maximum temperature of the reaction.

TEAM PREDICTIONS

Use your team graph to predict the temperature change for each subgroup if you were to use 3.5 g of your changing variable. Write your predictions in the table below.

Changing Variable Mass: 3.5 g	
Subgroup Symbol	***Prediction***
○	2.0°C
△	14.5°C

23

Next, have students fill in the sentence frame (notebook, page 23): *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 did you do during SciTrek?”

If there is time, have students analyze their team graphs to make predictions from each subgroups’ data. Students are asked to predict what the temperature change would be if they were to use 3.5 g of their changing variable. 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 vertically to their trend line, using a ruler. To find the predicted temperature change they will draw a second dotted line horizontally across to the y-axis, using a ruler. Students should write their predicted temperature changes next to their subgroup symbol in the chart. Have students repeat this process for the other trend line on their team graph.

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

Ask students the following questions:
How did you act like a scientist during this project?
What did you do that, scientists do?

After discussing how they acted like scientists, and talking about how everyone does things scientists do in their everyday lives, tell students, “Next session, you will make posters, and present your findings. I am looking forward to hearing about all of your experiments.”

Clean-Up:

1. Collect notebooks with attached nametags.
2. Put beakers, stir bars, $CaCl_2$ weigh boats, mix weigh boat (all other weigh boats should go in your group box), and any liquids, in the buckets.
3. Return the graduated cylinders, to their box.
4. Return the water bottles, to their box.
5. Return the stir plates, plugs, and extension cords, to their boxes.
6. Place all other materials into your group box and bring them back to UCSB.

Day 7: Poster Making/Poster Presentations

Note: Timing is tight on this day. It is possible the class 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, outside of SciTrek time, before the next SciTrek session.

Schedule:

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

Materials:

(3) Mentor Boxes:

☐ Nametags
☐ Notebooks
☐ Mentor instructions
☐ Mentor lab coat
☐ Poster diagram
☐ (2) Pencils
☐ (9) Paperclips
☐ (2) Highlighters
☐ Scissors
☐ (2) Glues
☐ (2) Clear rulers

Other Supplies:

☐ Poster paper tube

Lead Box:

☐ (3) Extra notebooks
☐ Lead instructions
☐ Thermal Transfer picture packet
☐ Lead lab coat
☐ Poster diagram
☐ Time card
☐ (2) Stickers on how to present the *Results Table*
☐ (2) Stickers on how to present the *Graph: Specific*
☐ (2) Pencils
☐ (2) Wet erase markers
☐ (2) Black pens
☐ (9) Paperclips
☐ (2) Highlighters
☐ (2) Scissors
☐ (2) Glues
☐ Stapler
☐ (3) Clear rulers
☐ Scotch tape
☐ (1 each color) Poster part packs

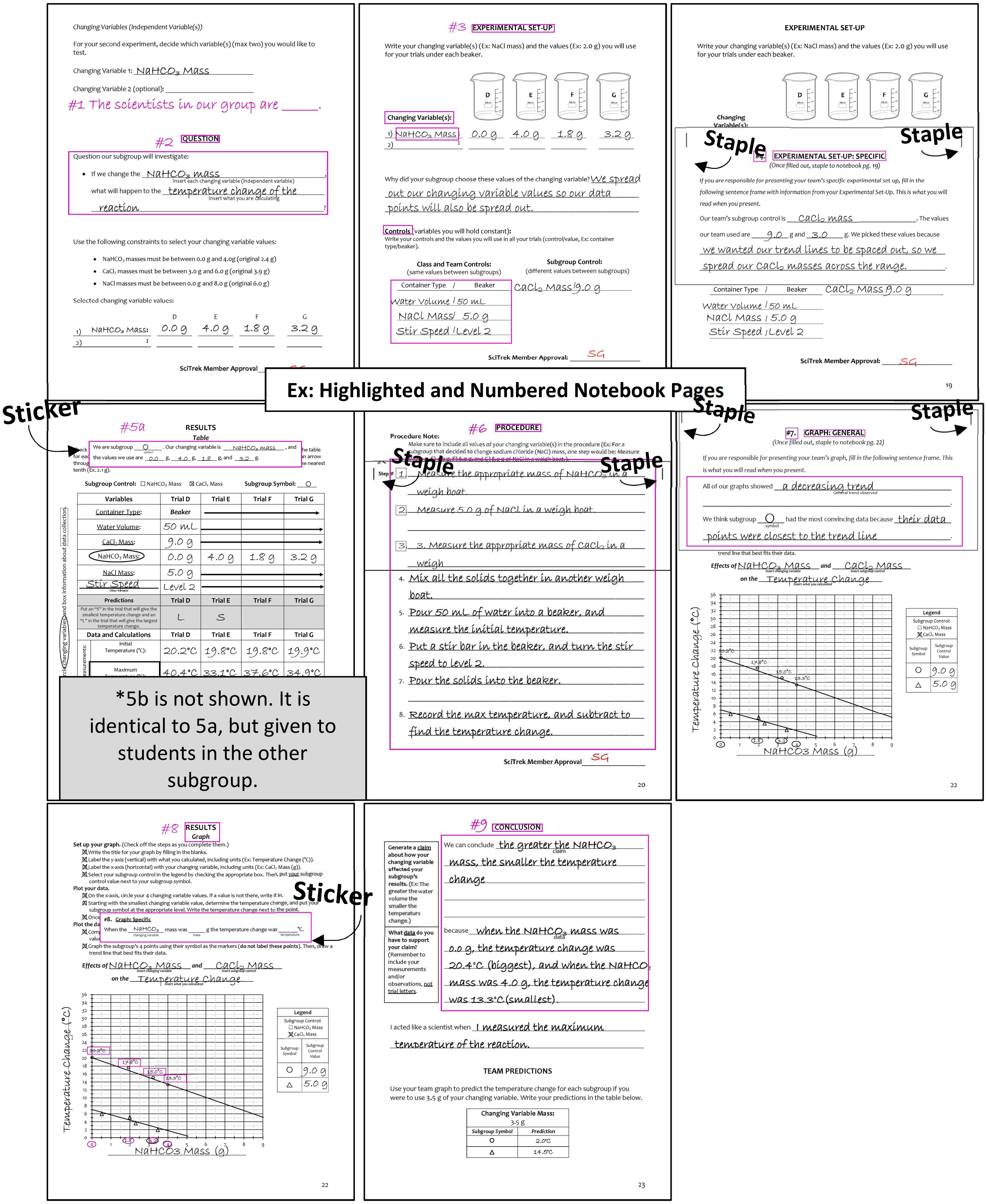
Preparation:

At SciTrek

At the SciTrek office prior to going to module a SciTrek staff member will highlight, number, sticker, and staple in the supporting documents for poster presentations. They will use the chart below to ensure all students on the team have a speaking part. If a student is presenting multiple sections, a paperclip will be used to clip those sections together to make it easy for them to flip back and forth between the pages.

Speaking Parts	Notes
1. Scientists' Names 2. Question 3. Experimental Set-Up: General 4. Experimental Set-Up: Specific *(Staple presentation sheet into notebook, pg. 19)* 5a. Results Table ○ *(Sticker, pg. 21)* 5b. Results Table Δ *(Sticker, pg. 21)* 6. Procedure *(paperclip instruction sheet to notebook and staple presentation piece into notebook, pg. 20)* 7. Graph: General *(Staple presentation sheet into notebook, pg. 22)* 8. Graph: Specific *(Sticker, fill in first blank in sticker, pg. 22)* 9. Conclusion	*Students highlighted in gray must be from the same subgroup (the subgroup with the most convincing data). *All students should have a speaking part. Depending on the size of the team it might be necessary to have students present more than one speaking part or divide speaking parts into two (Ex: two people present the procedure).

Ex: Highlighted and Numbered Notebook Pages



Changing Variables (Independent Variable(s))

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

Changing Variable 1: $NaHCO_3$ Mass

Changing Variable 2 (optional): ____

#1 The scientists in our group are ____.

#2 **QUESTION**

Question our subgroup will investigate:

- If we change the $NaHCO_3$ mass (insert each changing variable (independent variable)), what will happen to the temperature change of the reaction (insert what you are calculating)?

Use the following constraints to select your changing variable values:

- $NaHCO_3$ masses must be between 0.0 g and 4.0g (original 2.4 g)
- $CaCl_2$ masses must be between 3.0 g and 6.0 g (original 3.9 g)
- NaCl masses must be between 0.0 g and 8.0 g (original 6.0 g)

Selected changing variable values:

	D	E	F	G
1) $NaHCO_3$ Mass:	0.0 g	4.0 g	1.8 g	3.2 g
2) :				

SciTrek Member Approval ____

#3 **EXPERIMENTAL SET-UP**

Write your changing variable(s) (Ex: NaCl mass) and the values (Ex: 2.0 g) you will use for your trials under each beaker.

Changing Variable(s):	D	E	F	G
1) $NaHCO_3$ Mass:	0.0 g	4.0 g	1.8 g	3.2 g
2) :				

Why did your subgroup choose these values of the changing variable? We spread out our changing variable values so our data points will also be spread out.

Controls (variables you will hold constant):
Write your controls and the values you will use in all your trials (control/value, Ex: container type/beaker).

Class and Team Controls: (same values between subgroups)	**Subgroup Control:** (different values between subgroups)
Container Type / Beaker	$CaCl_2$ Mass / 9.0 g
Water Volume / 50 mL	
NaCl Mass / 5.0 g	
Stir Speed / Level 2	

SciTrek Member Approval: SG

EXPERIMENTAL SET-UP

Write your changing variable(s) (Ex: NaCl mass) and the values (Ex: 2.0 g) you will use for your trials under each beaker.

D E F G

Changing Variable(s):

Staple

Staple

#4. 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 $CaCl_2$ mass. The values our team used are 9.0 g and 3.0 g. We picked these values because we wanted our trend lines to be spaced out, so we spread our $CaCl_2$ masses across the range.

Container Type / Beaker	$CaCl_2$ Mass / 9.0 g
Water Volume / 50 mL	
NaCl Mass / 5.0 g	
Stir Speed / Level 2	

SciTrek Member Approval: SG

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Sticker

#5a **RESULTS**

Table

We are subgroup ○ (symbol). Our changing variable is $NaHCO_3$ mass, and the values we use are 0.0 g, 4.0 g, 1.8 g, and 3.2 g.

…eck … the table for eac… an arrow throug… he nearest tenth (Ex. 2.1 g).

Subgroup Control: ☐ $NaHCO_3$ Mass ☒ $CaCl_2$ Mass **Subgroup Symbol:** ○

Circle changing variables and box information about data collection.

Variables	Trial D	Trial E	Trial F	Trial G
Container Type:	*Beaker*	→	→	→
Water Volume:	50 mL	→	→	→
$CaCl_2$ Mass:	9.0 g	→	→	→
$NaHCO_3$ Mass:	0.0 g	4.0 g	1.8 g	3.2 g
NaCl Mass:	5.0 g	→	→	→
Stir Speed (Other Variable)	Level 2	→	→	→
Predictions	**Trial D**	**Trial E**	**Trial F**	**Trial G**
Put an "S" in the trial that will give the smallest temperature change and an "L" in the trial that will give the largest temperature change.	L	S		
Data and Calculations	**Trial D**	**Trial E**	**Trial F**	**Trial G**
Measurements: Initial Temperature (°C):	20.2°C	19.8°C	19.8°C	19.9°C
Maximum Temperature (°C):	40.4°C	33.1°C	37.6°C	34.9°C

*5b is not shown. It is identical to 5a, but given to students in the other subgroup.

#6 **PROCEDURE**

Procedure Note:
Make sure to include all values of your changing variable(s) in the procedure (Ex: For a subgroup that decided to change sodium chloride (NaCl) mass, one step would be: Measure D) 2.0 g, E) 4.0 g, F) 6.0 g, and G) 8.0 g of NaCl in a weigh boat.)

Staple

Staple

Step # 1. Measure the appropriate mass of $NaHCO_3$ in a weigh boat.

2. Measure 5.0 g of NaCl in a weigh boat.

3. 3. Measure the appropriate mass of $CaCl_2$ in a weigh

4. Mix all the solids together in another weigh boat.

5. Pour 50 mL of water into a beaker, and measure the initial temperature.

6. Put a stir bar in the beaker, and turn the stir speed to level 2.

7. Pour the solids into the beaker.

8. Record the max temperature, and subtract to find the temperature change.

SciTrek Member Approval SG

20

Staple

Staple

#7. GRAPH: GENERAL

(Once filled out, staple to notebook pg. 22)

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 (General trend observed).

We think subgroup ○ (symbol) had the most convincing data because their data points were closest to the trend line.

trend line that best fits their data.

Effects of $NaHCO_3$ Mass (*insert changing variable*) **and** $CaCl_2$ Mass (*insert subgroup control*) **on the** Temperature Change (*insert what you calculated*)

Legend	
Subgroup Control: ☐ $NaHCO_3$ Mass ☒ $CaCl_2$ Mass	
Subgroup Symbol	*Subgroup Control Value*
○	9.0 g
△	5.0 g

22

#8 **RESULTS** ***Graph***

Set up your graph. (Check off the steps as you complete them.)

- ☒ Write the title for your graph by filling in the blanks.
- ☒ Label the y-axis (vertical) with what you calculated, including units (Ex: Temperature Change (°C)).
- ☒ Label the x-axis (horizontal) with your changing variable, including units (Ex: $CaCl_2$ Mass (g)).
- ☒ Select your subgroup control in the legend by checking the appropriate box. Then, put your subgroup control value next to your subgroup symbol.

Plot your data.

- ☒ On the x-axis, circle your 4 changing variable values. If a value is not there, write it in.
- ☒ 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.
- ☒ Once…

Plot the da…

- ☒ Comp… value…
- ☒ Graph the subgroup's 4 points using their symbol as the markers (**do not label these points**). Then, draw a trend line that best fits their data.

Sticker

#8. Graph: Specific

When the $NaHCO_3$ (changing variable) mass was ____ (mass) g the temperature change was ____ (temperature) °C.

Effects of $NaHCO_3$ Mass (*insert changing variable*) **and** $CaCl_2$ Mass (*insert subgroup control*) **on the** Temperature Change (*insert what you calculated*)

Legend	
Subgroup Control: ☐ $NaHCO_3$ Mass ☒ $CaCl_2$ Mass	
Subgroup Symbol	*Subgroup Control Value*
○	9.0 g
△	5.0 g

22

#9 **CONCLUSION**

Generate a claim about how your changing variable affected your subgroup's results. (Ex: The greater the water volume the smaller the temperature change.)	We can conclude the greater the $NaHCO_3$ mass, the smaller the temperature change (claim)
What data do you have to support your claim? (Remember to include your measurements and/or observations, not trial letters.	because when the $NaHCO_3$ mass was 0.0 g, the temperature change was 20.4°C (biggest), and when the $NaHCO_3$ mass was 4.0 g, the temperature change was 13.3°C(smallest). (data)

I acted like a scientist when I measured the maximum temperature of the reaction.

TEAM PREDICTIONS

Use your team graph to predict the temperature change for each subgroup if you were to use 3.5 g of your changing variable. Write your predictions in the table below.

Changing Variable Mass: 3.5 g	
Subgroup Symbol	*Prediction*
○	2.0°C
△	14.5°C

23

SciTrek Lead:

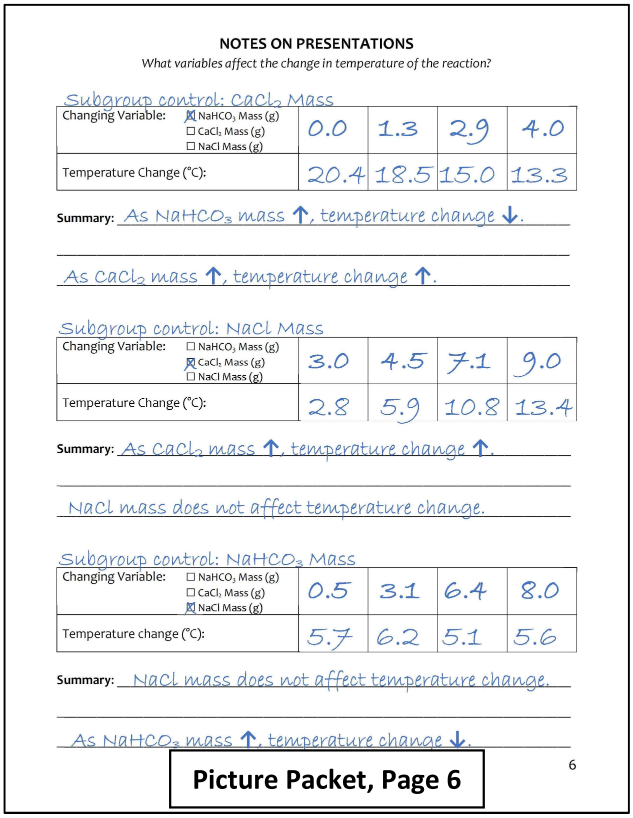
1. Notebooks should have been highlighted, stickered, and numbered at UCSB. Confimr this has taken place. If not, use the poster diagram page to have mentors do this quickly before starting SciTrek.
2. Make sure mentors are setting out notebooks.
3. Set up the document camera for the *Notes on Presentations* (picture packet, page 6).

SciTrek Mentors:

1. Set out notebooks/nametags.

Note: Set notebooks where students will sit during the module, even if another student is currently at that desk. If needed, students will move to these spots after the Introduction.

Picture Packet Page and Notebook Page:



NOTES ON PRESENTATIONS

What variables affect the change in temperature of the reaction?

Subgroup control: $CaCl_2$ Mass

Changing Variable: ☒ $NaHCO_3$ Mass (g) ☐ $CaCl_2$ Mass (g) ☐ NaCl Mass (g)	0.0	1.3	2.9	4.0
Temperature Change (°C):	20.4	18.5	15.0	13.3

Summary: As $NaHCO_3$ mass ↑, temperature change ↓.

As $CaCl_2$ mass ↑, temperature change ↑.

Subgroup control: NaCl Mass

Changing Variable: ☐ $NaHCO_3$ Mass (g) ☒ $CaCl_2$ Mass (g) ☐ NaCl Mass (g)	3.0	4.5	7.1	9.0
Temperature Change (°C):	2.8	5.9	10.8	13.4

Summary: As $CaCl_2$ mass ↑, temperature change ↑.

NaCl mass does not affect temperature change.

Subgroup control: $NaHCO_3$ Mass

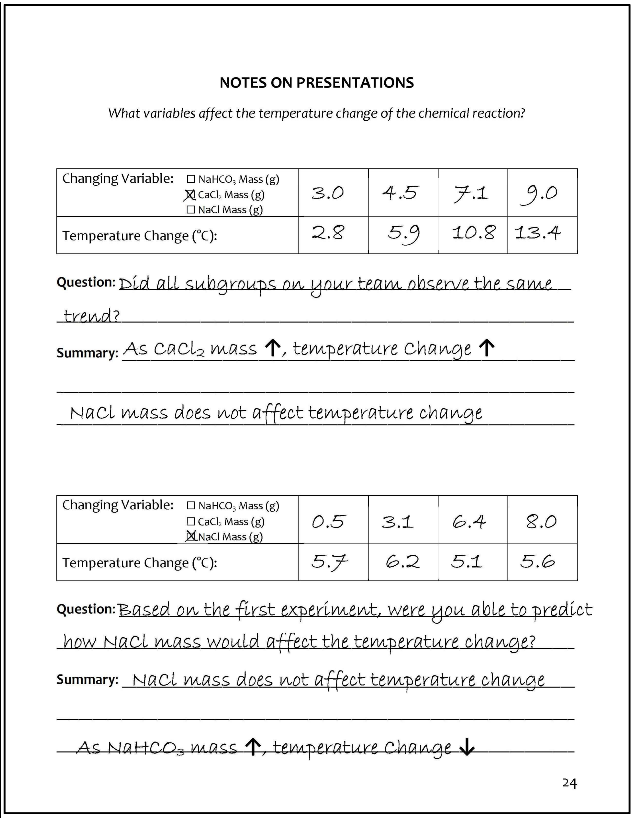
Changing Variable: ☐ $NaHCO_3$ Mass (g) ☐ $CaCl_2$ Mass (g) ☒ NaCl Mass (g)	0.5	3.1	6.4	8.0
Temperature change (°C):	5.7	6.2	5.1	5.6

Summary: NaCl mass does not affect temperature change.

As $NaHCO_3$ mass ↑, temperature change ↓.

Picture Packet, Page 6

6



NOTES ON PRESENTATIONS

What variables affect the temperature change of the chemical reaction?

Changing Variable: ☐ $NaHCO_3$ Mass (g) ☒ $CaCl_2$ Mass (g) ☐ NaCl Mass (g)	3.0	4.5	7.1	9.0
Temperature Change (°C):	2.8	5.9	10.8	13.4

Question: Did all subgroups on your team observe the same trend?

Summary: As $CaCl_2$ mass ↑, temperature Change ↑

NaCl mass does not affect temperature change

Changing Variable: ☐ $NaHCO_3$ Mass (g) ☐ $CaCl_2$ Mass (g) ☒ NaCl Mass (g)	0.5	3.1	6.4	8.0
Temperature Change (°C):	5.7	6.2	5.1	5.6

Question: Based on the first experiment, were you able to predict how NaCl mass would affect the temperature change?

Summary: NaCl mass does not affect temperature change

As $NaHCO_3$ mass ↑, temperature Change ↓

24

Introduction:

(2 minutes – Full Class – SciTrek Lead)

If students are not in their subgroups, tell them, "A notebook will be put on your desk, which is not your notebook and you should not move it. You will move to your notebook after the Introduction."

Ask the class, "What is the class question we have been investigating?" Students should reply, "What variables affect the temperature change of the chemical reaction?" Tell students, "When scientists complete their experiments, they make posters to present their findings to other scientists. Each team will create a poster to present to the class. This presentation will be your chance to tell the class what your team has discovered about the class question. You should write as neatly as possible on the poster parts so that the other class members can read your posters. You will have 25 minutes to make the posters, and then 5 minutes to practice presenting them with your teams. When you present, you will read from your notebooks."

Poster Making:

(25 minutes – Subgroups – SciTrek Mentors)

Each team (6-11 students) will make one poster about their 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.

The notebooks will already be highlighted with what part each student will fill out and the corresponding poster part will be paper clipped to their notebooks. Note: Part 4 and 7 do not have poster parts to fill out. They will just fill out the white paper stapled in their notebook. If a student is absent give their notebook to another student to fill out their part. While presenting the student will use both their and the absent student's notebook.

Below are specific notes for the student doing each of the noted sections.

Part 5 (Results Table): They will have a sticker (shown below) at the top of their results table that will be filled out that they should read when presenting.

We are subgroup _______________. Our changing variable is ________________________, and
the values we used are _____ g, _____ g, _____ g, and _____ g .

Part 6 (*Procedure*): Make sure when the student copies the procedure onto the poster part, they copy the modified steps that have been stapled into their notebook.

Part 7 (*Graph General*): Tell this student which subgroup's data (the subgroup of the person that is presenting the conclusion) was selected as the best data and have them think about why. Then have them record this on the white sheet stapled in their notebook.

Part 8 (*Graph Specific*): The following sentence frame sticker will be put in their notebook.

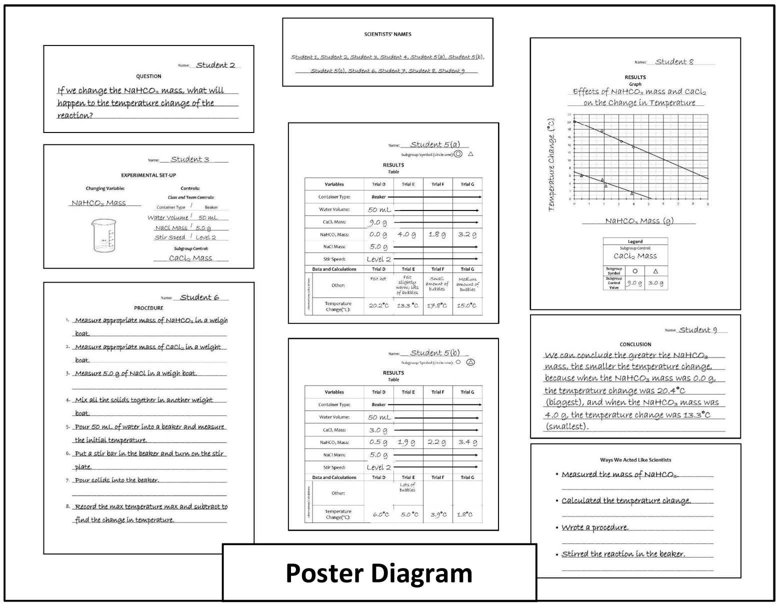
When the __**(this will be filled in)**__ mass was ______ g the temperature change was _______°C.
changing variable mass temperature

One of the blanks in the sentence frame will be filled out, do not fill in anymore of the blanks. Students will fill in their blanks orally as they present. An example of a first sentence might be: When the sodium hydrogen carbonate mass was **0** g the temperature change was **20.2**°C. Practice reading the four sentences with the student.

Once students have finished their section(s), 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 page 23 of their notebooks, or come up with new ones.

As soon as students have completed some of their pieces, start gluing them onto the large poster paper, in landscape orientation, <u>exactly</u> as they are arranged in the example below. Do not allow students to glue the poster parts on the posters. Do not wait until students have completed all the pieces to start gluing them onto the posters.

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



Name: Student 2

QUESTION

If we change the $NaHCO_3$ mass, what will happen to the temperature change of the reaction?

Name: Student 3

EXPERIMENTAL SET-UP

Changing Variable: $NaHCO_3$ Mass

Controls:

Class and Team Controls:

Container Type / Beaker
Water Volume / 50 mL
NaCl Mass / 5.0 g
Stir Speed / Level 2

Subgroup Control: $CaCl_2$ Mass

Name: Student 6

PROCEDURE

1. Measure appropriate mass of $NaHCO_3$ in a weigh boat.
2. Measure appropriate mass of $CaCl_2$ in a weight boat.
3. Measure 5.0 g of NaCl in a weigh boat.
4. Mix all the solids together in another weight boat.
5. Pour 50 mL of water into a beaker and measure the initial temperature.
6. Put a stir bar in the beaker and turn on the stir plate.
7. Pour solids into the beaker.
8. Record the max temperature max and subtract to find the change in temperature.

SCIENTISTS' NAMES

Student 1, Student 2, Student 3, Student 4, Student 5(a), Student 5(b), Student 5(c), Student 6, Student 7, Student 8, Student 9

Name: Student 5(a)

Subgroup Symbol (circle one): [✓ ○] △

RESULTS

Table

Variables	Trial D	Trial E	Trial F	Trial G
Container Type:	**Beaker** →	→	→	→
Water Volume:	50 mL →	→	→	→
$CaCl_2$ Mass:	9.0 g →	→	→	→
$NaHCO_3$ Mass:	0.0 g	4.0 g	1.8 g	3.2 g
NaCl Mass:	5.0 g →	→	→	→
Stir Speed:	Level 2 →	→	→	→
Data and Calculations	**Trial D**	**Trial E**	**Trial F**	**Trial G**
Other:	Felt hot	Felt slightly warm; lots of bubbles	Small amount of bubbles	Medium amount of bubbles
Temperature Change(°C):	20.2°C	13.3 °C	17.8°C	15.0°C

Name: Student 5(b)

Subgroup Symbol (circle one): ○ [✓ △]

RESULTS

Table

Variables	Trial D	Trial E	Trial F	Trial G
Container Type:	**Beaker** →	→	→	→
Water Volume:	50 mL →	→	→	→
$CaCl_2$ Mass:	3.0 g →	→	→	→
$NaHCO_3$ Mass:	0.5 g	1.9 g	2.2 g	3.4 g
NaCl Mass:	5.0 g →	→	→	→
Stir Speed:	Level 2 →	→	→	→
Data and Calculations	**Trial D**	**Trial E**	**Trial F**	**Trial G**
Other:		Lots of bubbles		
Temperature Change(°C):	6.0°C	5.0 °C	3.9°C	1.8°C

Name: Student 8

RESULTS

Graph

Effects of $NaHCO_3$ mass and $CaCl_2$ on the Change in Temperature

Legend		
Subgroup Control: $CaCl_2$ Mass		
Subgroup Symbol	○	△
Subgroup Control Value	9.0 g	3.0 g

Name: Student 9

CONCLUSION

We can conclude the greater the $NaHCO_3$ mass, the smaller the temperature change, because when the $NaHCO_3$ mass was 0.0 g, the temperature change was 20.4°C (biggest), and when the $NaHCO_3$ mass was 4.0 g, the temperature change was 13.3°C (smallest).

Ways We Acted Like Scientists

- Measured the mass of $NaHCO_3$.
- Calculated the temperature change.
- Wrote a procedure.
- Stirred the reaction in the beaker.

Poster Diagram

Practice Posters:
(5 minutes – Subgroups – SciTrek Mentors)

While mentors are practicing their poster presentations with their teams, the lead should organize posters, so they are presented from simplest to understand, to most difficult to understand (suggested order: $NaHCO_3$ mass, $CaCl_2$ mass, and NaCl mass).

Have your team practice their poster presentation, 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 ○, results table Δ, procedure, results graph: general, results graph: specific, and conclusion). 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. If a student is absent, the student that filled out their poster part should have both their notebook and the absent student's notebook to read out of.

Do not let poster practice go over 5 minutes.

Poster Presentations:
(31 minutes – Full Class – SciTrek Mentors/SciTrek Lead)

Have students return to their original class seats. Ask the class, "What is the question we have been investigating?" Students should reply, "What variables affect the temperature change of the chemical reaction?" Tell students, "During the presentations, you are going to take notes." Have them turn to page 24 in their notebooks, while you turn to page 6 of the picture packet. Tell them, "You will need to check the box for each team's changing variable after the team says their question. In addition, when the team presents their graph (specific), you will need to record the values of the changing variable, as well as the corresponding temperature change.

Tell students, "Everyone will need to generate at least one scientific question per presentation, and write it in their notebook. If you think of a question during the presentation, you can write it down then, or, you will be given 1 minute at the end of the presentation to write down your question. These questions should focus on helping you be able to understand or summarize the team's findings. After we have all written questions, you will be given time to ask them to the presenting group. These questions are important, because after asking questions, you will have to record a summary of what you learned from the team."

In addition to stopping the presentation after the question, also stop it after the team has presented their Experimental Set-Up: Specific and have the class identify the team's subgroup control. Then, record this above the data table on the *Notes on Presentations*, students do not need to record this if they do not want to. After the first presentation, stop the presentation after the team has read their procedure and have the class predict what trend they think the team saw both within their trend lines and between trend lines. Below is a list of what students should learn from each presentation along with the predictions they should be able to make.

Presentation 1 (Changing Variable: $NaHCO_3$ mass, Subgroup Control: $CaCl_2$ mass)
    What students should be able to predict:
        For this presentation they will not be able to predict anything
    What students should have learned from the presentation:
        The greater the $NaHCO_3$ mass, the smaller the temperature change
        The greater the $CaCl_2$ mass, the greater the temperature change
Presentation 2 (Changing Variable: $CaCl_2$ mass, Subgroup Control: NaCl mass)
    What students should be able to predict:
        The subgroup's line with the greatest $CaCl_2$ mass should be the highest on the graph (students learned this from the subgroup control of presentation 1)
    What students should have learned from the presentation:
        The greater the $CaCl_2$ mass, the greater the temperature change (confirmed what team 1 saw)
        NaCl mass does not affect the temperature change
Presentation 3 (Changing Variable: NaCl mass, Subgroup Control: $NaHCO_3$ mass)
    What students should be able to predict:
        There should be no trend (flat line) for NaCl mass (students learned this from the subgroup control of presentation 2)
        The subgroup's line the smallest $NaHCO_3$ mass should be highest on the graph (student learned this from the changing variable of presentation 1)
    What students should have learned from the presentation:
        NaCl mass does not affect the temperature change (confirmed what team 2 saw)
        The greater the $NaHCO_3$ mass, the higher the temperature change (confirmed what team 1 saw)

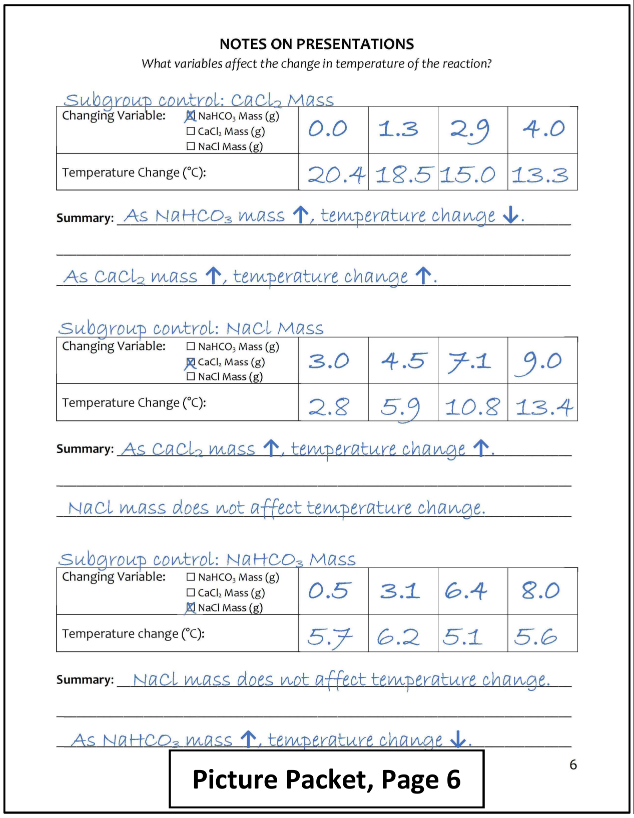
Mentors should make sure students are quiet and respectful when other teams are presenting. When your team is presenting, go to the front of the room with them; prompt students if they do not know who talks next and remind them to read from their notebooks.

After each team has given their presentation, take one of their notebooks and put the graph under the document camera, so it may be seen during student question time. If is helpful to label each of the lines with the subgroup control value. During this time, the lead and/or mentors should ask at least one question. Examples of possible questions are: "How do you know…?" or "Is there anything else you can do to get more information about your question?" Each team should answer approximately 10 questions (one question per student).

When students are done asking questions, have them summarize what the team found both for their changing variable and their subgroup control.

Notebooks only have room for notes and questions on two presentations. Therefore, students will not take notes on their own presentation.

An example filled-out *Notes on Presentations* (left) and student notes (right) are shown below.



NOTES ON PRESENTATIONS

What variables affect the change in temperature of the reaction?

Subgroup control: $CaCl_2$ Mass

Changing Variable: ☒ $NaHCO_3$ Mass (g) ☐ $CaCl_2$ Mass (g) ☐ NaCl Mass (g)	0.0	1.3	2.9	4.0
Temperature Change (℃):	20.4	18.5	15.0	13.3

Summary: As $NaHCO_3$ mass ↑, temperature change ↓.

As $CaCl_2$ mass ↑, temperature change ↑.

Subgroup control: NaCl Mass

Changing Variable: ☐ $NaHCO_3$ Mass (g) ☒ $CaCl_2$ Mass (g) ☐ NaCl Mass (g)	3.0	4.5	7.1	9.0
Temperature Change (℃):	2.8	5.9	10.8	13.4

Summary: As $CaCl_2$ mass ↑, temperature change ↑.

NaCl mass does not affect temperature change.

Subgroup control: $NaHCO_3$ Mass

Changing Variable: ☐ $NaHCO_3$ Mass (g) ☐ $CaCl_2$ Mass (g) ☒ NaCl Mass (g)	0.5	3.1	6.4	8.0
Temperature change (℃):	5.7	6.2	5.1	5.6

Summary: NaCl mass does not affect temperature change.

As $NaHCO_3$ mass ↑, temperature change ↓.

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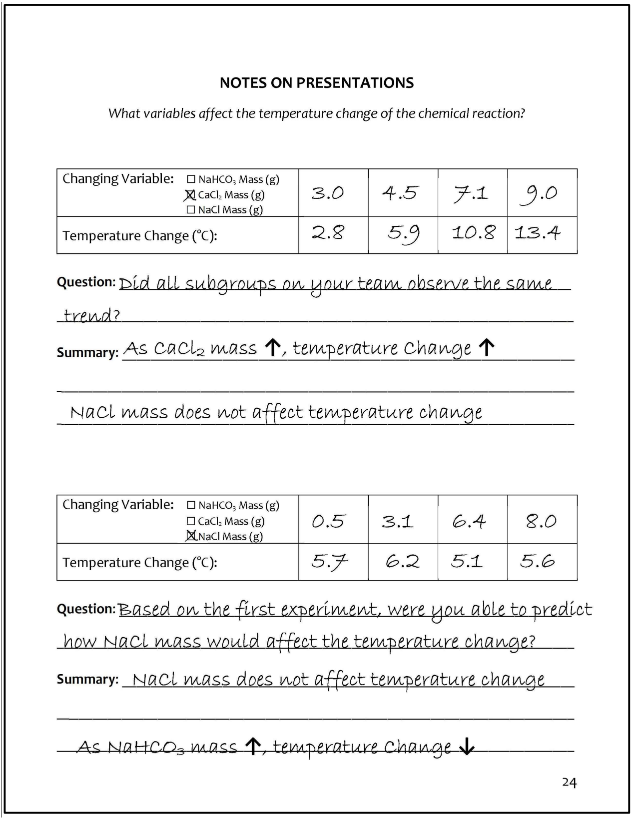
Picture Packet, Page 6



NOTES ON PRESENTATIONS

What variables affect the temperature change of the chemical reaction?

Changing Variable: ☐ $NaHCO_3$ Mass (g) ☒ $CaCl_2$ Mass (g) ☐ NaCl Mass (g)	3.0	4.5	7.1	9.0
Temperature Change (℃):	2.8	5.9	10.8	13.4

Question: Did all subgroups on your team observe the same trend?

Summary: As $CaCl_2$ mass ↑, temperature Change ↑

NaCl mass does not affect temperature change

Changing Variable: ☐ $NaHCO_3$ Mass (g) ☐ $CaCl_2$ Mass (g) ☒ NaCl Mass (g)	0.5	3.1	6.4	8.0
Temperature Change (℃):	5.7	6.2	5.1	5.6

Question: Based on the first experiment, were you able to predict how NaCl mass would affect the temperature change?

Summary: NaCl mass does not affect temperature change

As $NaHCO_3$ mass ↑, temperature Change ↓

24

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.

- As the $NaHCO_3$ *mass* increases, the temperature change decreases.
- As the *$CaCl_2$ mass* increases, the temperature change increases.
- The *NaCl mass* does not affect the temperature change.

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, outside of SciTrek time, before the next session.

Wrap-Up:

(2 minutes – Full Class – SciTrek Lead)

Tell students, "The mentors who have been working with you are undergraduate and graduate students who volunteer their time so you can do experiments. This is the last day you will see your mentors, so we should say thank you and goodbye to them. I will come back and work with you one more day."

Have students remove the paper parts of their nametags (which they can keep) from the plastic holders, and return the plastic holders to their mentors.

Clean-Up:

1. Collect plastic nametag holders and allow students to keep the paper part of their nametags.
2. Collect notebooks.
3. Leave posters in the classroom.
4. Place all other materials into your group box and bring them back to UCSB.
5. If you will not be attending the tie to standards day, remove all items from your lab coat pockets, remove your nametag, unroll your lab coat sleeves, and put your lab coat into the dirty clothes bag at UCSB.

Day 8: Analysis Assessment/Draw a Scientist/Tie to Standards/Content Assessment

Schedule:

Analysis Assessment (SciTrek Lead) – 10 minutes
Draw a Scientist (SciTrek Lead) – 5 minutes
Tie to Standards (SciTrek Lead) – 40 minutes
Content Assessment (SciTrek Lead) – 5 minutes

Materials:

Lead Box:

☐ (3) Extra notebooks
☐ Notebooks
☐ Lead instructions
☐ Thermal Transfer picture packet
☐ Picture of experimental set-up
☐ Lead lab coat
☐ (35) Analysis assessments
☐ (35) Draw A Scientist
☐ (35) Content assessments

☐ Time card
☐ (2) Pencils
☐ (2) Wet erase markers
☐ (2) Black pens
☐ (35) Clear rulers
☐ Water (8 oz)
☐ Paper towels
☐ Thermometer
☐ Dropper
☐ Beaker
☐ $NaCl$ exact container (4.0 g)
☐ Fresh $CaCl_2$ 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 and cord
☐ Magneticstir bar
☐ Extension cord
☐ Teacher final survey QR code

(2) Boxes, each with the following:

☐ Bag of 8 Experiment 1 sandwich bags (½ scoop $NaCl$, ½ scoop $NaHCO_3$, 1½ scoop $CaCl_2$)

☐ Bag of 8 Experiment 2 sandwich bags (½ scoop $NaCl$, 2 scoop $NaHCO_3$, ¼ scoop $CaCl_2$)
☐ (8) Waters (8 oz)

☐ (8) Droppers
☐ (8) 100 mL graduated cylinders
☐ Paper towels
☐ White rag

Other Supplies:

☐ Bucket with lid
☐ Tray
☐ Calculator box (content assessment)

Notebook Pages:

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 **$NaHCO_3$ mass** affect the temperature change? [✓ YES] NO

If YES, describe the trend: The greater the $NaHCO_3$ mass, the smaller the temperature change.

Does **$CaCl_2$ mass** affect the temperature change? [✓ YES] NO

If YES, describe the trend: The greater the $CaCl_2$ mass, the larger 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. Doing multiple trials tells us how much the results can vary from each other.

*When running multiple trials in an experiment, scientists collect a series of different 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.

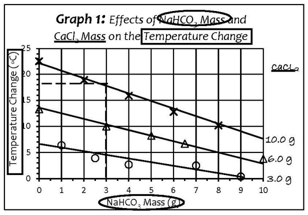
Substance Masses:	Temperature Change (°C):	Median:	Range:
0.0 g $NaHCO_3$ 4.0 g NaCl 5.0 g $CaCl_2$	11.9, 11.7, 12.1, 14.9, 13.4 ~~11.7~~, ~~11.9~~, 12.1, ~~13.4~~, ~~14.9~~	12.1°C	14.9°C -11.7°C 3.2°C

4. What does this tell us? As long as our predictions are within 3.2°C of the actual data, we can consider them correct.

25

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

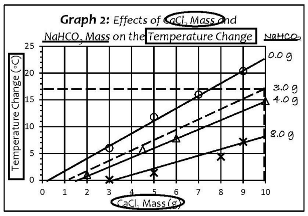
Why has the graph for NaCl mass been left out? NaCl mass does not affect the temperature change.



Graph 1 Controls			
Experiment Symbol	$CaCl_2$ Mass	~~NaCl Mass~~	Water Volume
○	3.0 g	~~4.0 g~~	50 mL
△	6.0 g	~~4.0 g~~	50 mL
X	10.0 g	~~4.0 g~~	50 mL

Does this graph show a trend that is consistent with the class findings?

[✓ YES] NO



Graph 2 Controls			
Experiment Symbol	$NaHCO_3$ Mass	~~NaCl Mass~~	Water Volume
○	0.0 g	~~4.0 g~~	50 mL
△	4.0 g	~~4.0 g~~	50 mL
X	8.0 g	~~4.0 g~~	50 mL

Does this graph show a trend that is consistent with the class findings?

[✓ YES] NO

6. Using data from the graphs, what temperature change would you expect to measure if you mixed 4.0 g NaCl, 3.0 g $NaHCO_3$, 10.0 g $CaCl_2$, and 50 mL water?

Which experiment(s) should you look at?

Graph 1: ○ △ [✓ X] Prediction: 18°C

Graph 2: [✓ ○ △] X Prediction: 17°C

Expected Temperature Change:
(Round to the nearest tenth)
17.5°C

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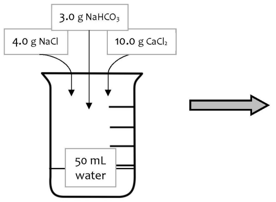
7. What temperature change was measured when we mixed 4.0 g NaCl, 3.0 g $NaHCO_3$, 10.0 g $CaCl_2$, and 50 mL water?



Initial Temperature	19.0°C
Maximum Temperature	35.7°C
Temperature Change	2 1 ~~3~~5.7°C -19.0°C 16.7°C

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

6 1
1~~7~~.5°C
-16.7°C
0.8°C

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

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

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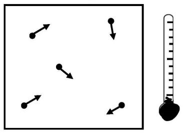
Why is the temperature change predictable?

11. **Temperature** is a measure of kinetic energy, which is the energy of motion.

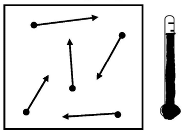
12. In the boxes below, indicate the speeds of the particles using arrows (larger arrows = faster speeds). Then, fill in the thermometers to represent their relative temperatures.

Kinetic Energy: Low



Particles are moving slow.

Kinetic Energy: High



Particles are moving fast.

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

Starting Material	Observations
NaCl	white, grainy, square pieces, solid
$CaCl_2$	white, small, solid balls
$NaHCO_3$	white, powdery, different size pieces, solid
Water	clear liquid

14. What did we end with? Liquid turned milky white with a solid at bottom of bag. Gas was produced that puff up the bag.

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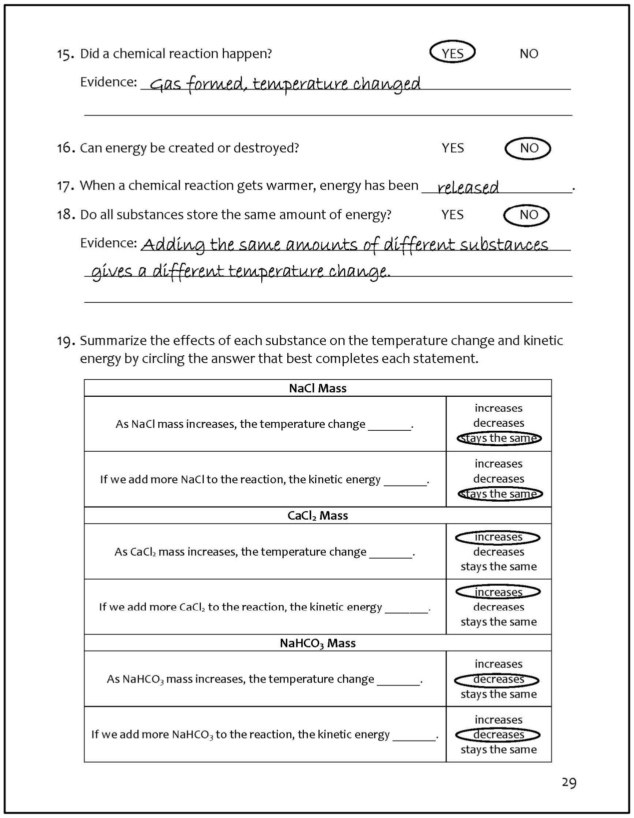


15. Did a chemical reaction happen? [✓ YES] NO

Evidence: Gas formed, temperature changed

16. Can energy be created or destroyed? YES [✓ NO]

17. When a chemical reaction gets warmer, energy has been released.

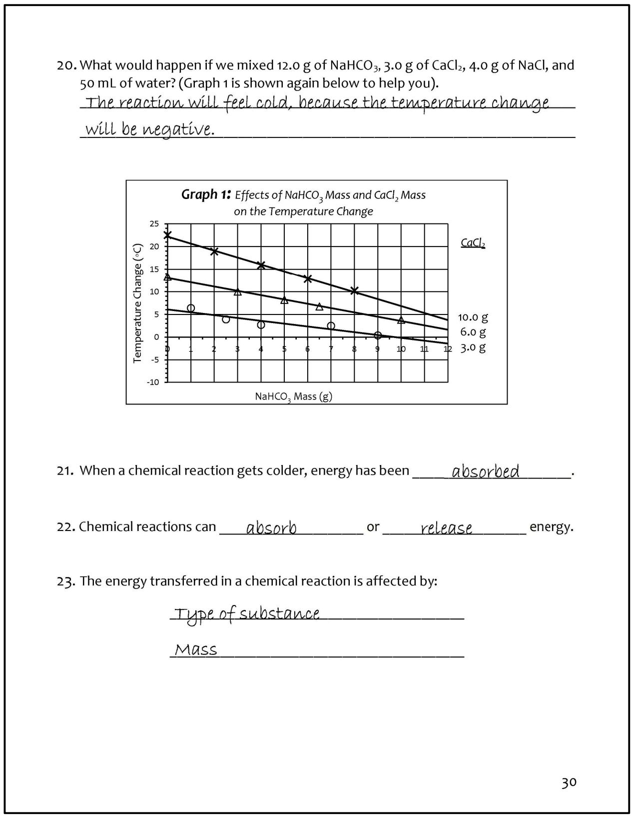
18. Do all substances store the same amount of energy? YES [✓ NO]

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.

NaCl Mass	
As NaCl mass increases, the temperature change _______.	increases decreases [✓ stays the same]
If we add more NaCl to the reaction, the kinetic energy _______.	increases decreases [✓ stays the same]
$CaCl_2$ Mass	
As $CaCl_2$ mass increases, the temperature change _______.	[✓ increases] decreases stays the same
If we add more $CaCl_2$ to the reaction, the kinetic energy _______.	[✓ increases] decreases stays the same
$NaHCO_3$ Mass	
As $NaHCO_3$ mass increases, the temperature change _______.	increases [✓ decreases] stays the same
If we add more $NaHCO_3$ to the reaction, the kinetic energy _______.	increases [✓ decreases] stays the same

29



20. What would happen if we mixed 12.0 g of $NaHCO_3$, 3.0 g of $CaCl_2$, 4.0 g of NaCl, and 50 mL of water? (Graph 1 is shown again below to help you).

The reaction will feel cold, because the temperature change will be negative.

Graph 1: *Effects of $NaHCO_3$ Mass and $CaCl_2$ Mass on the Temperature Change*

21. When a chemical reaction gets colder, energy has been absorbed.

22. Chemical reactions can absorb or release energy.

23. The energy transferred in a chemical reaction is affected by:

Type of substance

Mass

30

Preparation:

SciTrek Lead:

1. If the teacher is not leading the tie to standards activity, do the following:
    a. Ask the teacher if they completed the SciTrek final survey. If not, give them the QR code from the lead box and ask them to go to the website (at a later time) and fill out the evaluation of the program.
    b. Give the teacher an extra notebook and have them fill it out with their students, to follow along during the tie to standards activity.
    c. Collect the teacher's lab coat and put it in the lead box.
2. If you are a teacher and have not completed the final survey, take the QR code from the lead box, and fill out the evaluation of the program, at a later time.
3. Pass out the analysis assessments and notebooks.
4. Set up the document camera for the tie to standards activity (notebook, pages 25-30; picture packet, pages 7-9).
5. Set up the temperature change demonstration (just like Day 1 experimental set-up).
6. Put your lab coat in the lead box at the end of the day.

Analysis Assessment:

(10 minutes – Full Class – SciTrek Lead)

Tell students, "Before we start our activity today, we will determine how your ideas on analyzing and interpreting data are developing." Have students write their name, teacher's name, and date at the top of the assessment. Tell students, "When doing this assessment, you should work individually, so there should be no talking." As you are giving the assessment, walk around the room and verify students have written their names on their assessments.

For page 1, read the directions for annotating to the students. Then, have students annotate the first results table by underlining controls, circling changing variable(s), and boxing information about data collection. Read question *1b* (*Can this group make a conclusion?*) and have students answer the question. 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 the process for questions *2* and *3* (page 2).

For page 3 (top), pass out rulers to students. Read the directions for question *4* to students. Then, have students annotate the graph by underlining controls, circling changing variables, and boxing information about data collection. Have students plot the remaining points on the graph using circles as markers. Then, tell students, “Draw trend lines for each experiment on the graph.” Read questions *4d-4f* and give students time to answer each.

For page 3 (bottom) and 4, read the three *Attitudes Towards Science* questions (7-18) to students and have them answer them. When they are finished, collect the assessments and verify that the students’ names are on the top of the papers. Students should keep their rulers to use during the tie to standards activity.

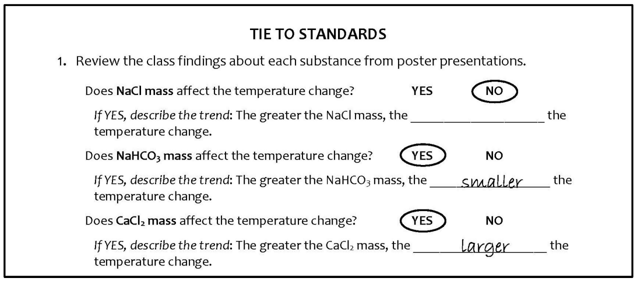
Draw a Scientist:
(5 minutes – Full Class – SciTrek Lead)

Pass out a *Draw a Scientist* paper to each student and have them write their name, teacher’s name, and date at the top of the paper. Tell students, “I am going to give you **exactly** 4 minutes to draw a picture of what you think a scientist looks like.” Start the timer and when 3 minutes is up, give students a 1-minute warning. After 4 minutes is over tell students, “If you drew a specific person, on the line at the bottom of the paper write who you drew. If you did not draw a specific person, leave the line blank.” When students are finished, collect the papers and verify the students’ names are written on the top of the papers.

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

Class Findings (3 minutes)

Tell students, “I enjoyed hearing about your experiments last session, let’s quickly review what we found out as a class.” Have students open to page 25 in their notebooks, and place the class notebook under the document camera. Ask students, “Does increasing NaCl mass affect the temperature change of the reaction and if so how?” Students should reply, “Change NaCl mass does not affect the temperature change of the reaction.” Circle *NO*. Ask students, “How do we know this?” Possible student response: there was no trend in the data for NaCl mass. Next, ask students, “Does increasing $NaHCO_3$ mass affects the temperature change of the reaction and if so, how?” Possible student response: yes, the greater the $NaHCO_3$ mass, the smaller the temperature change of the reaction. Circle *YES*, and fill in the sentence frame. Ask students, “Does increasing the $CaCl_2$ mass affects the temperature change of the reaction and if so, how?” Possible student response: yes, the greater the $CaCl_2$ mass, the larger the temperature change of the reaction. Circle *YES*, and fill in the sentence frame. If students have trouble remembering the class findings, refer to their notes on presentations (picture packet, page 6 and notebook, page 24). A filled-out question *1* is shown below.



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 **$NaHCO_3$ mass** affect the temperature change? [✓ YES] NO

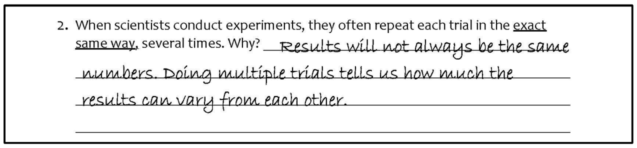
If YES, describe the trend: The greater the $NaHCO_3$ mass, the smaller the temperature change.

Does **$CaCl_2$ mass** affect the temperature change? [✓ YES] NO

If YES, describe the trend: The greater the $CaCl_2$ mass, the larger the temperature change.

Variations in Data (6 minutes)

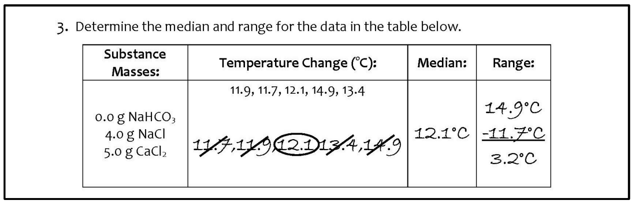
Ask students, “Sometimes, scientists run an experiment multiple times, why do you think scientists do this?” Allow a few students to share their ideas. Lead students to understand, oftentimes measured results will not always be the same between trials and doing trials multiple times tells us how much the results can vary. Have students answer question *2*, as shown below.



2. When scientists conduct experiments, they often repeat each trial in the <u>exact same way</u>, 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.

Tell students, “In my lab, I mixed 0.0 g $NaHCO_3$, 4.0 g NaCl, and 5.0 g $CaCl_2$. I repeated this trial 5 times, and each time I calculated a slightly different temperature change. I want to be able to report one number for this trial. The median, or the middle number in a series of measurements, is a mathematical tool scientists use to report the ‘best’ answer. To find the median, you put the values in increasing order, and then, identify the middle number.” Have students find, and record, the median for question *3*.

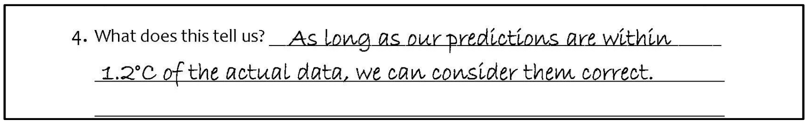
Tell students, “In addition to reporting the median, scientists like to report how much error is in their measurements. They do this by calculating the range, which is the difference between the largest, and smallest, measurements.” Have students calculate the range for the data points in question *3*.



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

Substance Masses:	Temperature Change (°C):	Median:	Range:
0.0 g $NaHCO_3$ 4.0 g NaCl 5.0 g $CaCl_2$	11.9, 11.7, 12.1, 14.9, 13.4 ~~11.7~~, ~~11.9~~, 12.1, ~~13.4~~, ~~14.9~~	12.1°C	14.9°C -11.7°C 3.2°C

Ask students, “What do the median and range tell us about our experiments, in general?” Possible student response: if we do the trial multiple times, we will get different temperatures. If we find the median of the temperatures, all measurements should be off by no more than 1.6°C from the median. Lead students to understand this means, when we are making predictions about this experiment, we can consider predictions correct if they are within 3.2°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 (10 minutes)

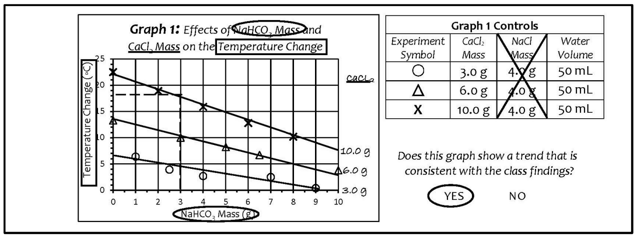
Tell students, “I did several experiments similar to the ones you designed, but I performed each trial three times for every experiment. Then, I took the median for each trial, and graphed the median points on 'team graphs,' grouped by the changing variable investigated. These graphs are shown on page 26 of your notebooks."

First, ask students, "Why do you think the graph on the effects of NaCl mass was left out?" Possible student response: NaCl mass does not affect the temperature change, therefore, it is not as useful for making predictions. Have students answer question *5*, as shown below.

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.

Next, annotate Graph 1 as a class. Ask students, "What is the changing variable of graph 1?" Students should reply, "Sodium hydrogen carbonate ($NaHCO_3$) mass." Circle it on the x-axis. Then, ask students, "What was calculated in this experiment?" They should reply, "Temperature change (°C)." Box it on the y-axis. Ask students, "Where else does this information appear on the graph?" They should reply, "The title." Circle the changing variable, and box the data in the title. Ask students, "What other information appears in the title, and what should we do to it?" Possible student response: one of the controls, $CaCl_2$ mass, is in the title, so we should underline it. Ask students, "What type of control is $CaCl_2$ mass?" Remind students that $CaCl_2$ 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, have students label each trend line with the corresponding subgroup control value. Ask students, "Does $NaHCO_3$ mass affect the temperature change, and how do you know?" Possible student response: yes, because all three lines are decreasing. Ask students, "Is this consistent with the class findings?" Students should reply, "Yes." Circle *YES* for the question on Graph 1, as shown below.

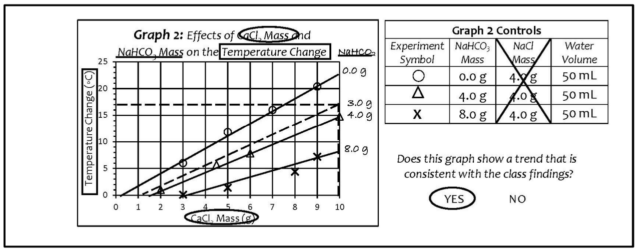


Graph 1 Controls			
Experiment Symbol	*$CaCl_2$ Mass*	~~*NaCl Mass*~~	*Water Volume*
○	3.0 g	~~4.0 g~~	50 mL
△	6.0 g	~~4.0 g~~	50 mL
X	10.0 g	~~4.0 g~~	50 mL

Does this graph show a trend that is consistent with the class findings?

[✓ YES] NO

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 have students check their work, and make changes, if needed. Ask students, "Does $CaCl_2$ mass affect the temperature change, and how do you know?" Possible student response: yes, because all three lines are increasing. Ask students, "Is this consistent with the class findings?" Students should reply, "Yes." Circle *YES* for the question on Graph 2, as shown below.

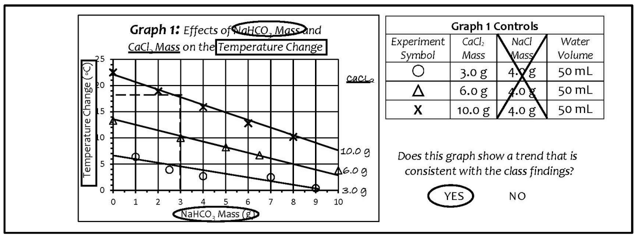


Graph 2 Controls			
Experiment Symbol	*$NaHCO_3$ Mass*	~~*NaCl Mass*~~	*Water Volume*
○	0.0 g	~~4.0 g~~	50 mL
△	4.0 g	~~4.0 g~~	50 mL
X	8.0 g	~~4.0 g~~	50 mL

Does this graph show a trend that is consistent with the class findings?

[✓ YES] NO

Read question *6*, and tell students, "We should use both graphs to make predictions." Have students look at Graph 1 first, and ask them, "Which experiment, or experiments, will be most useful to predict the temperature change?" Show students, the subgroup control they labeled on Graph 1 is $CaCl_2$ mass, so they should focus on the value given for $CaCl_2$ mass, which is 10.0 g. Students should notice that Graph 1 has a trend line that corresponds with 10.0 g of $CaCl_2$, which is represented by the symbol **X**. Have students circle ***X*** for Graph 1 on question *6*. Then, ask students, "Where will we find $NaHCO_3$ mass on Graph 1?" Students should reply, "The x-axis." Have students find 3.0 g, on the axis. Then, have them make a dashed line, from 3 on the x-axis, up to trend line **X,** with their ruler. Followed by making a dashed line from the intersection to the y-axis, with their ruler. This will allow them to determine the predicted temperature change (~18°C). Have students write the predicted temperature change for Graph 1, on question *6*. Remind students, their predictions can vary up to ~3°C.

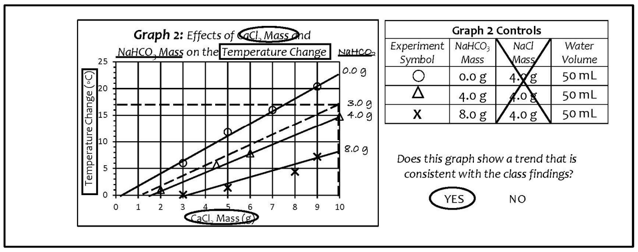


Graph 1 Controls			
Experiment Symbol	$CaCl_2$ Mass	~~NaCl Mass~~	Water Volume
○	3.0 g	~~4.0 g~~	50 mL
Δ	6.0 g	~~4.0 g~~	50 mL
X	10.0 g	~~4.0 g~~	50 mL

Does this graph show a trend that is consistent with the class findings?

[✓ YES] NO

Follow the same process to predict the temperature change from Graph 2. Show students, the subgroup control on Graph 2 is $NaHCO_3$ mass. Ask students, "Which experiments do we need to look at, considering we are using 3.0 g of $NaHCO_3$?" Possible student response: 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, "Should we draw a dashed line halfway between the circle and triangle trend lines?" Possible student response: no, 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 will we find $CaCl_2$ mass on Graph 2?" Students should reply, "The x-axis." Find 10.0 g on the x-axis. Have students make a dashed line, from 10 on the x-axis, up to the dashed trend line with their ruler. Followed by making a dashed line from the intersection, to the y-axis, with their ruler. This will allow them to determine their predicted temperature change (~17°C). Have students write the predicted temperature change for Graph 2, on question *6*. Remind students their predictions can vary up to ~3°C.

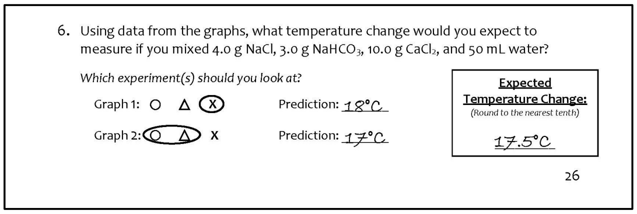


Graph 2 Controls			
Experiment Symbol	$NaHCO_3$ Mass	~~NaCl Mass~~	Water Volume
○	0.0 g	~~4.0 g~~	50 mL
Δ	4.0 g	~~4.0 g~~	50 mL
X	8.0 g	~~4.0 g~~	50 mL

Does this graph show a trend that is consistent with the class findings?

[✓ YES] NO

Tell students, "Now we need to get one expected temperature change. To do this, we will find the value that is halfway between our two predicted values." Then, combine the two predictions to make an overall temperature change prediction. **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." A filled-out question *6* is shown below.



6. Using data from the graphs, what temperature change would you expect to measure if you mixed 4.0 g NaCl, 3.0 g $NaHCO_3$, 10.0 g $CaCl_2$, and 50 mL water?

Which experiment(s) should you look at?

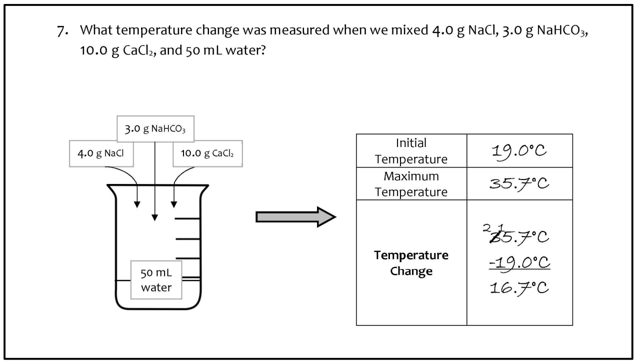
Graph 1: ○ △ [✓ X] Prediction: 18°C

Graph 2: [✓ ○ △] X Prediction: 17°C

Expected Temperature Change:
(Round to the nearest tenth)
17.5°C

26

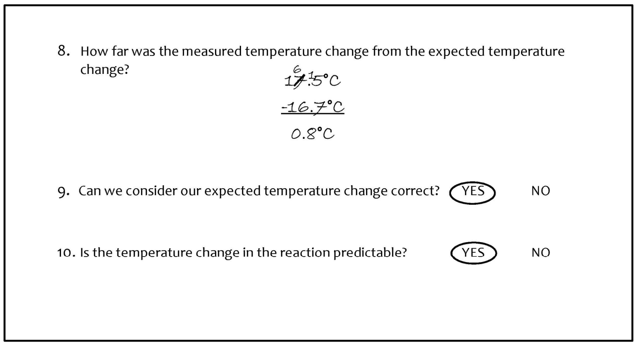
Turn to page 27 in the class notebook. Tell students, “We will now test our prediction.” Pour 50 mL of water into the beaker with a magnetic stir bar. Turn the stir plate on to level 2, and position the thermometer in the beaker with the plastic lid. Wait a moment for the temperature to stabilize. Tell students, “I weighed each substance ahead of time.” Then, pour each of the substances, from the exact containers, into the mix weigh boat. Record the initial temperature in the table under question *7*, and pour the substances in 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 in the table. Have students do subtraction with you, to find the temperature change for question *7*.



7. What temperature change was measured when we mixed 4.0 g NaCl, 3.0 g $NaHCO_3$, 10.0 g $CaCl_2$, and 50 mL water?

Initial Temperature	19.0°C
Maximum Temperature	35.7°C
Temperature Change	$\overset{2}{\cancel{3}}\overset{1}{5}.7^{\circ}\mathrm{C}$ $\underline{-19.0^{\circ}\mathrm{C}}$ 16.7°C

Ask students, “How can we 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 (predicted 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 does this tells us about our predicted temperature change?” If the difference calculated in question *8* is less than 3.2°C, it means 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 does this tell us about the temperature change of the reaction?” Students should reply, “It is predictable.” Circle *YES* for question *10*.



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

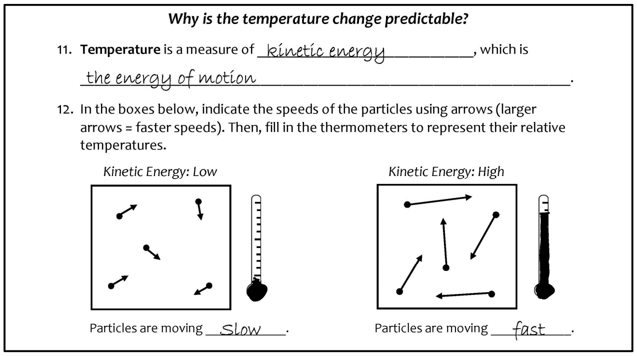
$1\overset{6}{\cancel{7}}.\overset{1}{5}^{\circ}\mathrm{C}$
$\underline{-16.7^{\circ}\mathrm{C}}$
0.8°C

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

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

Why Temperature Changes (14 minutes)

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



Why is the temperature change predictable?

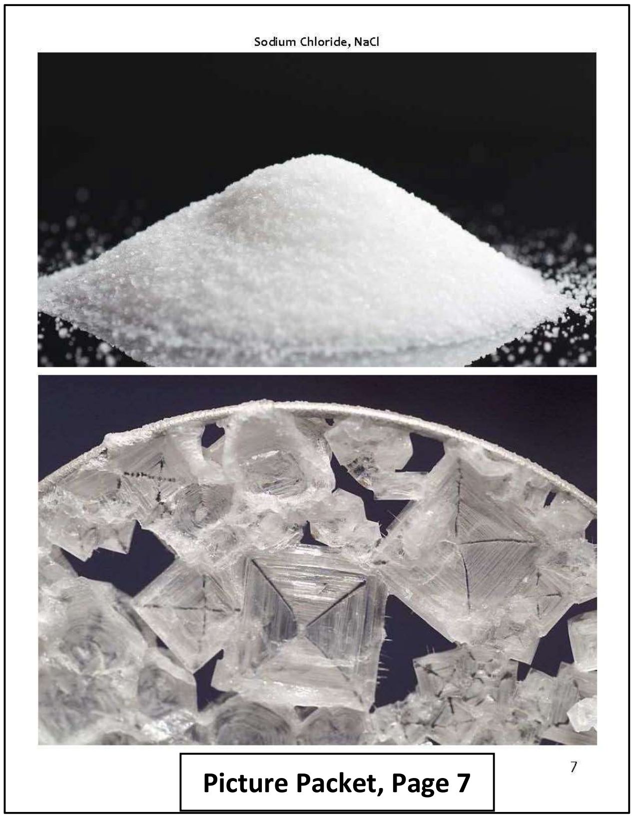
11. **Temperature** is a measure of kinetic energy, which is the energy of motion.

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.

Particles are moving slow.

Particles are moving fast.

Next, tell students, “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 7, of the picture packet, under the document camera, to show students what sodium chloride (NaCl) looks like. Have a few students share observations of sodium chloride, and record them in the table in question *12* of the class notebook. Repeat this process, with pages 8 ($CaCl_2$) and 9 ($NaHCO_3$) of the picture packet. While you are doing this, have a mentor, or the teacher, pass out water bottles, graduated cylinders, and Experiment 1 bags, to each pair of students. In addition, have them collect the rulers from students.



Sodium Chloride, NaCl

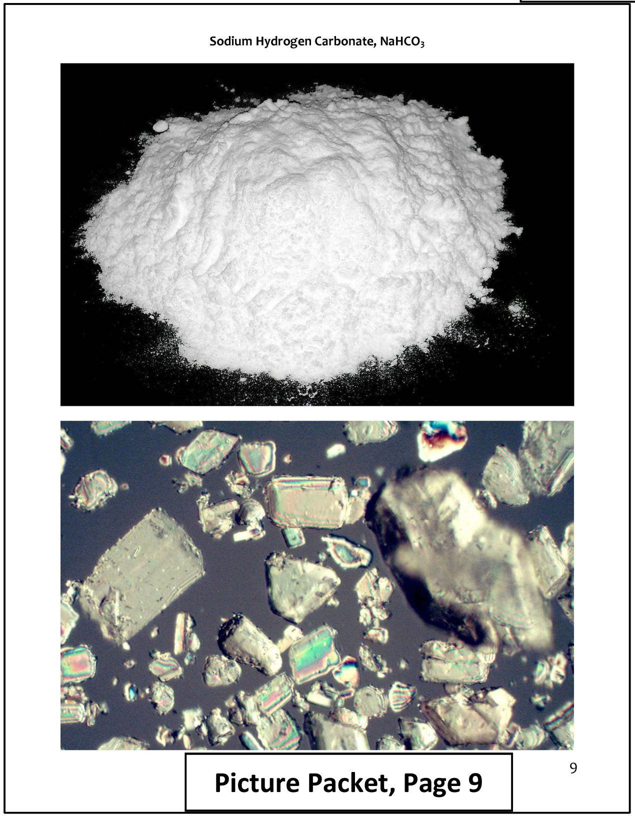
7

Picture Packet, Page 7

Calcium Chloride, $CaCl_2$

8

Picture Packet, Page 8



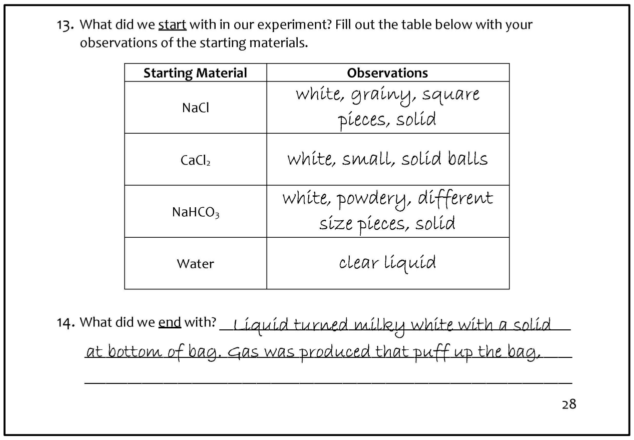
Sodium Hydrogen Carbonate, $NaHCO_3$

9

Picture Packet, Page 9

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, “You will work in pairs.” Pour 50 mL of water into a graduated cylinder, and have one student in each pair 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 all substances are contained on one side. Tell students, “Do not twist the bag more than three times or you will get a hole in the bag.” Have the other student in the pair do this with you. Once students are ready, have a mentor, 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, “You will do the same. Then, make sure there is not much air in the bag and it is closed.” Once all bags are securely closed, tell students, “We will release the substances, and shake the bag, so all substances mix with the water at the same time.” Count down from three, and shake the bags, so 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 warm.

Once reactions have completed, ask students, “What did we end with after the reaction?” Have students record their observations on question *14*. While students are writing observations, have a mentor, or the teacher, collect the bags from students, and place them in the bucket. If the bag looks like it might pop, open the bag to let the gas out. Then seal it again, before placing it in the bucket. Leave the other materials with students.



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

Starting Material	Observations
NaCl	white, grainy, square pieces, solid
$CaCl_2$	white, small, solid balls
$NaHCO_3$	white, powdery, different size pieces, solid
Water	clear liquid

14. What did we end with? Liquid turned milky white with a solid at bottom of bag. Gas was produced that puff up the bag.

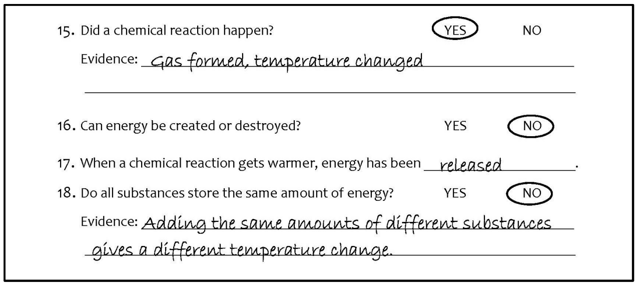
28

Have students turn to page 29 in their notebooks, while you do the same under the document camera. Ask students, “Did we just observe a chemical reaction happen, and how do we know?” Possible student response: yes, because a gas formed, the color changed, and the temperature changed. Circle *YES* for question *15*, and write down their evidence.

Ask students, “Can energy can be created, or destroyed?” Have a few students share their ideas. Then, tell students, “Energy can never be created, nor destroyed, it can only be transferred, this is called the Law of Conservation of Energy.” Students should circle *NO* for question *16*.

Ask students, “What happened to the temperature during the reaction?” Students should reply, “Got hotter. Ask students, “What does this tells us about the kinetic energy of the particles in the bag?” Possible student response: 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, 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, “Do all substances store the same amount of energy?” Call on a few students to share their ideas. Probe students further by asking, “If we added 4.0 g of NaCl or 4.0 g of $CaCl_2$ or 4.0 g of $NaHCO_3$ to water, would you expect to observe the same temperature change for each substance?” Students should reply, “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*.



15. Did a chemical reaction happen? [✓ YES] NO

Evidence: Gas formed, temperature changed

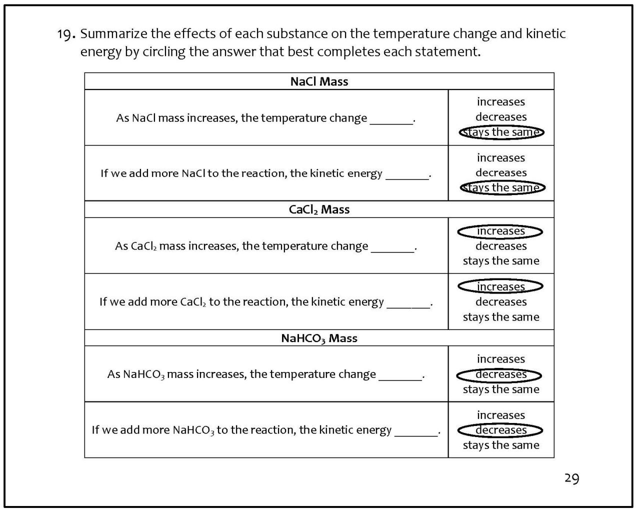
16. Can energy be created or destroyed? YES [✓ NO]

17. When a chemical reaction gets warmer, energy has been released.

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.

Tell students, "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. If needed, students can refer to the graphs on page 26. For the first statement, students should tell you, "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?" Student should reply, "No." 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, by the end of the conversation, students understand the direct relationship between temperature and kinetic energy: if the temperature change increases, the change in kinetic energy also increases.



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

NaCl Mass	
As NaCl mass increases, the temperature change _______.	increases decreases [✓ stays the same]
If we add more NaCl to the reaction, the kinetic energy _______.	increases decreases [✓ stays the same]
$CaCl_2$ Mass	
As $CaCl_2$ mass increases, the temperature change _______.	[✓ increases] decreases stays the same
If we add more $CaCl_2$ to the reaction, the kinetic energy _______.	[✓ increases] decreases stays the same
$NaHCO_3$ Mass	
As $NaHCO_3$ mass increases, the temperature change _______.	increases [✓ decreases] stays the same
If we add more $NaHCO_3$ to the reaction, the kinetic energy _______.	increases [✓ decreases] stays the same

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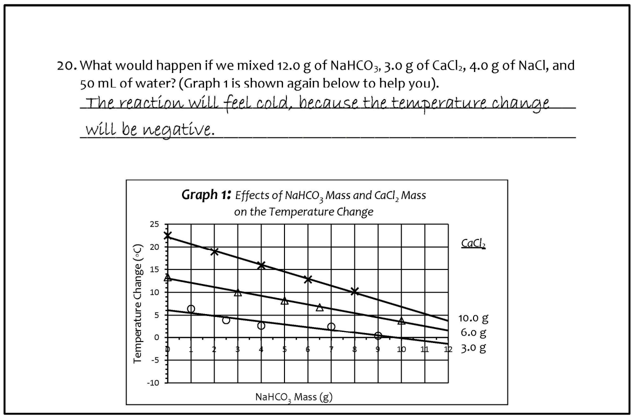
Cold Reactions (7 minutes)

Ask students, "Do you think it is possible to make our reaction feel cold?" If students are unsure, ask them, "Did any of the substances make the temperature change go down?" Students should reply, "Adding more $NaHCO_3$ made the temperature change decrease."

Read question *20* to students. Then, have them predict the temperature change from the graph. Show students, 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, we can find 12.0 g of $NaHCO_3$ on the x-axis and see where the circle trend line is." Ask students, "Does anyone notice anything different about the temperature change we would expect for this mixture of substances?" Students should reply, "This temperature change should be negative." Ask students, "What does this mean if we were feeling the bag?” Possible student response: the bag would get cold instead of warm. 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 mentor, or the teacher, pass out Experiment 2 bags.



20. What would happen if we mixed 12.0 g of $NaHCO_3$, 3.0 g of $CaCl_2$, 4.0 g of NaCl, and 50 mL of water? (Graph 1 is shown again below to help you).

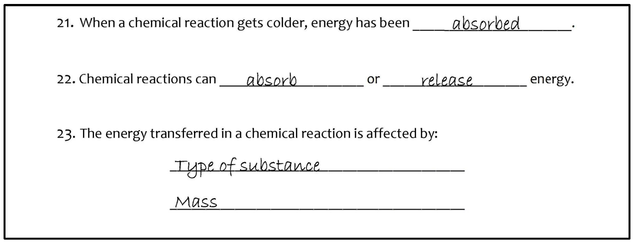
The reaction will feel cold, because the temperature change will be negative.

Graph 1: *Effects of $NaHCO_3$ Mass and $CaCl_2$ Mass on the Temperature Change*

Have students follow the same procedure as last time to run the reaction. Make sure students rotate between roles. For example, if a student held the bag last time this time, they will fill the graduated cylinder. Students should still observe the bag puff up with gas, and a milky white liquid form, but this time, the bag should get cold. Have a mentor, or the teacher, collect the bags from students, and place them in the bucket. If the bag looks like they might pop open the bag to let the gas out. Then seal them again, before placing it in the bucket.

Tell students, “When a reaction feels hot, energy is 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 reply, “The kinetic energy decreased.” Remind students that energy cannot be created or destroyed, and ask students, “Where did the energy go?” 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 *21*.

Ask students, “What are the two ways we have seen chemical reactions transfer energy?” Possible student response: chemical reactions can release, or absorb, energy. Have students fill this out for question *22*. Finally, ask students, “What are two factors, that we talked about today, that 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 *2*



21. When a chemical reaction gets colder, energy has been absorbed.

22. Chemical reactions can absorb or release energy.

23. The energy transferred in a chemical reaction is affected by:

Type of substance

Mass

Content Assessment:
(5 minutes – Full Class – SciTrek Lead)

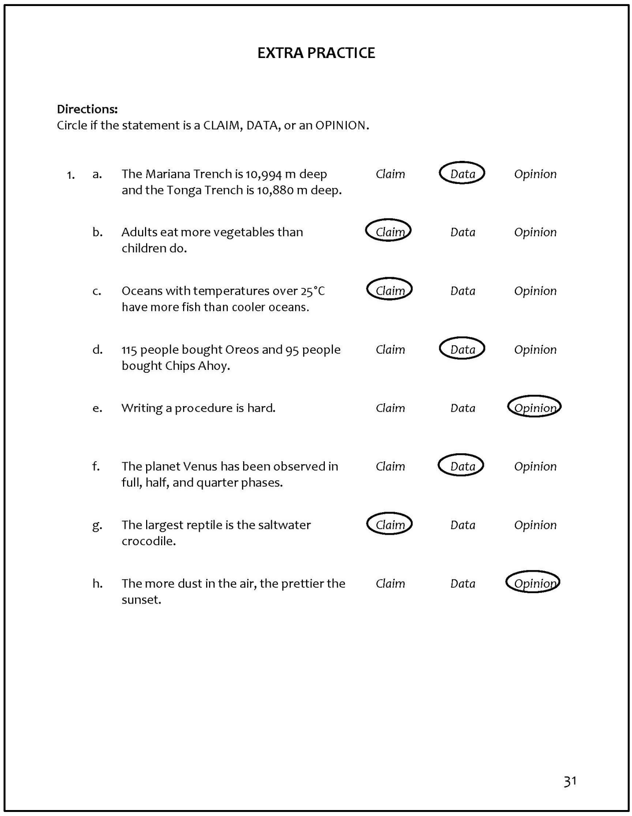
Have students close their notebooks, and place them in the corners of their desks. Pass out the content assessment to students. Have students write their name, teacher’s name, and date at the top of their assessment. Tell students, “When doing this assessment, you should work individually, so there should be no talking." Read each of the content questions to the students and have them select/fill out the correct answer. As you are giving the assessment, walk around the room and verify students have written their names on their assessments. When done, collect the assessments.

Tell students, "You can keep your notebooks, I have enjoyed working, and learning with you. I hope you will continue to see yourselves as scientists and explore the world around you."

Clean-Up:

1. Leave notebooks with students.
2. Collect waters, graduated cylinders, and any experiment bags that have not been collected and place them in the appropriate containers.
3. Place all other materials into the lead box and bring them back to UCSB.
4. Remove all items from your lab coat pockets, remove your nametag, unroll your lab coat sleeves, and put your lab coat into the dirty clothes bag at UCSB.

Extra Practice Solutions:



EXTRA PRACTICE

Directions:
Circle if the statement is a CLAIM, DATA, or an OPINION.

1. a. The Mariana Trench is 10,994 m deep and the Tonga Trench is 10,880 m deep. — *Claim* [✓ *Data*] *Opinion*
   b. Adults eat more vegetables than children do. — [✓ *Claim*] *Data* *Opinion*
   c. Oceans with temperatures over 25°C have more fish than cooler oceans. — [✓ *Claim*] *Data* *Opinion*
   d. 115 people bought Oreos and 95 people bought Chips Ahoy. — *Claim* [✓ *Data*] *Opinion*
   e. Writing a procedure is hard. — *Claim* *Data* [✓ *Opinion*]
   f. The planet Venus has been observed in full, half, and quarter phases. — *Claim* [✓ *Data*] *Opinion*
   g. The largest reptile is the saltwater crocodile. — [✓ *Claim*] *Data* *Opinion*
   h. The more dust in the air, the prettier the sunset. — *Claim* *Data* [✓ *Opinion*]

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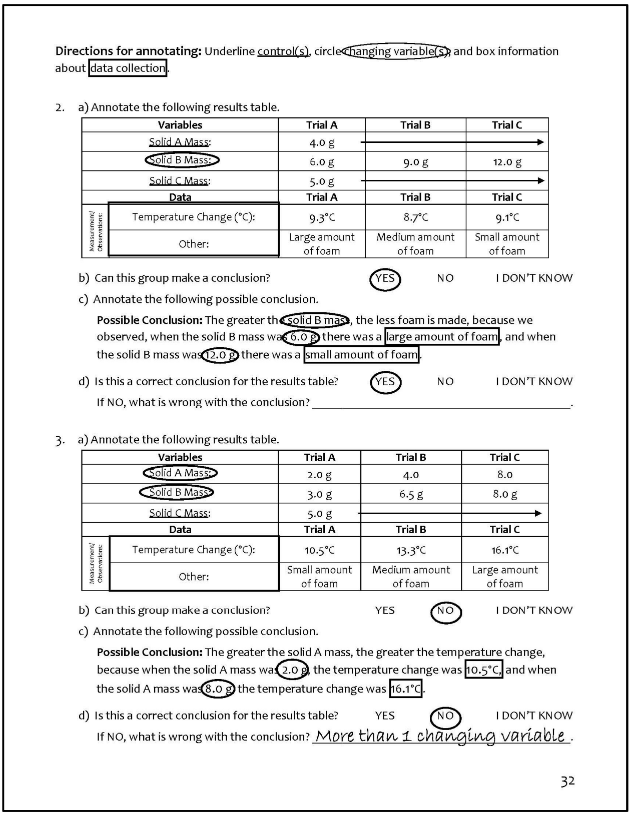

Directions for annotating: Underline control(s), circle changing variable(s), and box information about data collection.

2. a) Annotate the following results table.

	Variables	Trial A	Trial B	Trial C
	Solid A Mass:	4.0 g	→	
	Solid B Mass:	6.0 g	9.0 g	12.0 g
	Solid C Mass:	5.0 g	→	
	Data	**Trial A**	**Trial B**	**Trial C**
Measurement/ Observations:	Temperature Change (°C):	9.3°C	8.7°C	9.1°C
	Other:	Large amount of foam	Medium amount of foam	Small amount of foam

b) Can this group make a conclusion? [✓ YES] NO I DON'T KNOW

c) Annotate the following possible conclusion.

Possible Conclusion: The greater the solid B mass, the less foam is made, because we observed, when the solid B mass was 6.0 g there was a large amount of foam, and when the solid B mass was 12.0 g there was a small amount of foam.

d) Is this a correct conclusion for the results table? [✓ YES] NO I DON'T KNOW

If NO, what is wrong with the conclusion? ______________________.

3. a) Annotate the following results table.

	Variables	Trial A	Trial B	Trial C
	Solid A Mass:	2.0 g	4.0	8.0
	Solid B Mass:	3.0 g	6.5 g	8.0 g
	Solid C Mass:	5.0 g	→	
	Data	**Trial A**	**Trial B**	**Trial C**
Measurement/ Observations:	Temperature Change (°C):	10.5°C	13.3°C	16.1°C
	Other:	Small amount of foam	Medium amount of foam	Large amount of foam

b) Can this group make a conclusion? YES [✓ NO] I DON'T KNOW

c) Annotate the following possible conclusion.

Possible Conclusion: The greater the solid A mass, the greater the temperature change, because when the solid A mass was 2.0 g, the temperature change was 10.5°C, and when the solid A mass was 8.0 g the temperature change was 16.1°C.

d) Is this a correct conclusion for the results table? YES [✓ NO] I DON'T KNOW

If NO, what is wrong with the conclusion? More than 1 changing variable.

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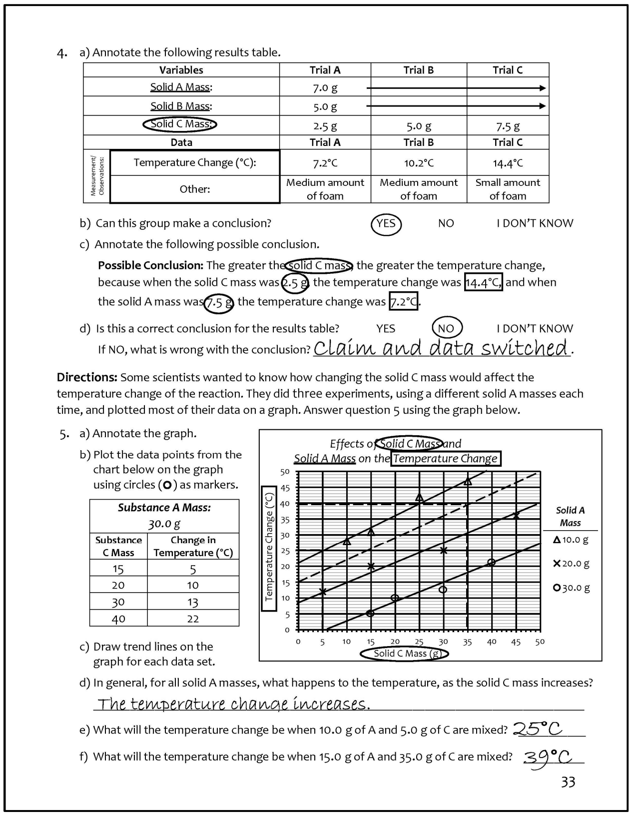

4. a) Annotate the following results table.

Variables		Trial A	Trial B	Trial C
Solid A Mass:		7.0 g	→	→
Solid B Mass:		5.0 g	→	→
Solid C Mass:		2.5 g	5.0 g	7.5 g
Data		**Trial A**	**Trial B**	**Trial C**
Measurement/ Observations:	Temperature Change (°C):	7.2°C	10.2°C	14.4°C
	Other:	Medium amount of foam	Medium amount of foam	Small amount of foam

b) Can this group make a conclusion? [✓ YES] NO I DON'T KNOW

c) Annotate the following possible conclusion.

Possible Conclusion: The greater the solid C mass, the greater the temperature change, because when the solid C mass was 2.5 g, the temperature change was 14.4°C, and when the solid A mass was 7.5 g, the temperature change was 7.2°C.

d) Is this a correct conclusion for the results table? YES [✓ NO] I DON'T KNOW

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

Directions: Some scientists wanted to know how changing the solid C mass would affect the temperature change of the reaction. They did three experiments, using a different solid A masses each time, and plotted most of their data on a graph. Answer question 5 using the graph below.

5. a) Annotate the graph.

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

Substance A Mass: *30.0 g*	
Substance C Mass	**Change in Temperature (°C)**
15	5
20	10
30	13
40	22

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

d) In general, for all solid A masses, what happens to the temperature, as the solid C mass increases?

The temperature change increases.

e) What will the temperature change be when 10.0 g of A and 5.0 g of C are mixed? 25°C

f) What will the temperature change be when 15.0 g of A and 35.0 g of C are mixed? 39°C

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