How Science Works

Grade 6

Module 1

Class Question:

Scientist (Your Name): ____________________________________________

Teacher’s Name: ________________________________________________

SciTrek Volunteer’s Name: ________________________________________
VOCABULARY

Science: The study of the material world using human reason. The scientific method is the way humans reason and apply logic to data to help gain knowledge of the world.

- **Observation:** A description using your five senses. This could include contents, mass, size, color, temperature, smell, texture ...
- **Opinion:** Something you believe or feel. Not a fact or observation.
- **Inference:** A guess based on past experiences.
- **Testable Question:** A question for which an experiment can be designed to answer.
- **Non-Testable Question:** A question for which an experiment cannot be designed to answer the question. For example, questions involving opinions, things that cannot be measured, or words that are not well defined.
- **Experimental Set-Up:** The materials, changing variable, and controls that are needed for an experiment.
- **Experiment:** A test or trial to discover something unknown.
- **Procedure:** A set of steps to conduct an experiment.
- **Controls:** The variables that are not changed in an experiment.
- **Changing Variable (Independent Variable):** The variable that is purposely changed in an experiment.
- **Results/Data (Dependent Variable):** The measurements/observations of the experiment, which are influenced/determined by the changing variable.
- **Prediction:** What you expect to happen based off of previous measurements/observations.
- **Scientific Practices:** A series of activities that scientists participate in to both understand the world around them and to communicate their results with others. (The specific practice worked on in this module is analyzing and interpreting data.)
- **Technique:** A method for a specific task.
- **Conclusion:** A claim supported by data.
- **Claim:** A statement that can be tested. The explanation of the data, the first part of a conclusion.
- **Data:** Evidence collected from experiment(s) (measurements or observations); the second part of a conclusion.
- **Analysis:** A scientific practice involving examining data critically and looking for patterns and trends.
- **Trend:** When data changes in one general direction; can go up or down.
- **Trend Line:** A line drawn on a graph to represent the direction of a trend
- **Pattern:** When data repeats in a predictable manner; can go up, down, and up again.
- **Chemical Reaction:** A process where one or more substances are altered into one or more different substances. Evidence of a chemical reaction can include: formation of a gas, and/or a change in color, smell, or temperature.
- **Graduated Cylinder:** A piece of laboratory equipment used to measure the volume of a liquid.
- **Beaker:** A piece of laboratory equipment used to contain chemicals and conduct chemical reactions.
- **Tare:** To zero the scale.
- **Heat:** A form of energy associated with the movement of particles in a material (also called “thermal energy”). When two systems are in contact, heat flows from the hotter system to the cooler system.
- **Kinetic Energy:** Energy of motion.
- **Temperature:** A physical property which measures the kinetic energy of particles in a substance; the faster the particles are moving, the higher the temperature.
- **Median:** The middle number in a series of measurements.
- **Range:** The difference between the biggest and smallest measurements.
## OBSERVATIONS

**Experimental Set-Up:**

<table>
<thead>
<tr>
<th>Formula</th>
<th>Substance Name</th>
<th>Physical Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Describe what happened during the experiment:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
<table>
<thead>
<tr>
<th>Variable</th>
<th>How will changing this variable affect the temperature change of the reaction?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Experimental Considerations:

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

Changing Variable(s) (Independent Variable(s))

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

Changing Variable 1: ________________________________
Discuss with your group how you think changing variable 1 will affect the temperature change.

Changing Variable 2 (optional): ________________________________
Discuss with your group how you think changing variable 2 will affect the temperature change.

QUESTION

Question our group will investigate:

- If we change the ________________________________,
  insert each changing variable (independent variable)

  ________________________________

  what will happen to the ________________________________,
  insert what you are measuring/observing (dependent variable)

  ________________________________?

SciTrek Member Approval ________________________________

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

Determine the values of your changing variable(s) (ex: NaCl mass) from the materials page and write the values (ex: 2.0 g) for your three trials under each beaker.

Changing Variable(s):

1) __________________________ : ___________ ___________ ___________
2) __________________________ : ___________ ___________ ___________

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

<table>
<thead>
<tr>
<th>Container Type</th>
<th>Beaker</th>
<th>Container Type</th>
<th>Beaker</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SciTrek Member Approval _______________________
PROCEDURE

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

1. 

2. 

3. 

4. 

5. 

6. 

7. 

8. 

SciTrek Member Approval ___________________________
Fill out the chart for each of your trials. If one of the variables remains constant for all trials write the value in trial A and then draw an arrow through each box indicating that this variable is a control. Remember to record masses to the nearest tenth of a gram (Ex. 2.1 g).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Trial A</th>
<th>Trial B</th>
<th>Trial C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Container Type:</td>
<td><strong>Beaker</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Volume:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CaCl₂ Mass:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NaHCO₃ Mass:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NaCl Mass:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Other Variable</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Predictions</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>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.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Data</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial Measurements:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial Temperature:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Temperature:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change in Temperature:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The independent variable(s) is(are) the changing variable(s) and the dependent variable is the change in temperature and other.
1. **Directions:** Fill in the missing definitions.

- **Conclusion:** __________________________________________

- **Claim:** A statement that can be tested. The explanation of the data, the first part of a conclusion.
  - **Example:** The ball mass does not affect the speed at which it rolls down a ramp.
  - A claim in a scientific experiment often includes the ____________________________.

- **Data:** Evidence collected from experiment(s) (measurements or observations), the second part of a conclusion.
  - **Example:** When the ball mass was 360 g its speed was 1.2 m/s, and when the ball mass was 100 g its speed was 1.1 m/s.
  - Data in a scientific experiment includes ______________ or ______________.
  - Data statements also often include values of the ____________________________.

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

   **a)**

<table>
<thead>
<tr>
<th>Variables:</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Trial 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Container Type:</td>
<td>Beaker</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substance A Mass:</td>
<td>2.0 g</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substance B Mass:</td>
<td>6.0 g</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substance C Mass:</td>
<td>5.0 g 7.0 g 9.0 g 11.0 g</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stirring Speed</td>
<td>Medium</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Trial 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final Observations/Measurements:</td>
<td>Change in Temperature: 8.5°C 10.5°C 18.1°C 22.7°C</td>
<td>Other: Made a little foam Made foam Foam filled to the top Overflowed with foam</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

   **Is this a correct conclusion?**
   - YES
   - NO
   - I DON’T KNOW

   If NO, what is wrong with the conclusion? ________________________________________________.
### Possible Conclusion: The greater the stirring speed the higher the temperature change, because when the stirring speed was slow the temperature change was 13.0°C and when the stirring speed was super-fast the temperature change was 10.2°C.

Is this a correct conclusion?  **YES**  **NO**  **I DON’T KNOW**

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

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

Is this a correct conclusion?  **YES**  **NO**  **I DON’T KNOW**

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

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

Is this a correct conclusion?  
YES  NO  I DON’T KNOW

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

---

e)  

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

Is this a correct conclusion?  
YES  NO  I DON’T KNOW

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

---

3. How many changing variables can you have to make a conclusion? _____________________
CONCLUSION

Making a Conclusion from Your Data

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

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

IF NO
Why?__________________________________________________________
__________________________________________________________________________________________
__________________________________________________________________________________________
__________________________________________________________________________________________

IF YES
We can conclude ____________________________________________________________________________claim
________________________________________________________
__________________________________________________________________________________________
__________________________________________________________________________________________

because________________________________________________________ data (measurement/observation)
__________________________________________________________________________________________
__________________________________________________________________________________________
__________________________________________________________________________________________

SciTrek Member Approval __________________________
TECHNIQUE
Trend Lines

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

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

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

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

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

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

b) Which changing variable affects the data?

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

     As Substance _____ increases, the temperature change ____________________.

3. Directions: Annotate Graph 3.

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

________________________________________________________
________________________________________________________
________________________________________________________

Graph 1
Effects of Substance A Mass on the Change in Temperature

Graph 2
Effects of Substance B Mass on the Change in Temperature

Graph 3
Effects of Substance B Mass on the Change in Temperature
**TECHNIQUE**  
*Designing Experiments*

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

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

![Graph 1](image1.png)  
**Effects of Substance A Mass, Substance B Mass, Substance C Mass, and Water Volume on the Change in Temperature**

<table>
<thead>
<tr>
<th>Scientist Symbol</th>
<th>Substance B Mass</th>
<th>Substance C Mass</th>
<th>Water Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>●</td>
<td>6.0 g</td>
<td>5.0 g</td>
<td>60 mL</td>
</tr>
<tr>
<td>○</td>
<td>10.0 g</td>
<td>8.0 g</td>
<td>100 mL</td>
</tr>
</tbody>
</table>

![Graph 2](image2.png)  
**Effects of Substance A Mass and Substance C Mass on the Change in Temperature**

<table>
<thead>
<tr>
<th>Scientist Symbol</th>
<th>Substance B Mass</th>
<th>Substance C Mass</th>
<th>Water Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>▲</td>
<td>6.0 g</td>
<td>5.0 g</td>
<td>70 mL</td>
</tr>
<tr>
<td>△</td>
<td>6.0 g</td>
<td>8.0 g</td>
<td>70 mL</td>
</tr>
</tbody>
</table>

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

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

- As Substance _____ increases, the temperature change ________________.

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

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

**Expected Temperature Change:** __________ °C

c) What does this mean for your experimental design? ___________________________________________
**SCIENTIFIC PRACTICES**

*Analyzing & Interpreting Data*

A large group of scientists studying the reaction between Substances A, B, C, and water collaborated by dividing into 3 teams. Each studied the effect of one of the substances on the temperature change. The 3 teams agreed to keep the water volume constant at 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.

![Team 1 Graph](image)

**Controls**

<table>
<thead>
<tr>
<th>Controls</th>
<th>Substance B</th>
<th>Substance C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientist Symbol</td>
<td>6.0 g</td>
<td>12.0 g</td>
</tr>
<tr>
<td>o</td>
<td>6.0 g</td>
<td>8.0 g</td>
</tr>
<tr>
<td>o</td>
<td>6.0 g</td>
<td>5.0 g</td>
</tr>
</tbody>
</table>

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

   YES  
   NO

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

- As Substance _____ increases, the temperature change ____________________.

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

<table>
<thead>
<tr>
<th>Substance A</th>
<th>5.0 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substance B</td>
<td>6.0 g</td>
</tr>
<tr>
<td>Substance C</td>
<td>8.0 g</td>
</tr>
</tbody>
</table>

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

- ![Graph](image)

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

<table>
<thead>
<tr>
<th>Substance A</th>
<th>3.0 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substance B</td>
<td>6.0 g</td>
</tr>
<tr>
<td>Substance C</td>
<td>10.0 g</td>
</tr>
</tbody>
</table>

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

- ![Graph](image)
2. **Directions:** Annotate the graph, draw trend lines for each experiment, and label trend lines with subgroup control values.

![Team 2 Graph](image)

**Team 2 Graph**

*Effects of Substance B Mass and Substance A Mass on the Change in Temperature*

### Controls

<table>
<thead>
<tr>
<th>Scientist Symbol</th>
<th>Substance A</th>
<th>Substance C</th>
</tr>
</thead>
<tbody>
<tr>
<td>♦</td>
<td>3.0 g</td>
<td>8.0 g</td>
</tr>
<tr>
<td>♣</td>
<td>6.0 g</td>
<td>8.0 g</td>
</tr>
<tr>
<td>♠</td>
<td>9.0 g</td>
<td>8.0 g</td>
</tr>
</tbody>
</table>

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

*YES*  *NO*

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

- As Substance _____ increases, the temperature change ______________________.

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

<table>
<thead>
<tr>
<th>Substance A</th>
<th>9.0 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substance B</td>
<td>3.0 g</td>
</tr>
<tr>
<td>Substance C</td>
<td>8.0 g</td>
</tr>
</tbody>
</table>

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

- ♦
- ♣
- ♠

### Expected Temperature Change:

_______________________ °C

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

<table>
<thead>
<tr>
<th>Substance A</th>
<th>7.5 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substance B</td>
<td>5.0 g</td>
</tr>
<tr>
<td>Substance C</td>
<td>8.0 g</td>
</tr>
</tbody>
</table>

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

- ♦
- ♣
- ♠

### Expected Temperature Change:

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

**Team 3 Graph**

Effects of Substance C Mass and Substance A Mass on the Change in Temperature

<table>
<thead>
<tr>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scientist Symbol</strong></td>
</tr>
<tr>
<td>▲</td>
</tr>
<tr>
<td>△</td>
</tr>
<tr>
<td>△</td>
</tr>
</tbody>
</table>

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

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

- As Substance _____ increases, the temperature change ________________.

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

<table>
<thead>
<tr>
<th>Substance</th>
<th>Mass (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substance A</td>
<td>2.0 g</td>
</tr>
<tr>
<td>Substance B</td>
<td>3.0 g</td>
</tr>
<tr>
<td>Substance C</td>
<td>8.0 g</td>
</tr>
</tbody>
</table>

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

▲ △ △

Expected Temperature Change: ________________ °C

---

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

<table>
<thead>
<tr>
<th>Substance</th>
<th>Mass (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substance A</td>
<td>5.0 g</td>
</tr>
<tr>
<td>Substance B</td>
<td>7.0 g</td>
</tr>
<tr>
<td>Substance C</td>
<td>10.0 g</td>
</tr>
</tbody>
</table>

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

▲ △ △

Expected Temperature Change: ________________ °C
The lab wants to know if the trends in their data can be used to predict the temperature change for different combinations of Substances A, B, and C that have not been tested yet. The Team 1 and 3 graphs are shown again below so you can help interpret the data.

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

<table>
<thead>
<tr>
<th>Controls</th>
<th>Scientist Symbol</th>
<th>Substance B</th>
<th>Substance C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>●</td>
<td>6.0 g</td>
<td>12.0 g</td>
</tr>
<tr>
<td>Team 1</td>
<td>○</td>
<td>6.0 g</td>
<td>8.0 g</td>
</tr>
<tr>
<td></td>
<td>○</td>
<td>6.0 g</td>
<td>5.0 g</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Controls</th>
<th>Scientist Symbol</th>
<th>Substance A</th>
<th>Substance B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>▲</td>
<td>2.0 g</td>
<td>7.0 g</td>
</tr>
<tr>
<td>Team 3</td>
<td>△</td>
<td>6.0 g</td>
<td>7.0 g</td>
</tr>
<tr>
<td></td>
<td>△</td>
<td>10.0 g</td>
<td>7.0 g</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Substance A</th>
<th>4.0 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substance B</td>
<td>10.0 g</td>
</tr>
<tr>
<td>Substance C</td>
<td>6.0 g</td>
</tr>
</tbody>
</table>

Team 1 Prediction: _____________ °C
Team 3 Prediction: _____________ °C

What experiment(s) do you need to look at?
Team 1: ● ○ ○
Team 3: ▲ △ △

Expected Temperature Change: _________________ °C
Changing Variables (Independent Variable(s))

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

Changing Variable 1: __________________________________

Changing Variable 2 (optional): ________________________

**QUESTION**

Question our group will investigate:

- If we change the ___________________________________,
  what will happen to the ________________________________?

  insert each changing variable (independent variable)
  insert what you are measuring/observing (dependent variable)

SciTrek Member Approval __________________________

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

Determine the values of your changing variable(s) (ex: NaCl mass) from the materials page and write the values (ex: 2.0 g) for your four trials under each beaker.

Changing Variable(s):

1) ___________________ : _______ _______ _______ _______ _______
2) ___________________ : _______ _______ _______ _______ _______

Why did your subgroup choose these values of the changing variable? _____________
________________________________________________________________________
________________________________________________________________________

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

Team Controls:  
Container Type / Beaker
________________ / ______________
________________ / ______________
________________ / ______________

Subgroup Control:
________________ / ______________

SciTrek Member Approval __________________
PROCEDURE

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

1. __________________________________________________________________

2. __________________________________________________________________

3. __________________________________________________________________

4. __________________________________________________________________

5. __________________________________________________________________

6. __________________________________________________________________

7. __________________________________________________________________

8. __________________________________________________________________

SciTrek Member Approval ______________________
**RESULTS**

*Table*

Select your subgroup control by checking one of the boxes, and write your subgroup symbol on the line. Then fill out the chart for each of your trials. If one of the variables remains constant for all trials write the value in trial D and then draw an arrow through each box indicating that this variable is a control. Remember to record masses to the nearest tenth of a gram (Ex. 2.1 g).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Trial D</th>
<th>Trial E</th>
<th>Trial F</th>
<th>Trial G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Container Type:</td>
<td>Beaker</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Volume:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CaCl₂ Mass:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NaHCO₃ Mass:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NaCl Mass:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**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.

**Data**

<table>
<thead>
<tr>
<th>Initial Measurements:</th>
<th>Trial D</th>
<th>Trial E</th>
<th>Trial F</th>
<th>Trial G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Temperature:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Temperature:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change in Temperature:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The independent variable is the changing variable and the dependent variable is the change in temperature and other.
RESULTS

Graph

Check off the steps as you complete them.
☐ Write the title for your graph by filling in the blanks.
☐ Label the x-axis (horizontal) with your changing variable, including units (example: CaCl₂ Mass (g)).
☐ Label the y-axis (vertical) with what you measured in your experiment, including units.
☐ 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 two 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 subgroups in your team.
☐ Complete the legend for one of the other subgroups 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 (you do not need to label these points). Then draw a trend line that best fits their data.
☐ Repeat this process to graph the data for the third subgroup in your team.

Effects of ___________ and ___________ on the _________________________________
insert changing variable insert subgroup control
insert what you measured/observed

List your team controls: Container Type / Beaker

Legend

Subgroup Control:
☐ NaHCO₃ Mass
☐ CaCl₂ Mass

Subgroup Symbol | Subgroup Control Value
--- | ---
[ ] |
[△] |
[X] |
CONCLUSION

We can conclude ________________________________

_________________________________________________________

_________________________________________________________

_________________________________________________________

because__________________________________________________

_________________________________________________________

_________________________________________________________

_________________________________________________________

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.

<table>
<thead>
<tr>
<th>Changing Variable Mass:</th>
<th>3.5 g</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Subgroup Symbol</strong></td>
<td><strong>Prediction</strong></td>
</tr>
<tr>
<td>O</td>
<td>°C</td>
</tr>
<tr>
<td>△</td>
<td>°C</td>
</tr>
<tr>
<td>X</td>
<td>°C</td>
</tr>
</tbody>
</table>
What variables affect the temperature change of the reaction?

<table>
<thead>
<tr>
<th>Changing Variable:</th>
<th>□ NaHCO₃ Mass (g)</th>
<th>□ CaCl₂ Mass (g)</th>
<th>□ NaCl Mass (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature change (°C):</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Question: ______________________________________________________________
________________________________________________________________________
________________________________________________________________________
Summary: ______________________________________________________________
________________________________________________________________________
________________________________________________________________________

<table>
<thead>
<tr>
<th>Changing Variable:</th>
<th>□ NaHCO₃ Mass (g)</th>
<th>□ CaCl₂ Mass (g)</th>
<th>□ NaCl Mass (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature change (°C):</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Question: ______________________________________________________________
________________________________________________________________________
________________________________________________________________________
Summary: ______________________________________________________________
________________________________________________________________________
________________________________________________________________________
TIE TO STANDARDS

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

Does \textbf{NaCl mass} affect the temperature change? \hspace{1cm} \textbf{YES} \hspace{1cm} \textbf{NO}

\textit{If YES, describe the trend:} The greater the NaCl mass, the \underline{__________} the temperature change.

Does \textbf{NaHCO}_3 mass affect the temperature change? \hspace{1cm} \textbf{YES} \hspace{1cm} \textbf{NO}

\textit{If YES, describe the trend:} The greater the NaHCO}_3 mass, the \underline{__________} the temperature change.

Does \textbf{CaCl}_2 mass affect the temperature change? \hspace{1cm} \textbf{YES} \hspace{1cm} \textbf{NO}

\textit{If YES, describe the trend:} The greater the CaCl\textsubscript{2} mass, the \underline{__________} the temperature change.

2. When scientists conduct experiments, they often repeat each trial in the \textbf{exact same way} several times. Why?

____________________________________________________________

____________________________________________________________

____________________________________________________________

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

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

<table>
<thead>
<tr>
<th>Substance Masses:</th>
<th>Temperature Change (°C):</th>
<th>Median:</th>
<th>Range:</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0 g NaHCO\textsubscript{3}</td>
<td>11.8, 11.7, 12.0, 12.4, 11.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.0 g NaCl</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.0 g CaCl\textsubscript{2}</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. What does this tell us?

____________________________________________________________

____________________________________________________________

____________________________________________________________

____________________________________________________________

____________________________________________________________
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? ________________________________

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

YES  NO

Graph 1: 

**Graph 1: Effects of NaHCO₃ Mass and CaCl₂ Mass on the Change in Temperature**

<table>
<thead>
<tr>
<th>Experiment Symbol</th>
<th>CaCl₂ Mass</th>
<th>NaCl Mass</th>
<th>Water Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>○</td>
<td>3.0 g</td>
<td>4.0 g</td>
<td>50 mL</td>
</tr>
<tr>
<td>△</td>
<td>6.0 g</td>
<td>4.0 g</td>
<td>50 mL</td>
</tr>
<tr>
<td>✗</td>
<td>10.0 g</td>
<td>4.0 g</td>
<td>50 mL</td>
</tr>
</tbody>
</table>

**Graph 2: Effects of CaCl₂ Mass and NaHCO₃ Mass on the Change in Temperature**

<table>
<thead>
<tr>
<th>Experiment Symbol</th>
<th>NaHCO₃ Mass</th>
<th>NaCl Mass</th>
<th>Water Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>○</td>
<td>0.0 g</td>
<td>4.0 g</td>
<td>50 mL</td>
</tr>
<tr>
<td>△</td>
<td>4.0 g</td>
<td>4.0 g</td>
<td>50 mL</td>
</tr>
<tr>
<td>✗</td>
<td>8.0 g</td>
<td>4.0 g</td>
<td>50 mL</td>
</tr>
</tbody>
</table>

6. Using data from the graphs, what temperature change would you expect to measure if you mixed 4.0 g NaCl, 3.0 g NaHCO₃, 10.0 g CaCl₂, and 50 mL water?

Which experiment(s) should you look at?

Graph 1: ○ △ ✗ Prediction: _______ °C

Graph 2: ○ △ ✗ Prediction: _______ °C

**Expected Temperature Change:**
(Round to the nearest tenth)

__________ °C
7. What temperature change was measured when we mixed 4.0 g NaCl, 3.0 g NaHCO₃, 10.0 g CaCl₂, and 50 mL water?

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

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

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

11. **Temperature** is a measure of ____________________________, which is ___________________________________________.

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**
   
   ![](https://via.placeholder.com/150)

   **Kinetic Energy: High**
   
   ![](https://via.placeholder.com/150)

   Particles are moving __________.  
   Particles are moving __________.

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

<table>
<thead>
<tr>
<th>Starting Material</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>NaCl</td>
<td></td>
</tr>
<tr>
<td>NaHCO₃</td>
<td></td>
</tr>
<tr>
<td>CaCl₂</td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td></td>
</tr>
</tbody>
</table>

14. What did we end with? ___________________________________________
   ___________________________________________
   ___________________________________________
15. Did a chemical reaction happen?  
   YES  NO  
   Evidence: ____________________________________________________________  
   ____________________________________________________________________

16. Can energy be created or destroyed?  
   YES  NO  

17. When a chemical reaction gets warmer, energy has been _______________.

18. Do all substances store the same amount of energy?  
   YES  NO  
   Evidence: ____________________________________________________________  
   ____________________________________________________________________

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

<table>
<thead>
<tr>
<th>Substance</th>
<th>As mass increases, temperature change</th>
<th>If more is added, kinetic energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>NaCl</td>
<td>increases</td>
<td>increases</td>
</tr>
<tr>
<td>CaCl₂</td>
<td>decreases</td>
<td>increases</td>
</tr>
<tr>
<td>NaHCO₃</td>
<td>decreases</td>
<td>increases</td>
</tr>
</tbody>
</table>
20. Is it possible to make this reaction feel cold? YES NO

Evidence: __________________________________________________________
__________________________________________________________________

21. What would happen if we mixed 12.0 g of NaHCO₃, 3.0 g of CaCl₂, 4.0 g of NaCl, and 50 mL of water? (Graph 1 is shown again below to help you).
__________________________________________________________________

22. When a chemical reaction gets colder, energy has been _____________________.

23. Chemical reactions can ____________________ or ____________________ energy.

24. The energy transferred in a chemical reaction is affected by:
__________________________________________________________________
__________________________________________________________________
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
Directions for annotating: Circle changing variable(s), underline control(s), and box information about data collection.

2. a) Annotate the following results table.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substance A Mass:</td>
<td>4.0 g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substance B Mass:</td>
<td>6.0 g</td>
<td>9.0 g</td>
<td>12.0 g</td>
</tr>
<tr>
<td>Substance C Mass:</td>
<td>5.0 g</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Final Observations/Measurements:</th>
<th>Change in Temperature (°C):</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Other:</td>
<td>Large amount of foam</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Change in Temperature (°C):</td>
<td>9.3°C</td>
<td>8.7°C</td>
</tr>
<tr>
<td></td>
<td>Other:</td>
<td>Medium amount of foam</td>
<td></td>
</tr>
</tbody>
</table>

b) Can this group make a conclusion? **YES**  **NO**  **I DON’T KNOW**

c) Annotate the following possible conclusion.

**Possible Conclusion:** The greater the Substance B mass the less foam is made, because when the Substance B mass was 6.0 g there was a large amount of foam and when the Substance 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.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substance A Mass:</td>
<td>2.0 g</td>
<td>4.0</td>
<td>8.0</td>
</tr>
<tr>
<td>Substance B Mass:</td>
<td>3.0 g</td>
<td>6.5 g</td>
<td>8.0 g</td>
</tr>
<tr>
<td>Substance C Mass:</td>
<td>5.0 g</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Final Observations/Measurements:</th>
<th>Change in Temperature (°C):</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Other:</td>
<td>Small amount of foam</td>
<td>Medium amount of foam</td>
</tr>
<tr>
<td></td>
<td>Change in Temperature (°C):</td>
<td>10.5°C</td>
<td>13.3°C</td>
</tr>
<tr>
<td></td>
<td>Other:</td>
<td>Small amount of foam</td>
<td>Medium amount of foam</td>
</tr>
</tbody>
</table>

b) Can this group make a conclusion? **YES**  **NO**  **I DON’T KNOW**

c) Annotate the following possible conclusion.

**Possible Conclusion:** The greater the Substance A mass the greater the temperature change, because when the Substance A mass was 2.0 g the temperature change was 10.5°C and when the Substance 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? ________________________________.
4. a) Annotate the following results table.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substance A Mass:</td>
<td>7.0 g</td>
<td>5.0 g</td>
<td>7.5 g</td>
</tr>
<tr>
<td>Substance B Mass:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substance C Mass:</td>
<td>2.5 g</td>
<td>5.0 g</td>
<td>2.5 g</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in Temperature (°C):</td>
<td>7.2°C</td>
<td>10.2°C</td>
<td>14.4°C</td>
</tr>
<tr>
<td>Other: Medium amount of foam</td>
<td>Medium amount of foam</td>
<td>Small amount of foam</td>
<td></td>
</tr>
</tbody>
</table>

b) Can this group make a conclusion? YES NO I DON’T KNOW

c) Annotate the following possible conclusion.

Possible Conclusion: The greater the Substance C mass the greater the temperature change, because when the Substance C mass was 2.5 g the temperature change was 14.4°C and when the Substance 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?  

Directions: Some scientists wanted to know how changing the Substance C mass would affect the temperature change of the reaction. They did 3 experiments, using a different Substance A mass each time, and plotted most of their data on a graph. Answer question 4 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.

<table>
<thead>
<tr>
<th>Substance A Mass:</th>
<th>30.0 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substance C Mass</td>
<td>Change in Temperature (°C)</td>
</tr>
<tr>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>30</td>
<td>13</td>
</tr>
<tr>
<td>40</td>
<td>22</td>
</tr>
</tbody>
</table>

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

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

Directions: Some scientists wanted to know how changing the Substance C mass would affect the temperature change of the reaction. They did 3 experiments, using a different Substance A mass each time, and plotted most of their data on a graph. Answer question 4 using the graph below.

e) What will the temperature change be when 10.0 g of A and 5.0 g of C are mixed?  
f) What will the temperature change be when 15.0 g of A and 35.0 g of C are mixed?  

33
CROSSWORD PUZZLE

Directions: Fill out the following crossword puzzle using the clues below. The list of words used for the word search can be found on the vocabulary page of your notebook (pg. 1).

Down
1. A description using your five senses.
2. A scientific practice in which data is examined critically to look for trends/patterns.
3. The energy of motion.
5. A set of steps to conduct an experiment.
9. The measure of kinetic energy.
12. A piece of laboratory equipment used to hold chemicals and conduct chemical reactions.
14. A variable that is purposely kept the same throughout an experiment.

Across
4. A statement that can be tested.
6. A claim supported by data.
7. When data changes in one general direction, there is a _________.
8. Measurements and observations are the two types of _________.
10. The button you push to “zero” a scale.
11. What you expect to happen based off of previous data.
13. A process where substances are altered into different substances.
SciTrek is an educational outreach program that is dedicated to allowing 2nd-12th grade students to experience scientific practices firsthand. SciTrek partners with local teachers to present student-centered inquiry-based modules that not only emphasize the process of science but also specific grade level NGSS performance expectations. Each module allows students to design, carry out, and present their experiments and findings.

For more information, please feel free to visit us on the web at [http://www.chem.ucsb.edu/scitrek/](http://www.chem.ucsb.edu/scitrek/) or contact us by e-mail at scitrekadmin@chem.ucsb.edu.

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