SI Chemistry - Full Discipline Demo

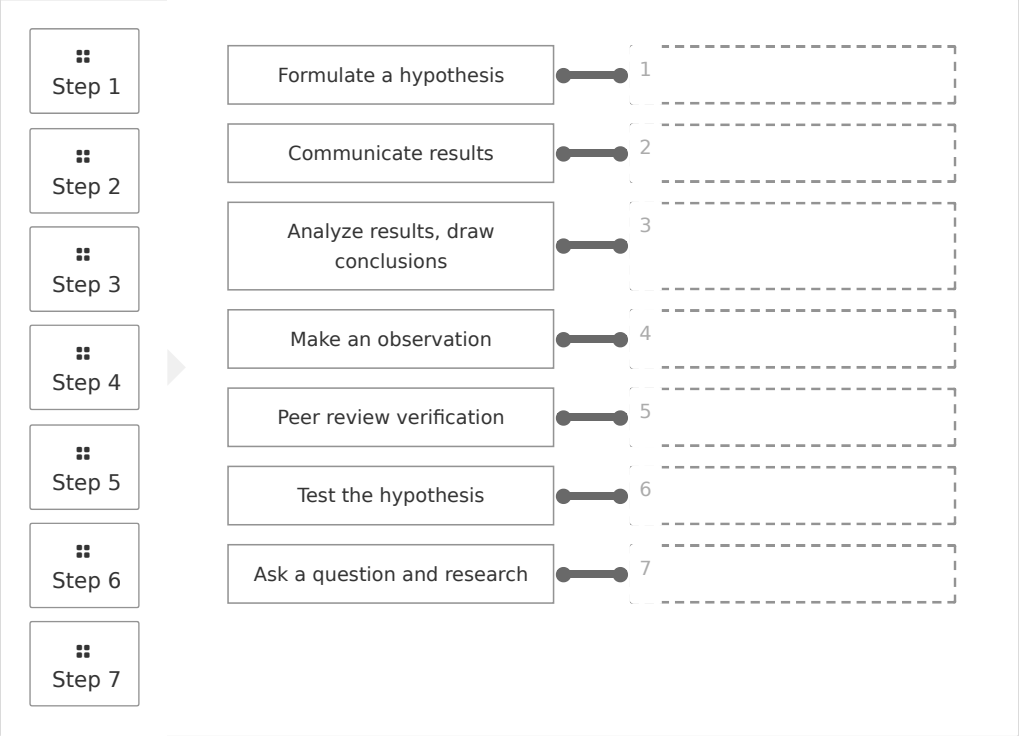
Using the Scientific Method to Identify Unknowns

Final Report - Answer Guide

Institution	Science Interactive University
Session	SI Chemistry - Full Discipline Demo
Course	SI Chemistry - Full Discipline Demo
Instructor	Sales SI Demo

Test Your Knowledge

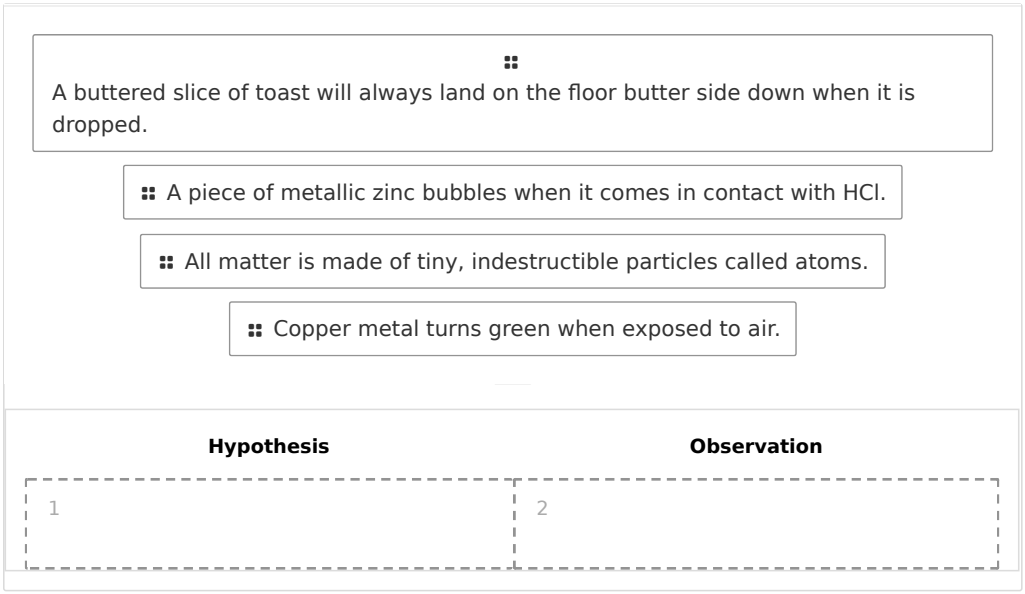
Order the steps of the scientific method.



Correct answers:

1 Step 3 2 Step 7 3 Step 5 4 Step 1 5 Step 6 6 Step 4 7 Step 2

Classify each statement as either an observation or hypothesis.



Correct answers:

1

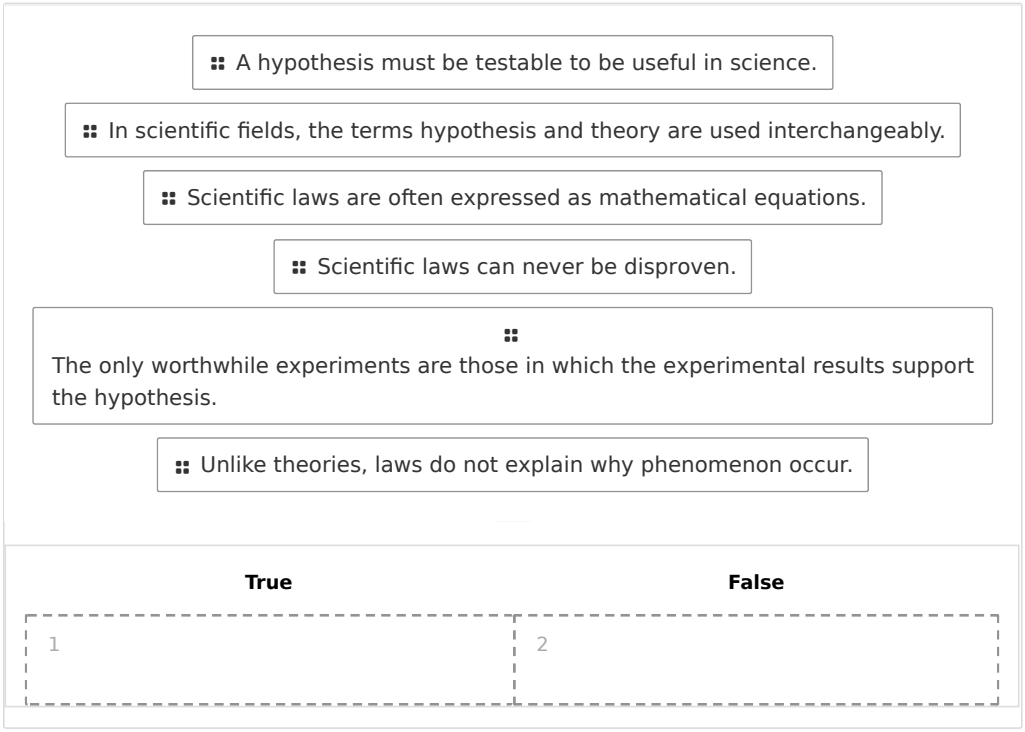
A buttered slice of toast will always land on the floor butter side down when it is dropped.

All matter is made of tiny, indestructible particles called atoms.

2 A piece of metallic zinc bubbles when it comes in contact with HCl.

Copper metal turns green when exposed to air.

Identify the statements as true or false.



Correct answers:

1 A hypothesis must be testable to be useful in science.

Scientific laws are often expressed as mathematical equations.

Unlike theories, laws do not explain why phenomenon occur.

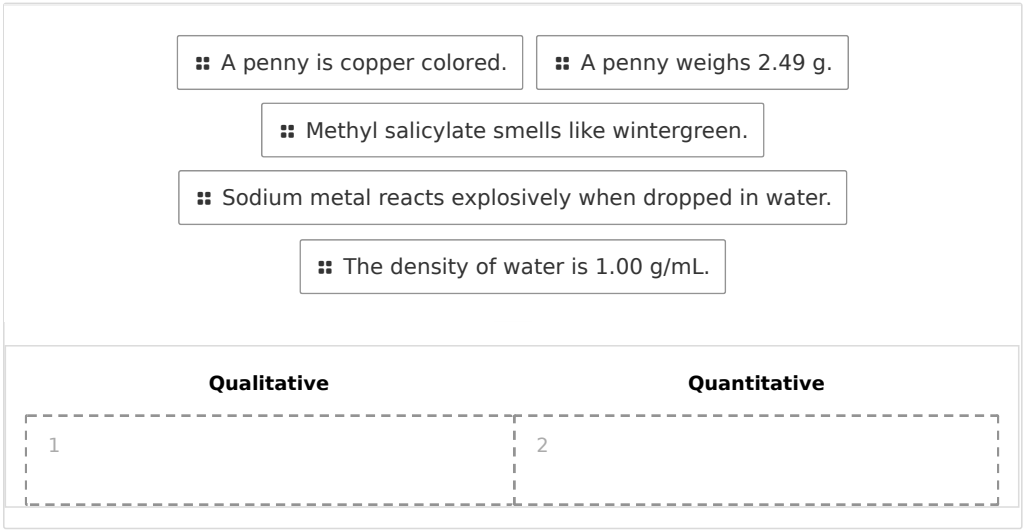
2

In scientific fields, the terms hypothesis and theory are used interchangeably.

Scientific laws can never be disproven.

The only worthwhile experiments are those in which the experimental results support the hypothesis.

Determine if each statement is qualitative or quantitative.



Correct answers:

1 A penny is copper colored. Methyl salicylate smells like wintergreen. Sodium metal reacts explosively when dropped in water.

2 A penny weighs 2.49 g. The density of water is 1.00 g/mL.

Exploration

The scientific method is a rigid process.

- True
- False ✔

Hypotheses are often stated in "if - then" language.

- True ✔
- False

Air temperature in degrees is an example of qualitative data.

- True
- False ✔

How do scientists share their data?

- Posting findings on a website
- Writing papers for peer-reviewed journals
- Presenting at meetings
- During volunteer and outreach opportunities
- All of the above ✔

Laws, but not theories, are supported by empirical data

- True
- False ✔

Exercise 1

List the steps of the scientific method.

1- Make an observation
2- Ask a question and conduct background research on what is already known
3- Formulate a hypothesis
4- Test the hypothesis through experimentation
5- Analyze the data and draw conclusions
6- Verify the conclusions through peer review
7- Communicate the result

When you make important decisions in your life, do you use any of the steps in scientific method? Compare a person's typical decision-making process to the scientific method. Which of the steps in scientific method do we typically use and which do we omit?

Student answers will vary.

Make a scientific observation about the world around you and construct a question to address the observation. State a testable hypothesis that focuses your question.

Student answers will vary.
Example answer:
Observation: Water that has table salt seems to boil faster than water that does not have salt.
Question: Does the amount of salt present affect how long water takes to boil?
Hypothesis: The amount of time required to boil water depends upon the presence and quantity of salt in the water.

Data Table 1: Scientific Method Data
(SAMPLE ANSWER BELOW)

Soy Bean Study	1) Ask a question	How does irrigation affect crop yield of soybean plants?
	2) Research what is already known	The amount of water in inches that soybean plants need varies during plant growth: seeding- 0.1 in; growth-0.2 in; flowering- 0.3 in; mature- 0.2 in. An average reported amount is 0.25 inches.
	3) Create a hypothesis	If plants receive at least 0.3 inches of water, they will have the greatest crop yield. (Student answers may vary within reason.)
	4) Test the hypothesis	Students should create a study design by which they would apply varying amounts of water to the plants. (The amount of water may range from 0 to 0.5 inches.) They may also include observation of quality of the produce.
Weight Loss Study	1) Ask a question	Is the weight-loss drug most effective in overweight women?
	2) Research what is	BMI categories: Very Severely Underweight, Severely Underweight, Underweight, Normal, Overweight, Obese Class I, Obese Class II, Obese Class III

	already known	
	3) Create a hypothesis	If the weight-loss drug is most effective in overweight women, they will safely lose the most weight of any BMI category. (Student answers may vary within reason.)
	4) Test the hypothesis	Students should create a study design by which they would test the weight loss drug on women in the BMI categories Normal, Overweight, Obese Class I, Obese Class II, and Obese Class III. Students should not test the drug's efficacy on women with BMIs less than the Normal category since this may be hazardous.

Exercise 2

A hypothesis for Exercise 2 might state, "If the five substances are distinct, then they will have unique characteristics that distinguish them from one another." Was this hypothesis supported or disproved? Support with your answer with a 1-2 sentence explanation.

This hypothesis was supported. No two substances are exactly alike because no two exhibited the exact same characteristics.

Define quantitative data and qualitative data. Which variables in the experiment were quantitative and which were qualitative?

Quantitative data are numerical, and qualitative data are non-numerical and often observation-based. Mass was the only quantitative measurement and all other tests (appearance, scent, behavior in water, and behavior in vinegar) were qualitative.

List each substance and its distinguishing characteristics. (You do not have to list every characteristic of each substance, just the characteristics that set each substance apart from the others.)

Baby powder- perfumed scent, does not dissolve in water or vinegar.
Baking soda- has no scent, forms bubbles in water and many bubbles in vinegar.

Corn starch- has no scent, does not dissolve.
Powdered sugar- has no scent, dissolves in water and vinegar.
Zinc oxide- granular appearance, smells like paint, insoluble in water and vinegar.

In Exercise 3, you will identify three unknown substances. Using the characteristics from the previous question, create a set of hypotheses that may be applied to each unknown. (Hint: Phrase the hypothesis as an "if-then" statement. For example, "If the unknown substance is an insoluble white powder that has no scent, then the substance is X.")

If the substance has a perfumed scent and does not dissolve in water or vinegar, then the substance is baby powder.

If the substance has no scent, forms bubbles in water, and forms many bubbles in vinegar, then the substance is baking soda.

If the substance has no scent and does not fully dissolve in water or vinegar, then the substance is corn starch.

If the substance has no scent and does dissolve in water and vinegar, then the substance is powered sugar.

If the substance has a granular appearance, smells like paint/ chemicals, and is insoluble in water and vinegar, then the substance is zinc oxide.

Data Table 2: Appearance
(SAMPLE ANSWER BELOW)

Baby Powder	Baking Soda	Corn Starch	Powdered Sugar	Zinc Oxide
Talc-looking, soft, nearly white with some small dark dots	Very fine white powder, slightly crystalline	Very fine white powder	Very fine white powder (very similar to corn starch)	Almost granular in appearance

Data Table 3: Scent
(SAMPLE ANSWER BELOW)

Baby Powder	Baking Soda	Corn Starch	Powdered Sugar	Zinc Oxide
Perfumed scent	No scent	No scent	No scent	Smells somewhat like paint; chemical scent to odorless

Data Table 4: Mass (g)
(SAMPLE ANSWER BELOW)

Baby Powder	Baking Soda	Corn Starch	Powdered Sugar	Zinc Oxide
0.8	1.2	0.7	0.6	1.1

Data Table 5: Behavior in Water
(SAMPLE ANSWER BELOW)

Baby Powder	Baking Soda	Corn Starch	Powdered Sugar	Zinc Oxide
None dissolves; some rests in the bottom of the test tube and some is suspended in solution; solution is slightly opaque	Mostly dissolved, small bubbles form; solution is clear	Less appears in the bottom of the test tube, some particles are suspended in solution	Mostly dissolves, water is slightly hazy	Insoluble; solid immediately moves to the bottom of the test tube

Data Table 6: Behavior in Vinegar
(SAMPLE ANSWER BELOW)

Baby Powder	Baking Soda	Corn Starch	Powdered Sugar	Zinc Oxide
Floats on top of solution	Instant reaction, lots of fizzing (CO_2)	Murky solution, powder is suspended	Dissolves	Sinks to the bottom of the well

Exercise 3

What were the three unknown substances? What characteristics do the three substances have in common? What characteristics set the three substances apart?

The three unknown substances were: powdered sugar, baking soda, and corn starch. All three substances are fine white powders that have no obvious scent. The masses of powdered sugar and corn starch are similar. The three substances have different behaviors in water and vinegar.

Was it necessary to apply every test to each of the unknowns? Why or why not?

It was not necessary to apply every test to the unknowns. The substances could be narrowed down by observing their testing their behavior in water and vinegar.

List an additional test that might have been useful in Exercises 2 and 3.

Student answers will vary; examples include melting point, solubility in various chemicals, reactions with other chemicals, and pH.

Summarize how you used the steps in the scientific method to identify the unknowns.

Student answers will vary but should indicate which steps of the scientific method were utilized.

Panel 1: Experimental Methods
(SAMPLE ANSWER BELOW)

Methods may vary among students. Each of the tests outlined in Exercise 2 may be applied to each unknown, or a subset of tests may be applied. At a minimum, students should perform three different tests for confirmation.

Data Table 7: Experimental Data and Conclusions
(SAMPLE ANSWER BELOW)

Unknown #	Appearance	Scent	Mass (g)	Behavior in water	Behavior in vinegar	Conclusion
1	Fine white powder	no scent	0.6	mostly dissolves in water	mostly dissolves in vinegar	The substance is powdered sugar
2	Fine white powder	no scent	1.2	Mostly dissolved, small bubbles form; solution is clear	Bubbles form in vinegar	The substance is baking soda
3	Fine white powder	no scent	0.7	Does not dissolve in water	Does not dissolve in vinegar	The substance is corn starch

Competency Review

The first few steps of the scientific method include making an observation, asking a question, and conducting research.

- True ✔
- False

A hypothesis is a(n) _____.

- educated prediction of expected results ✔
- non-numerical solution to a question
- close examination of collected data

Once a hypothesis is not supported, it may not be tested again.

- True
- False ✔

Qualitative data are _____.

- numerical
- non-numerical ✔

If a hypothesis is not supported, it is likely not useful for scientific progress.

- True
- False ✔

Laws are supported by empirical evidence and explain why phenomenon occur.

- True
- False ✔

Once a theory becomes a law, it can not be disproven.

- True
- False ✔

Consider the statement, "High temperatures are caused by the tilt of the Earth and the angle of the sun hitting the Earth." Is this a hypothesis or an observation?

- Hypothesis ✔
- Observation

An example of quantitative data is _____.

- scent
- mass ✔
- behavior in water
- appearance

A researcher would like to address the following question: "Should employees be able to work out during company time?" Give an example of a well thought out hypothesis that aligns with this question.

- Working out makes employees healthier, which means they may work for the company longer.
- If exercise is correlated to weight loss, then employees will lose weight.
- If employees are allowed to work out for 30 minutes each day, then productivity increases. ✔
- Employees won't work out if they must do so out of office hours.

A chemist would like to identify an unknown liquid chemical. What type of data are useful?

- Qualitative data are the most useful.
- Quantitative data are the most useful.
- Both qualitative and quantitative data are useful. ✔

If a white powder is placed in a test tube full of water, and the powder sinks to the bottom of the test tube, what conclusion may be drawn?

- ○ The white powder is baby powder.
- ○ The white powder is zinc oxide.
- ○ The white powder is corn starch.
- ○ The white powder does not dissolve in water, and more information is needed. ✔

Extension Questions

There is a common thought that hot water freezes faster than cold water. Develop a strategy to investigate this theory.
Construct a well thought out question and a testable hypothesis. Write a justification for your hypothesis; for instance, if you hypothesize that cold water freezes faster than hot water, include an explanation as to why you believe this to be true. Come up with an experimental design to test your hypothesis. Include an explanation of how the data you collect will be able to support or disprove the hypothesis.

(SAMPLE ANSWER BELOW)

The question: Does hot water freeze faster than cold water?
The initial hypothesis: The student could propose that hot water freezes faster, that cold water freezes faster, or that there is no difference.
Student answers may vary depending on their hypothesis.
Experimental design: The student should include something about timing freezing time for different temperatures of water. Additional variable may include type of water (distilled vs. tap); how the water was heated; the container used to contain the water; other variables are certainly possible. The student should mention that they would analyze the temperature vs. freezing time results and come to a conclusion as to what the optimal temperature is for fastest freezing. Future experiments could include examining some of the variable given for part c or others that the student can come up with.