Name:

25.1 Matter and Atoms

Question: What are the properties of different elements?

1 Atoms and elements

There are no questions to answer in Part 1.

2 Research your element

Each group will select or be assigned a different element. Research your element to determine the information below. Record the bibliographic data for all of the sources you use in your research.

- Symbol
- Atomic number
- Average atomic mass
- Melting point
- Boiling point
- Density
- Color
- Origin of the element's name
- One compound that contains the element and state its molecular formula
- One mixture that contains the element
- One use for the element
- Three interesting facts about the element

3 Sharing your information

Make a one-page poster that neatly displays the information you found for your element. Include a bibliography on the back of the poster.

4 Characterizing the element and comparing it with other elements

Answer the following questions regarding the element you researched:

a. Name three other elements with similar chemical properties. Where on the periodic table are elements with similar properties located in relation to each other?

b. How many atoms are in 1 kilogram of your element?

c. At 500°C, is your element a solid, liquid, or gas?

d. At 1,500°C, is your element a solid, liquid, or gas?

e. Does your element play a role in living organisms such as being in your body's chemistry or being recommended in food for nutrition or health reasons?

Name:

25.2 Temperature and the Phases of Matter

Question: What is temperature?

1 Setting up the experiment

Table 1: Temperature and volume data

Volume (ml)	
Hot temp. (°C)	
Cold temp. (°C)	

2 Observing the change of phase

There are no questions to answer in Part 2.

3 Thinking about what you observed

a. Why was it important to keep the cap loose during step 1 above?

b. Explain why the bottle changed its volume when it was immersed in the ice water.

c. Explain why the bottle regained its original volume when it was reheated.

d. Research the ratio of the volume of 100 grams of water at 100°C compared with 100 grams of steam at 100°C. Note that the temperature is the same but that water is a liquid phase and steam is a gas phase.

4 The solid phase of water

a. Is the density of solid water (ice) about the same as, greater than, or less than the density of liquid water? Use the observations from this experiment to justify your answer.

b. Most solid materials have a density that is greater than the same material in its liquid phase. Suppose the density of ice were greater than the density of water. What would happen to a body of water such as a lake in the winter when the temperature is well below freezing for a long period of time?

Name:

25.3 Heat and Thermal Energy

Question: What is the relationship between heat, temperature, and energy?

1 Thermal energy, Part 1: Steel and water

Table 1: Temperature and mass data

	Hot substance		Cold water		Mixture
	Mass (kg)	Temp (°C)	Mass (kg)	Temp (°C)	Temp (°C)
Steel			0.1		
Oil			0.1		
Water			0.1		

2 Thermal energy, Part 2: Oil and water

Record the data in the table.

3 Thermal energy, Part 3: Water and water

Record the data in the table.

4 Specific heat and energy

a. Do equal masses of steel, oil, and water at the same temperature contain the same amount of thermal energy? Explain the physical reasoning behind your answer.

b. Examine the data in Table 1. Were the final temperatures about the same, or was each final temperature different for each of the three cases—steel/water, oil/water, water/water?

c. Explain how the concept of specific heat explains the observed final temperatures.

d. (Challenging) Use the heat equation to derive a prediction for the final mixture temperature based on the mass, specific heats, and starting temperatures of the materials in the mixture. HINT: Let T_f be the final temperature and set the energy lost by the hot material equal to the energy gained by the cold material. Compare the prediction with the actual final temperatures.

Name:

26.1 Heat Conduction

Question: How does heat pass through different materials?

1 Heat flowing from a cup

There are no questions to answer in Part 1.

2 Heat flowing into a cup

Table 1: Temperature and mass data

Heat flowing cup to pan	Cold temp (T_c, °C)	Mass (kg)	50°C to 40°C (time in sec)	30°C to 20°C (time in sec)
Plastic cup				
Foam cup				
Foam cup, nails				

Heat flowing pan to cup	Hot temp (T_h, °C)	Mass (kg)	20°C to 30°C (time in sec)	40°C to 50°C (time in sec)
Plastic cup				
Foam cup				
Foam cup, nails				

3 Analyzing the data

a. Use the concept of thermal conductivity to explain the differences between the measurements for the plastic cup, the foam cup, and the foam cup with the nails pushed through the bottom.

b. Based on your observations, is the copper in the nails a thermal insulator or a thermal conductor?

c. Compare the time it took the water in the cup to cool down from 50°C to 40°C with the time it took to cool down from 30°C to 20°C. Explain the difference using what you know about how heat flows.

d. Compare the time it took the water in the cup to heat up from 20°C to 30°C with the time it took to heat up from 40°C to 50°C. Explain the difference using what you know about how heat flows.

e. The specific heat of water is 4,184 J/kg°C. Use the heat equation to calculate how much energy was used to change the temperature of the water from 20°C to 30°C.

f. Compare the amount of energy used to heat the water from 20°C to 30°C with the amount of energy used to heat the water from 40°C to 50°C. Is the energy the same? Do the same comparison for the energy removed to cool the water from 50°C to 40°C, and from 30°C to 20°C.

Name:

26.2 Convection

Question: Can moving matter carry thermal energy?

1 Observing free convection in water

There are no questions to answer in Part 1.

2 Reflecting on what you observed

a. Describe the motion of the cold water melting off the colored ice cube when it was partially immersed in hot water. Did the melting colored water move upward, downward, or to the side? Explain what you observed using the concepts of density and buoyancy of hot and cold liquids.

b. Compare the motion of the water melting off the colored ice cube when it was partially immersed in cold water. Did the melting colored water move upward, downward, or to the side? Was the motion faster or slower than it was in the hot water? Explain what you observed using the concepts of density and buoyancy of hot and cold liquids.

3 Forced convection

There are no questions to answer in Part 3.

4 Observing forced convection

a. Which situation mixed the colored water more rapidly into the clear water: free convection or forced convection?

b. In which situation would you expect more rapid flow of heat: free convection or forced convection?

Name:

26.3 Radiant Heat

Question: How does heat get from the sun to Earth?

1 Creating a focusing mirror for collecting solar radiation

There are no questions to answer in Part 1.

2 Observing radiant energy in action

Safety Tip: Never look directly at any bright light source, especially the sun!

Table 2: Temperature data

	Temp (°C)
In sunlight, outside of mirror	
After 30 seconds at focus	
After 30 seconds at focus, covered with aluminum	

3 Reflecting on what you observed

a. Explain why the thermometer at the focus of the mirror measured a much higher temperature than the same thermometer in sunlight outside the mirror. Your explanation should make use of the concepts of radiant heat and intensity.

b. Explain why the thermometer wrapped in aluminum foil measured a lower temperature rise than when the thermometer was not wrapped. Your answer should use the concepts of absorbed and reflected radiant energy.

4 The blackbody spectrum

There are no questions to answer in Part 4.

5 Observing the blackbody spectrum

a. Describe the relative amount of red, green, and blue light in the spectrum when the bulb is at its brightest setting.

b. Describe how the relative amounts of red, green, and blue light change as the bulb is turned to lower and lower brightness. The brightness diminishes but try to separate out the color changes from the change in overall brightness.

c. Explain your observations using the blackbody spectrum.

Name:

27.1 Properties of Solids

Question: How do you measure the strength of a solid material?

1 Force, strength, and stress

There are no questions to answer in Part 1.

2 Measuring the tensile strength

Table 1: Breaking force data

Diameter (cm)	Breaking force (N)	Cross sec. area (cm^2)	Stress (N/cm^2)

a. Calculate the cross-section area and stress for each of the clay cylinder samples.

b. Compare the force required to break each sample with the stress in each sample. Which is a better measure of the strength of the clay as a material: the breaking force or the stress?

c. Plot a graph showing the breaking force versus the cross-section area. What mathematical property of the graph is the tensile strength? Which is the maximum stress the clay can take before breaking?

Title: ______________________________

y label: ______________

x label: ______________________________

d. Use your data to estimate the force required to break a cylinder of clay that is 3 centimeters in diameter.

e. Suppose you could keep a constant force applied as the clay stretches. What happens to the stress in the clay once it starts stretching?

Name:

27.2 Properties of Liquids and Fluids

Question: What are some implications of Bernoulli's equation?

1 Bernoulli's equation

There are no questions to answer in Part 1.

2 Demonstrating Bernoulli's equation

a. Does the paper curl up into the moving air or down away from the moving air?

b. Use the relationship between speed and pressure to explain the direction in which the paper moves.

3 Using Bernoulli's equation to measure the speed of moving air

There are no questions to answer in Part 3.

4 Building an air-speed tester

There are no questions to answer in Part 4.

5 Calculating the air speed

Record your air speed in the large and small pipes below.

Extra space for notes and performing calculations:

Name:

27.3 Properties of Gases

Question: How much matter is in a gas?

1 Observing the mass of a gas

Safety Note: Be careful with the bottle, and DO NOT exceed 80 pounds per square inch (psi) of pressure.

Table 1: Pressure and mass data

Gauge pressure (psi)	Mass (g)	Volume (ml)

2 Analyzing the data

a. Calculate the first column of Table 2 (absolute pressure) by adding 14.7 psi to the gauge pressures from Table 1.

b. Calculate the second column of Table 2 by converting the absolute pressures in psi to Pa.

c. To calculate the mass of air, you need the mass of the bottle so that you can subtract it from the total mass you measured in Table 1. However, when the gauge reads zero pressure, there is still 14.7 psi of air in the bottle. Fortunately, *the balance measures only the mass of the bottle itself* and is not sensitive to the mass of air in the bottle as long as the pressure inside and outside the bottle is the same. Explain why this is true.

d. Calculate the third column of Table 2 by subtracting the mass of the bottle from the total mass.

e. Estimate the mass of air in the bottle at an absolute pressure of 14.7 psi (when the gauge measured zero pressure). Use the measurements you have to make the estimate.

f. Calculate the fourth column of Table 2 by adding the result from (e) above to the masses in column 3. The result is the total mass of air in the bottle as a function of the absolute (total) pressure in the bottle.

g. Make a graph showing the pressure of air versus the mass of air in the bottle. Describe a mathematical rule that the graph shows. For example, is the graph a straight line, demonstrating that the pressure is a linear function of the mass?

Table 2: Calculated pressure and mass data

1	2	3	4
Absolute pressure (psi)	**Absolute pressure (Pa)**	**Mass increase (g)**	**Total mass (g)**

Title: ____________________

y label: ____________________

x label: ____________________

3 The effect of temperature on pressure

a. What happens to the pressure in the bottle when the temperature is reduced?1

b. Does reducing the temperature change the total mass of air in the bottle?

c. Give a physical reason the pressure should depend on the temperature.

Extra space for notes and performing calculations: