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Per 5 Activity Sheet: Thermal Energy, the Microscopic Picture

5.1 How Is Temperature Related to Molecular Motion?

1) Temperature Your instructor will discuss molecular motion and temperature.

a) Watch the demonstration of diffusion in beakers of warm and cold water. Explain the differences in the diffusion rates.

b) At a particular temperature, do all of the molecules move at the same speed?

c) How does the average speed of molecules at a higher temperature differ from their average speed at a lower temperature?

2) Rates of Evaporation

a) Note the temperature of each thermometer while it is immersed in liquid. Remove the thermometers from the test tubes and allow the thermometers to lie on your table for several minutes. Then check and record their temperatures.

	Initial Temp	**Final Temp**	**Temp Change**
Alcohol	_________	_________	__________
Oil	_________	_________	__________
Water	_________	_________	__________

b) Explain the differences in temperature change.

3) Evaporative Cooling

What happens to the temperature of a liquid as it evaporates? Your instructor will demonstrate a cool tube (a cryophorus tube) that contains water.

a) What happens when one end of the tube is cooled with liquid nitrogen?

b) The middle of the tube remains near room temperature. Explain why water in the tube's bulb freezes.

c) Group Discussion Question: Can you think of examples of evaporative cooling in everyday life?

5.2 Temperature and Phase Changes

4) Volume, Temperature, and Phase Change

Fill a beaker with ice water. Note the volume of ice and water, including any ice above the surface of the water.

a) What happens to the total volume once the ice has changed phase from solid to liquid?

b) Do all substances behave this way when their temperature is increased?

5) Phase Changes

a) Your instructor will demonstrate weights supported by an ice cube. What happens? What causes the change of phase of the ice from solid to liquid water?

b) Would this demonstration work as well with a wide wire? Why or why not? (Hint: pressure = force/area of the wire)

c) Group Discussion Question: When the temperature is well below freezing, ice skaters find it more difficult to skate. Why is this?

6) Heat Capacity

Your instructor will discuss the heat capacity of objects.

What is the heat capacity of one kilogram of copper, if 6,500 joules of heat are required to increase the temperature of the copper by 15 ^{o}C?

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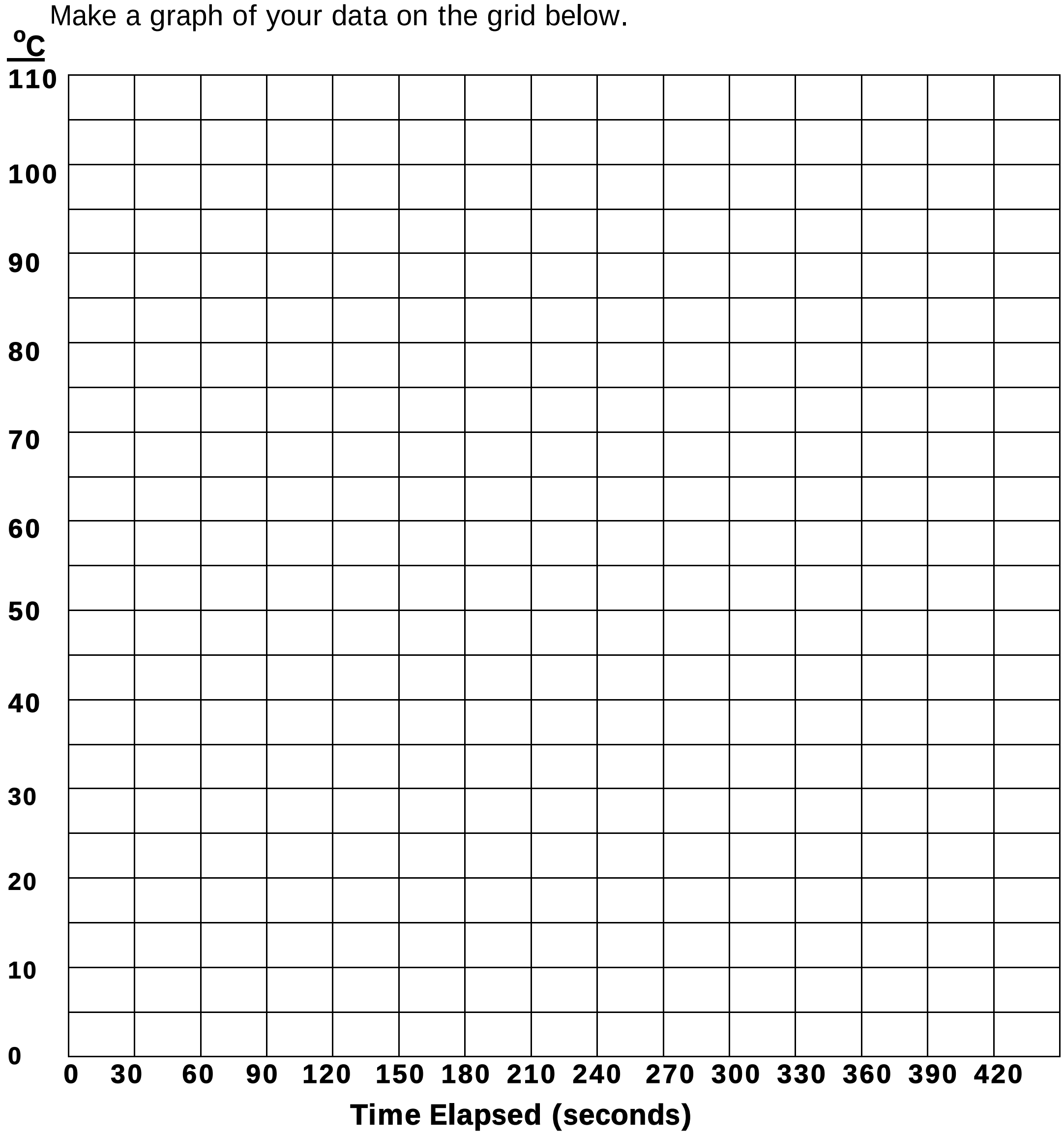
7) **Specific Heat** Your instructor will discuss specific heat ($\boldsymbol{s}_{heat}$).

a) Pour 500 ml of water into the hot pot and measure the temperature of the water before you plug in the pot. Record your measurement on the first line (0 seconds elapsed) of the table below.

b) Now, plug in the hot pot and measure the temperature of the water every 30 seconds. Record your data in the table.

Time Elapsed (seconds)	Temperature (°C)	Time Elapsed (seconds)	Temperature (°C)	Time Elapsed (seconds)	Temperature (°C)
0		150		300	
30		180		330	
60		210		360	
90		240		390	
120		270		420	

c) Make a graph of your data on the grid below.



d) Next, we will calculate the specific heat of the water using the equation
$Q = s_{heat} \times M \times DT$

Q = heat added in joules. The hot pots are rated at 600 watts (600 J/sec).

For how many seconds did you heat the water? ________.

How many joules of heat were added? _____________

M = mass in grams. One ml of water has a mass of 1 gram.

$DT = T_{final} - T_{initial}$ (Celsius degrees)

e) Group Discussion Question: Your instructor will give you a value for the specific heat of water. How well does your calculated value agree with the specific heat of water? What sources of error may be present in your experiment?

8) Latent Heat

a) To find how many calories of heat are required to convert 700 grams of water at a temperature of 40 ^{o}C into steam at 100 ^{o}C follow the three steps below.

Step 1: Find the heat required to raise the temperature of the water to water to 100 ^{o}C. The specific heat of liquid water is 1.00 calories/gram ^{o}C. Hint: use the equation $Q = s_{heat} \times M \times DT$

Step 2: Find the heat required for the phase change of 700 grams of water at 100 ^{o}C into steam at 100 ^{o}C. The latent heat of evaporation of water is 540 calories/gram. Hint: use the equation $Q = L_{heat} \times M$

Step 3: Find the total heat required to heat the water to 100 ^{o}C and the heat required to convert the liquid water into steam.

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5.3 Pressure, Temperature, Volume and the Ideal Gas Law

9) The Ideal Gas Law Your instructor will demonstrate the relationship among pressure, temperature, volume, and number of molecules of a gas and discuss the Ideal Gas Law. We will find that ratio reasoning is useful and can be based on proportionalities.

a) At a fixed volume of gas, what effect does doubling the temperature of the gas have on the pressure the gas molecules exert on the walls of their container?

b) Based on the fact that the pressure is proportional to the temperature, for a gas at fixed volume write an equation relating the pressure and temperature of the gas at one time to the pressure and temperature at a later time.

c) At a fixed temperature, what effect does decreasing the volume of the container by one half have on the gas pressure?

d) Based on the fact that the pressure is inversely proportional to the volume, for a gas at fixed temperature write an equation relating the pressure and volume of the gas at one time to the pressure and volume at a later time.

e) Combine your equations from parts b) and d) to write an equation showing the relationship between pressure, volume, and temperature for a gas at two different times.

f) At a fixed temperature and volume, what effect does tripling the number of gas molecules have on the pressure the gas exerts?

g) Your instructor will demonstrate a soda can with boiling water that is cooled quickly. What happens to the can? Why?

10) The Dippy Duck

The dippy duck contains liquid freon, which evaporates easily at room temperature. Wet the head of the duck and place the cup of water in front of the duck's head. Explain what happens to the dippy duck in terms of evaporative cooling, the ideal gas law, and the center of mass of the duck.