Laboratory Investigation Name ______________________

Chemistry: Form L6.3A Date ______________ Period ______

Finding Absolute Zero

based on an investigation by *Kathleen Davies*

PROBLEM

How do you determine absolute zero in Celsius degrees?

INTRODUCTION

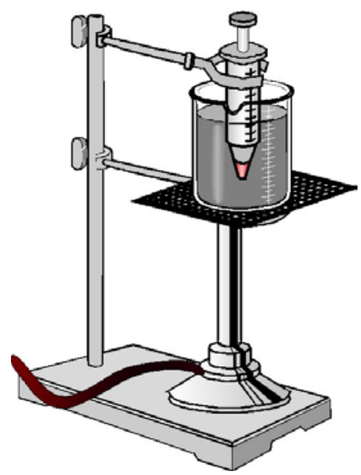
As the temperature of a substance increases, the particles that compose it move faster and collide harder. Harder, faster collisions cause particles to rebound harder moving them further apart. As a result, substances tend to expand as they are heated. The particles of gases are far apart to begin with, so the forces of attraction between them are weak, and gases are mostly space. Doubling the temperature of a gas causes the particles to spread out to twice the distance, doubling the volume of the gas. But what does it mean to double the temperature? Consider the following temperatures: 10°C = 50°F and 20°C = 68°F. The higher Celsius temperature appears to be twice that of the lower Celsius temperature, but this is not the case with the Fahrenheit equivalents. It is not possible to make ratios with these temperatures because 0° on either scale does not mean zero–*NO HEAT!* The real zero, absolute zero, is the point when the particles stop moving and the distance between them is zero. You will use temperature and volume measurements of a gas to locate this temperature.

MATERIALS *(per group)*

Beakers (2); Bunsen burner; ice; ring stand and iron ring; safety goggles; syringe; thermometer; wire gauze

PROCEDURE

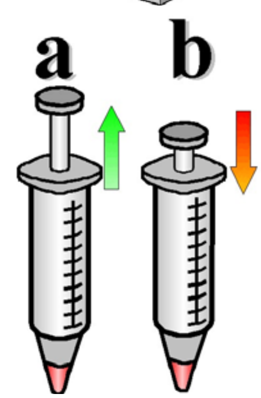
1. Remove the red plastic cap from a syringe. Draw 30-35 mL of air into the syringe. Replace the red cap. Test the syringe for leaks.



2. Set up a room temperature water bath. Fill a beaker partway with tap water. Set it on a wire gauze on a ring and ringstand. Immerse the syringe into the water bath and clamp it in place so the air remains submerged. Allow it to stand for at least four minutes.

3. Due to the friction between the piston of the syringe and the cylinder walls, it is necessary to measure the volume of the air at each temperature two different ways. See the diagram to the lower right. [a] Quickly pull the piston outward and release it. Then read the volume and record the results. [b] Quickly push the piston down and release it. Then read the volume and record the results. The second value will be smaller than the first due to friction.

4. Determine the average volume for the two readings and record the result.



5. Measure the temperature of the water at which the volume measurements were made and record the result.

6. Add several cubes of ice to the room temperature water bath to make a cold water bath. Allow the syringe to stand in the cold water bath for at least four minutes Repeat steps 3-5 of the procedure at the new, colder temperature.

7. Put on safety goggles. Light the Bunsen burner and heat the water bath to about 40°C. Allow the syringe to stand in the 40°C water bath for at least four minutes Repeat steps 3-5 of the procedure at the 40°C temperature.

8. Continue heating the water bath to about 60°C. Allow the syringe to stand in the 60°C water bath for at least four minutes Repeat steps 3-5 of the procedure at the 60°C temperature.

9. Continue heating the water bath to about 80°C for the final measurements. Allow the syringe to stand in the 80°C water bath for at least four minutes Repeat steps 3-5 of the procedure at the 80°C temperature

10. On a separate sheet of graph paper, prepare a graph of Celsius temperature versus average volume. Use the x- axis for temperature and the y-axis for average volume. Plot the observed data in just the right one-fifth of the page so you will have room to extend your line and your x-axis. Using a ruler, draw the best straight line through the points. Extend your x-axis and the graphed line (dot the extension) until they meet. This is the x-intercept. It is your value for absolute zero, the temperature at which a gas will theoretically occupy zero volume.

11. Label the x-axis with Kelvin temperatures by assigning the point where the line you plotted crosses the x-axis a value of 0 K. Determine the other values for the labels on the x-axis by adding the absolute value of the x intercept to the Celsius temperatures already listed.

$$K = {}^\circ C + |x_{intercept}|$$

OBSERVATIONS

Waterbath Description	Actual Temperature	Volume		
		Trial 1	Trial 2	Average
Room Temperature				
Cold Water				
About 40°C				
About 60°C				
About 80°C				

CONCLUSIONS

1. Based on your graph, what is the value for absolute zero (0 K) in degrees Celsius? ____

2. The accepted value for absolute zero is about –273°C. What is your percentage error? Show your work:

3. Based on your graph, what is the volume of the air at:

   a. 100 K? ________ b. 200 K? ________ c. 300 K? ________

4. Based on your graph, what is the relationship between the Kelvin temperature and the volume of a gas? ________