Lab 14.1b
Charles’ Law

I. PURPOSE
To study the relationship between the temperature of a gas and its volume at constant pressure.

II. MATERIALS
1. 600 mL beaker
2. 250 mL Erlenmeyer flask
3. 100 mL grad. cylinder
4. stopper with tube
5. tube-cap
6. thermometer
7. ring stand
8. iron ring
9. wire gauze
10. utility camp
11. Bunsen burner

III. PROCEDURES
1. Set up the ring stand, ring, gauze and Bunsen burner as shown by the instructor.
2. Add about 250 mL of hot water to the 600 mL beaker and place it on the wire gauze.
3. Place flask with stopper assembly into the beaker of water and secure it with the utility clamp. Adjust water level until the water is about 3–4 cm below the top of the beaker.
4. Heat the water to boiling and maintain this temperature for about 3 minutes. Take the temperature of the water. Record as $T_1$. CAUTION: Never let the thermometer touch the flask or beaker and never leave the thermometer unattended.
5. Place the tube-cap on the glass tube extending from the stopper. Now, transfer the flask assembly to the bucket of cool water provided, using the utility clamp as a handle.
6. Holding the flask upside-down, fully immersed, remove the tube-cap from the glass tube.
7. Keep the flask upside-down in the bucket for 3 minutes. While submerged, remove the utility clamp from the flask.
8. Record the temperature of the cool water as $T_2$.
9. Adjust the water level inside the flask to match the water level in the bucket. Put your finger on the tube and remove the assembly from the sink. Set the flask upright on the lab table.
10. With a pen, mark the depth of the stopper in the flask on the stopper. Remove the stopper and measure the volume of water in the flask. Record under item ‘c’ in the data table.
11. Fill the flask to the top of the opening and place the stopper assembly back into the flask to your mark. Now, remove the stopper and measure the volume of water in the flask. Record as $V_1$.

IV. PRE-LAB QUESTIONS
1. Explain vapor pressure.
2. Why do the procedures call for measuring the temperature of the water, rather than the temperature of the air?
3. Why must the water levels in the flask and bucket be equal before sealing and removing the flask?
4. What is the purpose of marking the stopper with a pen in Step 10?

V. DATA & CALCULATIONS
A. DATA
Data Table 1 – Temperature, Volume and Pressure of the Gas

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>Initial temp of air ($T_1$):</td>
</tr>
<tr>
<td>b.</td>
<td>Final temp of air ($T_2$):</td>
</tr>
<tr>
<td>c.</td>
<td>Volume of water in flask after experiment:</td>
</tr>
<tr>
<td>d.</td>
<td>Total volume of flask ($V_f$):</td>
</tr>
<tr>
<td>e.</td>
<td>Final volume of gas ($V_2$): $(d. - c.)$</td>
</tr>
<tr>
<td>f.</td>
<td>Atmospheric pressure: (see board)</td>
</tr>
<tr>
<td>g.</td>
<td>Vapor pressure of water at $T_2$: (see table)</td>
</tr>
<tr>
<td>h.</td>
<td>Pressure of dry gas: $(f. - g.)$</td>
</tr>
<tr>
<td>i.</td>
<td>Volume of dry gas ($V_2$) at atmospheric pressure: $(e. \cdot h. / f.)$</td>
</tr>
</tbody>
</table>

B. CALCULATIONS
1. Complete the data table, filling in items $e.$, $f.$, $g.$, $h.$, and $i.$ Show the calculations for each item below.
2. Plot the data with volume on the vertical axis ($y$) and temperature of the horizontal axis ($x$). The origin of the graph should be labeled 0 mL and -300 °C. The y-axis should run to 100 °C. The y-axis should rise high enough to accommodate the largest recorded volume. Plot ($a.$, $d.$) as one data point, and ($b.$, $i.$) as the second data point for this graph from your data table. Draw a best-fit line to describe the data trend. Extend your line to the x-axis.
3. The line should cross the x-axis at -273°C. What is your percent error?

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VI. QUESTIONS & DISCUSSION OF ERROR

A. QUESTIONS
   1. Describe at the molecular level what happened to the gas sample as the temperature was lowered.
   2. From your graph, describe the relationship between temperature and volume?
   3. What does the x-intercept represent? Relate your answer to the kinetic theory.
   4. Why was the calculation for item i. in the data table necessary?

B. DISCUSSION OF ERROR

VII. CONCLUSION