Postlab Questions and Laboratory Procedure

Estimating Absolute Zero

Materials

- Charles Law tube (40 cm capillary closed on one end, with a mercury plug placed about 15 cm from the open end)
- Thermometer reading -10 to 80 Celsius, with 0.1 degree scale divisions
- Rubber bands
- Tygon tubing sleeves
- Split stopper and finger clamp to hold capillary/thermometer assembly
- Ring stand
- 250 mL graduated cylinder
- Temperature baths: 45°C (with thermostat), ice/water, ice/rock salt/water
- 400 mL beaker

Procedure

Be careful with your capillary tube and thermometer. The thermometer is very expensive. More importantly, it contains mercury which is a hazardous material in its vapor form. Prolonged exposure to mercury vapor can cause central nervous system damage. If you do break a thermometer, let your instructor know at once. Do not try to pick up the mercury or broken glass yourself. Your instructor has a special clean-up kit for mercury spills.

Always keep the capillary upright to avoid mercury spills. Move the capillary and thermometer assembly by raising or lowering the finger clamp on the ring stand. Never remove the assembly from the finger clamp.

1. The capillary tube is attached to a thermometer with rubber bands. Carefully move the capillary up or down if necessary so that the bottom of the closed end of the capillary is aligned with the zero degree mark on the thermometer. Also align the capillary so that you can easily read the location of the bottom of the mercury slug on the thermometer’s scale.
2. Record the room temperature from the thermometer. Record the length of the trapped air column by reading the location of the bottom of the mercury slug from the thermometer scale.

3. Fill the 250 mL graduated cylinder with tap water. Carefully lower the thermometer and capillary into the graduated cylinder so that the gas up to the mercury slug is completely submerged. Wait about two minutes for the temperature of the thermometer to stabilize and then record the temperature and slug location.

4. Refill the graduated cylinder with water from the hot water bath on the side table. (Use the 400 mL beaker to carry the water to your workstation). Again, wait about two minutes for the temperature of the thermometer to stabilize and then record the temperature and slug location.

5. Repeat the measurements using water from the ice bath and from the ice/salt bath.

6. Use a spreadsheet to plot the slug location (on the y axis) vs. the temperature (in degrees Celsius). Decide what curve best fits the data and fit a trend line. Extend the x axis of your plot to show the point where the slug location would become zero. Print the equation of the trend line on your graph.

7. Use the trend line equation to calculate the temperature at which the volume of trapped air would become zero. This is an estimate of the lowest temperature possible, since the volume of trapped air could never be less than zero.

8. Read the air pressure in the building using the Fortin barometer. Your instructor will show you how to read the barometer.

**Postlab Questions**

1. Complete the following data table. Using a spreadsheet, plot the data and fit a trend line.

<table>
<thead>
<tr>
<th></th>
<th>Temperature (degrees Celsius)</th>
<th>Air column length (as read from thermometer scale)</th>
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<tbody>
<tr>
<td>room temperature</td>
<td></td>
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<tr>
<td>tap water</td>
<td></td>
<td></td>
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<tr>
<td>hot water bath</td>
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<tr>
<td>ice water bath</td>
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<tr>
<td>ice/salt/water bath</td>
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</tbody>
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2. State the relationship between temperature (in Celsius) and the slug location as an equation.
3. Use the equation in (2) to predict the absolute zero temperature in Celsius. At absolute zero, the volume of the gas would be zero, so the slug location would also be zero.

4. Show how the equation can be related to Charles’ Law \( \frac{V}{T} = \text{constant}, \text{at constant } P \text{ and } n \).

**Challenges**

If your group completes any of the following tasks or solves any of the following problems, group evaluation scores for everyone in the group are increased by the indicated amount. Challenges are optional, and should only be undertaken if the Postlab questions have been completed.

1. (1 point) Is your estimate of absolute zero “correct”? What would you have to know to answer the question objectively?

2. (1 point) Using your air pressure reading and your temperature / slug location data for the ice bath, estimate the number of moles of air trapped in your capillary tube. Hint: You may need to make some length measurements on the Charles law tube to estimate the volume. Ask your instructor for a ruler.
Group Evaluation

Evaluate the performance of other members of your group on a scale of 0-4. Your rating should be based on your co-worker’s preparation, quality and quantity of data collected, laboratory record keeping, assistance to other group members in lab and on post-lab questions, safety practices, experimental technique, and contribution to solution of problems.

You can not give any two group members the same rating.

You must write a 1-line justification for each rating.

Your instructor will not reveal your ratings to other students.

Your instructor will also rate you, and reserves the right to adjust your ratings if they are felt to be inaccurate.

<table>
<thead>
<tr>
<th>Partner Name</th>
<th>Rating</th>
<th>Justification</th>
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