Estimating Absolute Zero

Answer the questions posed in this prelab exercise on a separate sheet of paper. The questions are collected on the last sheet of this document. The completed prelab assignment is your ticket for admission to the lab. You won’t be allowed to do the lab without it.

Objective

In this exercise, we’ll determine the relationship between temperature and gas volume, and use it to estimate absolute zero on the Celsius temperature scale.

Goals

• Experimentally determine an ideal gas law (Charles’ Law)
• Read a Fortin barometer.
• Appreciate some of the difficulties and dangers in extrapolation.

Required Reading


Background

When the air in a hot air balloon is heated, the balloon expands. The gas inside the bag is now less dense than the gas outside, and the balloon rises. The exact relationship between gas volume and temperature was studied by Jaques Charles in the early 19th century and is now known as Charles’ Law.
In this exercise you will measure gas volume as a function of temperature to establish a mathematical relationship between these variables.

Since a gas may never have a volume less than zero, you will also be able to estimate the lowest possible temperature - absolute zero. This is the temperature at which the volume of the gas becomes equal to zero. You'll locate absolute zero by plotting gas volume (on the Y axis) vs. temperature (on the X axis) and extrapolating to zero volume.

A fixed amount of the air will be trapped in a thin glass tube sealed at one end and closed near the other by a moveable slug of mercury. When the slug isn't moving, we can assume the pressure of the trapped air is the same as the pressure of the room. The tube will be attached to a thermometer so that the bottom of the tube aligns with zero degrees on the thermometer. The scale on the thermometer can then be used to measure the height of the column of trapped air as the temperature is varied, as well as the temperature.

Since the capillary has a uniform cross-section, the height of the column is proportional to its volume. The relationship between column height and temperature can easily be converted to a relationship between volume and temperature by assuming that the air column is roughly cylindrical.

Prelab Questions

1. The following data were obtained for air trapped in a closed glass tube under a moveable plug of mercury:

<table>
<thead>
<tr>
<th>T, °C</th>
<th>8.4</th>
<th>370.7</th>
<th>886.3</th>
<th>2213.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>V, mL</td>
<td>101</td>
<td>231</td>
<td>416</td>
<td>892</td>
</tr>
</tbody>
</table>

   a) What relationship exists between the volume and the temperature of the gas?
   b) Plot a graph of the data to determine the value of absolute zero.

2. What precautions must you take while working with a Charles' Law tube plugged with mercury? (Hint: Read the Postlab!)