Thermodynamics

Determination of absolute zero

Absolute zero is the lowest possible temperature, that at which all molecular motion stops. Since pressure is dependent upon molecular motion and varies linearly with temperature we can use the pressure of a container of gas at various temperatures to extrapolate a line to determine the temperature at which pressure would be zero.

Purpose:
To determine absolute zero.

Equipment:
Vernier Gas Pressure Sensor
Vernier LabPro Interface
i-Book computer
Aluminum Air Chamber Assembly with temperature sensor
(3) water containers

Cautions:
This equipment is delicate. Everything should go together with the lightest of touches. Do not force anything!

You may find that some of the setup procedure has already been done for you. Check each step to make sure that it is done properly. The success of your work depends upon correct setup!

Procedure to set up the pressure sensor
1. Prepare three containers of water, one at room temperature, one with hot tap water, and one with ice.
2. Connect the tube from the aluminum air chamber with the temperature sensor to the Absolute Zero Gas Pressure Sensor Adapter.
3. Connect the other end of the Absolute Zero Gas Pressure Sensor Adapter to the pressure sensor.
4. Connect the gas pressure sensor to the “CH 1” port of the LabPro interface.
5. Connect the temperature sensor to the “CH 2” port of the LabPro interface.
6. Connect the LabPro interface to the iBook computer with the USB cable.
7. Plug the LabPro sensor into a power outlet. After a short pause, it will beep merrily.
8. Plug the i-Book computer in with its power adapter.
9. Turn on the i-Book and wait for it to boot up.
10. Log on to the computer with the username “student” and password “student”.
11. Launch the “Absolute Zero” Activity by double-clicking it.
Data Collection:

Important: Read steps 1-11 completely before performing them

1. Click on the collect button to start data collection
2. Immerse the aluminum air chamber and temperature probe in the ice water bath.
3. Watch the temperature value. It will decrease as the gas in the aluminum air chamber cools.
4. Wait patiently until the temperature stabilizes (does not change for 30 seconds or so)
   The temperature may switch back and forth between two values repeatedly. This is normal and does not indicate that the temperature is changing.
5. Click on the Keep button.
6. Enter a point number and click on OK. Number the data points 1, 2, and 3.
7. Immerse the aluminum air chamber in the room temperature water.
8. Repeat steps 3-6.
9. Immerse the aluminum air chamber and temperature probe in the hot water.
10. Repeat steps 3-6.
11. Click on the Stop button. You are through taking data.

Recording your data

Enter the data from the computer’s screen into this Data Table:

<table>
<thead>
<tr>
<th>Data Point</th>
<th>Pressure (kPa)</th>
<th>Temperature (C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Ice Water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Room Temp. Water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Hot Tap Water</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Computer Data Analysis

1. Click on the Linear Fit button (look for the “R=” button at the top of the screen)
2. A box appears. Look for the y-intercept value in the box. Write it here: 
3. Click on the “X” in the box to close it.
4. Double-click in the graph window. The Graph Options window appears
5. Click on Axes Options.
6. In the left hand column (y-axis) change the “Bottom” values to -300.
7. In the x-axis box at the bottom, change the “left” value to -10.
8. Click the Done button.
9. Click on the Linear Fit button (look for the “R=” again.
10. Notice that, at zero pressure, the line will indicate the temperature associated with absolute zero. That is how the value for absolute value is determined.
Graphical Data Analysis
1. On the attached graph paper, plot the temperature data. Note that the temperature is on the x-axis of this graph.
2. Draw your best-fit straight line through the data points.
3. Extrapolate the best fit line to the left until it crosses the P=0 line.
4. Determine the temperature at P=0, write the value here: [Blank]

Questions:
1. The accepted value for absolute zero is -273C. How well did your value correlate with the accepted value?

2. Would the effect of small errors in measurement be magnified in finding absolute zero? Explain why or why not.
3. How could the experiment be modified to improve the accuracy of its results. You need not limit yourself to the equipment at hand.