Lab 11: Absolute Zero

• IMPORTANT NOTES:

− For the experimental determination of absolute zero however, note that you should NOT be in SI units. Keep \( P \) = kPa, \( T \) = degrees C throughout experiment.. just as they are outputted from SciWkshp, no conversion necessary.

− During this lab, there have been MANY INSTANCES OF DATA DIS-APPEARING FROM THE COMPUTER mid-run, or worse, as you hit 'stop' to finish data collecting. This is probably due to some memory issues on the computers. For this reason, EVERY GROUP SHOULD HAND-COPY THE DATA POINTS AS THEY ARE OUTPUTTED FROM THE COMPUTER... just in case.

However, this should not be confused with the page scrolling down once the max number of data points that can be displayed on the screen has reached its limit. As long as new data points are being outputted, the run should not be considered a bust. Note that sometimes, one data point can disappear, which is OK, but when 2 or more data points don’t appear properly, there is trouble. If you still have mayhem ensue, feel free to combine groups as needed.

− expected value of absolute zero = -273.15 C

− don’t worry about final question on result sheet.

• EXPERIMENTAL PROCEDURE:
(1) Compare P theoretical, experimental at room temperature.

- theoretical: use ideal gas law, plug in provided \( n \), \( V \), and MEASURED room temperature* to predict pressure. (will come out in Pa).
  *do NOT use 293 K! get T from thermometer. (convert to K by adding 273.15)

- experimental: - read actual P value from Sciwkshp. (will need to convert from kPa to Pa).

Agreement is not always great... probably because canisters have slow leaks, so gas volume is less than given value.

Reminder: for the rest of the lab, you will use kPa, degrees C.

(2) Find absolute zero

- we will cool a canister of gas, and measure the pressure (Sciwkshp) vs. temperature (thermometer). Then, we’ll extrapolate the line back to determine absolute zero in degrees celsius.

For best results:

- get plenty of data points: start with hottest tap water, cool to near zero degrees celsius.

- cool slowly: if the canister/bath system is not in equilibrium, the thermometer (outside gas canister) will not accurately reflect the temperature of the gas.

- To get a slow enough cooling rate, \( T \) should not drop more than 1-3 degrees per reading. (readings are 1 min apart).

- At first, with hot tap water, cooling rate may be fast enough without
adding ice. Once cooling rate slows (approaching room temperature),
start carefully adding ice. As $T$ drops, more and more ice will need
to be added per reading to maintain this cooling rate.

- Cool uniformly: stir often, to try to maintain equilibrium of water/ice
  bath.
- Make sure canister is as fully immersed in bath as possible. Tape
canister down if it bobs up. Use turkey baster to keep bath from
overflowing.
- At the end, in Excel, eliminate any data points where cooling rate is
  too fast.

● ANALYSIS:

  - Export $P$ vs. $T$ data to Excel, plot. Absolute zero will be the x-intercept.
    To get the proper value, use \texttt{linest} as follows:

  - \texttt{linest} outputs 4 values: the left two are slope/error (of no interest in this
    experiment). the right two are y-intercept/error.

  - In this experiment, we are interested in the X-INTERCEPT/ERROR. To
    obtain this, we input the data series into the \texttt{linest} function with the
    x and y data columns REVERSED from normal... this "tricks" \texttt{linest},
    so when it gives us the "y-intercept/error", it is really giving us the x-
    intercept/error info we want.

  - So, hopefully this range of experimental absolute zero encompasses the
    actual value of -273.15 degrees C. Usually, 30-60\% of the groups get the
    desired results.