Expt 20 Charles' Law.

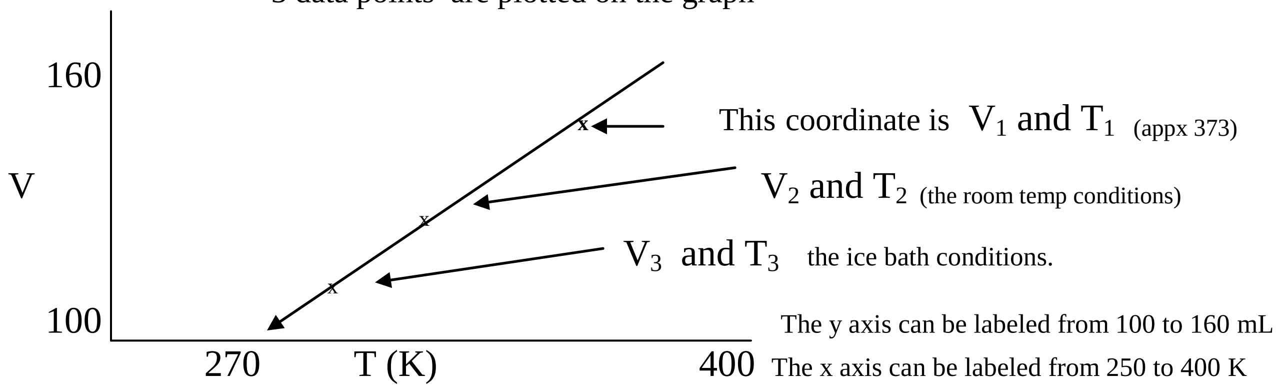
Introduction: Heating a gas causes it to expand, and cooling it causes it to contract. At constant pressure, the volume is directly proportional to the absolute (K) temperature.

$V = kT$ or, more commonly expressed as: $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

V_1 and T_1 are the initial conditions
V_2 and T_2 are the final conditions

In this experiment, V_1 is the total flask volume and T_1 is the high temperature (about 100^oC = 373 K)
V_2 (or V_3) is the reduced volume, after cooling, and T_2 is room temp, and T_3 is the ice bath temperature

3 data points are plotted on the graph

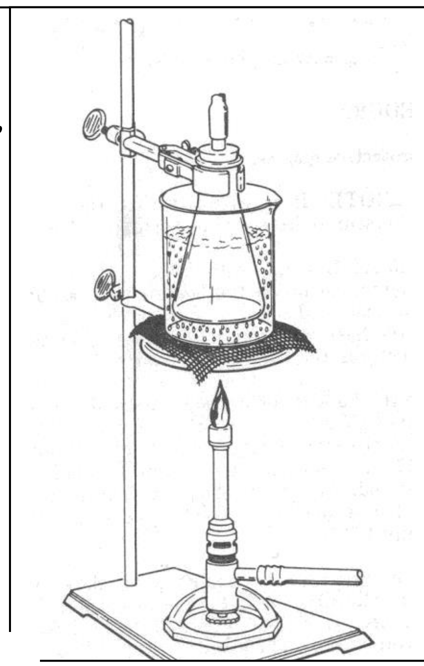


Materials: burner, iron ring & wire gauze, utility clamp, water trough, goggles a dry 125 mLErlenmeyer flasks. (do not wash this – it needs to be totally dry inside).(The actual volume of the flask is more than 125)
check out: 600 mL beaker, rubber stopper assembly as shown. with pinch clamp.
Chemicals: 3 boiling stones. tap water (**no** need to use deionized water)

Procedure: Tightly place the rubber stopper assembly onto the 125 flask and clamp it inside a 600 mL beaker as shown. Add water as shown, and the boiling stones to the beaker. Heat to boiling, and gently boil the water for 8 minutes.

Measure the temperature of the boiling water, (T)

Now, clamp the rubber hose with a pinch clamp, while the water is still boiling.

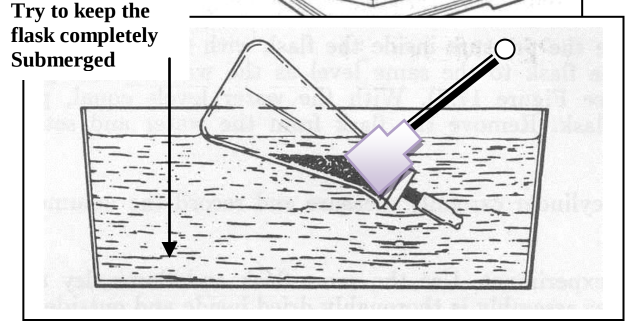


Carefully unscrew the utility clamp from the ringstand, and while keeping the clamp on the flask, immerse the flask in a trough, inverted such that the top of the flask with rubber assembly is below the bottom of the flask (see next diagram)

Keep the flask inverted, leave the utility clamp on (it is easier to control the flask by keeping the clamp on the flask.)

Now Remove the pinch clamp.

Water will enter the flask. Leave the flask immersed as shown for 8 minutes. Then, while pinching the hose with your fingers,remove the flask from the trough. DO NOT LET ANY WATER ESCAPE FROM THE FLASK while removing the flask from the trough.



Measure the temperature of the water (T_2)

Pour the water which entered the flask into a grad cylinder and measure the volume. Call it " V_w "
(you'll subtract this V_w from V_1 to calculate V_2)

Finally, fill the flask with tap water to the level where the rubber stopper fit. (You can place the stopper on the flask and make a mark with a grease pencil or marker or tape). Pour the water from the Erlenmeyer flask into a large grad cylinder and carefully measure the volume. (This will be V_1).
Calculate experimental V_2 by subtracting the volume of water which entered the flask,(Vw) from V_1.

If time permits, do another run, repeating the whole procedure with a dried flask. This can be done after Run 2. Set up the data for an extra run in your lab notebook. You should get the same values for V_w etc, but if not – you may want to plot both runs or take an average value to use in the graphing.

Run 2.
Repeat the experiment with the same dried flask. (You can dry the flask by carefully flaming it for a few seconds or placing it in an oven for a few minutes) Each flask is very slightly different, so you must use the same flask for run 2, that you did for run 1. Boil the water in the 600 mL beaker with the flask immersed as before. Put ice in the tub, so that the temperature of the ice-water mixture is close to 0^o C. Immerse the flask in the tub as before, collect and measure the water that enters the flask The volume of the flask minus the volume of water that enters the flask will be V_3 .

Analysis of Data

Graph . Plot the data by hand, on fine graph paper.(10 sq/inch or 10 sq/mm) Use the range of values appropriate to the data, (appx 100 – 160 mL on the y axis and T (K) from about 250 K to 380 K)
Draw the best straight line through the set of 3 points (more if you did extra runs) Circle the points. Label the points i.e. V_1 T_1 etc as shown in the introduction.

Using new arbitrarily chosen points on the line, (not previously plotted points in run 1 or 2), These points should be fairly far apart in order to increase the # of sig figs. Draw little boxes around these points so as to differentiate them from data points. Or use a different color pen.

calculate the slope of the line. (k) . $\mathbf{k} = \frac{y_2 - y_1}{x_2 - x_1}$. record the slope of the line on the report sheet.
Show calculation !

The equation of a straight line is given by: **y =** mx + b Use any point coordinates on the line to find "b" – the "y intercept" (show calculation).

Once you have b, you can find the value of x when y = 0 . (This is called the x intercept) Record this on the report sheet, along with calculation

Feel free to also do the graph using a graphing program such as Excel, and compare the slope with the slope obtained from the hand-drawn graph.

Expt 20. Charles' Law Report   Name : ______________________

section ____________ Due date___________ Date submitted________

Data Table

	Run 1	Run 2
Temperature of boiling water (T_1)	_____ K (T_1)	_____ K (T_1)
Temperature of water in tub	_____ K (T_2)	_____ K (T_3)
Volume of flask (V_1) (this is NOT 125	___________ mL	__________ mL
Volume of H_2O entering flask (V_w)	___________ mL	__________ mL
Volume air in flask when immersed (V_1 - V_w)	___________ mL (V_2)	__________ mL (V_3)
<u>Calculations</u> & Questions slope of line from hand-drawn graph show setup of Show calculation here include units	m = __________	

equation of line : y = mx + b : V = ___ T + ____ (y = V , x = T)

m (or k)   b

the k in Charles' Law = m (slope)

Using any V, T coordinate off the line, find **b**

(Show set-up of calculation here) : (Don't use one of the data points)

Enter the value of **b** in the equation above.

T at which V goes to 0. This T is called "absolute 0"

"Absolute 0" from your equation (T at which V = 0) _____________ K

show setup

% error compare your value of "absolute zero " with the actual value of 0 K ! We will somewhat arbitrarily choose 373 as the total reference range of your values for comparison.

$$\% = \frac{0 \ - \ \text{your value of "0" K}}{373} \times 100$$

______________ %

show setup

Questions

1. Why can't we experimentally find the temperature where the gas goes to "0 volume "?
   (Hint - When a gas is cooled to low temperatures, what usually happens to the gas ?)

2. This experiment works reasonably with dry air. However, V_2 and V_3 were determined in the flask when water was present. Water vapor enters the atmosphere and adds a little to the volume. This is not a problem at the boiling temperature, since we used a dry flask.

   In order to apply a correction accounting for the water vapor, we can calculate corrected V_2 and V_3.

   The vapor pressure of water at room T is about 20 torr units , or about (20/760) x 100 = 2.6 % of the total P. Thus the humid air has about 2.6 % by volume of water vapor

   Multiply your V_2 by 0.026 and determine whether it is a sufficiently significant quantity to subtract from the experimentally determined volume. If you think it is, plot a new point on the graph in a different color

   Show calculation of water vapor volume and subtract it from V_2

3. What is the vapor pressure of water at 0^oC (See the CRC Handbook or the reference page on your lab notebook.) Do you think this is significant compared to the total pressure ?

4. The greatest sources of errors in this lab are a) student mishandling of the equipment and b) leaky rubber stopper & hose.
   If a student hold the hot flask in the air for a period of time before immersing it in the tub, what might happen to cause an error in the V_w . What effect would it have on V_w ? Be specific in your answer.