Hints for the adiabatic lab workup.

There is no one correct way to do this. The data is easy to obtain, but the lab is quite hard to write up.

1. PLOT YOUR CALIBRATION LINE FOR VOLUME

Estimate the 95% confidence internal by plotting the line and the hyperbolae (trumpets). Use the middle of the line to estimate the error in the volume from a reading of the voltage. Use the graphical method choosing a reasonable value in the middle of the line and taking the place where a horizontal line intersects the trumpets on either side of the regression line. Make sure that you have set the confidence interval to 95% if you used the RLS spreadsheet.

2. PLOT THE LINEARIZED DATA IN AS MANY DATA SETS AS YOU CAN

Based on the adiabatic expansion formula, we have

$$P_1 V_1^{\gamma} = P_2 V_2^{\gamma}$$

where,

$$\gamma = \frac{C_p}{C_v}$$

In general the PV^{γ} product here is equal to a constant

$$C = PV^{\gamma}$$

which leads to

$$\ln(C) = \ln(P) + \gamma \ln(V)$$

or referenced to an initial pressure the equation can be set up for a linear regression.

$$\ln\left(\frac{P_i}{P_0}\right) = -\gamma \ln\left(\frac{V_i}{V_0}\right)$$

For each of the plots you will get a slope γ. You get the 95% confidence interval from the graph the same way that you did for volume. If you have 10 of these you may use the t-test to estimate the 95% confidence interval, which can serve as the error estimate for γ; $\sigma(\gamma)$.

3. CALCULATE THE PROPAGATION OF ERROR FOR $\gamma(P, V)$

Solve for γ to obtain $\gamma(P, V)$

I told you that you can obtain the error in P from V and then sequentially calculate the errors. But, remember from the ideal gas law that P = nRT/V, so you must calculate the error in P from the error V. When I said that are the “same” I meant that they are related by the ideal gas law.

$$\sigma(\gamma) = \sqrt{\left(\frac{\partial\gamma}{\partial P}\right)^2 \sigma_P^2 + \left(\frac{\partial\gamma}{\partial V}\right)^2 \sigma_V^2}$$

4. CALCULATE $C_p(\gamma)$

Since you know that $C_p = C_v + 1$ for an ideal gas (and that will hold for this experiment) then you also can obtain an equation for $C_p(\gamma)$.

5. CALCULATE THE PROPAGATION OF ERROR FOR $C_p(\gamma, V)$

By this point once have completed the measurement you will also have an error in the volume based on the fit to the standard line; $\sigma(V)$.

$$\sigma(C_p) = \sqrt{\left(\frac{\partial C_p}{\partial\gamma}\right)^2 \sigma(\gamma)^2 + \left(\frac{\partial C_p}{\partial V}\right)^2 \sigma_V^2}$$

But how do you get $\left(\frac{\partial C_p}{\partial V}\right)$?

For this you use the chain rule

$$\left(\frac{\partial C_p}{\partial V}\right) = \left(\frac{\partial C_p}{\partial\gamma}\right)\left(\frac{\partial\gamma}{\partial V}\right)$$

So these are all of the pieces, but I leave it you to do the derivatives. Please show only representative plots in the report. You may show your math in the Experimental section since this whole error analysis really counts and experimental methods. You could show the figures in the Results section along with any tables showing the numerical values.