This is the assignment for in-person students. Follow the procedures in the lab manual. Make note of your five measurements of temperature and pressure, and graph them on Capstone (or some other software). Answer the following questions:

1. What are the dimensions of temperature and pressure (base units)?
2. What are the dimensions of m and b?
3. What does the slope correspond to in the graph?
4. Based on the lab data, what is the predicted value of absolute zero in degrees Celsius?

Many properties of the low-density gases can be summarized in the **ideal gas law,**

$$PV = nRT$$

where P is the pressure in Pa, V is the volume in m^3, n is the number of moles of gas, T is the temperature in Kelvins, and R is the universal gas constant with the empirical value

$$R = 8.31 \text{ J/mol} \cdot \text{K}$$

A **mole** of molecules is Avogadro's number of them, denoted N_A:

$$N_A = 6.02 \cdot 10^{23}$$

Often we will want to discuss the **number of molecules**, denoted N:

$$N = n \cdot N_A$$

If you plug in $\frac{N}{N_A}$ for n in the ideal gas law, and group together the combination $\frac{R}{N_A}$ and call it a new constant k, you get

$$PV = NkT$$

This is an alternate form of the ideal gas law. The constant k is called **Boltzmann's constant,**

$$k = \frac{R}{N_A} = 1.381 \cdot 10^{-23} \text{ J/K}$$

5. The diameter of the bulb used in the experiment is 10 cm. Can you work out approximately how many moles of air are in the bulb?
6. Equation (3) in the manual states $P = n_N kT$, which is yet another way of writing the ideal gas law, using a quantity known as the number density of molecules, n_N. Show how this expression is equivalent to $PV = nRT$.
7. One of the assumptions in this experiment is that the density of air in the bulb stays constant. Can you think of any reasons why this may not be so? What errors can occur if the density is not constant? *Hint:* the number of moles can be written $n = \frac{m}{M}$ where m is total mass of the gas (kg) and M is the molar mass (kg/mol). Density is given by $\rho = \frac{m}{V}$. You can substitute these expressions into the ideal gas law and derive an expression that contains ρ.
8. What would happen if you accidentally spilled some liquid nitrogen on your hand? *Hint:* look into the Leidenfrost Effect.

Comment: the ideal gas law is an example of an **equation of state,** since it describes the relationship between three state variables, P, V, and T. However it only *approximately* describes the behavior of a real gas, since it doesn't take into account molecular size and intermolecular attractions (Van der Waals forces), which both cause deviations from ideal behavior. The ideal gas law is most accurate for gases at low densities and high temperatures, since under these conditions the molecules are far apart and moving at high speeds, such that intermolecular forces have little effect on the motion. There are, in fact, more complex equations of state that take into account the deviations from ideal behaviour caused by intermolecular attractions.