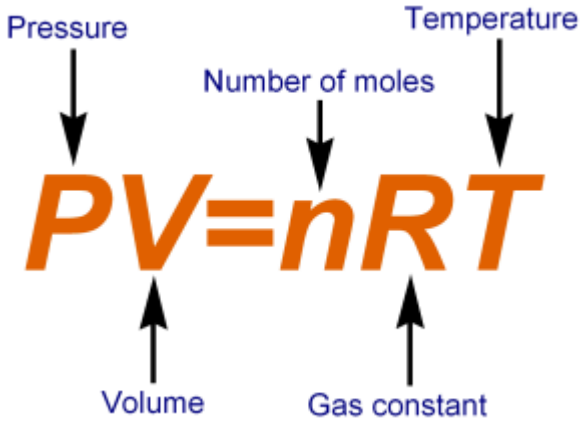
Ideal Gas Law



1st year physics laboratories

University of Ottawa

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INTRODUCTION

- In this experiment you will investigate the relationship between pressure and several variables (temperature, volume, number of gas molecules) that affect pressure in a closed system.
- The key equation to be used is Boltzmann's equation of state:

$$\boldsymbol{PV = nRT}$$

where $\boldsymbol{P}$ is pressure, $\boldsymbol{V}$ is volume, $\boldsymbol{n}$ is number of moles, $\boldsymbol{R}$ is the universal gas constant, and $\boldsymbol{T}$ is the temperature

- You will also find the following information useful:

One mole of gas $(\boldsymbol{n = 1\ mol})$ *occupies the same volume* $(\boldsymbol{V = 22.4\ L})$ *at standard pressure* $\left(\boldsymbol{P = 1.013 \times 10^5\ Pa}\right)$ *and standard temperature* $(\boldsymbol{T_0 = 273.15\ K = 0\ °C})$.

OBJECTIVES

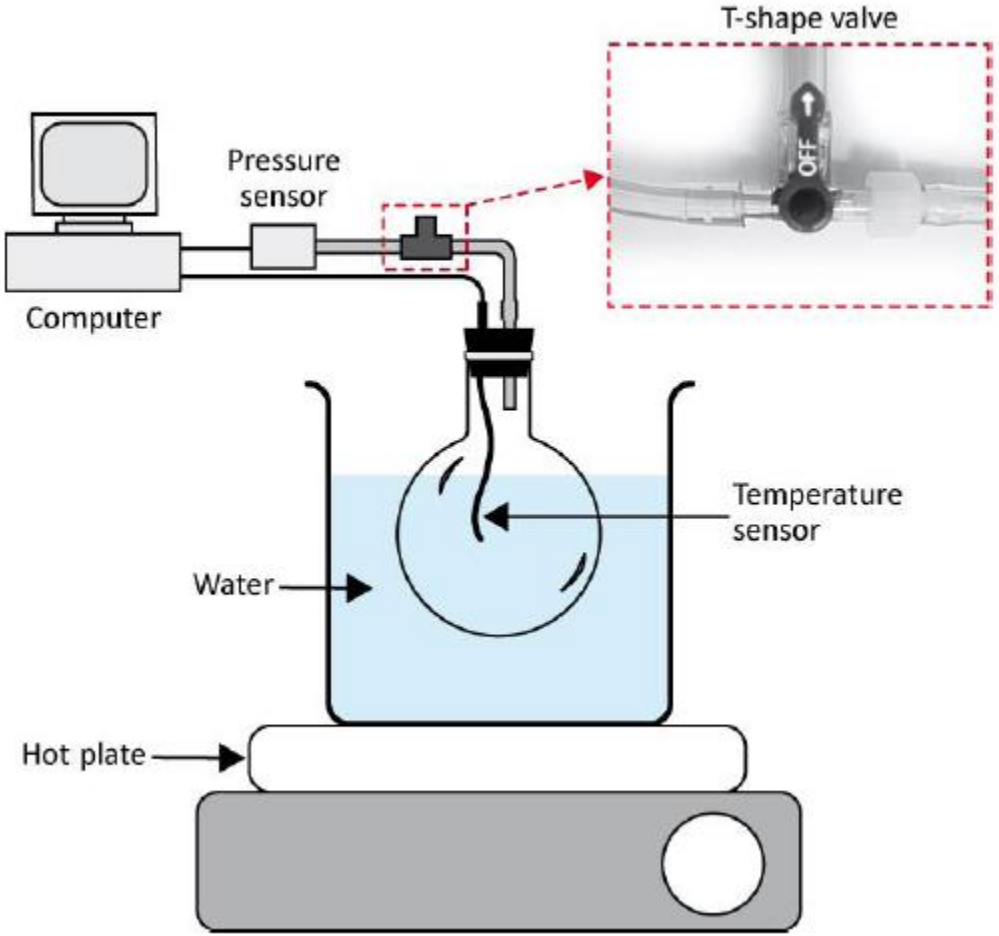
- Collect data for a sample of air in a closed system:
  1) pressure vs. volume
  2) pressure vs. number of moles
  3) pressure vs. temperature
- Determine the relationships between these variables and then formulate a single expression relating these variables.
- Determine whether air behaves as an ideal gas.
- Determine the absolute zero temperature.

SAFETY WARNING!!

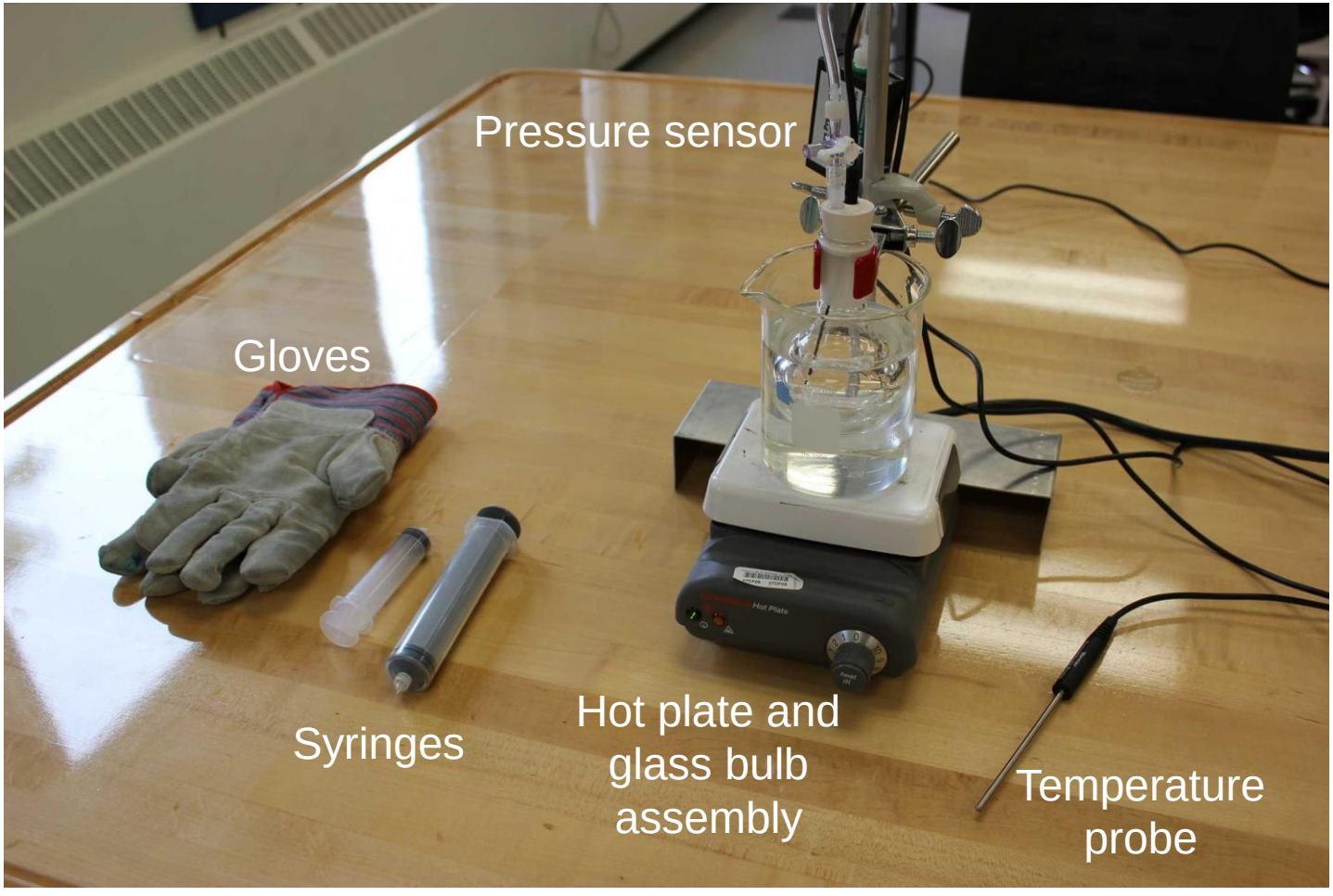
- You will be working with **near boiling water** in this experiment.
  - **Please wear protective gloves** when handling any high temperature surfaces.
- Please **turn off the hot plate when it is not in use**.
  - If the water begins to boil before your collection time is up, turn off the hot plate.

P vs. T

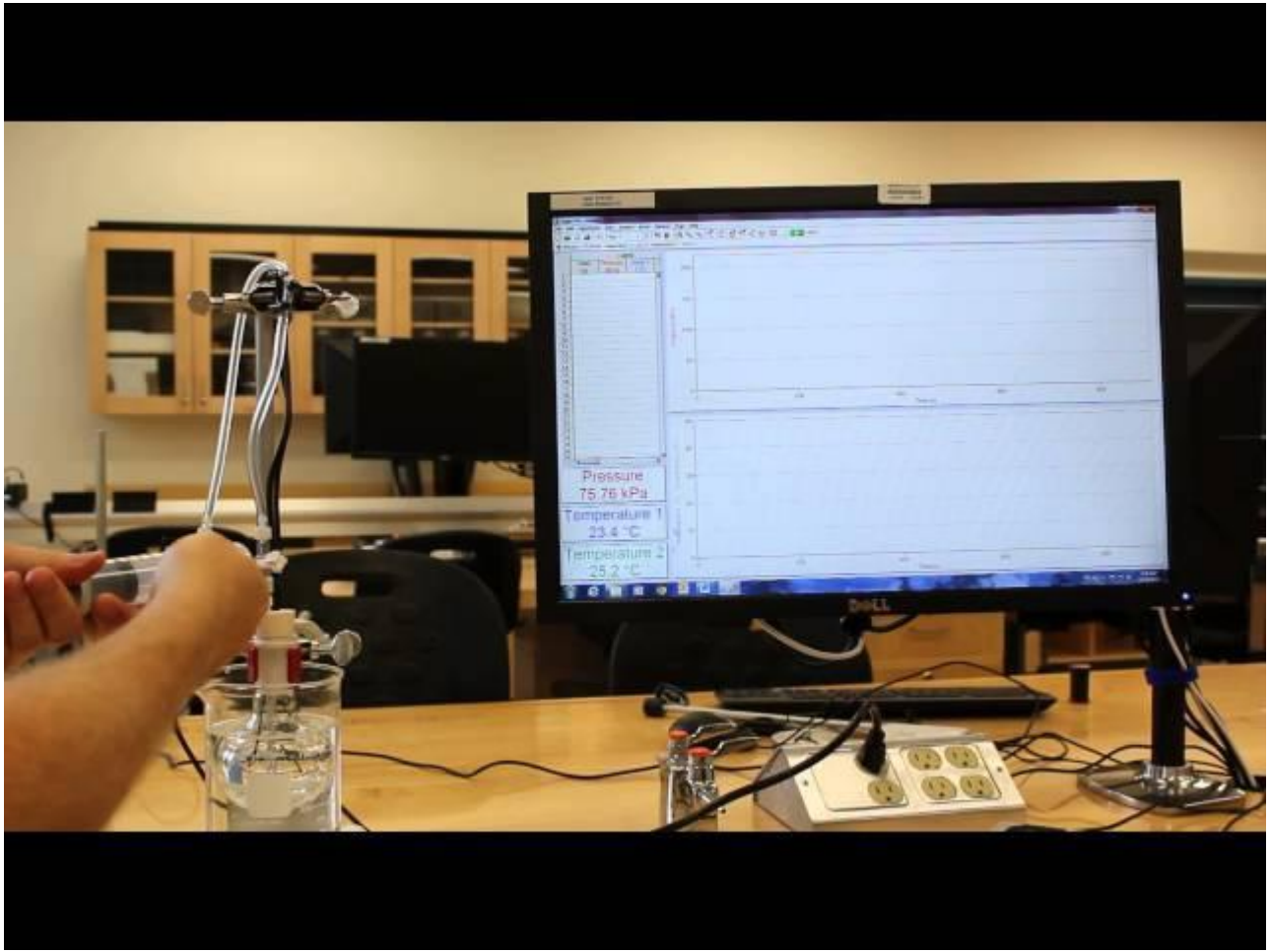
- Fill the beaker to the 350 mL mark.
- Your initial values should be around:
  $T \approx 22\ °C$,
  $P \approx 100\ \text{kPa}$.
- Reduce the pressure to between 50 and 60 kPa before you start.
  PHOTOS AND VIDEO ON NEXT TWO SLIDES.



The setup for P vs. T



Decreasing the initial pressure

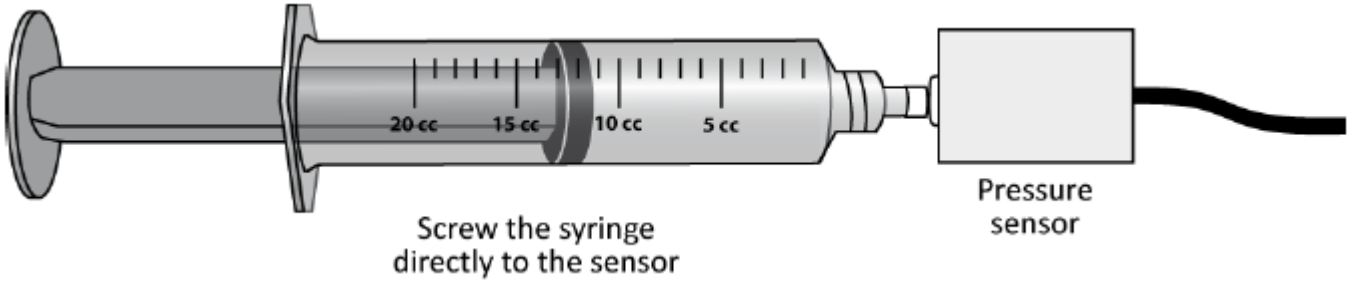


P vs. T (cont.)

- Set data collection to 600 s.
- Turn the hot plate to maximum and wait until the temperature has increased by 5 °C before pressing collect.
- Make sure to stop data collection if your water begins to boil before the 600 s is finished.
- Prepare your graph of pressure vs. temperature.

P vs. V

- Attach the 20 mL syringe directly to the pressure sensor.



- Use “Events with Entry” mode for data collection and make sure you use a **10 s average**.
- Record the pressure at each step as you change the volume from 10 to 20 mL by steps of 2 mL. Repeat for 20 to 10 mL.
- Prepare your graph of pressure vs. inverse volume.

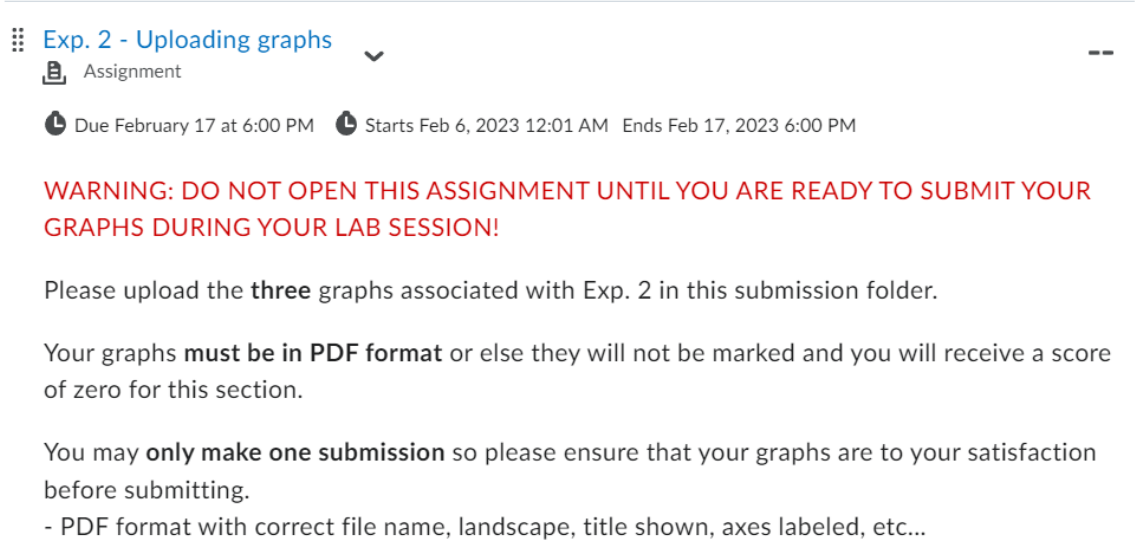
The setup for P vs. $1/V$ and P vs. n

P vs. n

- This part uses the same setup as part 2 (pressure and volume).
- **NB: 1 *puff* = 3 mL**
- Disconnect the syringe and position the piston so V = 1 *puff.* Reconnect the syringe and adjust the volume to 10 mL. Record the pressure.
- Increase the number of *puffs* by 1 and repeat the measurement until you hit a total of 6 *puffs*. Remember you are adjusting the **pressure to a constant 10 mL each time you re-connect the syringe**.
- Prepare your graph of pressure vs. # puffs.

GRAPHS

- There are three graphs to create and submit for this lab. Use the “Uploading graphs” tool at the bottom of the experiment page in Brightspace.



CLEAN UP

- Turn off the computer and **don't forget to take your USB key.**
- Make sure the **hot plate is turned off and unplugged.**
- Leave the water in the beaker for the next students.
- **Re-connect the pressure sensor to the flask assembly** like it was at the beginning of the lab session.
- Please recycle scrap paper and throw away any garbage. Please leave your station as clean as you can.
- Push back the monitor, keyboard, and mouse. Please push your chair back under the table.

- Thank you!

DUE DATE

The report is due at the end of the lab session, i.e., at 12:50pm or 5:20pm.

PRE-LAB

Don't forget to do your pre-lab for the next experiment!