

# Ideal Gas Law

Pressure

Temperature

Number of moles

**$PV=nRT$**

Volume

Gas constant

The diagram shows the equation  $PV=nRT$  in large orange letters. Five black arrows point from labels to the variables: 'Pressure' points down to 'P', 'Temperature' points down to 'T', 'Number of moles' points down to 'n', 'Volume' points up to 'V', and 'Gas constant' points up to 'R'.

1<sup>st</sup> year physics laboratories

University of Ottawa

<https://uottawa.brightspace.com/d2l/home>

# 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:

$$PV = nRT$$

where ***P*** is pressure, ***V*** is volume, ***n*** is number of moles, ***R*** is the universal gas constant, and ***T*** is the temperature

- You will also find the following information useful:

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

# OBJECTIVES

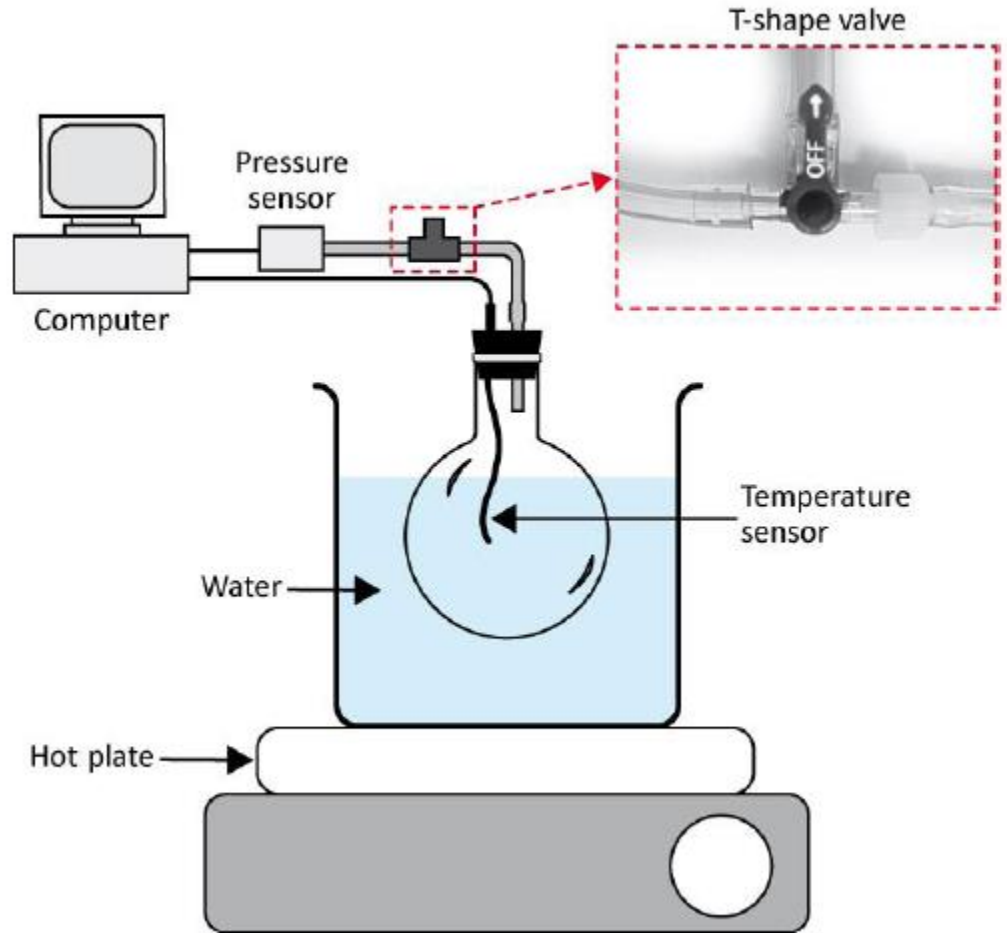
- Collect data for a sample of air in a closed system:
  - 1) pressure vs. volume
  - 2) pressure vs. number of moles
  - 3) pressure vs. temperature
- Determine the relationships between these variables and then formulate a single expression relating these variables.
- Determine whether air behaves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

# SAFETY WARNING!!

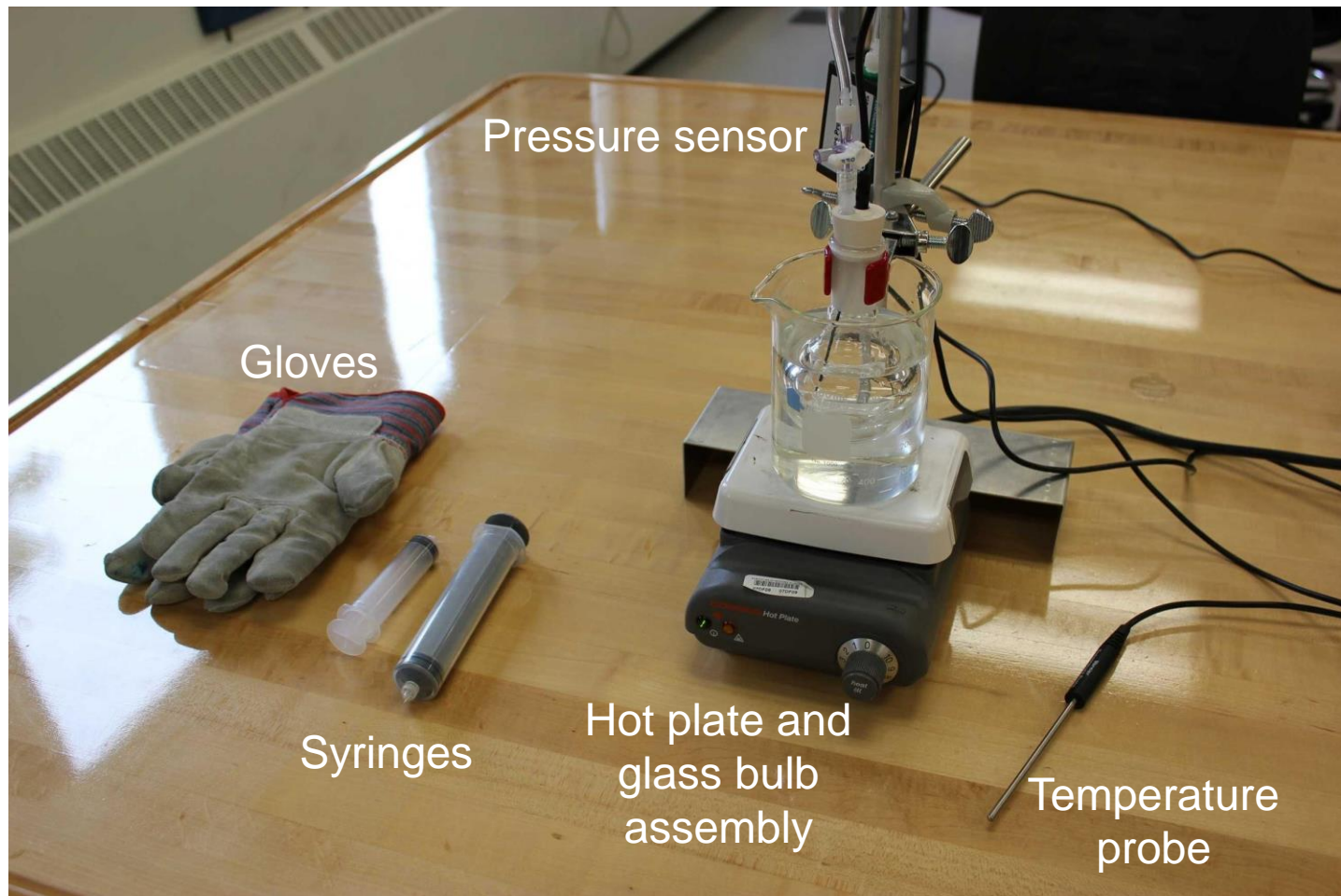
- You will be working with **near boiling water** in this experiment.
  - **Please wear protective gloves** when handling any high temperature surfaces.
- Please **turn off the hot plate when it is not in use.**
  - If the water begins to boil before your collection time is up, turn off the hot plate.

# *P vs. T*

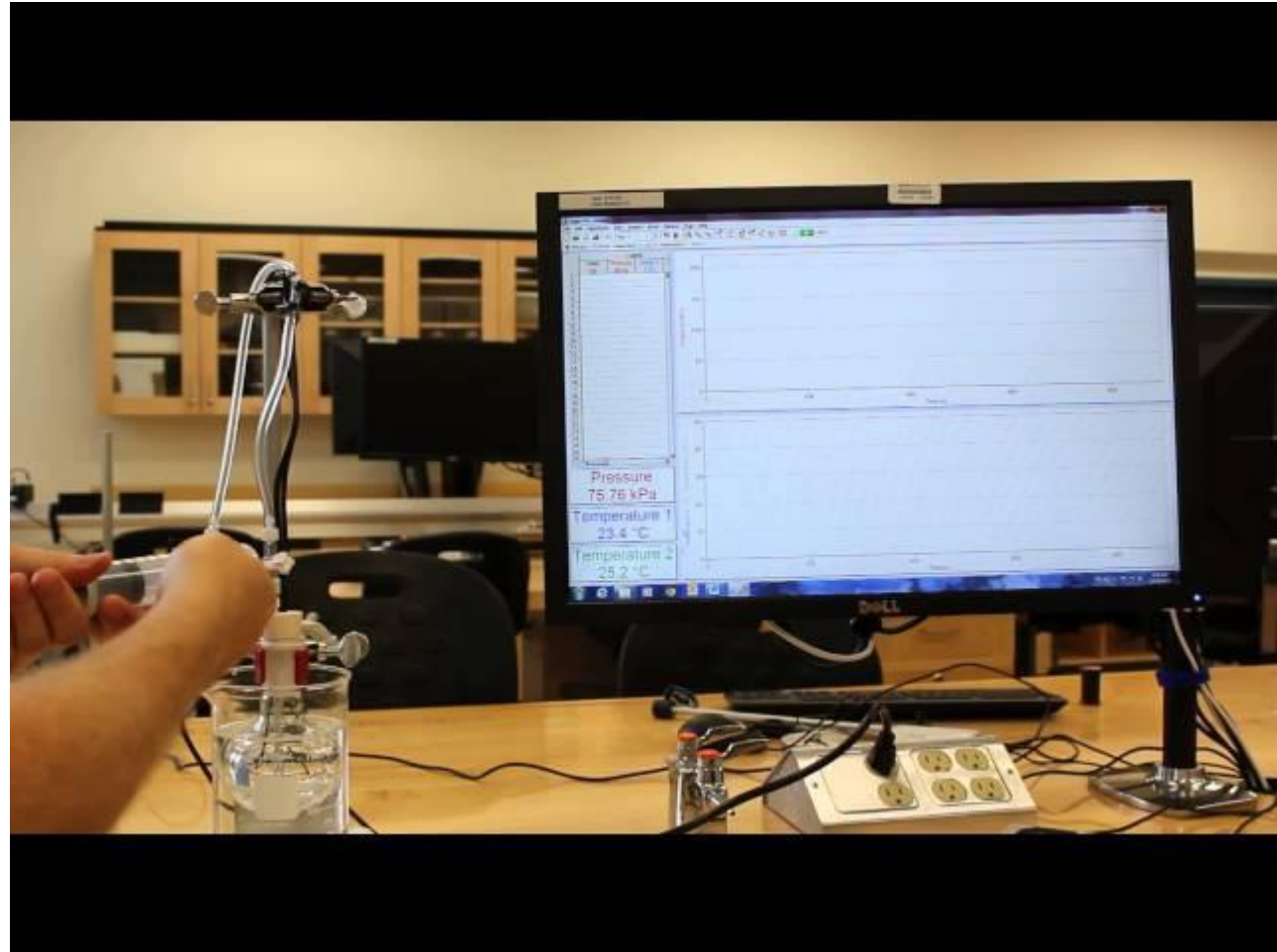
- Fill the beaker to the 350 mL mark.
- Your initial values should be around:  
 $T \approx 22\text{ }^{\circ}\text{C}$ ,  
 $P \approx 100\text{ kPa}$ .
- Reduce the pressure to between 50 and 60 kPa before you start.  
PHOTOS AND VIDEO ON  
NEXT TWO SLIDES.



# The setup for $P$ vs. $T$



# Decreasing the initial pressure



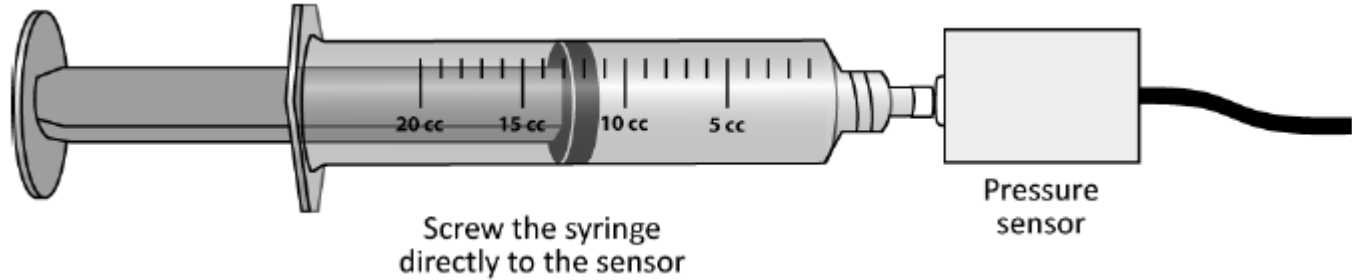
## *P vs. T (cont.)*

- 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.

☰ Exp. 2 - Uploading graphs

📁 Assignment

🕒 Due February 17 at 6:00 PM 🕒 Starts Feb 6, 2023 12:01 AM Ends Feb 17, 2023 6:00 PM

**WARNING: DO NOT OPEN THIS ASSIGNMENT UNTIL YOU ARE READY TO SUBMIT YOUR GRAPHS DURING YOUR LAB SESSION!**

Please upload the **three** graphs associated with Exp. 2 in this submission folder.

Your graphs **must be in PDF format** or else they will not be marked and you will receive a score of zero for this section.

You may **only make one submission** so please ensure that your graphs are to your satisfaction before submitting.

- PDF format with correct file name, landscape, title shown, axes labeled, etc...

# 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!