Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Physics 123:Fall 2015

**Lab: Heat Engine and Gas Processes**

The pressure, volume and temperature of a given gas are related and it is only necessary to specify two of these parameters to describe fully the state of the gas. For instance, the state of a gas can be fully described by stating its pressure and volume. Its temperature can be easily determined using Gay-Lussac’s law.

Although, we are using predominantly real gas (air) in this experiment, we will model it after an ideal gas, where its pressure (P), volume (V) and temperature (T) obey equation (1).

$PV= NK\_{B}T$ (1)

 where N is the number of molecules/atoms in the gas and KB is the Boltzmann’s constant. Equation (1) is the generalization of the gas laws. If N and P are kept constant, it leads to Charles law and if N and T are kept constant, it leads to Boyle’s law.

**Experimental**

**General setup:** connect physically the temperature sensor to the port labeled A on the Science Workshop 750 interface. (This is usually above or close to the computer.) Likewise connect the pressure sensor[[1]](#footnote-1) to the port labeled B. On the computer, find the “Capstone” software and launch it. Click on the icon “hardware setup” (Left top) and a box that looks like the interface will appear. Click on the label “A” and select temperature sensor from the menu. Likewise, click on “B” and select pressure sensor, Absolute. Make sure your readings are accurate, i.e., the temperature should be around 20oC and the pressure should be around 101kPa.

Fill the steam generator halfway with water and turn it on. You will need this later in part II and III.

Figure . Schematic sketch of the Heat Engine/ Gas Law Apparatus connected to a pressure sensor.1

**Part I. Boyle’s Law:** In this part of the experiment, you will keep the temperature of a gas fixed and you will change the volume by pressing or pulling the plunger on the heat engine base apparatus. You will record the pressure as you change the volume.

Adjust the piston position on the “Heat Engine/Gas Law Apparatus” to 30 millimeter and secure it by tightening the thump-screw. Connect the other pressure port on the apparatus to an Aluminum canister with a rubber stopper. Loosen the thump-screw and allow the piston to move freely. Measure the height of the piston and calculate the total volume of the gas. (You will need to determine the volume of the canister.) Record your results on Table 1. Now, push-down or pull-up the piston and record the corresponding pressure and height on Table 1. Repeat this until you get at least 5 data points.

**Table 1:** Pressure and volume of air at constant temperature, T = \_\_\_\_\_\_\_\_\_\_\_\_ K. The volume on column 3 is the total volume of the gas, which includes the volume of the gas in the Aluminum canister.

|  |  |  |  |
| --- | --- | --- | --- |
| Pressure(kPa) | Height( ) | Volume(m3) | Volume-1(m-3) |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

🡪 **Plot Pressure versus the inverse of the volume and discuss your results. (Don’t forget to include caption in your figure.)**

**Part II. Charles’ Law:** In this part of the experiment, you will keep the pressure fixed but you will heat or cool the air in order to measure the change in volume.

Disconnect the canister from the Gas Law apparatus. Place the “Heat Engine/Gas Law Apparatus” apparatus horizontally, so that the weight of the piston does not exert pressure on the gas. Adjust the piston position to 30 millimeter and secure it by tightening the thump-screw. Connect the other pressure port on the apparatus to the canister. Loosen the thump-screw and allow the piston to move freely.

Place the canister in one of the Styrofoam cups and fill one fourth of the cup with crushed ice and water. Insert and secure the thermometer. Make sure there is good thermal contact between the canister and the ice-water bath.

After the system has reached a thermal equilibrium, measure the temperature and height of the piston. Although, the pressure is supposed to remain constant, you need to keep track of it. Record your results on Table 2.

Using a pipet take a hot boiling water and add it to the ice-water bath. Try to change the temperature of the bath by at least 5 oC and record your results on Table 2. If you find it that you are running out of room in the Styrofoam, remove some of the water using a pipet and dump it. You should have extra beaker or Styrofoam cup.

Repeat the above step until the temperature of the bath reaches about 70oC.

Table 2: Temperature and volume of air at constant pressure. Temperature is measured from measuring the temperature of the reservoir.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Pressure (kPa) | Temperature (oC) | Height ( ) | Volume (m3) | Volume-1(m-3) |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

**Plot Temperature versus volume and make sure all units are in SI. Discuss your results. (Don’t forget to include caption in your figure.)**

**Part III. Isochoric Process:** In this part of the experiment, you keep the volume of the gas fixed and allow the pressure to change while you heat or cool the gas. You can fix the volume of the gas by fixing the position of the piston.

Disconnect the canister from the Gas Law apparatus. Place the “Heat Engine/Gas Law Apparatus” apparatus horizontally, so that the weight of the piston does not exert pressure on the gas. Adjust the piston position to 30 millimeter and secure it by tightening the thump-screw. Connect the other pressure port on the apparatus to the canister. **Make sure the piston remains fixed.** Place the canister in one of the Styrofoam cups and fill one fourth of the cup with crushed ice and water. After the system has reached a thermal equilibrium, measure the temperature and pressure of the gas. Record your results on Table 3. Try to change the temperature of the bath by at least 5 oC by adding hot water and record your results on Table 3. Keep changing the temperature until its reaches about 70oC.

Table 3: Pressure and temperature of air during isochoric process. Temperature is measured from measuring the temperature of the reservoir.

|  |  |
| --- | --- |
| Pressure (kPa) | Temperature (oC) |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

**Plot Pressure versus temperature and make sure all units are in SI. Discuss your results. (Don’t forget to include caption in your figure.)**

**Write a full lab report that includes, Abstract, Introduction, Experimental, Results, Discussion/Conclusion and Reference.**

1. Image from Pasco Scientific manual 012-06014B [↑](#footnote-ref-1)