611-2302 (30-176) Advanced Boyle's Law Apparatus

Introduction: Boyle's Law was first published in 1662, by the Irish philosopher Robert Boyle. His law describes the relationship between the volume of a gas and pressure. It is a special case of the *ideal gas law*. A modern description of the law could be written thusly:

For a fixed amount of an ideal gas kept at a fixed temperature, *P* [pressure] and *V* [volume] are inversely proportional.

This means that as one increases, the other decreases. Written another way: as you pressurize a gas, its volume will decrease. If you remove pressure from a gas, its volume will increase.

Boyle's law assumes a constant temperature. More than 100 years later, Charles's law would describe how the volume of a gas is directly related to its temperature. That is, if you increase the temperature of a gas, its volume will increase. Thus, in order to properly observe Boyle's Law, temperature must be kept constant. If it is allowed to increase or decrease, the volume will be affected. This in turn will give an inaccurate understanding of Boyle's Law.

Boyle's law also assumes an *ideal gas*. An ideal gas is one whose molecules occupy essentially no volume, whose molecules do not attract each other, and whose molecules undergo perfectly elastic collisions. Most real gases are very similar to the ideal gas under most circumstances. Very high pressures or very low temperatures are exceptions to this.

Operation: To use your Advanced Boyle's Law Apparatus, you must first note an important point.

Boyle's Law concerns gasses, which among other things are compressible fluids. However, gasses tend to be invisible; meaning you students will have a difficult time experimenting with them! For this reason, we use a liquid dyed a light blue. Also, the apparatus is different from the one used by Boyle to reflect this fact.

1. To use your apparatus, you will need to add some of the included fluid to the reservoir on the base plate. A small funnel will be helpful here. The volume of liquid added is up to you, but it must be a *known* volume. 100ml is a good amount.

2. Next, you will want to connect the pump to the reservoir. This pump attaches to the valve like a regular bicycle pump. **Before pumping**, make sure the two screw valves are completely sealed with an O-ring beneath them! One of these is the valve you used to fill the reservoir; the other is on top of the column. Failure to properly seal the unit will cause the liquid to fountain out! Although this is very entertaining for your students, you may get covered with the liquid, and in any case it does little to advance their understanding of the gas laws.

3. When the fluid has been added, the pump connected, and the valves sealed, pressurize the unit. A gauge on top of the reservoir will indicate pressure in kPa.

4. As you pressurize, note the fluid rising in the column. You can permanently mark the level the liquid reaches with the orange tabs. The fluid being evacuated from the reservoir is analogous to a gas being pressurized; as pressure increase, the initial volume of the liquid decreases.

5. On the side of the tube is a scale marked in centimeters. The inside of the diameter of the tube is 0.68cm. This means that 2.75cm of fluid is equivalent to 1cubic centimeter, or 1 milliliter of volume.

6. Thus, if you pressurize the reservoir and have a vertical gain of 27.5cm, you have effectively decreased the volume of the liquid in the reservoir by 10mL. Since you know the pressure required to do this by using the gauge, you can now compute k.

7. Boyles law gives the equation pV=k. this means:

   Pressure times volume equals “k”

K is a special, constant value that describes the relationship between pressure and volume for a specific gas. While this value is different for different gasses, it should remain constant for a specific gas. Under extreme circumstances it may vary; however, these conditions cannot be produced in a classroom.

8. Compute the k value for several different pressures. It should remain fairly constant. Slight variations may be caused through inaccurate measurement, and the inherent inaccuracies of this design. However, these variations should be small enough that they become irrelevant for classroom purposes.

9. If your k value is not close to constant, check your calculations. If they are done correctly, you may need to go back and gather new experimental data.

Warranty and Parts:
We replace all defective or missing parts free of charge. Additional replacement parts may be ordered toll-free. We accept MasterCard, Visa, checks and School P.O.s. All products warranted to be free from defect for 90 days. Does not apply to accident, misuse or normal wear and tear. Intended for children 13 years of age and up. This item is not a toy. It may contain small parts that can be choking hazards. Adult supervision is required.