BOYLE'S LAW APPARATUS
STUDY GUIDE

BOYLE'S LAW

Boyle's Law states that at constant temperature, the volume of a fixed mass of gas varies inversely with pressure. One way of stating this law of physics mathematically is:

$$P1 \times V1 = P2 \times V2$$

where P1 is absolute pressure at a certain volume (V1) and P2 is absolute pressure at a second volume (V2). As the pressure on a gas increases, the volume decreases in direct proportion. For example, if the pressure on a gas doubles, the volume will be halved.

ASSEMBLY

1. Put a small amount of lubricant on the black piston seal of the syringe. Use Vaseline or dishwashing soap if lubricant is not provided.
2. Make sure the bottom part of the syringe is fully seated in the bottom wooden block. Press down firmly.
3. Put the small black or red rubber cap securely on the tip of the syringe.
4. Place the piston in the syringe with a piece of thread between the black rubber piston seal and the syringe wall. This allows air to escape as you adjust the syringe initial volume.
5. Adjust the initial volume of the syringe to 30 cc, wait a few minutes for the gas to equalize and then remove the string.

BOYLE'S LAW EXPERIMENT

Elasticity of Gases

1. Use several large stackable objects (books work well) weighing 2 to 3 pounds each. Weigh each book and record the weight. The more accurate your weights, the better your calculations will be at the end of the experiment.
2. Before taking readings, twist the piston one-fourth turn and lift slightly above the rest position, release and read the scale where the piston comes to rest. Then push the piston slightly below the rest position, and read the scale. The average of the two readings is the value recorded.
3. Add the objects one by one on the upper block of the apparatus to compress the gas in the syringe. Record in Table 1 the volume of the gas in the syringe and the total weight on the syringe plunger each time you add an object.
4. Add as many objects as you can without tipping over the apparatus or until the syringe no longer compresses appreciably.
5. Take another set of readings when removing the objects one by one. If the readings for the same load are inconsistent, some air has escaped, and the experiment should be repeated.
6. Convert the weight of each reading to absolute pressure using the equations provided with Table 1.
7. Graph the absolute pressure (P) for each reading versus volume (V) using a piece of graph paper. Plot pressure on the X-axis and volume on the Y-axis. ***What relationship between pressure and volume do you observe from the graph?***
8. For each data point, multiply the absolute pressure by its corresponding volume. You should see a direct relationship in your data. ***What variables could account for any variations in your results?***
9. Some variables that could affect your results are friction, mass or number of molecules of air, and temperature. ***Which of these do you think are constant for the entire experiment and which do you think are changing? Why?***

CHARLES'S LAW

Charles's Law states that at a constant pressure, the volume of a gas varies directly proportional with absolute temperature. Another way of stating this law of physics mathematically is:

$$T1 \div V1 = T2 \div V2$$

where T1 is the absolute temperature at a certain volume (V1) and T2 is the absolute temperature at a second volume (V2). This equation states that as the temperature increases on a gas, the volume increases in direct proportion. For example, if the temperature on a gas doubles, the volume will double.

CHARLES'S LAW EXPERIMENT

Thermal Expansion of Gases

1. If the syringe has not been used recently, wipe grit off the piston seal and smear lubricant on the edges of the rubber seal.
2. Insert the piston to about the 10ml mark and install the rubber cap on the tip.
3. Remove the syringe from the bottom wooden block. The top block is not removable.

4. With the piston adjusted to desired starting position, immerse the sealed part of the syringe in a beaker or pot of water. Use kitchen tongs, a test tube clamp or ring stand and clamp to hold the syringe in the water.
5. Heat the water slowly. Stir periodically.
6. About every 15-20°C, record both the temperature of the water and the air volume in Table 2. Before taking each volume reading, twist the piston to keep it from sticking. Then push the piston slightly below the rest position, and read the scale.
7. Calculate absolute temperature for each reading and plot absolute temperature (T) versus volume (V) using a piece of graph paper. Plot temperature on the X-axis and volume on the Y-axis. ***What relationship between temperature and volume do you observe?***
8. Calculate the ratio T/V for each data-point. ***What variables could account for any variations in your results?***
9. Some variables that could affect your results are friction, mass or number of molecules of air, and pressure. ***Which of these do you think are constant for the entire experiment and which do you think are changing? Why?***

Table 1: Results of Boyle's Law Experiment

Data Point	Weight [1] (g or lbs)	Weight [2] (lbs)	Pressure [3] (psi)	Pressure [4] (psia)	Volume [5] ml	PV [6]
1	0	0	0	14.7		
2						
3						
4						
5						
6						
7						

1. Record the total weight, in grams or lbs., on the syringe after adding each object.
2. If your weight was recorded in grams convert to lbs. by dividing by 454 g/lb.
3. Calculate the <u>incremental</u> pressure (lbs/in^2 or psi) on the syringe by dividing the weight in lbs. by the cross-sectional area of the syringe, 0.655 in^2 for a 30ml syringe (i.e. πr^2).
4. Calculate the <u>absolute</u> pressure (lbs/in^2 absolute or psia) on the syringe by adding atmospheric pressure (14.7 psia) to each incremental pressure calculated in column 3.
5. Record the volume, in ml, in the syringe after adding each object.
6. Calculate PV by multiplying absolute pressure from column 4 by volume from column 5.

Table 2: Results of Charles's Law Experiment

Data Point	Volume [1] ml	Temperature [1] (° Celsius)	Temperature [2] (° Kelvin)	T/V [3]
1				
2				
3				
4				
5				
6				
7				

1. Record the temperature, °C, and syringe volume, ml, about every 15-20°C.
2. Calculate absolute temperature (° Kelvin) by adding 273° to each reading in °C.
3. Calculate T/V by dividing absolute temperature (from column 2) by volume.