Erlenmeyer's Balloon

Kitchen Table Demonstration

The Rundown

Time: 10 minutes
Content: Charles's Law, Atmospheric Pressure, Boiling Point, Vapor Pressure
Safety Concerns: Minimal
Materials Availability: Common

Atmospheric pressure is a powerful force. It can crush metal containers, it can force water into flasks, it can support a column of mercury nearly a meter high, and it can raise a drink to your lips without so much as groan.

This all assumes, of course, that the pressure the atmosphere is acting against is somewhat lower…

In this demonstration, you will demonstrate how atmospheric pressure can be used to "inflate" a balloon – inside out – lining the inside an Erlenmeyer flask.

Content Application

- Combined Gas Law
- Atmospheric Pressure
- Vapor Pressure
- Boiling Point

Enduring Understandings

- There is a direct relationship between the temperature of a sample of gas and its volume.
- There is a direct relationship between the temperature of a sample of gas and its pressure.
- There is an indirect relationship between the volume of a sample of gas and its pressure.
- A differential in pressure between the system and its surrounding will result in an effort by the system and surroundings to achieve equilibrium.

Chemistry

Atmospheric pressure is defined as the pressure derived from the weight of the column of the atmosphere above it.

The **Combined Gas Law** states that there is a direct relationship between the temperate and volume of a gas, a direct relationship between the temperature and pressure of a gas, and an indirect relationship between the pressure and volume of a gas, assuming that the mass remains constant. The Combined Gas Law is expressed mathematically as:

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

In this demonstration, the temperature of the flask (and the gas inside it, see the **Procedure**, below) is directly manipulated. This results in a response by pressure and volume to maintain equilibrium between the system (the inside of the flask/balloon) and the surroundings (the outside of the flask/balloon). The sudden change in temperature results in a commensurate change in the volume of the gas (water vapor) inside the flask, which also causes a drop in pressure. Atmospheric pressure then presses against the membrane of the balloon and stretches it until the pressure inside equalizes with the atmosphere.

It can be argued that the elasticity of the balloon prevents the pressure of the system from changing as its surface area responds to the temperature and volume change. However, since the elastic coefficient of the balloon is actually not constant as the latex stretches, the pressure must change to account for this.

Vapor pressure is defined as the pressure of a vapor when it is in equilibrium with its non-vapor phase (usually liquid, although solids also sometimes exhibit a vapor pressure).

Boiling point is the temperature at which the vapor pressure of a substance equals the environmental pressure – in this case, atmospheric pressure. Water is boiled within the flask to generate a gas (water vapor, or steam) that can be quickly cooled to reduce the volume, and therefore the pressure, inside the flask.

Materials

- 250 mL Erlenmeyer flask or small glass soda bottle
- 9” latex party balloon
- Ice bath large enough to immerse the flask
- Water (tap water is fine)
- Hot plate or Bunsen burner and lab striker
- Tongs

Safety

- Goggles – hot water and steam can cause serious burns.
- Hot mitt – the Erlenmeyer flask (or other glass container) will be hot after heating. Use a silicone or Nomex mitt or flask tongs to handle the flask until it is safe to touch with bare skin.
- Allergies – students with an allergy to latex should not handle the balloons or flasks used for balloons in this demonstration.

Procedure

1. Light the Bunsen burner.
2. Add a few milliliters of water to the flask and grip with the tongs.
3. Hold the flask over the burner until the water begins to boil. Allow it to boil for a few moments, but do not allow the flask to boil dry (if it goes dry, start over – do not proceed or you will break the flask!).
4. Once the water is boiling and steam is rising from the flask, remove the flask from the flame and place it on the lab table surface (use a hot pad if the bench is not designed for hot contact).
5. Carefully and quickly stretch a latex party balloon over the mouth of the flask. **CAREFUL!** The flask will be hot.
6. Pick the flask up with the tongs and immerse it in the ice bath (while being certain to keep the water level below the neck of the flask).
7. Watch as the balloon is forced into the flask!

Disposal

- Balloons can be disposed of in the trash. Ballooned Erlenmeyer flasks make wonderful stocking stuffers.

Follow-Up and Student Participation

Be sure to explain to students the balloon is not “sucked” into the flask – it is “pushed” in by atmospheric pressure. A diagram on the board is usually helpful.

Check the companion site for this manual at http://demos.digitaldapp.org for video of this demonstration and for two other gas laws-related demos – implosion of a soft drink can and the filling of a flask with water.

1. Ask students to design a procedure to remove the balloon from the flask without simply peeling it off.

2. Repeat the procedure in progressively larger flasks and have students explain the pattern that they observe.

3. Use the combined gas law to calculate the change in pressure inside the flask during the experiment.