Solar Balloon exercise

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Lesson Objective

Determine the correlation between Pressure, Temperature, and density and their relation to atmospheric science

Importance of lesson objective

Allows students to gain a deeper understanding of the ideal gas law and how it applies to atmospheric science.

Activity Outline

1. *Introduce lesson objective and explain the importance*
2. *Give background information behind ideal gas law*

- Equilibrium states of a system: when the variables that describe the system are the same throughout

- Equation of state: relationship between volume, pressure, and temperature

1. **Boyle's Law:** When temp is kept constant
   - Volume is inversely proportional to Pressure
2. **Charles's Law:** When Pressure is kept constant
   - Volume is directly Proportional to Temperature
3. **Gay-Lussac's Law:** When Volume is kept constant
   - Pressure is directly Proportional to Temperature

3. Introduce Solar Balloon experiment
   a. Give background information

   A solar balloon is a balloon that gains lift or buoyancy when the air inside of it becomes heated. This heating is due to solar radiation. As the air inside the balloon becomes heated, the air becomes less dense than that of the surrounding air, and as an effect, the buoyant force acting on it, which is due to the denseness of the air surrounding the balloon lifts the balloon, causing it to float.

Experimental Activity

Time allotted: *2 days*

Materials

1. Solar Balloon
    - Can be bought on amazon
2. 3 lightweight wireless barometer/thermometer (Instruments such as the kestrel barometer can be purchased online at relatively low costs
3. String/Rope
    - to tie one end of the balloon to prevent air from being released
5. Stopwatch

Part I Understanding the Relationship Between Temperature and Pressure

Method

1. **Tie one end of the solar balloon in a simple know to prevent air from escaping**
2. attach 1 wireless barometer and thermometer to the interior of the solar balloon using light weight tape and insure it is connected to a blue-tooth enabled computer or tablet.
    - Inside of the balloon
        - in order to determine the temperature and pressure inside and determine the temperature and pressure differences between air contained inside the balloon and the surrounding environment

2. Attach 1 lightweight barometer and 1 thermometer to the closed end of the solar balloon
    - Outside of the balloon
        - For same reason given in step 1
3. Inflate the balloon with surrounding air until balloon is firm and tie open end of the balloon, ensuring no air is released from the balloon and the balloon remains firm.
4. Attach 1 lightweight barometer and thermometer to the tied end of the balloon and allow balloon to elevate
5. Let balloon float for approximately 30 minutes, recording temperature and pressure in the following table every 3 minutes—I think this might need to be shorter intervals (10 or 20 seconds)

Time	Temp (˚C)	Pressure (kg/m^3)
Table 1: Data from temperature and pressure experiment		

Part II Understanding the Relationship Between Temperature and Density

Method

1. With the wireless barometers still attached, untie one end of the solar balloon to evacuate the warmed air from the balloon.
3. Reinflate the balloon with surrounding air until it is partially filled and tie the open end of the balloon to ensure that no air is released.
4. Attach 1 lightweight barometer and thermometer to the tied end of the balloon and allow balloon to heat up in the sunlight.
5. Let balloon float, recording temperature and pressure in the following table every 30 seconds until the pressure begins to rise.

6. Calculate the air density inside of the balloon using the equation below and record the values in Table 2.
   - Accomplished using ideal gas law
     - by substituting V = m/d into equation for ideal gas law
       - PV = nRT = P(m/d) = (mass of air)RT/(molar mass of air)
       - n = (mass of air)/(molar mass of air)
         - d = (mass of air)/V = (mass of air)*P/nRT = (molar mass of air)*P/RT

Time	Temp (˚C)	Pressure (kg/m^3)	Density (calculated)

Time	Temp (˚C)	Pressure (kg/m^3)	Density (calculated)
Table 2: Data from temperature and density experiment			

7. **Using the blank graph in figure 1 plot the air pressure and temperature data recorded in part I (I'll add that later)**

1. Using the blank graph in figure 2 plot the density and temperature data recorded in part II

8.

Discussion:

1. **Examine the graph produced in step 7 above.** Using complete sentences explain how air pressure in the balloon was affected by the internal temperature of the balloon.
2. Would you expect to see the same results as described in your answer to question 1 if the temperature was allowed to rise and one end of the balloon was left open? Why or why not?

3. **Examine the graph produced in step 8 above.** Using complete sentences explain how the density of air in the balloon was affected by the internal temperature of the balloon.
4. Using complete sentences explain how air density with in the balloon affected the balloon's buoyancy in air.
5. Based on your answer to question 4 how do you expect air near a heated surface to behave? Would you expect air in all regions of our environment to behave identically throughout the day? Explain your answer.