A02-620S-Y01

Atmospheric Pressure Demonstration Kit

Purpose

1. Observation of increasing pressure
2. Observation of decreasing pressure
3. Relationship between pressure and volume in a tube
4. Relationship between pressure and temperature in a vacuum pressurized cabin
5. The changing volume of balloon under different pressure in a vacuum pressurized cabin
6. The causes of cloud formation
7. Magdeburg hemispheres experiment
8. Sound propagation in vacuum

Theory

- **Atmospheric pressure**

  Due to the Earth's gravity, air around the Earth forms atmosphere which causes pressure on objects. This pressure is atmospheric pressure. The weight of air is the source of atmospheric pressure. Normally, the air pressure is 6~7kg/cm2. But in mountains, the atmosphere is thinner and the air gravity is smaller so pressure at high altitudes is smaller than it is at low latitudes. Pressure in mountains is smaller than it is at sea level.

- Barometer

  An instrument which is used to measure atmospheric pressure is a barometer.

Frequently used pressure units in meteorology are:

1. Pa: Often written in hPa.

2. Bar: 1bar=100,000Pa, mbar=hPa.

The unit in Torricelli's experiment is cm-Hg.

Figure 2-1 Manometer

The pressure unit in this experiment is shown in **Figure 2-1**:

$$76 \text{ cm-Hg} = 29.9 \text{ in-Hg}$$

$$1 \text{ kg/cm}^2 = 14.2 \text{ Lb/in}^2$$

- **Standard atmospheric pressure**

The average pressure at sea level is 101.325 kPa which equals to 76 cm-Hg. This is standard atmospheric pressure. The SI unit is atm. One standard atmospheric unit is 1 atm.

1 atm = 76 cm-Hg = 760 mm-Hg

= 1033.6 gw/cm^2 = 1.0336 kg/cm^2 = 14.7 Lb/in^2

= 1013 hPa = 1.01325 bar

- **Magdeburg hemispheres**

In 1654, Magdeburg mayor, Otto Von Guericke, demonstrated an experiment in front of German Emperor and the nobility at Magdeburg, Germany.

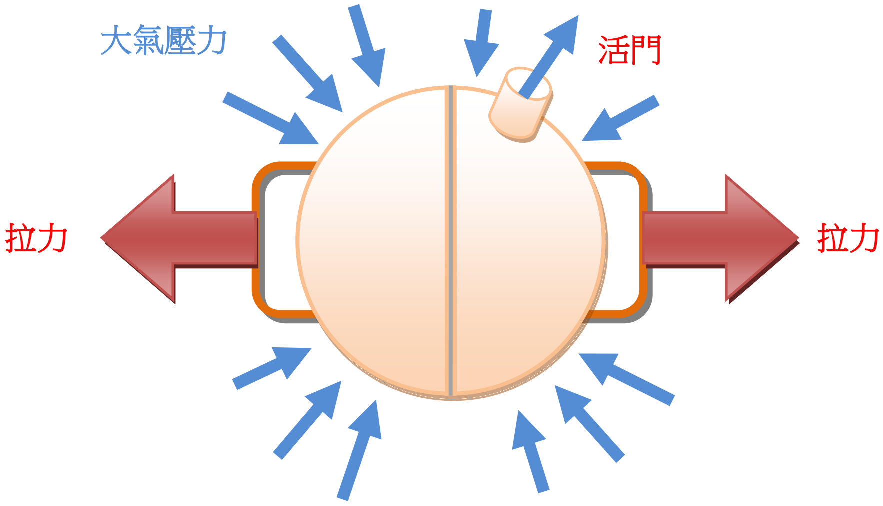


Figure 2-2 Magdeburg hemispheres

Otto Von Guericke designed two copper hemispheres (diameter 37 cm) with flap valves. He put them together and pumped all the air out, locking them together with a vacuum seal. He locked the flap valves to prevent the outside air from entering the hemispheres so the hemispheres became a vacuum, as shown in **Figure 2-2**. When von Guericke attempted to separate the hemispheres, they were held so tight that it took 16 horses to pull them apart.

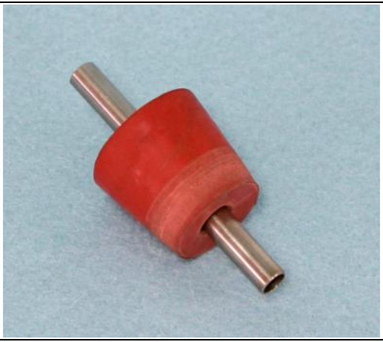
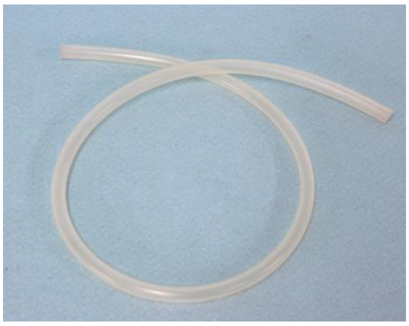
He again put hemispheres together and pumped the air out but left the flap valves open, letting air entering the hemispheres. He pulled the hemispheres apart with bare hands. This experiment demonstrated that when the hemisphere became a vacuum, the atmospheric pressure of each hemisphere equaled to the pulling force of 8 horses.

- Relationship between temperature and volume under pressure

- Pressure (P) is the force (F) on per unit area (A). It can be expressed as $P = \frac{F}{A}$.
- Charles' law is constant-pressure change: $\frac{V_1}{V_2} = \frac{T_1}{T_2}$ (V is gas volume and T is temperature)
- Boyle's law is isothermal change: $P_1V_1 = P_2V_2 = PV = const$ (P is gas pressure)
- Gay-Lussac law is isochoric change: $\frac{P_1}{P_2} = \frac{T_1}{T_2}$
- Ideal gas equation is: $PV = nRT$ (n is number of moles and R is the ideal gas constant)

Instruments

Instrument list					
No.	**Accessory**	**Qty**	**No.**	**Accessory**	**Qty**
1	Vacuum pressure cabin	**1**	**2**	Pump	**1**
3	Magdeburg hemisphere	**1**	**4**	Pump connector	**1**
5	Sound generator	**1**	**6**	Thermometer	**1**
7	Tube	**2**	**8**	Balloon piston	**1**
9	Balloon	**1**			

Instrument picture		
1. Vacuum pressure cabin	**2. Pump**	**3. Magdeburg hemisphere**
		
4. Pump connector	**5.Sound generator**	**6. Thermometer**
		
7. Tube	**8. Balloon piston**	**9. Balloon**
		

Procedure

1. Observation of increasing pressure

a. The experimental setup is shown as **Figure 3-1**. Use the tube to connect the valve and the manometer on the vacuum pressurized cabin. Close the valve to keep the reading of manometer zero.

Figure 3-1 Pressure increasing device

b. Use another tube to connect the valve and the vent of pump, as shown in **Figure 3-2**.

Figure 3-2 Vent of the pump

c. Switch on the valve and pull the pump. Observe the reading on the manometer.

2. **Observation of decreasing pressure**

a. Set up the experiment as Experiment 1. Use the tube to connect the valve and the manometer on the vacuum pressurized cabin. Close the valve to keep the reading on manometer zero.

b. Use another tube to connect the valve and the vent of pump, as shown in **Figure 3-3**.

Figure 3-3 Suction of pump

c. Switch on the valve and pull the pump. Observe the reading on the manometer.

3. **Relationship between pressure and volume in the tube**

a. Set up the experiment as Experiment 1. Use the tube to connect the valve and the manometer on the vacuum pressurized cabin. Close the valve to keep the reading on manometer zero.

b. Pull the piston of the pump to the button and then use another tube to connect the valve and the vent of pump, as shown in **Figure 3-4**.

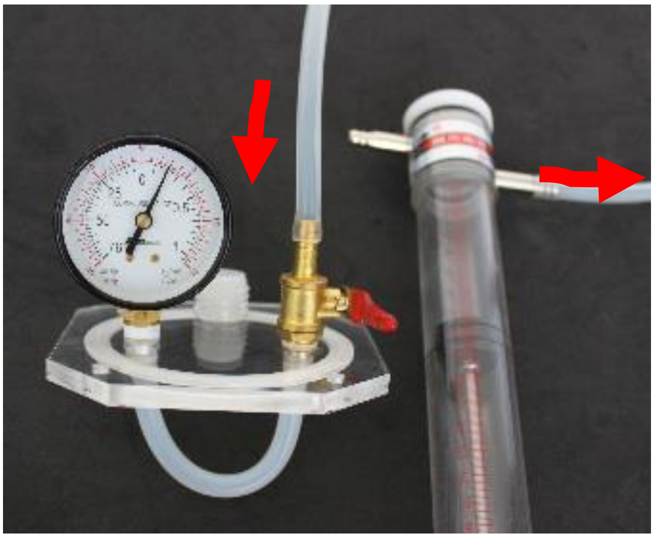


Figure 3-4 Pressure increasing device

c. Push the piston. Compare whether the volume in the tube is inversely proportional to the reading on the manometer

d. When pushing the piston to the end, the air volume in the tube is at its minimum. Reset the manometer and connect the valve to the suction, as shown in **Figure 3-5**.

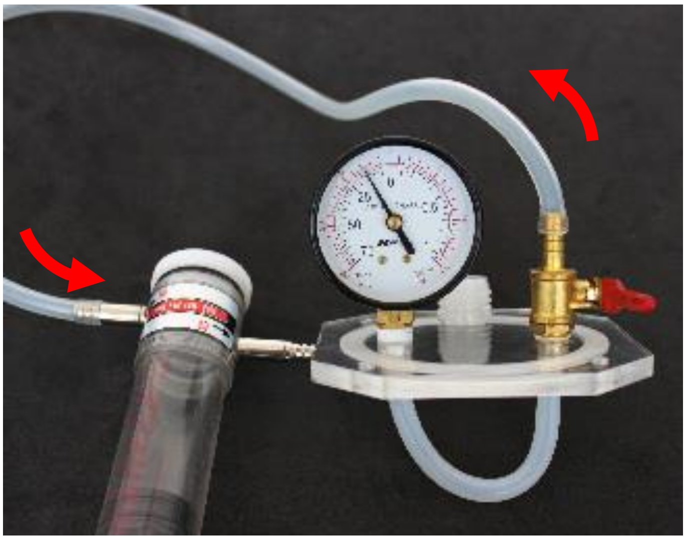


Figure 3-5 Pressure decreasing device

e. Pull the piston to observe whether the air volume in the tube is inversely proportional to the reading on the manometer.

4. Relationship of pressure and temperature in vacuum pressurized cabin

a. The experimental setup is shown in **Figure 3-6**. Fix the four knobs on the vacuum pressurized cabin. Turn off the valve when resetting the manometer. Connect the tube to the pump.

Figure 3-6 Vacuum pressurized cabin

b. Connect the tube to the vent and push the piston to increase pressure. Observe whether the temperature is directly proportional to increasing pressure.

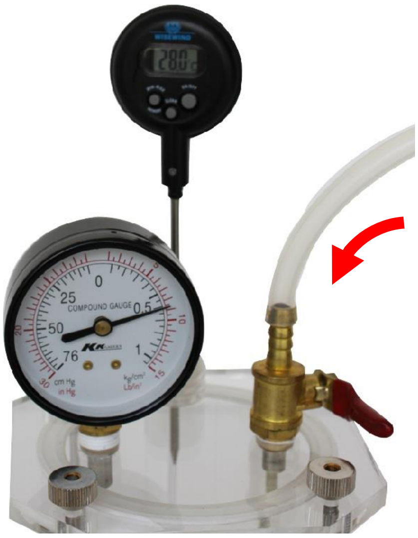


Figure 3-7 Relationship between pressure and temperature