Graham’s Law of Effusion

**Description:** With knowledge of the kinetic-molecular theory of gases, predictions can be made on relative rates of diffusion between H$_2$ and N$_2$ or between CO$_2$ and N$_2$.

**Materials:**

- H$_2$ diffusion apparatus (Dab 114)
- 400 mL beaker
- H$_2$ filled balloon
- Ring stand
- Dry Ice
- Clamps

**Procedure:**

For larger lecture halls, project demonstration using document camera.

1. Set up the apparatus as shown below. First, show that no change occurs when the beaker (filled with air) is placed over the porous cup. Carefully fill a balloon with H$_2$ gas. Invert a beaker and displace the air with H$_2$ by releasing the gas from the balloon into the beaker. Quickly place the inverted beaker over the porous cup and note the pressure change which can be observed by the ejection of water from the apparatus.

2. The reverse observation is made when the air in the beaker is displaced by CO$_2$ gas from the sublimation of dry ice. When placed over the porous cup, air should be sucked into the apparatus causing bubbling to occur inside the bottle.
Discussion: According to the kinetic-molecular theory of gases, when the beaker filled with $\text{H}_2$ is placed over the porous cup, the pressure inside the cup should increase. This occurs because the $\text{H}_2$ molecules move inside the cup faster than the $\text{N}_2$ molecules can diffuse out of the cup. The pressure increase is relieved by the expulsion of water from the bottle. When the beaker is removed, the $\text{H}_2$ molecules move out of the cup faster than the outside air molecules (mostly $\text{N}_2$) can move back inside the cup causing a temporary decrease in pressure inside the cup. This draws water back inside the bottle. The same effect is observed (decrease in pressure inside the cup) when the beaker is filled with $\text{CO}_2$ and is placed over the ceramic cup.

Safety: As water is ejected in this demonstration, keep setup a considerable distance from electronic equipment. Wear insulating gloves when handling solid $\text{CO}_2$. Keep hydrogen gas away from any open flames or sparks as it is explosive.

References:


Video:

http://genchem.chem.wisc.edu/demonstrations/Gen_Chem_Pages/05gasespage/gases.htm