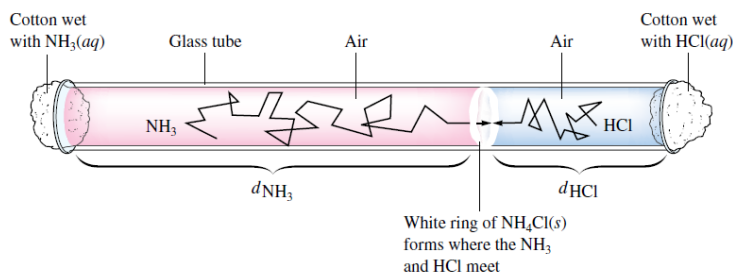
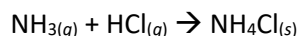


Objective: Students will apply Graham's Law to calculate the velocity of two gases, ammonia (NH_3) and hydrochloric acid (HCl), and predict the meeting point of the gases along a given length of glass tubing when the gases are set at opposite ends. Then students will perform the experiment to determine the percent error of the process.

Background information: Diffusion is frequently illustrated by the lecture demonstration represented in which two cotton plugs soaked in ammonia and hydrochloric acid are simultaneously placed at the ends of a long glass tube. A white ring of ammonium chloride (NH_4Cl) forms where the NH_3 and HCl molecules meet several minutes later according to the equation and illustration below:



Materials: Cotton balls, forceps, 6 M HCl solution, 6 M NH_3 solution, glass tube of undetermined length, meter stick, wax pencil, timer

Method and Observations: Prior to experimentation, students will need to determine the total length of the glass tubing that will be used. If the tubing is broken at the end, the length should be determined from the shortest ends, as that will be the point at which the cotton balls will be placed. Using the distance measured, determine the root mean square of the velocity of the two gases to determine the meeting place of the gases. Using a wax pencil, place a small mark on the outer surface of the glass tube where the gases should meet. Once that has been determined, use a forceps to soak one end of a cotton ball in NH_3 and another forceps to soak the other cotton ball in HCl , being careful not to inhale the fumes or expose the skin to the liquids. If liquid does get onto the skin, quickly dilute with lots of water. Place the cotton balls with the liquid facing inward in opposite ends of the glass tube **AT THE SAME TIME** and do not disturb the tube thereafter. Start your timer as both are secured into the tube. In the area below, show all of your calculations and observations for the experiment, including a measurement of where the gases actually met and a recording of your error to determine the % error.

Calculations and Results:

Length of glass tubing (from closest edge of glass, if broken at an angle): _____ cm

Root mean square velocity of NH₃ at room temperature:

Root mean square velocity of HCl at room temperature:

Calculated meeting place of the two gases (cm):

Using masses from the periodic table rounded to 0.1 g, calculate the ratio of velocity of the gases (Graham's Law). This is your **theoretical ratio**:

Time elapsed to meeting place of the gases:

Distance NH₃ traveled:

Distance HCl traveled:

Using your time and distance, calculate the ratio of the velocities. This is your **experimental ratio**:

Calculate the percent error of your data:

$$[\text{Percent error} = (\text{Theoretical ratio} - \text{Experimental ratio}) / \text{Theoretical ratio} \times 100\%]$$

Conclusion questions:

Would changing the temperature of the system change the diffusion rates? Why or why not?

Would changing the temperature of the system change the ratio of the diffusion rates (i.e. Graham's Law)? Why or why not?

List and discuss TWO factors that may explain why the gases did not meet where you calculated