

Graham's Law of Diffusion

Two gases enter, one solid leaves

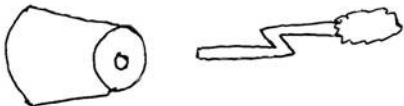

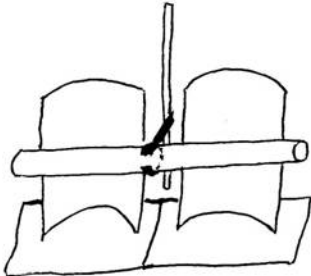
Chemicals and Equipment Needed

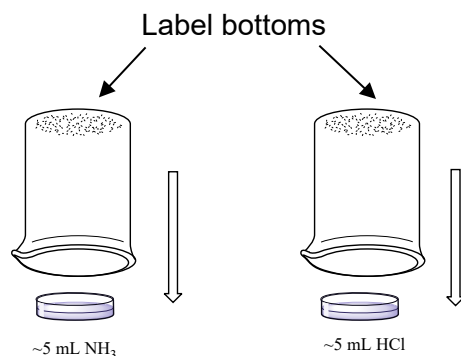
- Concentrated HCl – **K1**
- Concentrated NH₃ – **S2**
- Short ringstand with buret clamp – **J**
- Long glass tube (2.2 cm x 50 cm) – **P5**
- 2 black backgrounds – **A1**
- 2 *teeny tiny* glass petri dishes – **P3**
- 2 *teeny tiny* watch glasses – **P3**
 - To fit on top of petri dishes
- 2-600 mL tall beakers (**w/o spout**) – **Q2**
- 2- #3 stoppers with hole – **U3**
- 2 Q-tips with plastic sticks – **U1**
- 2 Weighboats – **A3**
- Gloves – **U2**

Hazards

- Concentrated HCl and concentrated NH₃ are extremely caustic. The fumes from either can cause respiratory issues. Always handle these chemicals while wearing gloves and a lab coat, and in a fume hood or next to an in-bench/downdraft hood.
- If skin exposure occurs, flush the affected area with water for 10-15 minutes and seek medical attention as needed.

Preparation

- To mount the Q-tips in the stoppers- Cut off one cotton tip, then bend the swab in two places to make a "Z" bend near the middle of the stick:
- Push the stick into the smaller end of the stopper, squeezing the "Z" to force it into the hole. When you are finished, only the tip should be showing, projecting ~5 mm:
- Mount the buret clamp on the ringstand then mount the glass tube horizontally in the clamp. Place the black backgrounds behind the tube to either side of the clamp:
- Place a prepared stopper in each weigh boat. Label one watch glass **conc. NH₃** and the other **conc. HCl**
- On delivery, place one stopper and one petri dish to either end of the tube. While wearing gloves, and with the in-bench hood on, pour ~5 mL concentrated ammonia into one glass petri dish. Cover with the appropriate watch glass and invert the 600 mL beaker over the watchglass-covered petri dish. Repeat for the concentrated HCl.



The beakers to use
don't have spouts

Presentation

- While wearing gloves, remove the beakers from the dishes of concentrated reagents. Quickly and simultaneously, remove the watch glasses, dip one Q-tip in each reagent, and insert a stopper in each end of the tube. Replace the watch glasses and beakers.
- Graham's Law:

$$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$$

- The molecular masses of NH_3 and HCl are 17.0 and 36.5, respectively. Because NH_3 is lighter, the ammonia molecules move faster down the tube before meeting the HCl molecules to form a ring of NH_4Cl (s). The distances travelled by the two gases can be qualitatively or quantitatively related to Graham's Law of Diffusion.
- This reaction is not instantaneous. It does take some time for the gases to travel the length of the tube. You will also see ridges of white where the reaction has occurred at different times because of the distribution of speeds in each gas.

Clean-Up

- Place the entire apparatus and the beakers of HCl and NH_3 in the hood. While wearing gloves, carefully remove the stoppers from the tube. Rinse the Q-tips thoroughly and dispose in trash. Fill the 600 mL beakers with water and, in the hood, carefully pour the remaining concentrated ammonia into one beaker, the concentrated HCl into the other, rinsing out the petri dishes, then pour the diluted acids and bases down the sink with plenty of running water.
- Tagline courtesy of Zechariah D. A. H. F. Thompson, PhD (expected 2020)

NOTES

- You have to use the Q-tips/cotton swabs with plastic sticks. The cardboard ones just break.