CALIFORNIA STATE SCIENCE FAIR
2010 PROJECT SUMMARY

Name(s)

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Project Number

S1916

Project Title

The Effect of Molecular Mass on the Abruptness of the Vertical Interface Between Different Density Gases

Abstract

Objectives/Goals

The purpose of this experiment was to determine whether the abruptness of the vertical boundary between two gases with different densities is more dependent on the ratio of the densities or the magnitude of the densities of the two gases. Interfaces investigated were carbon dioxide to air and helium to air.

Methods/Materials

A plastic bag inside a plastic container was filled with the test gas. Container was upright for carbon dioxide, inverted for helium. Bag was opened to create interface with air and the gas density was measured as a function of vertical position and time. Gas density revealed percentage of each gas in the mixture at that point of the interface. Gas density was determined by measuring the speed of sound using the resonant frequency of an open pipe to determine this. The resonant frequency was measured by sweeping tone frequency into headphones held near an open plastic pipe and monitoring sound intensity with a microphone placed at the midpoint of the pipe. Concentrations measured in 12.7 cm increments from deepest point in container (0 cm) to mouth of the container (63.5 cm). Measurements conducted over 1300 seconds.

Results

The percentage of the test gas in air was recorded by position and time. The highest rate of change for helium was 1.7% per cm. The highest rate of change for carbon dioxide was 4.6% per cm. The helium concentration decreased to 50% at 0 cm at 1200 seconds and increased to 15% at 50.8 cm. The carbon dioxide concentration stayed near 100% up to the 12.7 cm point and near 0% above the 50.8 cm point for the duration of the experiment.

Conclusions/Discussion

The hypothesis was that more dense gases would maintain a more abrupt interface than less dense gases, even if the ratio of densities was smaller. The data supported this hypothesis. The densities of helium, air and carbon dioxide at STP are 0.1664 g/L, 1.205 g/L, and 1.842 g/L respectively. For helium to air, the ratio is 7.24 and for carbon dioxide to air, the ratio is 1.53. The steepest point of the carbon dioxide to air interface was almost three times steeper than the steepest point for helium. The flow of helium across the interface was also shown by the decrease in concentration over time deep in the container and the increase near the opening. The carbon dioxide concentration stayed near 100% deep in the container and 0% near the opening, showing much less flow across the interface.

Summary Statement

This project evaluates whether the ratio of gas densities or the magnitude of gas densities is more important in the balance between buoyancy and diffusion in maintaining a vertical interface between different density gases.

Help Received

Father helped with construction and some graphs