Understanding the Invisible: Parts per Million

Parts Per Million
Many scientific measurements of liquids or gases use the unit “parts per million” (ppm). This unit is a way of understanding what percentage of a mixture is composed of the element or compound you are studying. For example: if we have one million molecules of a mixture of carbon dioxide, nitrogen, and oxygen and 200 of those molecules are oxygen molecules, then your mixture is 200ppm oxygen.

Since we cannot see ppm, how can we better understand this type of unit in a way we can sense? By using a gas that we can smell.

This activity can either be performed in a large group or with a small set of friends. Observations may be discussed or recorded in a science journal.

Materials: A room where you are allowed to change the room’s odor, a stopwatch or clock with a second hand, a gas (or rapidly vaporizing liquid) with a strong odor that is non-toxic to breathe, e.g. a cheap perfume. Do not conduct this activity unless you are certain that the material and concentration you will be using are safe! If you are under 18, ask an adult for help. We recommend using an inexpensive perfume.

Steps:
1. Close the doors and windows of your room. Calculate the volume of the room you are in using the unit cubic meters.

2. Record the volume of perfume (or other liquid/gas) you will be using for the experiment. If you are using a liquid, you may need to determine this number at the end of your experiment by subtracting remaining fluid from the amount of fluid you started with. (The missing amount of fluid will be the amount that has vaporized.) Weight is a good way to do this.

3. Without doing a complete calculation, make some guesses: what do you think the ratio of normal air to perfume will be after 10 minutes? How long to you think it will take for the perfume to spread to the farthest side of the room?

4. Have one person hold the bottle of perfume while the others spread out to different distances in the room. Once all participants have taken their places, everyone except for the person holding the perfume (the recorder) should close their eyes.

5. Without announcing when the experiment has begun, the recorder should spray some perfume into the air or open then container holding the non-toxic gas.
Steps continued:

6. As each participant is able to smell the perfume, he or she should raise a hand. Once a person has raised his or her hands, he (she) may then open his (her) eyes. As soon as a person raises a hand, the recorder writes down the time and that person’s name.

7. Once everyone’s eyes are open, the recorder should announce how long it took the odor (in other words, the perfume) to reach each person. Was the diffusion faster or slower than you expected? Record your observations in your science journal.

8. Based on the volume of the room, calculate the ratio of regular air to perfume. Be sure to record all observations and calculations. Convert this ratio into parts per million (e.g., the volume of air becomes 1 million cm^{2}). Now you know what that number of ppm smells like!

Further Resources