Teaching Activity: Understanding PPM/PPB and Gas Concentrations

Introduction: An atmospheric chemist studying the constituents of the Earth's atmosphere is dealing with very tiny amounts of molecules within a huge sample of air. The results of a study of this type are generally expressed in either parts *per million (ppm)* or *parts per billion (ppb).* For example, a notation of 350 ppm of water vapor means that for every 1 million parts of air studied, 350 of them are water vapor. A notation of 50 ppb of lead means that for every 1 billion parts of air studied, 50 of those parts are lead. A part of a million or a part of a billion is s difficult concept to visualize. The activity that follows offers some help in forming a visualization of what a million or a billion parts of anything would be equal to and how these measurements are applied to greenhouse gas concentrations in the atmosphere.

Objective:

- To illustrate ppm and ppb concentration levels;
- To correlate those concentrations to the amount of greenhouse gases in the environment;

Important Terms: Concentration, parts per million, parts per billion;

Materials: Ice cube tray, 2 small cups of water, medicine dropper, 10 drops of food coloring, marker, paper/pencil;

Procedure:

1. Instruct students to number the cells in their ice cube tray from 1-10.

2. In cell #1, they should place 10 drops of food coloring and no water.

3. Instruct students to take 1 drop of the liquid in cell #1 and transfer it to cell #2.

4. Students should clean the dropper and use the clean water to add 9 drops of water to cell #2. They should then stir the mixture.

5. Students should then take one drop from cell #2 and transfer it to cell #3. They should clean the dropper, add 9 drops of water to cell # 3 and stir the mixture.

6. Students should repeat this procedure for cells #4 through #10.

7. Students should then complete the activities in the **Analysis and Comprehension** section.

Student Activity Sheet: Understanding PPM/PPB and Gas Concentrations

Introduction: An atmospheric chemist studying the constituents of the Earth's atmosphere is dealing with very tiny amounts of molecules within a huge sample of air. The results of a study of this type are generally expressed in either parts *per million (ppm)* or *parts per billion (ppb).* For example, a notation of 350 ppm of water vapor means that for every 1 million parts of air studied, 350 of them are water vapor. A notation of 50 ppb of lead means that for every 1 billion parts of air studied, 50 of those parts are lead. A part of a million or a part of a billion is s difficult concept to visualize. The activity that follows offers some help in forming a visualization of what a million or a billion parts of anything would be equal to and how these measurements are applied to greenhouse gas concentrations in the atmosphere.

Objective:

- To illustrate ppm and ppb concentration levels;
- To correlate those concentrations to the amount of greenhouse gases in the environment;

Procedure:

1. Take your ice cube tray and number the cells 1-10 with the marker.

2. In cell #1, place 10 drops of food coloring.

3. Take 1 drop of the food coloring from cell #1 and transfer it to cell #2.

4. Clean the dropper and use the clean dropper to add 9 drops of water to cell #2. Stir the mixture.

5. Take one drop of the mixture from cell #2 and transfer it to cell #3. Clean the dropper and add 9 drops of water to cell #3. Stir the mixture.

6. Repeat this procedure for cells #4 through #10.
   Remember to clean the dropper between uses!!!

7. Complete the activities in the **Analysis and Comprehension** section.

Student Activity Sheet #1: Understanding PPM/PPB and Gas Concentrations

Part I: Analysis and Comprehension

1. Record the color of the contents of each cell in the Data Table (Part II).

2. In which cell is the color most intense? _____ Why? _____
_____
_____

3. In which cell is the color least intense? _____ Why? _____
_____
_____
_____

4. a. Are there any cells where the liquid is colorless? _____

   b. Is their any food coloring in these cells? _____

   c. How do you know? _____

5. Cell #1 contains food coloring and no water added. What is the percent concentration of the food coloring in cell #1?_____

6. One hundred percent (100%) can be written 100/100. Complete the following fraction so that both side are equal: 100/100 = _____/1,000,000.

7. The concentration of food coloring in cell #1 is 1,000,000 ppm or 1 millions parts per million. The concentration in cell #2 is 100,000 ppm. Using this information, complete the ppm row of the Data Table.

8. Earth's atmosphere contains 78% nitrogen (N) and 21% oxygen (O). Write these percentages as concentrations in ppm:
   78% = _____ / 100 = _____ /1,000,000 = _____ ppm
   21% = _____ / 100 = _____ / 1,000,000 = _____ ppm

9. Which of the cells is closest in concentration in ppm for nitrogen? _____
   Which of the cells is closest in concentration for oxygen? _____

10. Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and CFCs are gases which affect the temperature of the Earth's atmosphere. Their concentrations are listed below. Which of the cells of food coloring is closest in concentration to the concentration of each gas?

GAS	CONCENTRATION	CELL #
CO_2	355ppm = _____ ppb	
CH_4	1.7 ppm = _____ ppb	
N_2O	0.3 ppm= _____ ppb	
CFC-11	.0003 ppm = _____ ppb	
CFC-12	.0005 ppm = _____ ppb	

11. How does the concentration of the greenhouse gases compare to the concentration of nitrogen and oxygen? _____

_____

12. How can gases such as CO_2 and CH_4 have such a large effect on our atmosphere?

_____

_____

_____

13. Illustrate a slice of the atmosphere indicating the concentrations of the various gases. Make a graph, chart, picture or drawing, but represent the gases of the atmosphere in their ppm.

GAS	PPM
N_2	780,000
O_2	210,000
water vapor *	40,000
Argon	10,000
CO_2 *	345
Neon	8
He	5
CH_4 *	1.7
$^{T}O_3$ *	0.01 - 0.5
$^{S}O3$	0.04 - 0.2
Cl from CFCs *	0.035

Student Activity Sheet #2

PART II: DATA TABLE

CELL	1	2	3	4	5	6	7	8	9	10
COLOR										
PPM										