2E One in a Million

Drinking water is allowed to contain up to 1.3 parts per million of copper (by mass) and be considered safe.
What does parts per million (ppm) mean?

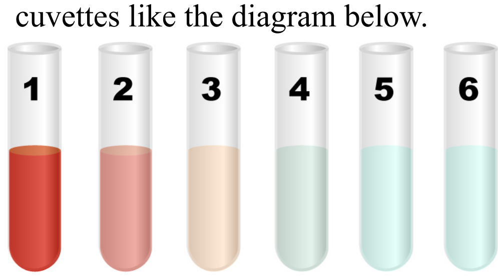
Living things and the environment can be greatly affected by small concentrations of substances. Sometimes the amounts are so small that we use parts per million (ppm) or parts per billion (ppb) to describe them. For example, fish live by extracting oxygen dissolved in water. A fresh water bass thrives when the concentration of dissolved oxygen is above 4 parts per million. In this activity you will make solutions and measure parts per million.

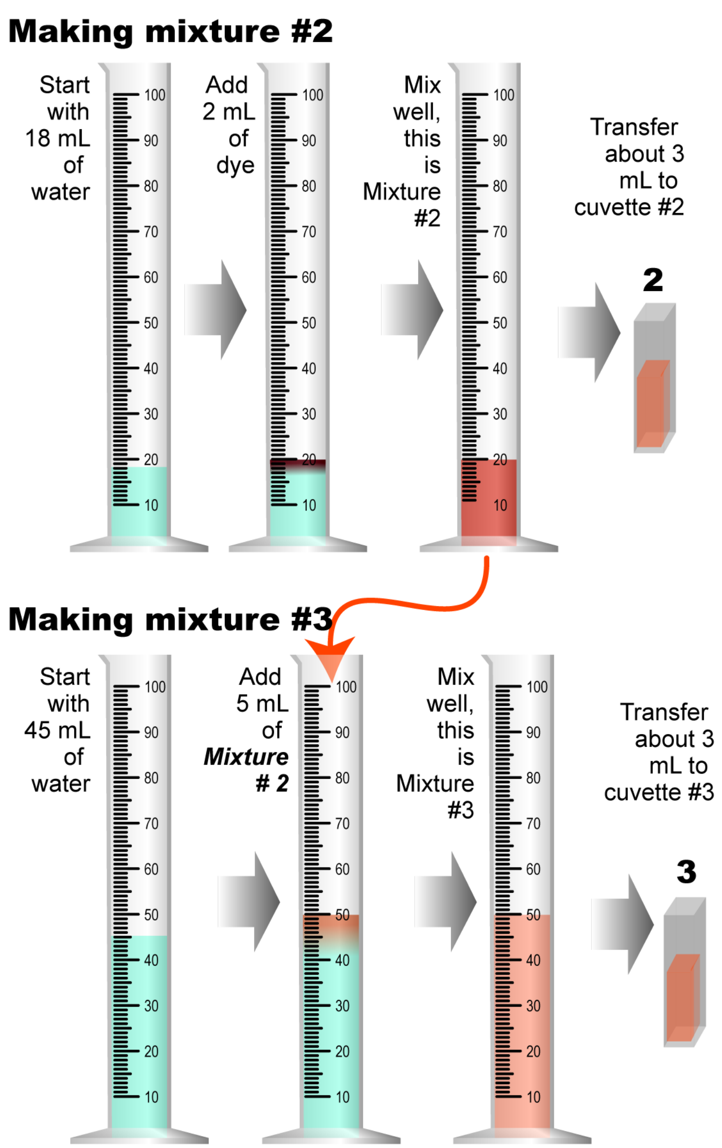
Materials

- 2-3 cuvettes
- 2 100 ml graduated cylinders
- 6 12 mm test tubes
- test tube rack
- Probe system

Part 1: Setting up

1. Mixture #1 is full-strength dye (red, green, or blue). Put 2 mL in a cuvette and measure RGB.
2. To make mixture #2, add 18 mL of water and 2 mL of dye.
3. Put about 10 mL in cuvette #2 and save it for measuring later
4. Make mixture #3 by adding 45 mL of water and 5 mL of <u>mixture 2</u>.
5. Put 3 ml in cuvette #3 and save it for measuring later.
6. Clean out the first graduated cylinder. Make mixture #4 by adding 45 mL of water and 5 mL of <u>mixture #3</u>
7. Save 3 mL in cuvette #4
8. Repeat the process three more times, each time mixing 5 mL of each mixture with 45 mL of water to get the next mixture. You should finish with 6 cuvettes like the diagram below.





Part 2: Observations

a. What can you say about the appearance of the six solutions? How do they compare to each other? Which is lightest? which is darkest? Do any appear the same? Give an answer of 2 or 3 sentences.

b. Do your observations agree with what you expect?

Part 3: Doing the math

Each of the test tubes has a different concentration of dye. In this next step, you are going to calculate the concentration of each one. The tricky part is figuring how much dye there is once you get to #2 and higher.

Use the examples below to calculate:

a. First calculate the volume of dye in each mixture using the concentration of the previous mixture.

b. Use the result of (a) to calculate the concentration of the mixture itself.
Use Table 1 to record your calculations.

Formula **Percent concentration**

$$\underset{\textit{percent by volume}}{\text{concentration}} = \left(\frac{\text{volume of substance}}{\text{total volume}}\right) \times 100\%$$

Example: Mixture #1

$$\frac{5 \text{ mL dye}}{50 \text{ mL mixture}} \times 100\% = 10\%$$

Example: Mixture #2

Volume of dye (substance) = concentration x total volume
= (0.1) x (5 mL)
= 0.5 mL

$$\frac{0.5 \text{ mL dye}}{50 \text{ mL mixture}} \times 100\% = 1\%$$

Formula **Parts per million (ppm)**

$$\underset{\textit{parts per million volume}}{\text{concentration}} = \left(\frac{\text{volume of substance}}{\text{total volume}}\right) \times 1{,}000{,}000$$

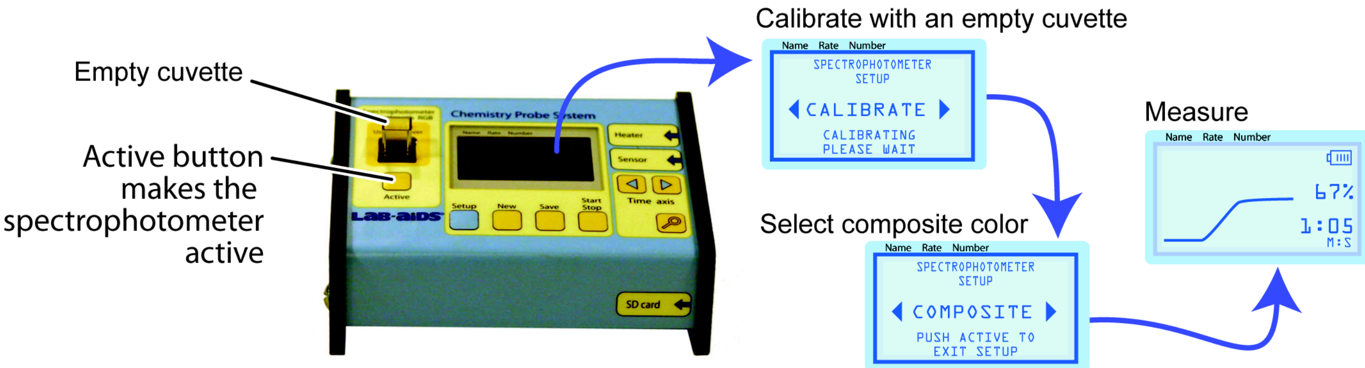
Example: Mixture #2

$$\frac{0.5 \text{ mL dye}}{50 \text{ mL mixture}} \times 1{,}000{,}000 = 10{,}000$$

Table 1: Concentration data

Test Tube #	Vol. of dye (mL)	Total Vol. (mL)	Concentration %	parts per million
1	5	50	10	100,000
2	0.5	50		
3		50		
4		50		
5		50		
6		50		

Part 4: The Chemistry Probe System



1. Turn on the probe system
2. Push the ACTIVE button to activate the spectrophotometer
3. Put about 3 mL of clear water in a cuvette.
4. Put the cuvette in the spectrophotometer and select CAL. Wait for the calibration to be finished.
5. Select RGB and then press ACTIVE again to make the spectrophotometer work.
6. Put 3 mL from test tube #1 into a cuvette and put it in the spectrophotometer.
7. Record the reading from each mixture 1-6, cleaning out the cuvette each time. Record your data in Table 2, along with concentration data from Table 1.

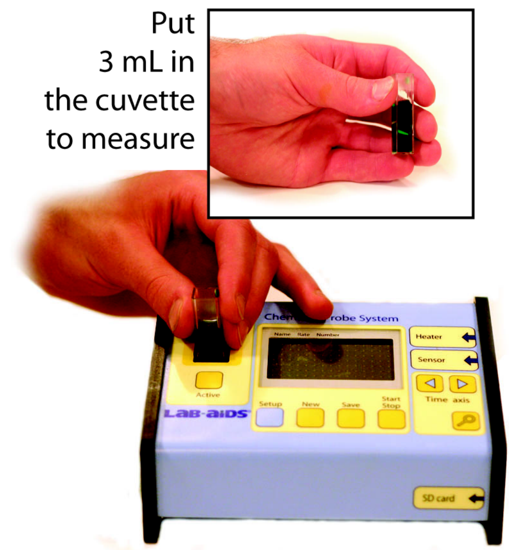


Table 2: Spectrophotometer data

Cuvette #	Concentration %	parts per million	R	G	B
1					
2					
3					
4					
5					
6					

Part 5: Thinking about what you observed

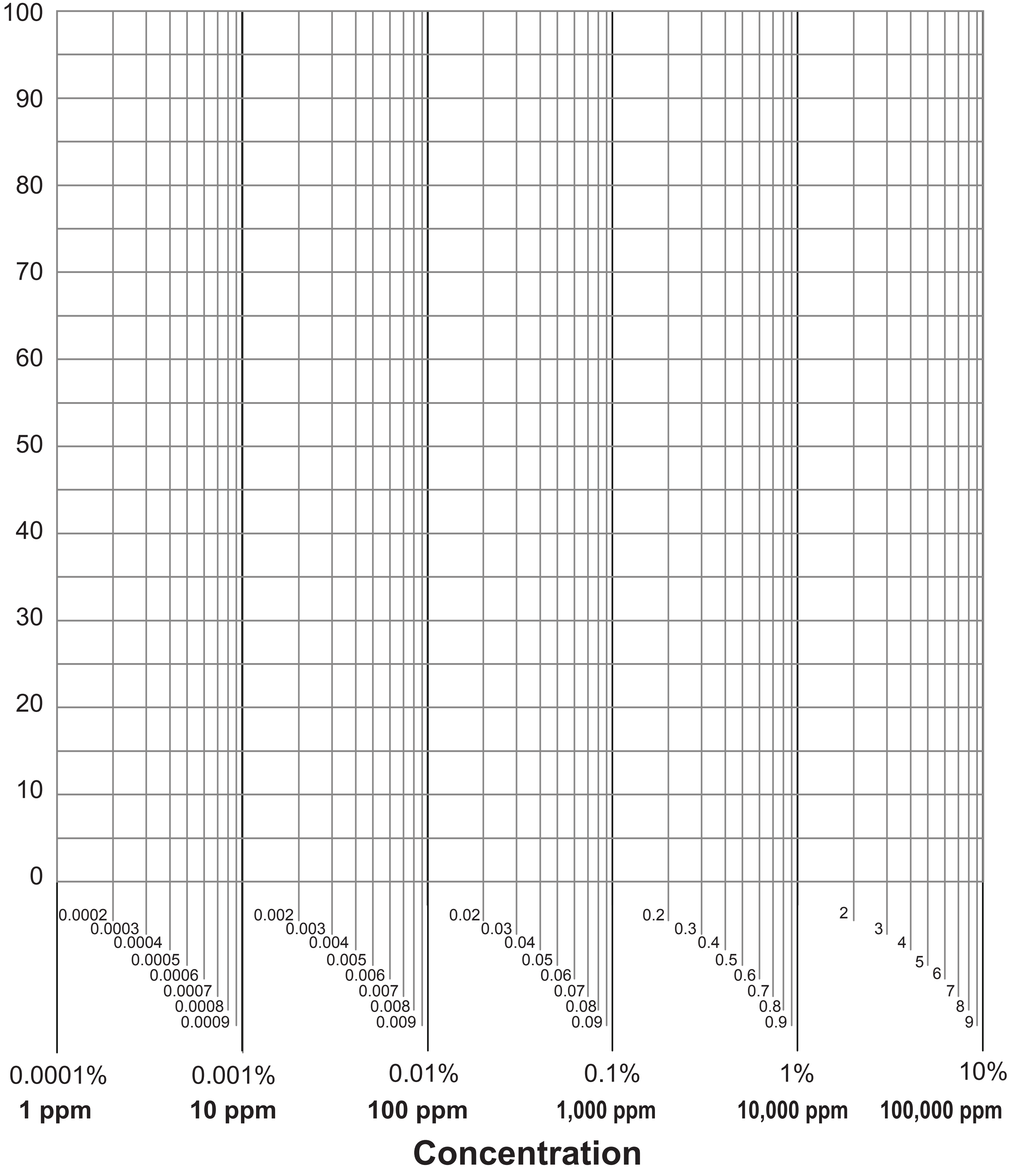
a. What does the spectrophotometer measure?

b. How low a concentration of dye is visible to the eye? This is called the limit of detection by eye.

c. How low a concentration of dye is detectable to the spectrophotometer? What is the limit of detection by instrument?

d. Can you suggest a way to detect a dye concentration of 1 part in 10 million?

RGB Values vs Concentration



13A Acids and bases

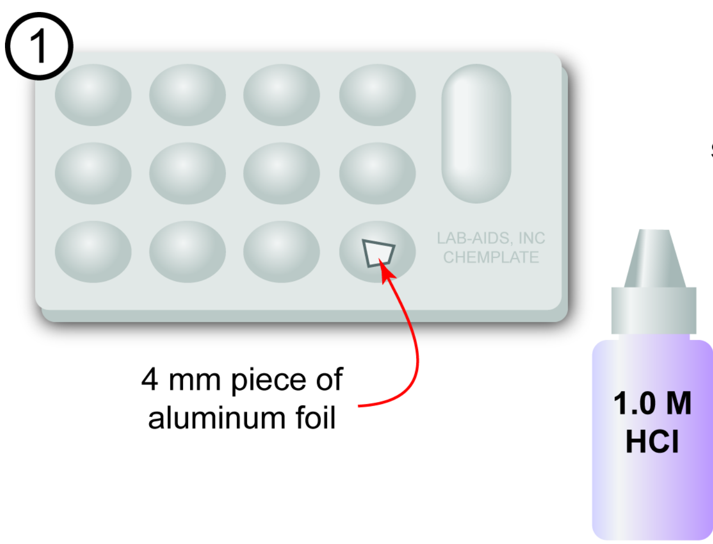
Why do acids do?

Acids are a very important class of solutions in chemistry. Some, like lemonade, are harmless enough to drink! Others, like hydrochloric acid can give you severe burns if they touch your skin. In this investigation you will learn what acids do and how you can make a dangerous solution completely harmless.

Materials

- Lab Aids Chemplate
- 30 mL small graduated cylinders
- Calcium carbonate chips
- Aluminum foil
- 6 M Hydrochloric acid
- Red litmus paper
- Blue litmus paper
- Milk of Magnesia
- 1.0 M Hydrochloric acid solution

Part 1: A first look



CAUTION

HCl is a strong acid that can burn skin, eyes, and the inside of your nose.

DO NOT get on fingers or clothes

WEAR safety glasses

PUT the acid ONLY in the Chemplate a few drops at a time

1. Put a very small, flat piece of aluminum foil (no more than 3 mm square) in cavity #1 of the Chemplate.
2. Put one piece of Calcium carbonate in cavity #2 of the Chemplate.
3. Add several drops of 6 M Hydrochloric acid solution to these two cavities.
4. Watch the reaction for at least 5 minutes. It usually looks pretty boring until the oxids coating on the aluminum is eaten away by the acid. DO NOT DRIP ACID ON YOUR CLOTHES, SKIN, OR ANY PLACE BESIDES IN THE CHEMPLATE WELL!

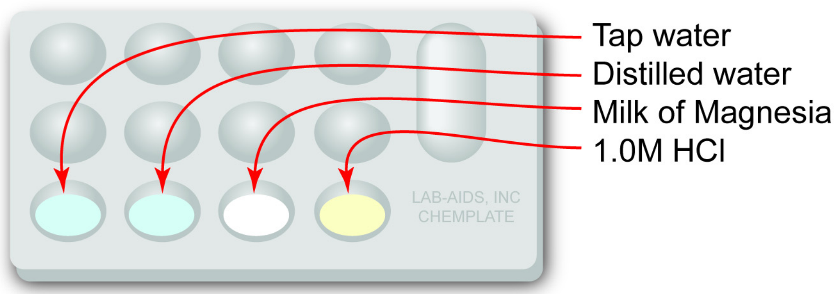
Part 2: What happens?

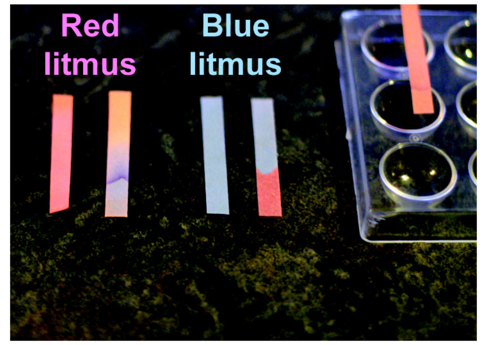
a. What happened to the aluminum?

b. What happened to the limestone?

c. Can you write a chemical reaction for both?

Part 3: A test for acid





Test each solution with both red and blue litmus

4. Rinse and dry the Chemplate.
5. Put distilled water, tap water, 1.0 M HCl, and Milk of Magnesia (MgOH) in the Chemplate as shown in Table 1 below.
6. Dip a different strip of red litmus paper into each solution, then take it out. Watch for any color changes.
7. Dip a different strip of blue litmus paper into each solution, then take it out. Record your results in Table 1.

Table 1: Testing litmus paper

Cavity #	Does red litmus paper change?	Does blue litmus paper change?
distilled water		
tap water		
1.0M HCl		
MgOH		

Part 4: What does this mean?

a. Which litmus paper do you use to tell if a solution is acidic?

b. Which litmus paper do you use to tell if a solution is basic? (MgOH (aq) is a base.)

c. How can you prove that a solution is neutral (neither acidic nor basic)?

d. Is your tap water acidic, basic, or neutral?

Part 5: You try it

1. Collect small samples of the liquids in Table 2 below.
2. Choose three other liquids to test and record them in the blank spaces of the table. (You can try different brands of soda or juice, for example.)
3. Use litmus paper to test all of your samples, and record your results.
4. Label your samples and keep them for later.

Table 2: Acid or base characteristics of some common liquids

Substance	Does it turn red litmus paper blue?	Does it turn blue litmus paper red?	Is it acid, base, or neutral?
Tap water			
Bottled water			
Baking soda dissolved in water			
Vinegar			

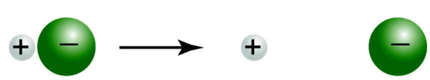
Part 6: Acid base reactions

You will need: scientific calculator

Water (H_2O) has the curious property of coming apart into two ions: H^+ and OH^-. This takes some energy so on average only 1 out of every 10 million water molecules is *dissociated* into H^+ and OH^- ions. However, the H+ ion is a very powerful little beast! It is a single proton, with no electrons. In fact, the H^+ ion is the ONLY time in all of chemistry where a nucleus (proton) participates directly in reactions.

Acids are substances that dissolve in water to create more H^+ ions than there are in neutral water. A base is a substance that dissolves to create more OH^- ions. Now, we know H^+ and OH^- combine to make water (H_2O). That means acids and bases combine to cancel each other out! Here's how it works.

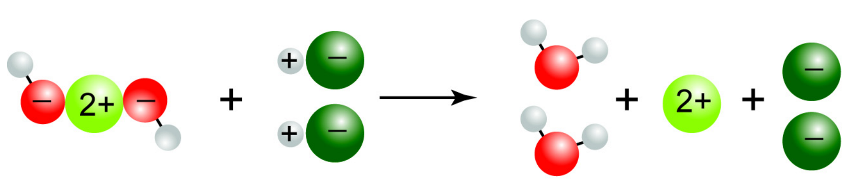
The hydrochloric acid (HCl) dissociates to make H^+ and CL^- ions. HCl is therefore an acid.



$$HCl \rightarrow H^+ + Cl^-$$

Magnesium hydroxide is a virtually insoluble salt in water. Milk of Magnesia is really a suspension of tiny particles of $Mg(OH)_2$ dispersed in water. A tiny fraction of the $Mg(OH)_2$ dissociates to make Mg^{2+} and OH^- ions. MgOH is therefore, a very weak base.

When both are put together, the result is that the H^+ from the acid rips the OH^- away from the magnesium hydroxide to make neutral water. The Mg^{2+} and CL^- ions are both soluble in water, so they stay dissolved. As a result, the cloudy suspension turns into a clear solution!



$$Mg(OH)_2\,(s) + 2HCl\,(aq) \rightarrow 2H_2O\,(l) + Mg^{2+}(aq) + 2Cl^-(aq)$$

Part 7: Calculating a reaction

How much 1M hydrochloric acid do you need to react completely with a teaspoon (5mL) of Milk of Magnesia? This is precisely the reaction that goes on in your stomach when you take Milk of Magnesia.

We do the calculation in three steps

a. Calculate the formula mass of $Mg(OH)_2$ ______________________________

b. On the back of the bottle, find the concentration of $Mg(OH)_2$ in the Milk of Magnesia ___________

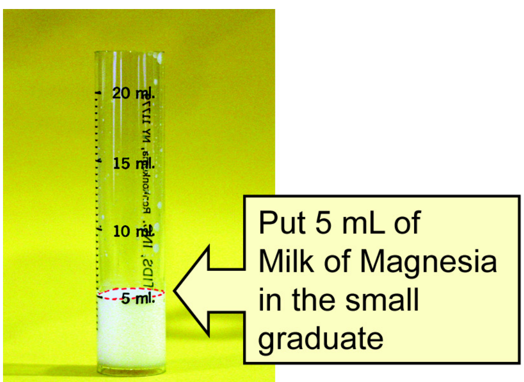
c. How many grams of Mg(OH)2 are in 5 mL? ____________________________

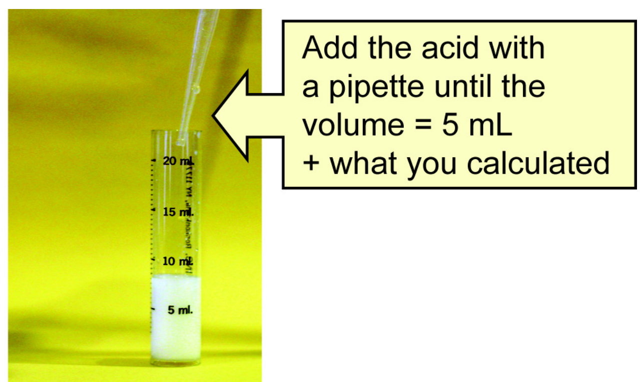
d. How many moles of $Mg(OH)_2$ are in 5 mL? _________________________

e. From the balanced equation, how many moles of HCl do you need? _________________________

f. What volume of 1.0M hydrochloric acid reacts completely with the $Mg(OH)_2$ in 5 mL of Milk of Magnesia? ________________________

Part 8: Do the reaction



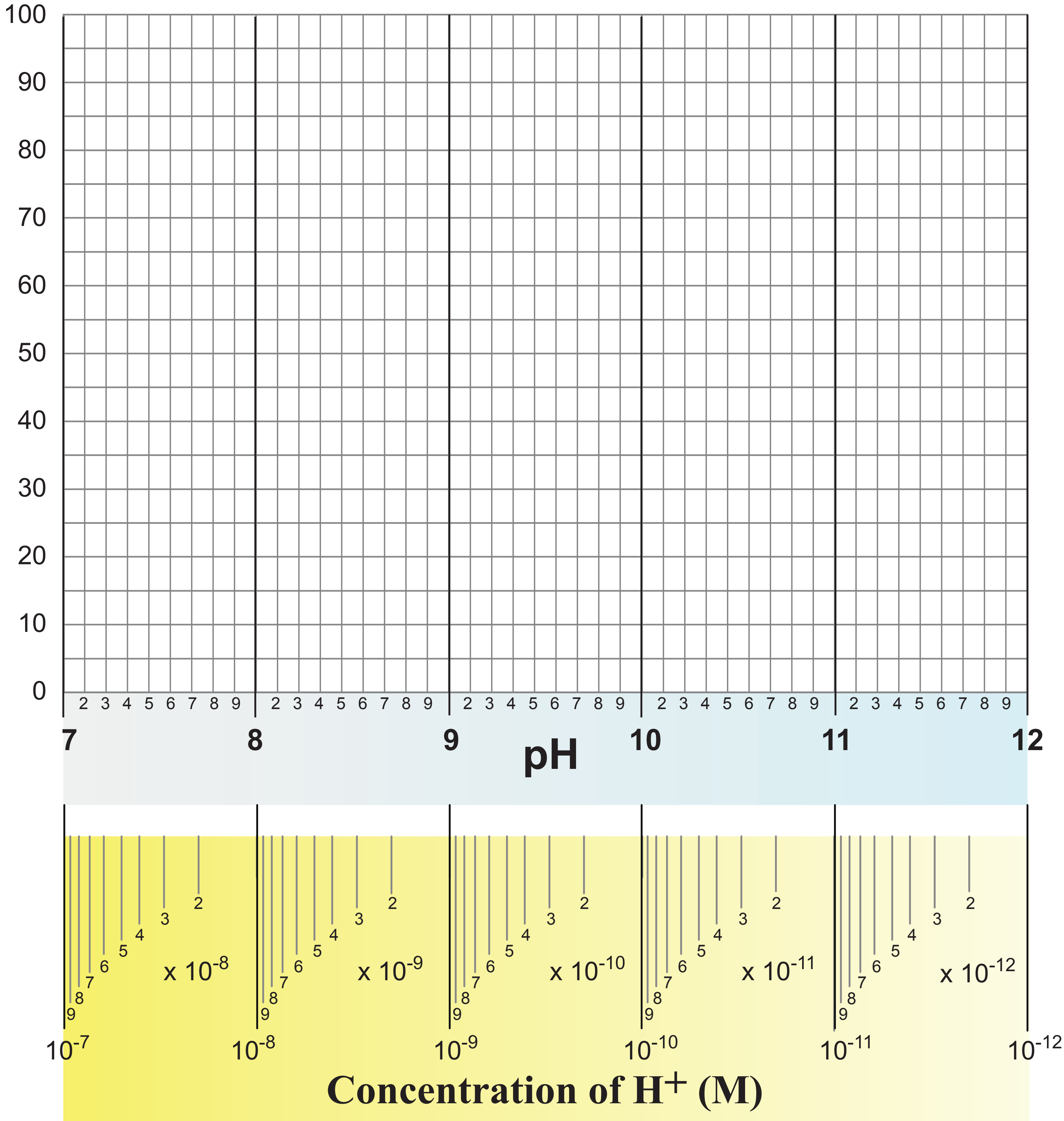


RGB Calibration vs. pH for Bases

A Natural Approach to Chemistry

Indicator ____

Amount per cuvette ______________________________



RGB Calibration vs. pH for Acids

Indicator ______________________________

Amount per cuvette ______________________________