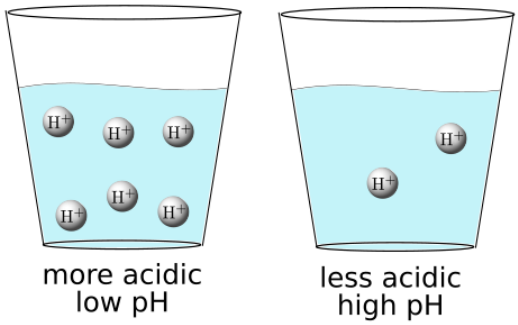
Acids, Bases, and Titration

- **Acids** (eg: vinegar) are chemicals that like to drop hydrogen ions (H+) when dissolved in water.
- **Bases** (eg: baking soda) are chemicals that like to grab extra hydrogen ions (H+) out of solution.
- The **pH** of a **solution** measures how many H+ ions are present
  - Low pH (below 7) means the solution is acidic (lots of H+ ions).
  - High pH (above 7) means the solution is basic (few H+ ions)
  - Neutral pH (at 7) means the solution is neither acidic nor basic.
- A **pH indicator** turns different colors depending on the pH of the solution.
- Baking soda + vinegar makes **carbon dioxide gas** (CO_2) . The more acidic the solution, the more gas can be made.



Part 1: pH Indicator

1. Take a fist-sized piece of purple cabbage. Cut it up into chunks.

2. Put the chunks in a large microwaveable bowl with 2 cups water. Microwave for 2 minutes. Afterwards, let it stand for 2 minutes more

3. Put two teaspoons of the purple cabbage juice into each of 6 wells in the egg carton.

4. Add one teaspoon of each of the substances in the table below, one per well. Fill in the table with the color observed, and your best estimate of of the pH.

Substance	Color	pH estimate
water		
vinegar		
Baking soda ($\frac{1}{4}$ teaspoon)		
Lemon or lime juice		
7-up		
Windex		

List the substances from most acidic to most basic:

Two of the substances have very similar colors (similar acidities). Which two?

Can you think of another substance in your home that might be either acidic or basic?

Substance: _____ predicted acid or base? _____

Make a prediction, then get a sample and test it out in a separate well!

Part 2: Testing pH with a Titration

Mixing an acid with a base can **neutralize** them both – the base soaks up the extra H+ ions from the acid. If you mix in just enough acid to exactly cancel out the base, you will end up with a neutral solution (pH 7). Chemists use this idea to precisely measure and compare pH. **Titration** involves first making a basic solution with a pH indicator mixed in, then slowly adding an acid of unknown pH until the solution changes color. When the color goes back to neutral, you know the acid and the base have exactly neutralized each other. The stronger the unknown acid, the less you have to add to get to neutral!

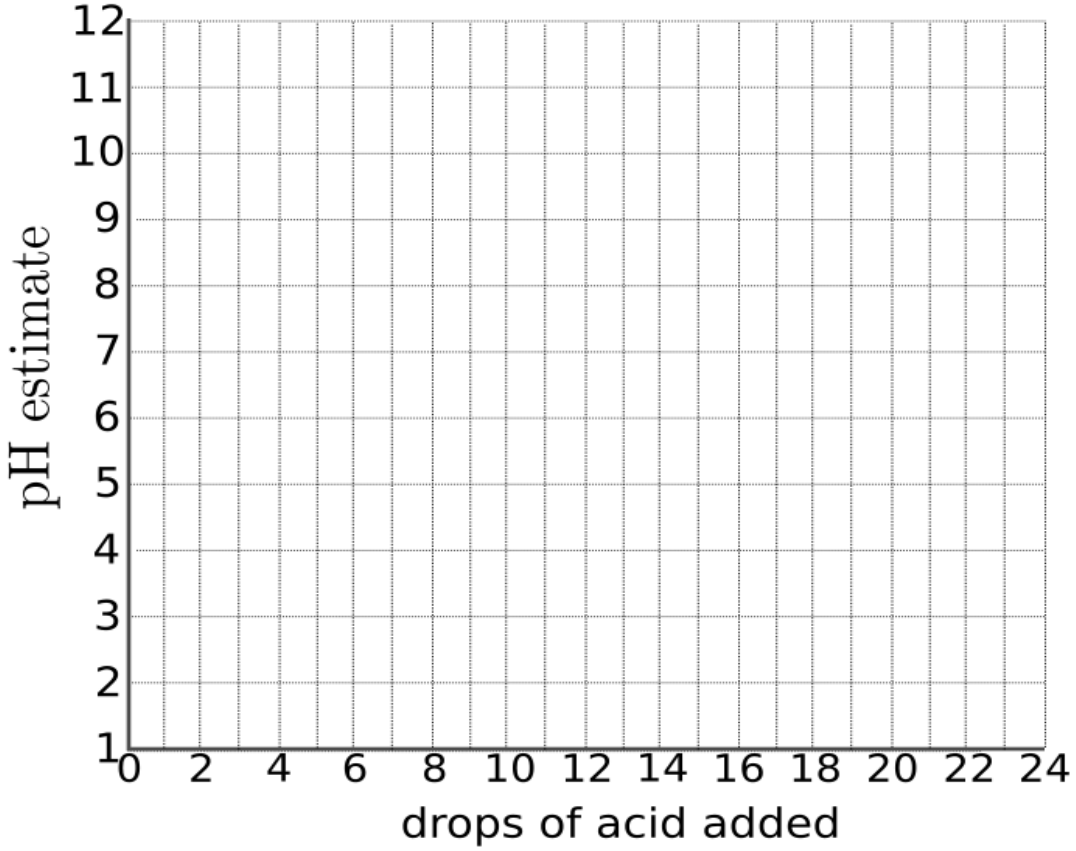
1. Put 3 teaspoons of purple cabbage juice into each of 3 clean wells. Add 1 teaspoon of Windex to two of the wells and mix.

The last well will be your "**negative control**". It lets you see the color of the indicator when nothing is added, for comparison.

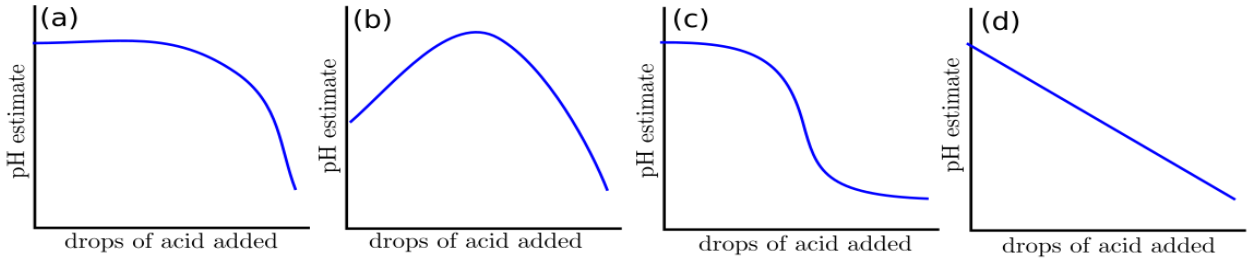
2. Suck up some lemon juice in a pipette. Start adding the juice slowly, one drop at a time to Well #1. Use a clean spoon to stir after each drop you add. Count the drops you add. Whenever you notice the color change enough to correspond to a different pH, write down the number of drops added and the color. Stop when your solution turns the same color as you saw for the lemon juice in Part 1.

Lemon Juice, Well 2			**Vinegar, Well 3**	
# drops added	**pH estimate**		**# drops added**	**pH estimate**
0				

3. Repeat step 2 with vinegar, writing down your results as you add drops one at a time.
4. Use the data in your table to plot points on the graph below. Make the lemon juic points one color and connect them with straight lines. Make the vinegar points another color and connect them with straight lines.



Which of the following graph shapes does your graph look most like?



Approximately how many drops of lemon juice did you need to get a neutral solution?

Approximately how many drops of vinegar did you need to get a neutral solution?

Which of your substances is more acidic (circle one): lemon juice vinegar

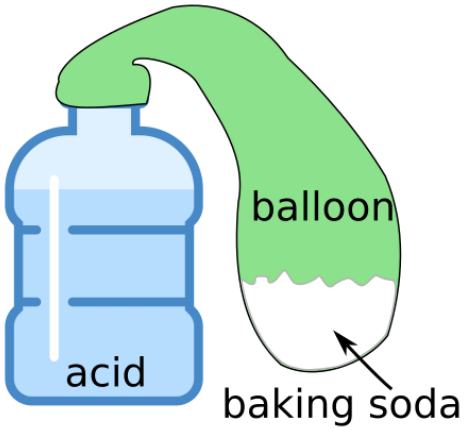
Part 3: Acid-Base Reactions

When an acid and a base are mixed together, their H+ and OH- ions combine to make water. If we use baking soda for the base, the chemical reaction looks like this:

$$\text{acid + baking soda} \longrightarrow \text{water + gas}$$

$$H^+ + HCO_3^- \longrightarrow H_2O + CO_2$$

An acid with lower pH (more acidic) will have more H+ ions and will be able to produce more gas.



1. Label one plastic bottle "vinegar" and one "lemon juice".
2. Add 4 tablespoons of vinegar to one and 4 tablespoons of lemon juice to the other.
3. Put 2 teaspoons of baking soda into each of 2 balloons. A funnel is very helpful here.
4. Attach each balloon to the neck of a bottle, without dropping in the baking soda yet.

Make a prediction:
What will happen to the balloons?

In which bottle will there be more gas produced and why?

5. Lift up the balloon to release the baking soda into the bottle. Swirl the bottle to let the reaction go to completion.

What made the balloons inflate?

Is one of the balloons now bigger than the other? Which one?

Was your prediction correct?