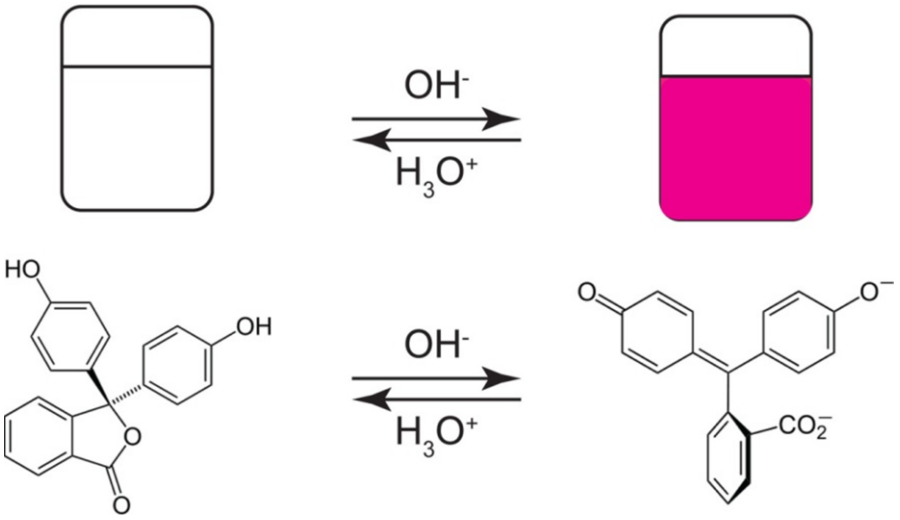
Background

Acid-Base Chemistry offers many fascinating experiments that combine excellent teaching opportunities with fun applications - this experiment is an example of just that. Phenolphthalein, a very common indicator of solution basicity, is colorless under acidic conditions and pink under basic conditions. As demonstrated by the image below, this change occurs due to a hydroxide mediated extraction of a proton (H^+) from the structure on the left to form the structure on the right. This chemical reaction results in an altered electronic structure that absorbs light differently – this is why the basic solution is pink and the acidic solution is not. This experiment addresses **Standards PS-4, and 7.5**. Advanced discussions and applications of this experiment can be used to satisfy **Standard C-4.2**.



Exercise: As written, this chemical equation is not balanced. Have the students determine the products of the reaction. If the students have not seen chemical structures written in this format, it may be useful to rewrite the reaction in linear format:

$$C_{20}H_{14}O_4 + OH^- \rightleftharpoons C_{20}H_{13}O_4^- + \_\_\_\_$$

Balance the reverse reaction:

_____ + _____ ⇌ _____ + _____

The experiment described below will examine this reaction with a fun twist that will, ideally engage the students. When the indicator is prepared under basic conditions, it can be squirted onto a white piece of fabric (or a napkin) and, as expected, will generate a pink stain. If this stain is left for a couple of minutes, the stain will disappear. This occurs due to CO_2 in the air

reacting with the water around the indicator to form carbonic acid (H_2CO_3). The stain can be regenerated if it is exposed to basic conditions – swabbing the region with liquid ammonia (NH_4OH) is a cheap way to accomplish this. If the stain is left exposed to air, it will again slowly disappear. The process can be accelerated by swabbing it with an acidic solution – vinegar (acetic acid, CH_3CO_2H) works well for this.

Experimental Preparation

Materials: Common Sources of Chemicals

- Phenolphthalein (or another pH indicator)
- Ethanol (or another cheap alcohol like isopropanol)
- 1M Sodium Hydroxide (caution, caustic) – prepare by dissolving 4g NaOH in 100mL H_2O
- Vinegar
- Ammonia (diluted 1:2 with water)
- Water (tap water will suffice, but distilled is better)
- pH paper and/or pH meter
- Dry ice (solid CO_2)
- Old white t-shirt or sock – a napkin will suffice
- 2 Beakers (50 or 100 mL)
- cotton swabs or cotton balls

Preparation of solutions for students:

- Prepare a 1% (1g in 100mL) Phenolphthalein solution in 50% ethanol : 50% water.
- Prepare a 1mM NaOH solution (1 mL of 1M NaOH added to 1L H_2O).

Procedure:

1. Prepare stock solutions for students as detailed above.
2. Prepare the dye. Add several drops of 1% phenolphthalein to ~20 mL H_2O. Dropwise, add 1mM NaOH to the solution until it turns deep pink.
3. Test the pH of this solution by placing 1 drop on pH paper the pH paper.
4. You may choose to do the next several steps as a demonstration instead of having each student do it independently.
    a. Squirt some of the dye onto the cloth or napkin. Add more if the stain is not dark enough to see.
    b. Observe the stain for several minutes. What happens?
    c. Swab the stain with ammonia.
    d. Swab the stain with vinegar.
5. Determine the pH of the ammonia and vinegar solutions.

6. Slowly add vinegar to the phenolphthalein solution (from step 2). When the solution turns clear, test the pH.
7. Slowly add ammonia to the beaker. When the solution turns pink again, test the pH.
8. Add a small piece of dry ice to the beaker. What happens? Based on what you observed in steps 5-7, form a hypothesis about why dry ice has the effect that it does.
9. To test this hypothesis -
    a. Add 20mL H_2O to a clean beaker. Test the pH.
    b. Drop a small piece of dry ice into the water. Test the pH.
    c. Is this what you expected? Explain.

Data:

	Observations	pH
Vinegar		
Ammonia		
Phenolphthalein		
Step 6		
Step 7		
Step 8		
Hyphothesis:		
Step 9a		
Step 9b		

Questions:

One molecule of dry ice (CO_2) reacts with one molecule of water to form the acid that was observed in the experiment. Write a balanced chemical equation.

_____ + _____ ⇌ _____

Write a balanced chemical equation predict how this molecule will react with the basic form of phenolphthalein.

$C_{20}H_{13}O_4^-$ + _____ ⇌ _____ + _____

Based on the experiment that was just conducted, why does the pink ink disappear when it is left open to the air?

If you were to squirt grapefruit juice on the pink ink, what would happen and why? How about Coca Cola?