

The Blue Bottle Reaction

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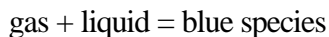
Description: A 500ml flask containing a colorless liquid is vigorously shaken. The solution rapidly becomes blue. After about 45 seconds, the blue color fades, and the solution becomes colorless again. The process can be repeated for up to 3 hours.

Materials: 7.5 ml 8M NaOH
500 ml flask and stopper
1-2 drops methylene blue indicator
250 ml glucose solution (12grams glucose/250ml deionized H₂O)

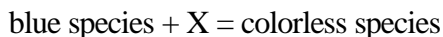
Procedure: Prepare the reaction mixture before class. To do this, pour 7.5 ml of 8M NaOH into the 500 ml flask. Add 250 ml glucose solution. Lastly, add 1-2 drops methylene blue indicator solution. The blue solution will eventually become colorless.

Show your students the flask with the colorless solution. Give the flask a few vigorous shakes. The solution turns blue. After a while, the blue color will fade until the solution is colorless again. Repeat the process several times.

Reaction: Reaction causing the blue color:



Reaction causing the clearing of the solution:



The actual reaction involves the reduction of methylene blue by an alkaline glucose solution. Upon shaking, the reduced product is reoxidized by dissolved oxygen to the blue dye. See the references below for more details.

Hazards: 8M NaOH is a caustic solution and may cause burns. Handle with care. Wear safety goggles at all times.

Clean-up: The solution may be poured down the sink and followed with running water.

Reference: Summerlin & Ealy, *Chemical Demonstrations - A Sourcebook for Teachers, Book 1*, American Chemical Society, 1985 p. 90.

Shakhashiri, B.Z., *Chemical demonstrations: A Handbook for Teachers of Chemistry, vol. 2*, The University of Wisconsin Press, 1985, p. 142-146.

Illustrating the Scientific Method

This demonstration offers an excellent way to illustrate the scientific method. Rather than requiring students to memorize the steps of the scientific method, have them make observations, present their own hypotheses, and design experiments to test them.

Question: Why does shaking the flask cause the solution to become blue?

Hypothesis: Something is on the stopper causing the solution to turn blue when the flask is shaken.

Response: Carefully turn the bottle upside down without shaking it. (Do this slowly to prove the point). Obviously, the stopper doesn't have any effect on the reaction.

Hypothesis: Shaking the solution adds heat and causes the color change. The contents then cool and the blue color fades. (Temperature dependent equilibrium.)

Response: Place the flask in a warm water bath for a short while. No change in the solution's color occurs.

Hypothesis: Air is inside the flask and the color change is due to reaction between the liquid and gas phases on the inside of the container.

Response: Remove the stopper and flush the flask with methane gas until all the air is forced out. Quiz the students concerning the lack of effect that methane gas has on the solution. Eventually, point out to the students that oxygen is the gaseous reagent, or even better, do an experiment to prove it.

Using the Blue Bottle Demonstration as a Demonstration Assessment

Prepare and perform the blue bottle demonstration as directed in the procedure. Run through the hypotheses and tests as described except **do not** perform any procedures that require removing the stopper from the flask.

After the class has observed the blue bottle system work and is familiar with the relative rates of the color changes, present the system as a demonstration assessment.

- 1) Remove the stopper from the flask.
- 2) Flush the flask for several seconds with a strong stream of methane gas.
- 3) Replace the stopper as the hose from the methane outlet is removed.
- 4) Repeatedly shake the flask. (No color changes are observed.)
- 5) Remove the stopper and wait about 20 seconds.
- 6) Replace the stopper and give the flask one vigorous shake. (The solution will turn blue.)

Have the students record their observations and write an explanation.

Solution Preparation for Blue Bottle

8.0 M NaOH Solution

The heat of solution of NaOH is quite exothermic so extreme caution should be used when preparing this solution. **Always wear your safety goggles.** Add the solid in small amounts and stir until it all dissolves. Allow the solution to cool between each addition of NaOH. If your skin comes in contact with the solid NaOH or the solution, rinse with copious amounts of water.

To prepare 100 ml of 8.0 M NaOH

- 1) Weigh out 32 g of solid NaOH.
- 2) Add about 85 ml of water to a 250 ml flask.
- 3) Slowly add a small amount of the solid NaOH to the flask and stir.
- 4) After the solution has cooled, add another small amount of the solid and stir.
- 5) Continue step 4 until all the 32 g of NaOH has been dissolved.
- 6) After the solution has cooled to room temperature, slowly add water and stir until the total volume of the solution is 100 ml. (This dilution is also exothermic so used caution.)

To prepare 2 liters of glucose solution

- 1) Weigh out 96 g of glucose.
- 2) Transfer the glucose into a plastic 2-L bottle.
- 3) Add 1,900 ml of distilled water. (In many communities, tap water will work fine for this demonstration.)

To prepare 250 ml of glucose solution

- 1) Weigh out 12 g glucose.
- 2) Add this to a 500 ml flask.
- 3) Add about 240 ml distilled water.