

Blue + Blue \neq Blue

Concentration of Solutions

Introduction

Use this simple, counter-intuitive demonstration to introduce numerous chemical concepts to students, using materials commonly found around the lab.

Concepts

- Concentration
- Dilutions
- Observation
- Spectrophotometry

Materials

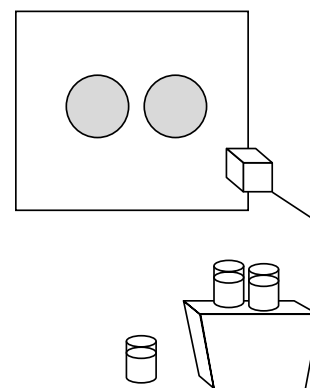
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|---------------------------------|----------------------------|
| Blue food dye | Water, 900 mL |
| Beaker or Erlenmeyer flask, 1-L | Beaker, 150-mL |
| Beakers, 600-mL, 4 | Graduated cylinder, 100-mL |
| Overhead projector and screen | Stirring rod |

Safety Precautions

This activity is considered nonhazardous. Wear chemical splash goggles. Wash hands thoroughly with soap and water before leaving the laboratory. Follow all laboratory safety guidelines. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Procedure

1. Add about five drops of blue food coloring to 700 mL of water and mix well.
2. Label three beakers A, B, and C.
3. Add 200 mL of water to beaker C.
4. Add 200 mL of the blue water to beakers A and B.
5. Place beaker A and B on an overhead projector to compare the colors.
6. Ask students what blue + blue equals. Clarify this question by asking what they believe will happen if these two identical solutions are mixed. Students will most likely answer that the color intensity will not change.
7. Add approximately 100 mL of liquid from beaker A into beaker B. The remaining 100 mL in beaker A will serve as a “control.”
8. Ask students to describe the color of the solutions in both beakers from a horizontal viewing angle and a vertical viewing angle. The color should appear the same in the horizontal angle but Beaker B will be considerably darker on the overhead screen (vertical angle).
9. Pour approximately 100 mL of blue solution from beaker B back into beaker A so that the colors are again the same from both angles.
10. Ask students to predict how the colors will change if the 200 mL of water from beaker C is added to beaker A (beaker B will be used as a control for comparison). Generally students will respond that adding water will dilute the solution and therefore the solution will become lighter in color on the screen.
11. Ask the students to describe the color of the solutions in both beakers from a horizontal viewing angle and a vertical viewing angle. The color in A will appear lighter in the horizontal angle, but the color intensity will appear equal in both beakers from the vertical angle.



12. Ask the students to write down a prediction when 100 mL of the blue solution is added to a 150-mL beaker, a 600-mL beaker, and a 100-mL graduated cylinder. Fill each item with 100 mL of the blue solution and discuss the result.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. The waste solutions may be disposed of according to Flinn Suggested Disposal Method #26b.

Tips

- Remind students to focus on the overhead screen, not the beakers themselves—this shows the color intensity from a “birds-eye view,” which is different from the way the colors appear from a side view. *Note:* The way the colors look from the side of the beaker will typically meet students’ expectations, e.g., when the solution is diluted with water the color will fade. Some students may believe that the overhead projector causes an illusion. If this is the case, physically take the beaker over to the students so they can see that the color displayed on the overhead screen is accurate, or simply place a piece of paper between the beakers and the students to help them focus on the overhead screen.
- Other colors of food dye may be used, but blue is the easiest to view.

Discussion

The concentration of a solution is not the only factor that determines the color intensity. When two solutions of the same color intensity are mixed, most students will predict that the color of the resulting solution will be the same as the two starting solutions. If the solution is viewed from the side, then this is true, but this is not the case when viewing the solutions from a downward perspective. Although the concentration is the same, the number of dye particles present in a larger volume is greater than each individual solution. A solution with a greater number of dye particles will absorb more photons of light and will thus appear darker. Explain to students the inappropriateness of using beaker A as a control in step 5. Since 100 mL is added to beaker B from beaker A, the number of dye particles present in beaker A is going to be cut in half, less light will be absorbed, and the sample is not an accurate control. During the demonstration students will most likely believe that it is a good control since nothing is being added to the beaker. If they do notice the difference in beaker A after the volume is reduced, they are beginning to understand the main concepts!

This concept also comes into play when using a spectrophotometer. Cuvets containing a sample must be oriented the same way each time during a set of measurements in order to obtain the most accurate results possible. Even a small difference in cuvet placement may change the path length and, therefore, the amount of particles encountered by the light beam affecting the amount of light absorbed and the accuracy of the reading.

In the last part of the demonstration, the color on the overhead appears the same as it did before the addition of water. Although the depth of the solution has increased, the number of dye particles remains the same. Dye particles are more spread out, but the same amount of light is absorbed. An alternative way to think about this scenario is to imagine that the two liquids, the blue dye solution and water, are immiscible. If this were the case, students would guess that the color would remain unchanged by the addition of water because the clear water would not mix with the blue solution. The same holds true for solutions that are miscible.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12

- Evidence, models, and explanation
- Constancy, change, and measurement

Content Standards: Grades 5–8

- Content Standard B: Physical Science, properties and changes of properties in matter

Content Standards: Grades 9–12

- Content Standard B: Physical Science, structure and properties of matter

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Blue + Blue \neq Blue* activity, presented by Penney Sconzo, is available in *Absorption Spectroscopy and Concentration of Solutions*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Blue + Blue \neq Blue* are available from Flinn Scientific, Inc.

Catalog No.	Description
V0003	Food Coloring Dyes
GP1015	Beaker, 150-mL
GP1030	Beaker, 600-mL
GP3055	Erlenmeyer flask, 1000-mL
GP2056	Graduated cylinder, 100-mL

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.