Educational Innovations

DEN-460
Poly Density Bottle

When a 1 L bottle is shaken, the blue and white beads mix within the liquid as expected. However, when allowed to settle, the beads separate, white at the top and blue at the bottom. Shortly, the two separated colored beads slowly come together until they meet in the center of the liquid, white on top of blue. It is curious to see beads floating half way in a liquid. The mixing and separating can be observed over and over.

Please note: Rubbing alcohol is available in both 70% and 91%. Both are acceptable, but it is critical that you follow the correct procedure for the type of alcohol that you are using.

Preparation using 91% isopropanol:

1. Remove the cap from the bottle containing extremely pure salt (NaCl), and both the white and blue beads.
2. Add 400 ml of clean water, and recap. The water level will be about 11 cm (4.25") from the bottom of the bottle. Shake for several minutes until the salt dissolves.
3. Add 450 ml of 91% rubbing alcohol (isopropanol), and tightly recap. The liquid level will now be about 19 cm (7.3") from the bottom of the bottle.

Preparation using 70% isopropanol:

1. Remove the cap from the bottle containing extremely pure salt (NaCl), and both the white and blue beads.
2. Add 265 ml of clean water, and recap. The water level will be about 7.25 cm (2.85") from the bottom of the bottle. Shake for several minutes until the salt dissolves.
3. Add 585 ml of 70% rubbing alcohol (isopropanol), and tightly recap. The liquid level will now be about 19 cm (7.3") from the bottom of the bottle.

Explanation:

Water and isopropanol are soluble in all proportions; they are miscible. Both the water molecules and the alcohol molecules have -OH groups that easily hydrogen bond to each other. The sodium chloride salt particles, Na^{1+} and Cl^{1-}, however, preferentially bind with the water molecules forcing the alcohol molecules out of the water solution. This causes two layers to form: alcohol on top and the more dense water and salt layer on the bottom. Isopropanol and salt water are immiscible; they do not mix in all proportions. This "salting out" technique is commonly used to remove organic molecules from an aqueous solution.

When the bottle is shaken, the two liquid layers momentarily mix, forming a pseudo homogenous mixture with a density between the two separate liquid densities. The white beads with a lesser density than this liquid mixture float on top and the blue beads with a greater density sink to the bottom. Then, as the aqueous salt layer separates from the alcohol, the blue beads rise in the bottom aqueous layer and the white beads sink in the top alcohol layer until they meet in the center. From lowest density to highest density the order is as follows: isopropanol, white beads, blue beads, and salt water. Because the beads float between the two liquids, the actual alcohol/salt water interface is difficult to observe, adding to the mystery. Order spontaneously forming from disorder is unexpected and gives the illusion of a violation of the Second Law of Thermodynamics.

Science teacher, Lynn Higgins, created this demonstration.

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MATERIAL SAFETY DATA SHEET
MONOSODIUM CHLORIDE

Section I - IDENTIFICATION
PRODUCT: Sodium Chloride
SYNONYMS: Sodium Monochloride, Monosodium Chloride, Table Salt
CHEMICAL FORMULA: NaCl
CHEMICAL ABSTRACT NUMBER: 7647-14-5
PRODUCT CODE NO.: 17529

Section II - HEALTH & FIRST AID INFORMATION
INHALATION: May irritate the mucous membranes. Remove to fresh air. Inhalation of aerosols may cause pulmonary edema. Get medical attention for any breathing difficulty.
INGESTION: Excessive quantities may cause nausea, vomiting and central nervous system depression. Regular ingestion of small quantities may cause hypertension resulting in cardiovascular disease and possibly death. Give 1 - 2 large glasses of water or milk. Induce vomiting. Immediately seek medical aid. Never give liquids to an unconscious person.
SKIN CONTACT: Sensitive persons exposed to even weak solutions may display irritation accompanied by erythema. If contact does occur, the affected area should be washed with soap and water. Get medical advice if irritation develops. Prolonged contact will cause dermal absorption to occur, producing symptoms similar to ingestion.
EYE CONTACT: Weak solutions will cause a stinging sensation. Above about 5% solutions will cause osmotic reduction of the water in the vitreous humor, temporarily shrinking the eyeball and causing focusing difficulties. Wash thoroughly with running water. Get medical advice if irritation develops.
EFFECTS OF OVEREXPOSURE: Inhalation of dust may cause mild irritation to mucous membranes, nose and throat. Symptoms may include coughing, dryness, and sore throat. Ingestion: very large doses can cause vomiting, diarrhea, and prostration. Dehydration and congestion occur in most internal organs. Hypertonic solutions can produce violent inflammatory reactions in the gastrointestinal tract.
OTHER HEALTH INFORMATION:
The acute toxicity by ingestion is 990 mg/kg (LD50, 3 days, humans), 3000 mg/kg (LD50, 1 day, rats)

Section III - PHYSICAL DATA
MELTING POINT: 801°C (1474°F)
BOILING POINT: 1412°C (2575°F)
VAPOUR PRESSURE: 1.0 mm Hg at 865°C
VAPOUR DENSITY (AIR=1): N/A
SOLUBILITY IN WATER: 360 g/l at 20°C
APPEARANCE & ODOUR: White crystals. Odorless.
SPECIFIC GRAVITY (H2O=1): 2.16

Section IV - FIRE AND EXPLOSION HAZARDS
FLASH POINT & METHODS USED: none, considered non-flammable
FLAMMABLE LIMITS IN AIR; % BY VOL. LOWER: none
FLAMMABLE LIMITS IN AIR; % BY VOL. UPPER: none

Section V - REACTIVITY
STABILITY: stable. Will absorb atmospheric dihydrogen monoxide if exposed.
HAZARDOUS POLYMERISATION: will not occur
CONDITIONS & MATERIALS TO AVOID: Lithium, bromine trifluoride. Most common metals, including stainless steel, will corrode in the presence of it, especially under humid conditions. Avoid electric fields.
HAZARDOUS DECOMPOSITION PRODUCTS: Solutions may emit chlorine, hydrogen and oxygen in the presence of an electric field. When heated to decomposition (above 1413°C) may emit toxic fumes of Na2O and Cl2

Section VI - PRECAUTIONS: HANDLING, STORAGE & USAGE
Store in a cool dry place away from direct light in a tightly closed container. . Do not wear contact lenses when working with chemicals.

