Teacher Guide: The Cooler and Delivery Truck Evidence

Time: 4–5 days
Grades: 11 and 12 (2nd-year Chemistry)

Objectives

1. Students will solve a forensics case using their knowledge of chemistry (for performance assessment #1 this includes density, data interpretation, dimensional analysis, gas laws, kinetic molecular theory, and surface tension).
2. Students will assemble their evidence in the format of a lab report.
3. Students will answer the following questions:

   Part I
   a. What is the density range of the blue cooler pieces?
   b. In which lake should police begin their search for the body?
   c. Would the body fit inside the cooler?
   d. Would the cooler have been able to float with the body in it, plus a chain wrapped around it?
   e. Would the cooler float after water filled it through a bullet hole?

   Part II
   a. According to volume data, explain why the police should be able to still get evidence from the delivery truck after retrieving the truck from the lake?
   b. Describe the pressure verses volume graph. Use the words direct or inverse in your description of the relationship, along with data from the graph, in your answer to describe which gas law this graph represents.
   c. Describe the volume verses temperature graph. Use the words direct or inverse in your description of the relationship, along with data from the graph, in your answer to describe which gas law this graph represents.
   d. Using the ideas supporting the kinetic molecular theory, explain why the number of moles of gas in the deployed airbag would stay the same throughout the volume calculations.

Preparation

Part I

Students will need a variety of liquids with varying densities in order to determine the density range for the ***blue*** cooler pieces from the recycled sample. The recycled sample consists of polystyrene (blue pieces), nylon (yellow pieces), acrylic (white pieces), and polypropylene (clear pieces), which have density ranges of 1.05–1.07 g/ml, 1.15 g/ml, 1.15–

1.20 g/ml, and 0.90–0.91 g/ml respectively. Make sure the density range of the cooler matches the density range of the lake near which the investigation will take place.

Part II

No set-up required for this part.

The Lab

Part I

Students write their own hypothesis, design their own procedure, and create their own data table. The work that they do will be assembled in a lab report as part of their evidence file (to be maintained throughout the year).

Part II

Students will be graphing and analyzing data collected by the police about volume, pressure, and temperature and calculate using the ideal gas law.

Question Guidelines

For calculations, formulas, and work, see the student example at the end of the chapter.

Part I

1. The blue cooler pieces should have a density range of 1.03-1.07 g/mL (NOTE: one likely source of error in this range would be the result of surface tension of the liquids when determining the density range of the plastic pieces)
2. Clinton lake (of the three lake density ranges, the cooler pieces should float in this range ONLY)
3. Yes, the body of Kirsten K. would fit in the cooler
4. Yes, the cooler would only be partially submerged because the height of the water displaced is not greater than the height of the cooler
5. Yes, it will still float even if it was filled with water so the suspect(s) had to dispose of the cooler by recycling it

Part II

1. The airbag volume will not go above the maximum 65 liters as calculated for each of the various depths. The maximum volume of the airbag only gets to 63.8 liters at the surface as the delivery truck is extracted from Clinton Lake, so evidence should still be able to be collected from inside the delivery truck.
2. The pressure verses volume graph shows an indirect relationship. The volume of the airbag at the bottom of the lake is 27.1 L and the pressure is 2.24 atm, but as the volume

increases to 64 L as the truck gets closer to the surface of the lake, the pressure decreases to 1.01 atm. This shows the relationship in Boyle's Law.

3. The volume verses temperature graph shows a direct relationship. The volume of the airbag is 27.1 L and the temperature is $5^{o}C$, but as the temperature is increased to $22^{o}C$ near the surface of the lake, the volume of the airbag increases to 63.8 L. This shows the relationship in Charles' Law.
4. As long as the airbag stays closed and is not punctured with holes at all as the delivery truck is being extracted from the lake, the number of moles of gas will stay the same inside the airbag. According to the kinetic molecular theory, the gas molecules inside the airbag will increase in movement as the temperature of the molecules are increased as the truck is brought to the surface. This would also account for why the airbag would change in volume because of the greater number of collisions of the molecules inside the airbag because of the increase in their movement from the temperature increase.

Materials

Part I

- Recycled Sample
    - Mixture Separation Challenge (a kit from Educational Innovations)
    - *www.teachersource.com/Density/DensityKits/MixtureSeparationChallenge.aspx*
- Various liquid samples with varying densities. Some examples include: water (1.000 g/ml), salt water (1.03–1.05 g/ml), 95% EtOH (0.789 g/ml), 90% isopropyl alcohol (0.786 g/ml), canola oil (0.912–0.924 g/ml)
- Forensics Tags (included in Appendix D)
- Additional supplies may include: spoons, plastic cups, beakers, graduated cylinders, tweezers

Part II

- Graph Paper (included in the assessment handout)