Name:_____Class:_____Date:_____

The Case of Kirsten K.:
The Cooler and Delivery Truck Evidence

All Reports are to be filed using the correct format, following the Lab Report Style Guide

Part I: The Cooler Evidence

Case Background

On September 4th, Kirsten K. went missing from the Bloomington-Normal area. A missing person's report was filed by her husband, Larry J., and the police are still investigating. No sign of the body has been found yet, but police are currently investigating a lead and have narrowed their search down to four suspects. Police were informed that one of the suspects was seen taking a cooler to a recycling plant after allegedly dumping the body. When questioned, the manager of the recycling plant remembered a blue cooler being brought in sometime early in the week of September 7th. He remembers it for two reasons:

1. It had what looked like a bullet hole in it, and he remembers thinking "that it wouldn't work very well as a cooler with a hole in it."
2. The suspect was carrying a chain in the other hand when dropping off the cooler.

Police confiscated the recycled sample, which included pieces of the cooler and other items that were recycled with it. The recycled sample is currently en route to the CSI (Crime Scene Investigation) lab at the local police station. Police believe the suspect(s) stored the missing body inside of the cooler at one point in an attempt to dispose of the body in one of the following lakes: Lake Bloomington, Clinton Lake, or Lake Springfield. Police believe that the suspect(s) tried to recycle the evidence after failing to sink the cooler in one of these bodies of water.

Background Information on Lakes

Lake Bloomington—located just north of Bloomington, Illinois, this lake has a surface area of 635 acres and an average density of 0.98 g/mL. The smaller size of this lake allows for the water to change temperature more rapidly than the other lakes in the area. Therefore, the water in Lake Bloomington is, on average, warmer than in the other lakes. This means that less gas is dissolved in the water, making it *slightly* less dense than the average density of water.

Clinton Lake—located approximately 30 miles south of Bloomington, Illinois, this lake has a surface area of 4900 acres and an average density of 1.05 g/mL. The larger size of this lake means that the water temperature does not change as rapidly as smaller lakes. Therefore, the water in Clinton Lake is, on average, cooler than in the other lakes. This allows for more gas to be dissolved in the water, making it denser than the average density of water.

Lake Springfield—located approximately 50 miles south of Bloomington, Illinois, this lake has a surface area of 4234 acres and an average density of 1.01 g/mL. The lake is of average size and of average temperature.

Purpose

Your investigation should help police to determine the following three questions:

1. What is the density range of the cooler in which the suspect(s) tried to store the missing body?
2. In which body of water should police start looking for the body?
3. Would the suspect(s) have been successful in trying to dispose of the body, by sinking it in the cooler using the methods described?

Hypothesis

In which scenarios (ex. bullet holes, chains, filling with water) would the suspect(s) have been successful or unsuccessful in sinking the cooler? Address all scenarios in your hypothesis.

_____

_____

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Procedure

Write out your experimental procedure (numbered list of steps) below. Be specific!!

Materials

- Various liquids of varying densities
- Recycled sample
- Small dishes
- Spoons

Data

Construct a data table or tables to collect data as described in the procedure.

Analysis-Calculations

There are three key questions that police must address in order to verify or refute the evidence from the cooler:

1. Would the body have actually fit inside the cooler?
2. Would the cooler have even been able to float with the body inside?
3. Would the cooler have floated with a bullet hole in it that would have allowed water to fill the cooler?

Answer the questions below, which will help to answer these three key questions. Address these three questions in your conclusion and support them with the calculations below.

1. The igloo cooler that was used in this case was believed to have had the labeled capacity of 162 quarts. Kirsten K.'s body had a volume of approximately 59.5 L (0.95 L = 1 quart). Would the body have even fit in the cooler? Show work to support your answer.

2. The cooler was believed to have had dimensions of 104 cm long, 45.7 cm wide, and 53.3 cm deep. If the cooler sinks one centimeter, calculate the volume of water it displaces.

3. The density of lake water where you determined police should start their investigation is _____ g/cm^3. Calculate the mass in kilograms of the lake water displaced by the volume you calculated in question #2. (1000grams = 1 kilogram)

4. Kirsten K.'s body weighed 128 pounds. The empty cooler has a mass of 13.6 kg, and the chain that police believed the suspect wrapped around the cooler to try to make it sink, has a mass of 13.6 kg as well. Calculate the total mass of the body, the cooler, and the chain. Using your calculation from question #3, how many centimeters will the cooler with the body wrapped in chains sink? Will the cooler be completely submerged below the surface of the water? (1 kg = 2.21 lbs)

5. Now let's determine if the cooler will still float if you shoot a hole in it and allow water to enter. Let's consider the extreme case in which water fills the entire cooler (which it won't). The inside dimensions of the cooler are 35.5 cm by 94.0 cm by 43.2 cm deep. Calculate the inside volume of the cooler in liters. (1 mL = 1 cm^3)

6. Calculate the mass of lake/creek water that would completely fill the cooler. Remember to use the density of lake/creek water you found in the Cooler Evidence.

7. Calculate the total mass of the cooler, chain, and lake/creek water. How many centimeters will the cooler sink? Will it be completely submerged if it is full of lake/creek water?

Conclusion

In which body of water should the police start their investigation and what specific data supports this? Be sure to refer back to your hypothesis.

Discussion

1. Describe the likelihood of the body being able to fit inside the cooler. Use calculations to support your answer.

2. Describe the ways in which the suspects tried to dispose of the cooler. Were they successful? Support your statement with evidence.

3. Describe what affect the bullet hole would have had on the ability of the color to sink in the lake.

Part I—The Cooler Evidence: *adapted from "Murder She Floats," by Robert Mentzner, ChemMatters, Dec. 2002, pp 17-19. Copyright 2002 American Chemical Society*

Part II: The Delivery Truck Evidence

Background Information About Airbags

A sensor in front of the car detects the sudden deceleration and sends a signal to a cylinder containing a mixture of chemicals. In the cylinder, an igniter goes off, starting a series of chemical reactions that release a large volume of nitrogen gas. The bag literally bursts from its storage site at up to 200 mph. When the airbag deploys, the maximum volume it can hold is 65 Liters. The gas fills the airbag, and you hit the soft bag instead of the steering wheel or dashboard. A second later the gas quickly dissipates through tiny holes in the bag, thus deflating the bag so you can move. The bag has to inflate in less than a tenth of a second, and it has to inflate with exactly the right amount of gas. If it under-inflates, it would not provide enough protection; if it over-inflates, it might rupture or cause an explosion.

The first reaction set off by the igniter is the decomposition of sodium azide into sodium metal and nitrogen gas.

$$2NaN_3 \rightarrow 2Na + 3N_2$$

By itself, this reaction cannot fill the airbag fast enough, and the sodium metal that is produced is dangerously reactive. To solve these problems, engineers included potassium nitrate in the mixture of reactants. The potassium nitrate reacts with the sodium produced in the first reaction, releasing even more nitrogen gas.

$$10Na + 2KNO_3 \rightarrow K_2O + 5Na_2O + N_2$$

The heat released by this reaction raises the temperature of the gaseous product, helping the bag inflate even faster. The heat causes all the solid reaction products to fuse together with SiO_2, powdered sand, which is also part of the reaction mixture.

Background Information About the Case

Police have started searching Clinton Lake, as you suggested, looking for evidence regarding the missing person's report they received for Kirsten K. Police have found an abandoned delivery truck at the bottom of the lake, which may hold evidence that could lead to finding the person(s) responsible for the kidnapping of Kirsten K. The airbag has been deployed, but there was a malfunction and the airbag remained deployed even after entering the lake. Police want to make sure the airbag will not explode as they lift the truck up from the bottom of the lake to the surface in order to preserve all possible evidence in the delivery truck that has not yet been destroyed. They have asked you to help collect evidence and double check some of the data they have already taken.

Purpose

To determine if the vehicle can be safely removed from the lake without the airbag exploding.

Hypothesis

Looking at the data provided by the police about the depth, temperature, and pressure of the lake, predict what will happen to the volume of the airbag as the truck is removed from the bottom of

Clinton Lake. Consider the Pressure (P), Temperature (T), and Volume (V) relationships as well when giving your prediction.

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Data

Below is the lake data from the police including the depths, temperatures, and pressures to help you determine the volume of the airbag at various depths.

Table 1: Clinton Lake Police Measurements

Depth (feet)	Temperature (^oC)	Pressure	Calculated Volume (L)
40	5	2.24 atm	
30	10	1520 mmHg	
20	15	1140 mmHg	
10	20	1.07 atm	
0	22	1.01 atm	

Analysis—Graphing

Before you arrived at the scene, police started to collect data about the temperature, pressure, and volume to try to gain more information about the abandoned vehicle.

Graph #1: Pressure vs. Volume

Graph the pressure from the lake verses the volume to show the relationship between the two variables.

Graph #2: Volume vs. Temperature

Graph the volume that you calculated for each of the various temperatures in the lake to show the relationship between the two variables. (***You will not be able to create this graph until after you do the Analysis—calculations section of the assessment.)

Analysis—Calculations

You have been hired by the police as a chemical engineer responsible for investigating the abandoned vehicle found with a deployed air bag. For police to gain insight into case, they need you to calculate if the delivery truck can be safely removed from the lake without the airbag expanding too much, bursting, and destroying evidence.

1. Calculate the number of moles of gas in the airbag at maximum volume, 65 liters, at room temperature, 25°C, and at 1 atmosphere (atm) of pressure.

2. Calculate the volume at the various depths given by the police to determine if the airbag will expand to a volume greater enough to make it explode.

Depth (ft)	Volume Calculations using Ideal Gas Law
40	
30	
20	
10	
0	

Conclusion

Explain to the police whether or not they will be able to gather evidence from the delivery truck and why, based on your calculations.

Discussion Questions

1. According to volume data, will the police be able to retrieve evidence from the delivery truck after retrieving the truck from the lake? Explain.

2. 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.

3. 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.

4. 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.