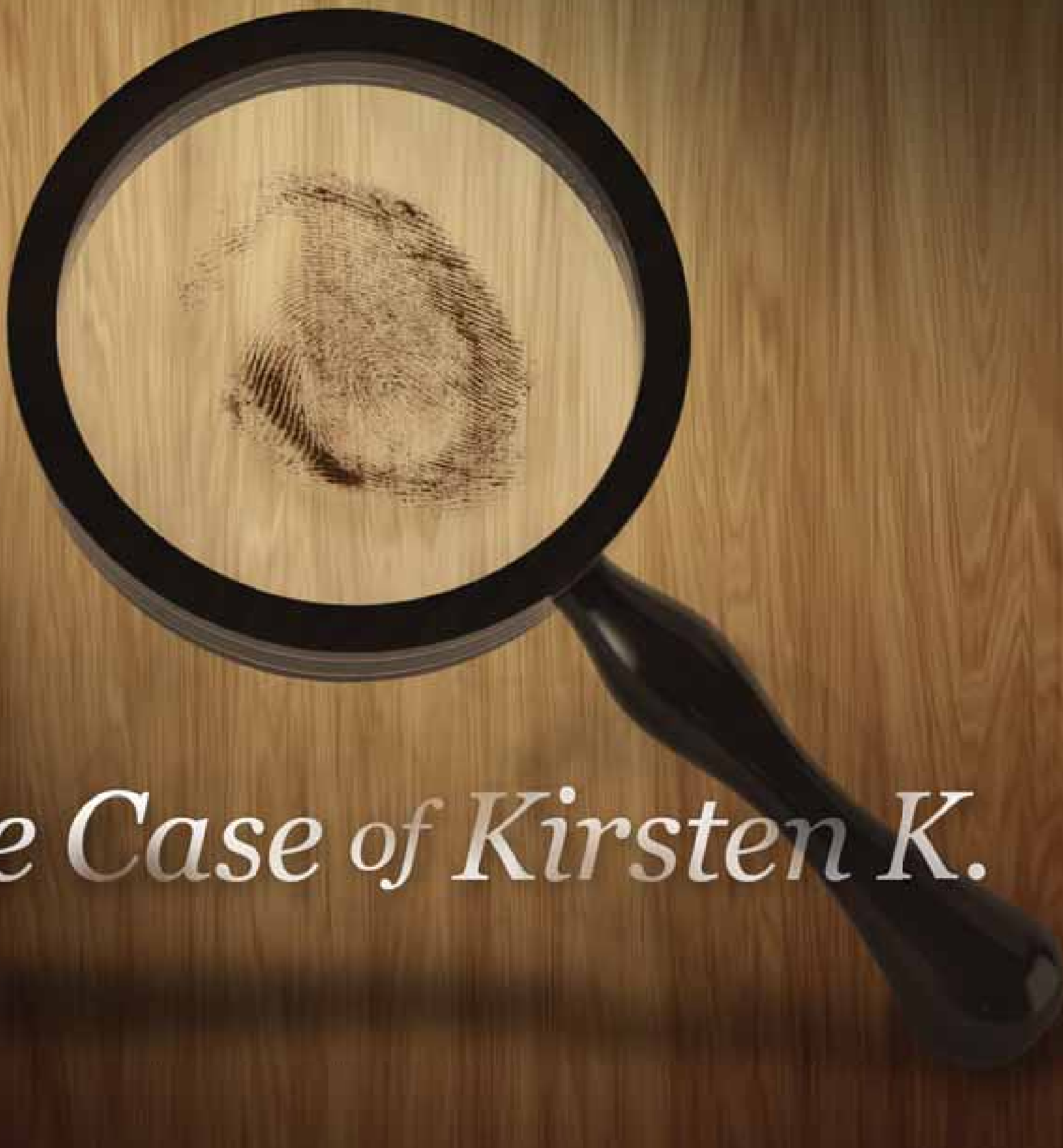
# FORENSICS in CHEMISTRY



## The Case of Kirsten K.

Sara McCubbins
and Angela Codron

NSTApress
National Science Teachers Association

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Arlington, Virginia

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# ABOUT THE AUTHORS

**Sara A. McCubbins,** M.S., is a project and office manager for the Center for Mathematics, Science, and Technology (CeMaST) and an instructor and advisor in chemistry education at Illinois State University. Her interests include curriculum development, professional development for teachers, university and community outreach, analyzing the role informal science plays in scientific knowledge acquisition, and student attitudes toward science.

**Angela R. Codron** is currently a chemistry and biology teacher at Normal West High School in Normal, Illinois. Her educational experiences range from an undergraduate degree in chemistry eeducation to a Master's in athletic administration, both from Eastern Illinois University, and a Type 75 Educational Administration Certificate from Illinois State University. Her areas of interest in education include developing and incorporating performance-based assessments for use in the science classroom and aligning and assessing curriculum with specific learning targets.

# ACKNOWLEDGMENTS

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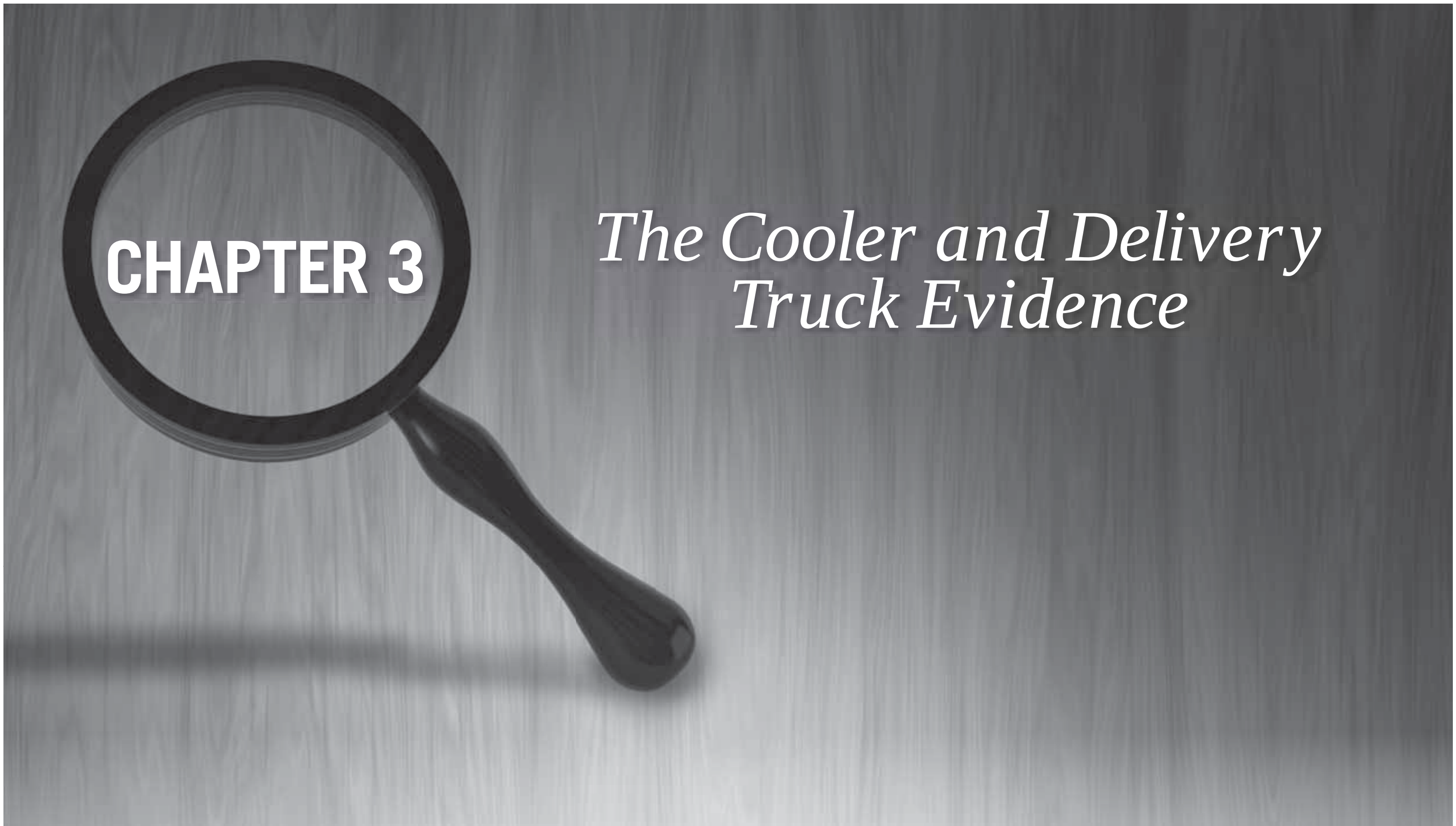
## NSTA PRESS EXTRAS

On the NSTA Press Extras page for *Forensics in Chemistry* you will find downloadable PDFs for student assessment handouts, teacher guides, and grading rubrics for each lesson in the book. Please visit *www.nsta.org/publications/press/extras/kirstenk.aspx*.



# CHAPTER 3 The Cooler and Delivery Truck Evidence

## CHEMISTRY CONTENT

- Density
- Data interpretation
- Dimensional analysis (unit conversions)
- Gas laws
- Kinetic molecular theory
- Surface tension

## NATIONAL SCIENCE EDUCATION STANDARDS ADDRESSED

Content Standard A: Science as Inquiry
Content Standard B: Physical Science
Content Standard G: History and Nature of Science

## CASE INFORMATION

Based on your students' knowledge of chemistry, local police have asked for their help in solving a local missing-persons case. The victim in this case is Kirsten K. Your students will try to determine which of the suspects is most likely responsible for her disappearance based on the evidence provided by the police and analyzed by the students. The included suspect file provides additional evidence and the relationships of the suspects to one another. Suspects in this case include:

1. Harold M., a local plumber
2. Gladys V., a retired pharmacist and Lake House owner
3. Elizabeth G., a neighbor of the victim and local business owner
4. Larry J., the victim's husband

In the first part of this performance assessment, your students will analyze samples from a recycling plant to determine where police should begin their search for the victim. In the second part, your students will analyze data from an airbag deployment to determine whether the delivery truck driven by the victim prior to her disappearance can be extracted from the lake so that further evidence can be recovered.

### *Part I: The Cooler Evidence*

In Part I of this performance assessment, students learn that Kirsten K. has been reported missing and is believed to have been murdered, although this has not yet been confirmed. However, police are not sure where to start looking for the body. Police have narrowed their search down to three local bodies of water but need the students' help to determine in which body of water they should start their search. Choosing the bodies of water is up to the discretion of the teacher.

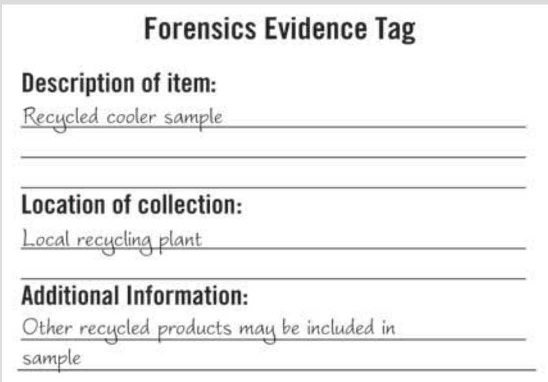
The students find out that the police received a call from a local recycling plant of a suspicious person who came into the plant with a blue cooler that had a bullet hole in it. The person of interest was also carrying a large chain. Police believe the suspect may have tried to destroy evidence by sending the cooler through the recycling plant. Students then receive baggies of recycled pieces from the plant. The recycled sample has blue, yellow, and white pieces of small plastic, all with different densities. According to the police report, the blue pieces are believed to be part of the cooler. The recycled sample baggies are labeled with a forensics tag, as seen in Figure 3.1 (for a full sheet of forensic tags, see Appendix D).

## MAP OF CENTRAL ILLINOIS WITH LAKE LOCATIONS


We selected Clinton Lake, Lake Springfield, and Lake Bloomington because of their proximity to our school. Additionally, Clinton Lake is near a nuclear power plant, which will aid us in analyzing evidence in the Nuclear Radiation assessment presented in Chapter 5.

## FIGURE 3.1

**FORENSIC TAG**


**Forensics Evidence Tag**

**Description of item:**
Recycled cooler sample

**Location of collection:**
Local recycling plant

**Additional Information:**
Other recycled products may be included in sample

Students learn that the police believe one of the suspects tried to dispose of the body by stuffing it into a cooler and sinking it in one of the three bodies of water. The police believe the suspect was unable to sink the cooler and so tried to dispose of the body elsewhere and recycle the cooler to get rid of the evidence. Therefore, if the students can determine the body of water in which the cooler pieces float, the police can begin searching for the victim near that location. Given the density ranges of the bodies of water and a variety of liquids with varying densities, the students design their own experiment to determine the density of the cooler and, therefore, in which body of water the cooler pieces will float.

In this activity, many methods can be used to solve this piece of the forensic puzzle, and students may use any materials they request, including the cups and spoons that come with the kit, as well as their lab drawer filled with standard chemistry equipment. You are likely to get a variety of experimental procedures from your students. In fact, each lab group may have a slightly different experiment or method, which is one of the benefits of inquiry-based lab activities such as this. Some students only test the blue pieces out of the sample because the cooler was blue; whereas, other students test the whole sample. Some measure or count to make sure each sample has the same number of pieces, while others don't measure or count anything. The only concept that I make sure to remind them of is "surface tension," which we studied in the previous unit. Sometimes the pieces are so small they are not able to overcome surface tension, making it appear as if the cooler pieces float at various densities. It is important that

We wanted the pieces of the cooler to float in the Clinton Lake sample because we knew we wanted to use the nuclear power plant later. Whatever you decide, just make sure that the body of water you select as the starting point for the police search has the same density range as the pieces of plastic you choose to represent the cooler.

the cooler pieces float only in the density range of the body of water you wish to use as your investigation starting point.

In this assessment, students will also do a series of calculations to determine the likelihood of sinking the cooler using various methods. They will calculate whether or not the body would fit in the cooler, if the cooler would sink with the body in it, if the cooler would sink with a chain around it, and if the cooler would sink with a bullet hole in it that allowed it to fill with water. In all cases, the students' calculations support the fact that the blue cooler would not sink in any of the given situations, which leads them to the reason why the suspect would recycle the cooler instead of throwing it to the bottom of the lake. This also leads police to believe that the body of Kirsten K. still needs to be found and that they should start looking at the location identified by the students based on the recycled cooler data.

## *Part II: The Delivery Truck Evidence*

In Part II of the assessment, police have discovered a wedding cake delivery truck with a deployed airbag found in the lake matching the evidence from Part I. The delivery truck is believed to have been the truck that Kirsten K. was using to deliver wedding cakes on the night of her disappearance. Police need to know if they can extract the delivery truck from the lake without the volume of the airbag exceeding its maximum volume of 65 L, so that the deployed airbag stays intact and further evidence can be gathered from inside the delivery truck. Police have taken the temperature and pressure measurements at various depths in the lake, which will allow students to calculate how the volume of the airbag will change as the delivery truck is brought up to the surface of the lake. In addition, students will graph the evidence to show the various trends relating to gas laws. Students are expected to recognize if the trend shown in their graph is a direct or an indirect relationship. Students should find that the airbag will not explode, so further evidence can be gathered from the delivery truck. In this part of the assessment, students are also asked to calculate the number of moles of gas that will fill the airbag at a given temperature, maximum volume, and pressure. They will also need to explain how the number of moles of gas does not change as the delivery truck with the deployed airbag is brought to the surface of the lake. Based on the cooler and delivery truck evidence, students are allowed to create whatever scenario fits within their conclusions. The importance of the evidence collected from this performance assessment in the overall case will depend on other evidence collected through the other four performance assessments, especially the chemical evidence in assessment #2 (see Chapter 4: The Chemical Evidence).

In the remaining pages of this chapter, you will find a teacher guide, student handout, suspect file, student lab report example, and grading rubric for Performance Assessment 1: The Cooler and Delivery Truck Evidence. More information about how to use the grading rubric for this and future performance assessments can be found in Appendix B.

# Teacher Guide:

# *The Cooler and Delivery Truck Evidence*

**Time:** 4–5 days
**Grades:** 11 and 12 (second-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*

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

### *Part II*

1. 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?
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.

## 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 setup 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 1.05–1.07 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 L as calculated for each of the various depths. The maximum volume of the airbag only gets to 63.8 L 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°C, but as the temperature is increased to 22°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 is increased as the truck is brought to the surface. This would also account for the airbag's change in volume; the greater number of collisions of the molecules inside the airbag is caused by the increase in their movement as the temperature increases.

## MATERIALS

### *Part I*

- Recycled sample
  - o Mixture Separation Challenge (a kit from Educational Innovations)
  - o *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)
- Forensic tags (included in Appendix D)
- Suspect File A
- Additional supplies may include: spoons, plastic cups, beakers, graduated cylinders, tweezers

### *Part II*

- Graph Paper (included in the assessment handout)

Name:___________________________________ Class:__________________ Date:__________

# The Case of Kirsten K.:

# *The Cooler and Delivery Truck Evidence*

## PART I: THE COOLER EVIDENCE

### *Case Background*

On September 4, 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 7. He remembers it for two reasons:

1. It had what looked like a bullet hole in it, and he remembers thinking "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 the 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 4,900 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 4,234 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 determine answers to 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 (e.g., 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.

________________________________________
________________________________________
________________________________________
________________________________________
________________________________________

### *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 thee key questions that the 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 qts. Kirsten K.'s body had a volume of approximately 59.5 L (0.95 L = 1 qt.). 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 cm, 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 (1,000 g = 1 kg).

4. Kirsten K.'s body weighed 128 lbs. 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 holding the body and 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 that you chose 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 effect the bullet hole would have had on the ability of the coolor 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 a car detects 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 L. The gas fills the airbag, and the passenger hits 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 the person 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 inflated 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 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.

### *Data*

Table 1 shows the lake data from the police including depths, temperatures, and pressures to help you determine the volume of the airbag at various depths.

### *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.

## TABLE 1

**CLINTON LAKE DATA MEASUREMENTS FROM POLICE**

| DEPTH (FEET) | TEMPERATURE (°C) | 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 | |

## 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 the 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 greate 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*

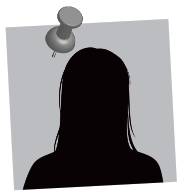
1. According to volume data, will the police be able to retrieve evidence from the delivery truck after raising the truck from the lake? Explain.

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.

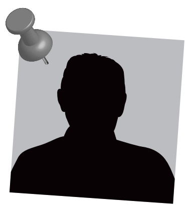
# SUSPECT FILE A



**Victim: Kirsten K.**

Occupation: Nurse

Residence: Normal, IL.



**Suspect #1: Harold M.**

Occupation: Plumber

Residence: Clinton, IL. (just off Highway 10)

**Suspect #2: Gladys V.**

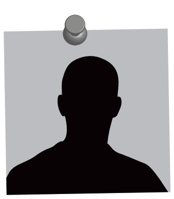
Occupation: Retired pharmacist

Residence: Bloomington, IL (Owns a lake house on Clinton Lake)

**Suspect #3: Elizabeth G.**

Occupation: Owner of a wedding cake design/ catering business

Residence: Normal, IL (neighbor to the victim and her husband)



**Suspect #4: Larry J.**

Occupation: Investment banker

Residence: Normal, IL (husband of the victim)

Name:____________________ Class:__________ Date:________

# Student Lab Report Example:

# *The Cooler and Delivery Truck Evidence*

## I. INTRODUCTION

### *(A) Background Information*

The cooler was found in the recycling plant with a bullet hole in it. The fact that the cooler was taken to the factory by a person carrying a chain helps solidify that the chain, cooler, and bullet hole can be submitted into evidence. The victim, Kirsten K., was disposed of in Lake Bloomington, Clinton Lake, or Lake Springfield. By using the information provided by the police, it will be possible to determine if the truck found had anything to do with Kirsten K.'s murder as long as the airbag stays intact as they extract the delivery truck from the lake.

### *(B) Purpose*

The purpose is to discover where the crime scene is located for the kidnapping of Kirsten K. and to calculate if the suspect(s) could have sunk the victim in a cooler into the lake. It also needs to be determined if the sunken delivery truck can be removed from the lake without it bursting as it rises to the surface, so evidence can be used from the truck to find the prime suspects at this point in the investigation.

### *(C) Hypothesis*

If there was a body in the cooler, a bullet hole in it, and a chain wrapped around it, then it will still float and the suspect will have to dispose of the cooler differently which is why the cooler had to be recycled.

If the police are able to remove the truck from the lake without the volume going over 65 L, then the evidence from the sunken delivery truck will be able to safely be retrieved.

### *(D) Procedure*

1. Pour the various liquids into the cups provided using the same amount of liquid in each cup.
2. Place the same number of blue pieces in each cup of liquid.
3. Use a spoon to push down on the blue pieces to make sure they are not floating because of surface tension.

4. Record whether or not the blue pieces sink or float in the liquid.
    a. If cooler sample sinks, then the density of the blue cooler pieces is greater than the density of that liquid.
    b. If the cooler sample floats, then the density of the blue cooler pieces is less than the density of that liquid.

### *(E) Materials*

Various known liquids with different densities
Recycled sample containing blue cooler pieces
Small dishes
Spoons

## II. DATA

### *Part 1: The Cooler Evidence*

**TABLE 1:**

**RECYCLED COOLER AND LAKE SAMPLES**

| LIQUID | DENSITY (G/ML) | SINKS | FLOATS |
|---|---|---|---|
| Water | 1.00 | Yes | No |
| Salt | 1.05 | No | Yes |
| Ethanol | 0.79 | Yes | No |
| Mineral Oil | 0.80 | Yes | No |
| Vinegar | 1.01 | Yes | No |

### *Part II: The Delivery Truck Evidence*

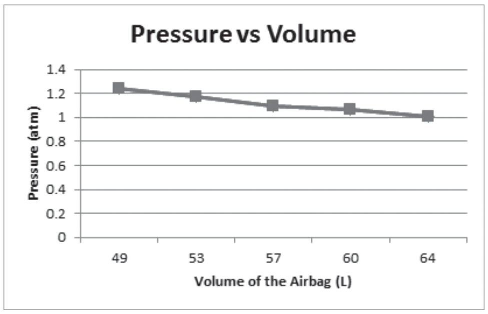
**TABLE 2:**

**CALCULATED VOLUME OF AIRBAG FROM THE SUNKEN DELIVERY TRUCK**

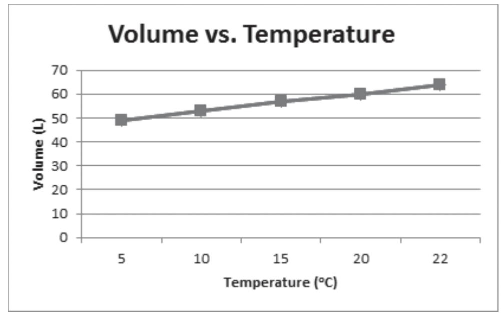
| DEPTH (FEET) | TEMPERATURE ($^0$C) | PRESSURE (ATM) | CALCULATED VOLUME (LITERS) |
|---|---|---|---|
| 40 | 5 | 2.24 atm | 27.1 |
| 30 | 10 | 1.520 mmHg x $\frac{1 \text{ atm}}{760 \text{ atm}}$ = 1.17 atm | 30.9 |
| 20 | 15 | 1140 mmHg x $\frac{1 \text{ atm}}{760 \text{ atm}}$ = 1.10 atm | 57.2 |
| 10 | 20 | 1.07 atm | 59.8 |
| 0 | 22 | 1.01 atm | 63.8 |

## III. ANALYSIS: CALCULATIONS

### GRAPH 1: PRESSURE VS. VOLUME




### GRAPH 2: VOLUME VS. TEMPERATURE




### *Part I: The Cooler Evidence*

1. $59.5\ L \times \frac{1.057\ qts}{L} = 62.9\ qts$

   >162 qts = body does not fit
   <162 qts = body does fit
   62.9 qts < 162 qts = yes, body will fit inside the cooler

2. 1 ml = 1 $cm^3$
   104 cm x 45.7 cm x 1 cm = 4,752.8 $cm^3$ of water displaced if cooler sinks 1 cm

3. $4{,}752.8\ cm^3 \times \frac{1.05\ g}{1\ cm^3} = 4990.4\ g \times \frac{1000\ g}{1\ kg} = 4.9904\ kg$

   OR

   Density = mass/volume    1.05 g/$cm^3$ = mass/4,752.8 $cm^3$
   Mass = 4,990.4 g

4. 128 lbs x 1 kg = 58.2 kg + 13.6 kg + 13.6 kg = 85.4 kg
   (body) (cooler) (chain)

   $\frac{4.9904\ kg}{1\ cm} = \frac{85.4\ kg}{x\ cm}$

   x = 17.1 cm → no, not completely submerged because it's below the cooler height of 53.5 cm

5. $35.5\ cm \times 94.0\ cm \times 43.2\ cm = 144158.4\ ml \times \frac{1\ L}{1000 ml} = 144\ L$

   Volume = length x width x height
   1 $cm^3$ = 1 ml = 0.001 L

6. $144 \text{ L} \times \frac{1000 \text{ ml}}{1 \text{ L}} \times \frac{1 \text{ cm}^3}{1 \text{ ml}} \times \frac{1.05 \text{ g}}{1 \text{ cm}^3} = 151{,}200 \text{ g} \times \frac{1 \text{ kg}}{1000 \text{ g}} = 151 \text{ kg}$

7. $\underbrace{151 \text{ kg}}_{\text{(salt water)}} + \underbrace{13.6 \text{ kg}}_{\text{(chain)}} + \underbrace{13.6 \text{ kg}}_{\text{(cooler)}} = 178 \text{ kg}$

$$\frac{4.9904 \text{ kg}}{1 \text{ cm}} = \frac{178 \text{ kg}}{x \text{ cm}}$$

$x = 35.7$ cm → no, not completely submerged because it's below the cooler height of 53.5 cm

## PART II: THE DELIVERY TRUCK EVIDENCE

1. Ideal Gas Law
   $P = 1$ atm
   $V = 65$ L
   $R = 0.0821$ L-atm/mole-K
   $T = 25°C + 273 = 298K$

   $P V = n R T$
   $(1) \times (65) = n \times (0.0821) \times (298)$
   $65 = n \times (24.4658)$
   $n = 2.66$ moles

2.

**CALCULATIONS FOR THE VOLUME OF THE AIRBAG AT VARIOUS DEPTHS**

| DEPTH (FEET) | VOLUME CALCULATIONS USING IDEAL GAS LAW |
|---|---|
| 40 | $PV = nRT$<br>$(2.24) \times (V) = (2.66) \times (0.0821) \times (278)$<br>$2.24\,V = (60.7)$<br>$V = 27.1$ L |
| 30 | $PV = nRT$<br>$(2.0) \times (V) = (2.66) \times (0.0821) \times (283)$<br>$2.0\,V = (61.8)$<br>$V = 30.9$ L |
| 20 | $PV = nRT$<br>$(1.5) \times (V) = (2.66) \times (0.0821) \times (288)$<br>$1.5\,V = (41.9)$<br>$V = 57.2$ L |
| 10 | $PV = nRT$<br>$(1.07) \times (V) = (2.66) \times (0.0821) \times (293)$<br>$1.07\,V = (64.0)$<br>$V = 59.8$ L |
| 0 | $PV = nRT$<br>$(1.01) \times (V) = (2.66) \times (0.0821) \times (295)$<br>$1.01\,V = (64.4)$<br>$V = 63.8$ L |

## IV. CONCLUSION

The purpose of the experiments was to be able to find the location of the crime scene where the kidnapping of Kirsten K. took place, determine if the body was able to be disposed of inside the cooler using the various options, and check to see if the delivery truck could be safely removed from the lake without the deployed airbag exploding. The hypothesis was supported for Part I: The Cooler Evidence because the suspect(s) were not successful in trying to sink the cooler with the body in it, with a chain wrapped around it, or shooting a bullet hole it to allow the cooler to fill with water. The hypothesis for Part II: The Delivery Truck Evidence was also supported because the airbag did not increase above 65 Liters in volume so it will not explode when police remove it from the bottom of the lake, so evidence will be able to be extracted from the airbag of the truck.

The data collected from the density gradient experiment proves that Kirsten K.'s body was disposed of in the Clinton Lake because the blue recycled cooler pieces did not float in the salt water only. The salt water had a density of 1.05 g/ml and the vinegar had the next highest density of 1.01 g/ml. The recycled blue cooler pieces did not float in the vinegar, so this puts the density of the cooler pieces between a 1.01 g/ml and 1.05 g/ml range in density. The only lake that the cooler would have floated in would have been Clinton Lake because it has a density of 1.05 g/ml. The density of Lake Springfield (1.01 g/ml) would have matched the density of the vinegar that was tested where the blue cooler pieces sank. So if the suspect(s) were trying to sink the cooler in Lake Bloomington or Lake Springfield, they would have been successful and wouldn't have had to recycle the cooler to get rid of the evidence. The calculations for the various situations create additional support for the suspect(s) not being successful in sinking the cooler using other methods, such as wrapping chain around it or shooting a hole in it to fill it with water. According to the calculations in numbers four and five specifically, even if the cooler had a hole in it, the cooler with the body in it would have still floated.

The police were also able to successfully remove the delivery truck from the lake without exploding the airbag, so additional evidence will be able to be retrieved from the truck to determine the lead suspect(s) at this point in the investigation. According to the calculations, the volume of the airbag will only get to 63.8 L and the maximum capacity of the airbag is 65 L, so the police should be able to remove the truck with the deployed airbag exploding and compromising important evidence in the truck.

The two most likely suspects for Kirsten K.'s murder are Harold M. and Gladys V. They are the best suspects because they both have houses in Clinton and live in the area and would be most familiar with Clinton Lake. Harold M. may be more likely than Gladys V. to be able to maneuver the victim and cooler to try to sink it. If Gladys V. were working alone, it would be highly unlikely that she would be able to move the cooler and chains to wrap it by herself. But since she is a retired pharmacist she may have access to drugs to kidnap the victim. But again, she is most likely not working alone since she may not have the strength required to be able to force Kirsten K. to be taken from one location to another.

## V. DISCUSSION

### *Part I: The Cooler Evidence*

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

   The body would have fit in the cooler because according to calculation #1, the cooler can hold 162 quarts and Kirsten's body only takes up 62.9 quarts of space.

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

   The cooler would have still floated even with the weight of Kirsten K.'s body inside of it. In calculation #2, the cooler with a mass of 4.872 kg would displace 4,753.8 $cm^3$ of water if it sank 1 cm. But with the mass of the body inside the cooler and a chain around it, plus the mass of the cooler itself, it would have only sank 17.5 cm which is not higher than the height of the cooler, which is 53.3 cm (as stated in calculation #2).

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

After the suspects tried to sink the cooler with the body in it and were not successful, they now had to try to dispose of the cooler separately from the victim's body. The suspects would not have been successful trying to fill the cooler with water as it was in the lake either. With the mass of the cooler, the mass of the chain, and the mass of the water inside the cooler, the total mass of the cooler would be 175 kg. According to calculation #7, the cooler would only sink 35.7 cm, so it is not completely submerged because it does not cover the 53.5 cm height of the cooler, so some of the cooler would still be able to be seen at the top of the lake.

## *Part II: The Delivery Truck Evidence*

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

The maximum capacity for the volume of the airbag is 65 L, so if the volume of the airbag does not increase above the 65 L limit as the police are extracting the delivery truck from the lake, then the deployed airbag will not explode and compromise evidence. According to the calculation for volume at a depth of 0 feet (so right at the surface of the lake), the volume of the airbag was 63.8 L, which is not above the maximum capacity, so the airbag will stay intact.

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.

The pressure verses volume graph shows an indirect relationship, because the two variables in the graph do the opposite thing. According to the graph, as the pressure at the various depths in the lake decreases as the delivery truck is removed from the lake, the volume of the airbag will increase. 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 63.8 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. The only difference here is that temperature is not held constant, but the same relationship between pressure and volume is seen as in Boyle's Law.

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.

The volume verses temperature graph shows a direct relationship, because the two variables in the graph do the same thing. According to the graph, as the temperature increases as the truck is brought closer to the surface, the volume of the airbag increases as well. The volume of the airbag is 27.1 L and the temperature is 5°C, but as the temperature is increased to 22°C near the surface of the lake, the volume of the airbag increases to 63.8 L. This shows the relationship in Charles' Law. The only difference is that the pressure is not held constant because the pressure changes as well as the truck goes from being on the bottom of the lake to the top, closer to the surface.

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.

   Once the airbag deploys, there are a certain number of moles of gas produced from the reactants inside the bag. As long as the airbag stays closed and 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.

## GRADING RUBRIC A

**Name** ______________________________ **Score** _____ **/60** __________**%** **Grade**_____

### I. Introduction

| Application | # | wgt | Exemplary (10) | At Standard (8) | In Progress (7) | Still Emerging (6) | No Evaluation (0) |
|---|---|---|---|---|---|---|---|
| Defining Problems | 1a | ½ | Makes insightful connections between ideas or events that might not be obvious—abstract thinking evident (4 of 4)<br>❑ Background Information includes highlighted information about both the cooler and delivery truck cases and the suspect files that are relevant to answering the purpose<br>❑ Purpose is clearly stated and correct<br>❑ A hypothesis is given for both the cooler evidence testing and the delivery truck gas laws data<br>❑ Procedure supports purpose with a detailed, numerical list of steps for developing a density gradient for the cooler evidence | Makes general, logical connections between ideas or events; mostly concrete in nature (3 of 4) | Makes superficial connections between ideas; thinking might be confused or incomplete (2 of 4) | Makes incorrect or no connections between ideas (1 of 4) | No work shown for this section |

### II. Data—Part I: The Cooler Evidence

| Application | # | wgt | Exemplary (10) | At Standard (8) | In Progress (7) | Still Emerging (6) | No Evaluation (0) |
|---|---|---|---|---|---|---|---|
| Interpreting Models | 1b | ½ | Interprets visuals or models at a complex level (4 of 4)<br>❑ Sufficient number of tests/trials to obtain meaningful density data for each liquid sample with the blue cooler pieces<br>❑ All qualitative measurements are accurately recorded in a data table format, not just listed<br>❑ Completed data table includes a relevant **title** explaining the data sets<br>❑ Correct labels/units are used for the qualitative data | Interprets visuals or models at a general level (3 of 4) | Interpretation of visual or model contains errors that restrict understanding (2 of 4) | Shows fundamental errors in use and understanding of visual (1 of 4) | No work turned in for this section |

### II. Data—Part II: The Delivery Truck Evidence

| Application | # | wgt | Exemplary (10) | At Standard (8) | In Progress (7) | Still Emerging (6) | No Evaluation (0) |
|---|---|---|---|---|---|---|---|
| Interpreting Models | 1b | ½ | Interprets visuals or models at a complex level (4 of 4)<br>❑ The calculated volume for each depth is shown in a data table format<br>❑ All calculated measurements for converting the mmHg to atm are shown within the data table, not just listed<br>❑ Completed data table includes a relevant **title** explaining the data sets<br>❑ Correct labels/units are used for both the qualitative and quantitative data | Interprets visuals or models at a general level (3 of 4) | Interpretation of visual or model contains errors that restrict understanding (2 of 4) | Shows fundamental errors in use and understanding of visual (1 of 4) | No work turned in for this section |

## III. Analysis: Graph—Part II: The Delivery Truck Evidence

| Application | # | wgt | Exemplary (10) | At Standard (8) | In Progress (7) | Still Emerging (6) | No Evaluation (0) |
|---|---|---|---|---|---|---|---|
| Interpreting Models | 1b | ½ | Interprets visuals or models at a complex level (4 of 4)<br>❑ Points are plotted correctly on both of the gas law graphs and even intervals are shown on both axes of the graph<br>❑ A best fit line is correctly drawn for each of the graphs for both relationships<br>❑ Completed graphs include a relevant **title** explaining the data sets<br>❑ Correct labels/units are used for both the x and y-axis | Interprets visuals or models at a general level (3 of 4) | Interpretation of visuals or models contains errors that restrict understanding (2 of 4) | Shows fundamental errors in use and understanding of visuals (1 of 4) | No work turned in for this section |

## III. Analysis: Calculations—Part I: The Cooler Evidence

| Application | # | wgt | Exemplary (10) | At Standard (8) | In Progress (7) | Still Emerging (6) | No Evaluation (0) |
|---|---|---|---|---|---|---|---|
| Problem Calculations | 2a | ½ | All essential information is evident through well-organized work while justifying the solution (4 of 4)<br>❑ Calculations (#1) for proving discussion question #1 are complete, correct, and all work was shown including units for all numbers throughout calculation<br>❑ Calculations (#2-#4) for proving discussion question #2 are complete, correct, and all work was shown including units for all numbers throughout calculation<br>❑ Calculations (#5-#7) for proving discussion question #3 are complete, correct, and all work was shown including units for all numbers throughout calculation<br>❑ Significant figures are considered when writing final answers for each of the calculations | Most essential information is evident through organized work while leading to the solution (3 of 4) | Minimum information is evident through work with a solution present (2 of 4) | Work is extremely unorganized with no solution present (1 of 4) | No work shown for this section |

## III. Analysis: Calculations—Part II: The Delivery Truck Evidence

| Application | # | wgt | Exemplary (10) | At Standard (8) | In Progress (7) | Still Emerging (6) | No Evaluation (0) |
|---|---|---|---|---|---|---|---|
| Problem Calculations | 2a | ½ | All essential information is evident through well-organized work while justifying the solution (4 of 4)<br>❑ The correct equation was shown for the gas law that was used for calculating the number of moles of gas in the airbag and the volume at each of the depths<br>❑ Calculations for the number of moles of gas in the airbag are complete, correct, and all work was shown<br>❑ Calculations for the volume of the airbag at various depths are complete, correct, and all work was shown<br>❑ Units for ALL numbers were consistently used throughout the calculations in this section | Most essential information is evident through organized work while leading to the solution (3 of 4) | Minimum information is evident through work with a solution present (2 of 4) | Work is extremely unorganized with no solution present (1 of 4) | No work shown for this section |

### IV. Conclusion—Part 1: The Cooler Evidence

| Application | # | wgt | Exemplary (10) | At Standard (8) | In Progress (7) | Still Emerging (6) | No Evaluation (0) |
|---|---|---|---|---|---|---|---|
| Connecting Ideas | 1d | ½ | Makes insightful connections between ideas or events that might not be obvious—abstract thinking evident (4 of 4)<br>❑ The purpose is answered for which lake police should start looking around to find more evidence and designate a crime scene<br>❑ Specific data (evidence) from the density gradient lab work is used to support the lake choice<br>❑ Evidence to support or not support the hypothesis for the cooler evidence uses specific examples from the data<br>❑ Where is the evidence leading so far?? Any suspects more likely than others at this point based on the evidence and suspect file information? Make sure you say why!! | Makes general, logical connections between ideas or events; mostly concrete in nature (3 of 4) | Makes superficial connections between ideas; thinking might be confused or incomplete (2 of 4) | Makes incorrect or no connections between ideas (1 of 4) | No work shown for this section |

### IV. Conclusion—Part II: The Delivery Truck Evidence

| Application | # | wgt | Exemplary (10) | At Standard (8) | In Progress (7) | Still Emerging (6) | No Evaluation (0) |
|---|---|---|---|---|---|---|---|
| Connecting Ideas | 1d | ½ | Makes insightful connections between ideas or events that might not be obvious—abstract thinking evident (4 of 4)<br>❑ The purpose is answered for if the police will be able to safely extract the sunken delivery truck from the lake without the volume of the airbag going over the maximum capacity<br>❑ Specific data (evidence) is used to support the whether or not the airbag will stay intact when the truck is retrieved from the lake<br>❑ Evidence to support or not support the hypothesis for the delivery truck evidence uses specific examples from the data<br>❑ Where is the evidence leading so far?? Any suspects more likely than others at this point based on the evidence and suspect file information? Make sure you say why!! | Makes general, logical connections between ideas or events; mostly concrete in nature (3 of 4) | Makes superficial connections between ideas; thinking might be confused or incomplete (2 of 4) | Makes incorrect or no connections between ideas (1 of 4) | No work shown for this section |

### V. Discussion Questions—Part I: The Cooler Evidence

| Application | # | wgt | Exemplary (10) | At Standard (8) | In Progress (7) | Still Emerging (6) | No Evaluation (0) |
|---|---|---|---|---|---|---|---|
| Supporting Ideas | 3b | ½ | Support used is varied, the best available, and strongly enhances audience understanding (4 of 4)<br>❑ Questions #1 is answered correctly and answer is supported with data to explain why<br>❑ Questions #2 is answered correctly and answer is supported with data to explain why<br>❑ Questions #3 is answered correctly and answer is supported with data to explain why<br>❑ Answers are written in complete sentences for all questions that require explanations | Support is accurate and sufficiently detailed—all basics evident (3 of 4) | Support is insufficient, inaccurate, or vague in places—enough to confuse audience somewhat (2 of 4) | Support is missing, inaccurate, or vague overall (1 of 4) | No work shown for this section |

## V. Discussion Questions—Part II: The Delivery Truck Evidence

| Application | # | wgt | Exemplary (10) | At Standard (8) | In Progress (7) | Still Emerging (6) | No Evaluation (0) |
|---|---|---|---|---|---|---|---|
| Supporting Ideas | 3b | ½ | Support used is varied, the best available, and strongly enhances audience understanding (4 of 4)<br>❑ Questions #1 is answered correctly and answer is supported with volume data to explain why<br>❑ Questions #2 is answered correctly connecting the graph to the correct gas law and answer is supported with data to explain why the graph shows the relationship stated<br>❑ Questions #3 is answered correctly connecting the graph to the correct gas law and answer is supported with data to explain why the graph shows the relationship stated<br>❑ Questions #4 is answered correctly and answer is supported with logical connections to the kinetic molecular theory to explain why | Support is accurate and sufficiently detailed—all basics evident (3 of 4) | Support is insufficient, inaccurate, or vague in places—enough to confuse audience somewhat (2 of 4) | Support is missing, inaccurate, or vague overall (1 of 4) | No work shown for this section |

## Overall Evidence Report Formatting

| Application | # | wgt | Exemplary (10) | At Standard (8) | In Progress (7) | Still Emerging (6) | No Evaluation (0) |
|---|---|---|---|---|---|---|---|
| Technology Applications | 1c | ½ | Technology used is best available and appropriate for the required research, data representation, interpretation, and communication of results. (4 of 4)<br>❑ Entire Lab Report is computer generated<br>❑ Lab Report is in an Outline Format<br>❑ The use of personal pronouns is non-evident<br>❑ Lab Report includes all sections required in the Lab Report Style Guide as required by the rubric | Technology was used for the required research, data representation, interpretation, and communication of results. (3 of 4) | Technology used was insufficient for the required research, data representation, interpretation, and communication of results. (2 of 4) | Evidence of Technology use is missing and/or insufficient (1 of 4) | No work shown for this section |

## Content Recall

| Application | # | wgt | Exemplary (10) | At Standard (8) | In Progress (7) | Still Emerging (6) | No Evaluation (0) |
|---|---|---|---|---|---|---|---|
| Content Recall | 1f | ½ | Recalls virtually all essential terms and factual information<br>❑ 0 Content Questions were asked to the instructor for the duration of this performance assessment | Recalls most essential terms and factual information<br>❑ 1 Content Question was asked to the instructor for the duration of this performance assessment | Recalls a minimum of essential terms and factual information<br>❑ 2 Content Questions were asked to the instructor for the duration of this performance assessment | Recalls virtually no essential terms and factual information<br>❑ 3 or more Content Questions were asked to the instructor for the duration of this performance assessment | No work shown for this section |

**Some things I think I did well on this assessment are:**

**Some things I still have questions about performance assessments, lab reports, this class, etc. are:**

**If I graded myself on this, my score would be a __________/120, then divide that by 2 to get score out of 60 because each section is weighted by ½.**

*Page numbers printed in **boldface** type refer to figures or tables.*

# FORENSICS in CHEMISTRY

*The Case of Kirsten K.*

"Forensics seems to have the unique ability to maintain student interest and promote content learning … I still have students approach me from past years and ask about the forensics case and specific characters from the story. I have never had a student come back to me and comment on that unit with the multiple-choice test at the end."

—*from the Introduction to* Forensics in Chemistry: The Case of Kirsten K.

How did Kirsten K.'s body wind up at the bottom of a lake—and what do wedding cake ingredients, soil samples, radioactive decay, bone age, blood stains, bullet matching, and drug lab evidence reveal about whodunit? These mysteries are at the core of this teacher resource book, which meets the unique needs of high school chemistry classes in a highly memorable way. The book makes forensic evidence the foundation of a series of hands-on, weeklong labs. As you weave the labs throughout the year and students solve the case, the narrative provides vivid lessons in why chemistry concepts are relevant and how they connect.

All chapters include case information specific to each performance assessment and highlight the related national standards and chemistry content. Chapters provide

- Teacher guides to help you set up
- Student performance assessments
- Suspect files to introduce the characters and new information about their relationships to the case
- Samples of student work that has been previously assessed (and that serves as an answer key for you)
- Grading rubrics

Using *Forensics in Chemistry* as your guide, you will gain the confidence to use inquiry-based strategies and performance-based assessments with a complex chemistry curriculum. Your students may gain an interest in chemistry that rivals their fascination with *Bones* and *CSI*.

**Grades 9–12**

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