# FORENSICS In CHEMISTRY

## The Case of Kirsten K.

Sara McCubbins and Angela Codron



## FORENSICS In CHEMISTRY

## The Case of Kirsten K.

# **FORENSICS** In CHEVICASE of Kirsten K.

Sara McCubbins and Angela Codron



Arlington, Virginia



Claire Reinburg, Director Jennifer Horak, Managing Editor Andrew Cooke, Senior Editor Wendy Rubin, Associate Editor Agnes Bannigan, Associate Editor Amy America, Book Acquisitions Coordinator

ART AND DESIGN Will Thomas Jr., Director Lucio Bracamontes, Graphic Designer Cover photography by Talaj for iStock

PRINTING AND PRODUCTION

Catherine Lorrain, Director Jack Parker, Electronic Prepress Technician

NATIONAL SCIENCE TEACHERS ASSOCIATION Francis Q. Eberle, PhD, Executive Director David Beacom, Publisher

1840 Wilson Blvd., Arlington, VA 22201 www.nsta.org/store For customer service inquiries, please call 800-277-5300.

Copyright © 2012 by the National Science Teachers Association. All rights reserved. Printed in the United States of America. 15 14 13 12 4 3 2 1

NSTA is committed to publishing material that promotes the best in inquiry-based science education. However, conditions of actual use may vary, and the safety procedures and practices described in this book are intended to serve only as a guide. Additional precautionary measures may be required. NSTA and the authors do not warrant or represent that the procedures and practices in this book meet any safety code or standard of federal, state, or local regulations. NSTA and the authors disclaim any liability for personal injury or damage to property arising out of or relating to the use of this book, including any of the recommendations, instructions, or materials contained therein.

#### PERMISSIONS

Book purchasers may photocopy, print, or e-mail up to five copies of an NSTA book chapter for personal use only; this does not include display or promotional use. Elementary, middle, and high school teachers may reproduce forms, sample documents, and single NSTA book chapters needed for classroom or noncommercial, professional-development use only. E-book buyers may download files to multiple personal devices but are prohibited from posting the files to third-party servers or websites, or from passing files to non-buyers. For additional permission to photocopy or use material electronically from this NSTA Press book, please contact the Copyright Clearance Center (CCC) (*www.copyright.com*; 978-750-8400). Please access *www.nsta.org/ permissions* for further information about NSTA's rights and permissions policies.

LIBRARY OF CONGRESS CATALOGING-IN-PUBLICATION DATA

McCubbins, Sara.
Forensics in chemistry: the case of Kirsten K. / by Sara McCubbins and Angela Codron.
p. cm.
Includes bibliographical references.
ISBN 978-1-936137-36-7—ISBN 978-1-936959-83-9 (e-book) 1. Chemistry, Forensic—Study and teaching (Secondary) I.
Codron, Angela. II. Title.
HV8073.M3325 2012
363.25071'2—dc23
2011049549

## Contents

- vii About the Authors
- ix Acknowledgments
- 1 Chapter 1: Introduction to the Curriculum
- 1 Development of the Project
- 3 The Importance of Performance-Based Assessment
- 3 Preparing Your Students for Inquiry Labs

#### 5 Chapter 2: The Big Picture

- 5 Details About the Case
- 6 The Complete Scenario
- 9 Chapter Organization
- 9 Chemistry Concepts Chart
- 9 Grading Rubric: Notes to the Teacher and Applications of Learning
- 10 Lab Report Style Guide
- 10 Forensic Tags
- 10 Sample Inquiry-Based Lab

#### 11 Chapter 3: The Cooler and Delivery Truck Evidence

- 11 Case Information
- 11 Part I: The Cooler Evidence
- 14 Part II: The Delivery Truck Evidence
- 15 Teacher Guide: The Cooler and Delivery Truck Evidence
- 18 The Case of Kirsten K.: The Cooler and Delivery Truck Evidence
- 26 Suspect File A
- 27 Student Lab Report Example: The Cooler and Delivery Truck Evidence
- 35 Grading Rubric A

#### 39 Chapter 4: The Chemical Evidence

- 39 Case Information
- 40 Part I: The Delivery Truck and Crime Scene Evidence
- 41 Part II: The Suspect Evidence
- 41 Part III: The Amount of Chemical Substance
- 42 Part IV: The Cake Shop Ingredients Analysis
- 43 Teacher Guide: The Chemical Evidence
- 45 The Case of Kirsten K.: The Chemical Evidence
- 50 Suspect File B
- 51 Student Lab Report Example: The Chemical Evidence
- 62 Grading Rubric B

#### 65 Chapter 5: The Nuclear Radiation Evidence

- 65 Case Information
- 66 Part I: The Crime Scene Soil Sample Evidence
- 66 Part II: The Shoe Print Evidence
- 67 Part III: The Bone Age Analysis
- 68 Part IV: The Medical Tracer Evidence
- 69 Teacher Guide: The Nuclear Radiation Evidence
- 72 The Case of Kirsten K.: The Nuclear Radiation Evidence
- 79 Suspect File C
- 80 Student Lab Report Example: The Nuclear Radiation Evidence
- 86 Grading Rubric C

#### FORENSICS IN CHEMISTRY

#### CONTENTS

#### 89 Chapter 6: The Weapon Analysis Evidence

- 89 Case Information
- 90 Part I: The Fingerprint Analysis
- 91 Part II: Gun and Bullet Matching
- 91 Part III: Gunshot Residue
- 92 Part IV: Blood Stain Analysis
- 93 Teacher Guide: The Weapon Analysis Evidence
- 97 The Case of Kirsten K.: The Weapon Analysis Evidence
- 103 Suspect File D
- 104 Student Lab Report Example: The Weapon Analysis Evidence
- 111 Grading Rubric D

#### 113 Chapter 7: The Drug Lab Evidence

- 113 Case Information
- 113 Part I: The IR Spectra Analysis
- 114 Part II: Caffeine Extraction
- 115 Part III: Thin Layer Chromatography of an Unknown Drug
- 115 Part IV: Thin Layer Chromatography of Pen Matching
- 117 Teacher Guide: The Drug Lab Evidence
- 125 The Case of Kirsten K.: The Drug Lab Evidence
- 131 Suspect File E
- 132 Student Lab Report Example: The Drug Lab Evidence
- 137 Grading Rubric E

#### **139 Chapter 8: The Final Assessment**

- 139 Evolution of the Final Project
- 141 Flexibility of the Case
- 142 Final Grading Rubric
- 143 Student Project Examples

#### 145 Appendixes

- 145 Appendix A: Chemistry Concepts Chart
- 151 Appendix B: Grading Rubric: Notes to the Teacher and Applications of Learning
- 153 Appendix C: Lab Report Style Guide
- 157 Appendix D: Forensic Tags
- 159 Appendix E: Sample Inquiry Lab

#### 173 Index

## 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

s with any large-scale project, this work owes a great deal to many individuals and organizations. The authors would like to recognize the Center for Mathematics, Science, and Technology (CeMaST) at Illinois State University for its continued support of this project; Dr. William Hunter, director of CeMaST, for his guidance and support; Abby Newcomb and Mary McCubbins, for their help in testing some of the curriculum; Amanda Fain, for her editing; Dr. Darci Harland, for her guidance in the proposal process; and Mary McCubbins, for her uncanny ability to take what was written and create meaningful graphics.

We also wish to thank the science department and the administration at Normal Community West High School for their continued support of curriculum that revolves around performance-based assessments and for allowing its science classrooms to be a true laboratory for learning. A special thank you to the Chemistry II students who have readily participated in these assessments; without their feedback and patience these assessments would not be as successful as they are in the classroom.

This body of work was the result of the Partnerships for Research in Science and Mathematics education (PRISM) Project, a program that originated in 2001 and was supported by the National Science Foundation grant 0086354 from the Graduate Teaching Fellows in K–12 Education program.

Sara McCubbins would like to thank the following people: Mrs. Angie Lawrence, for first planting the seed and teaching me to truly love science; Ms. Lisa Thomas, who taught me to love both science and writing-after all, you were the first to call me Sara, the Writer; Dr. William Hunter, not only for cultivating that love of science and writing, but also for always daring me to dream bigger; Ms. Angie Codron, for showing me what true inquiry in the classroom looks like, and for always saying "yes" to any harebrained ideas we might dream up-you are a true friend, and the partnership we have developed over the years can only lead to great things; and to my family and friends, who continue to support me and encourage me always to pursue my passions.

Angela Codron would like to thank the following people: the science department at St. Charles North High School for helping engrain the value of performance based assessment in curriculum planning during her first year of teaching; Dr. William Hunter, for believing in the importance of science education and the use of unique instruction for

İX

#### **ACKNOWLEDGMENTS**

maximum student learning; Ms. Elisa Palmer and Ms. Darci Harland for the inspiration to use biology based forensics and transform it for my chemistry classroom; Ms. Sara McCubbins, for providing the spark for me to begin to share what I do in the classroom and helping me have the confidence to think others would really be interested in it; and my family for supporting the task of writing a book and allowing me to cross one more thing off my list of things to accomplish in my career.

#### **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

#### **CHAPTER 3**

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).



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.

#### National Science Teachers Association

#### FIGURE 3.1

#### FORENSIC TAG

#### **Forensics Evidence Tag**

Description of	item:	
<u>Recyclea cooler</u>	sample	
	le e Norr	
Location of col	lection:	
<u>Local recycling p</u>	lant	
Additional Info	rmation:	
Other recycled p	roducts may be included in	
sample	0	

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.



#### **CHAPTER 3**

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**

- 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

- 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.
- 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

- 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.

National Science Teachers Association

#### 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)

- 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.

18

#### 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. 3. The density of lake water where you determined police should start their investigation is \_\_\_\_\_\_ g/cm<sup>3</sup>. 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)

- 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.
- 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<sup>3</sup>)

National Science Teachers Association

20

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.

#### Discussion

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

- 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?
- 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.

#### 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.

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.

22

#### 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.

24

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**

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

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.

#### 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)

26 National Science Teachers Association

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.

#### **CHAPTER 3**

- 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
vínegar	1.01	Yes	No

## Part II: The Delivery Truck Evidence TABLE 2:

CALCULATED VOLUME OF AIRBAG FROM THE SUNKEN DELIVERY TRUCK

DEPTH (FEET)	TEMPERATURE (°C)	PRESSURE (ATM)	CALCULATED VOLUME (LITERS)
40	5	2.24 atm	27.1
30	10	1.520 mmHg x $\frac{1}{760}$ atm = 1.17 atm	30.9
20	15	1140 mmHg x $\frac{1 \text{ atm}}{760 \text{ atm}} = 1.10 \text{ atm}$	<i>57</i> .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 x  $\frac{1.057}{1}$  qts = 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.  $1 \text{ ml} = 1 \text{ cm}^3$ 104 cm x 45.7 cm x 1 cm = 4,752.8 cm<sup>3</sup> of water displaced if cooler sinks 1 cm
- 3.  $4,752.8 \text{ cm}^3 \times \frac{1.05 \text{ g}}{1 \text{ cm}^3} = 4990.4 \text{ g} \times \frac{1000 \text{ g}}{1 \text{ kg}} = 4.9904 \text{ kg}$

OR

Densíty = mass/volume  $1.05 \text{ g/cm}^3 = \text{mass/4},752.8 \text{ cm}^3$ 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)

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

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

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

Volume = length x width x height 1 cm<sup>3</sup> = 1 ml = 0.001 L

#### **CHAPTER 3**

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

```
7. 151 kg + 13.6 kg + 13.6 kg = 178 kg (salt water) (chain) (cooler)
```

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

x = 35.7 cm  $\rightarrow$  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) x (65) = n x (0.0821) x (298) 65 = n x (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
	$P \vee = n RT$
40	$(2.24) \times (\vee) = (2.66) \times (0.0821) \times (278)$
10	$2.24 \lor = (60.7)$
	V = 27.1 L
	PV = nRT
30	$(2.0) \times (\vee) = (2.66) \times (0.0821) \times (283)$
50	$2.0 \lor = (61.8)$
	V = 30.9 L
	$PV = \mu RT$
20	$(1.5) \times (\vee) = (2.66) \times (0.0821) \times (288)$
20	$1.5 \vee = (41.9)$
	V = 57.2 L
	$P \vee = n R T$
10	$(1.07) \times (\vee) = (2.66) \times (0.0821) \times (293)$
10	$1.07 \vee = (64.0)$
	V = 59.8 L
	$P \vee = n R T$
0	$(1.01) \times (\vee) = (2.66) \times (0.0821) \times (295)$
U	$1.01 \vee = (64.4)$
	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

#### **CHAPTER 3**

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<sup>3</sup> 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  $5^{\circ}$ C, but as the temperature is increased to  $22^{\circ}$ 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.

<b>GRADING</b> I							
Name				Score		0%	Grade
I. Introduct	tion						
Application	#	wgt	Exemplary (10)	At Standard (8)	In Progress (7)	Still Emerging (6)	No Evaluation (0)
Defining Problems	1a	27	<ul> <li>Makes insightful connections between ideas or events that might not be obvious—abstract thinking evident (4 of 4)</li> <li>Background Information includes highlighted information about both the cooler and delivery truck cases and the suspect files that are relevant to answering the purpose</li> <li>Purpose is clearly stated and correct</li> <li>A hypothesis is given for both the cooler evidence testing and the delivery truck gas laws data</li> <li>Procedure supports purpose with a detailed, numerical list of steps for developing a density gradient for the cooler evidence</li> </ul>	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—P	art l	: The	e Cooler Evidence				
Application	#	wgt	Exemplary (10)	At Standard (8)	In Progress (7)	Still Emerging (6)	No Evaluation (0)
Interpreting Models	1b	2	<ul> <li>Interprets visuals or models at a complex level (4 of 4)</li> <li>Sufficient number of tests/trials to obtain meaningful density data for each liquid sample with the blue cooler pieces</li> <li>All qualitative measurements are accurately recorded in a data table format, not just listed</li> <li>Completed data table includes a relevant <u>title</u> explaining the data sets</li> <li>Correct labels/units are used for the qualitative data</li> </ul>	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—F	art l	II: TI	he Delivery Truck Evidence				
Application	#	wgt	Exemplary (10)	At Standard (8)	In Progress (7)	Still Emerging (6)	No Evaluation (0)
Interpreting Models	1b	<sup>1</sup> / <sub>2</sub>	<ul> <li>Interprets visuals or models at a complex level (4 of 4)</li> <li>The calculated volume for each depth is shown in a data table format</li> <li>All calculated measurements for converting the mmHg to atm are shown within the data table, not just listed</li> <li>Completed data table includes a relevant <u>title</u> explaining the data sets</li> <li>Correct labels/units are used for both the qualitative and quantitative data</li> </ul>	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

#### The Cooler and Delivery Truck Evidence

FORENSICS IN CHEMISTRY

35

c	ц		e			e	
No Evaluatior (0)	No work turned i for this section		No Evaluatior (0)	No work shown for this section		No Evaluatior (0)	No work shown for this section
Still Emerging (6)	Shows fundamental errors in use and understanding of visuals (1 of 4)		Still Emerging (6)	Work is extremely unorganized with no solution present (1 of 4)		Still Emerging (6)	Work is extremely unorganized with no solution present (1 of 4)
In Progress (7)	Interpretation of visuals or models contains errors that restrict understanding (2 of 4)		In Progress (7)	Minimum information is evident through work with a solution present (2 of 4)		In Progress (7)	Minimum information is evident through work with a solution present (2 of 4)
At Standard (8)	Interprets visuals or models at a general level (3 of 4)		At Standard (8)	Most essential information is evident through organized work while leading to the solution (3 of 4)		At Standard (8)	Most essential information is evident through organized work while leading to the solution (3 of 4)
Exemplary (10)	<ul> <li>Interprets visuals or models at a complex level (4 of 4)</li> <li>Points are plotted correctly on both of the gas law graphs and even intervals are shown on both axes of the graph</li> <li>A best fit line is correctly drawn for each of the graphs for both relationships</li> <li>Completed graphs include a relevant <u>title</u> explaining the data sets</li> <li>Correct labels/units are used for both the x and y-axis</li> </ul>	ations—Part I: The Cooler Evidence	Exemplary (10)	<ul> <li>All essential information is evident through well-organized work while justifying the solution (4 of 4)</li> <li>Calculations (#1) for proving discussion question #1 are complete, correct, and <u>all work</u> was shown including units for <u>all</u> numbers throughout calculation</li> <li>Calculations (#2-#4) for proving discussion question #2 are complete, correct, and <u>all work</u> was shown including units for <u>all</u> numbers throughout calculation</li> <li>Calculations (#2-#4) for proving discussion question #3 are complete, correct, and <u>all work</u> was shown including units for <u>all</u> numbers throughout calculation</li> <li>Calculations (#5-#7) for proving discussion question #3 are complete, correct, and <u>all work</u> was shown including units for <u>all</u> numbers throughout calculation</li> <li>Calculations (#5-#7) for proving discussion question #3 are complete, correct, and <u>all work</u> was shown including units for <u>all</u> numbers throughout calculation</li> <li>Calculations (#5-#7) for proving discussion question #3 are complete, correct, and <u>all work</u> was shown including units for <u>all</u> numbers throughout calculation</li> </ul>	ations—Part II: The Delivery Truck Evidence	Exemplary (10)	<ul> <li>All essential information is evident through well-organized work while justifying the solution (4 of 4)</li> <li>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</li> <li>Calculations for the number of moles of gas in the airbag are complete, correct, and <u>all work</u> was shown</li> <li>Calculations for the volume of the airbag at various depths are complete, correct, and <u>all work</u> was shown</li> <li>Units for ALL numbers were consistently used throughout the calculations in this section</li> </ul>
wgt	2	lcula	wgt	2	lcula	wgt	24
#	1b	: Ca	#	2a	: Ca	#	2a
Application	Interpreting Models	III. Analysis	Application	Problem Calculations	III. Analysis	Application	Problem Calculations

#### **CHAPTER 3**

\_

7. Conclusion       # wgt         pplication       # wgt         onnecting       1d       ½         onnecting       1d       ½       Makes ir         obvious-       0vious-       0vious-         eas       1d       ½       Makes ir         onnecting       1d       ½       Makes ir         pplication       # wgt       0       1f         pplication       # wgt       0       1f         obvious-       0       1d       ½       Makes ir         obvious-       0       1d       ½       Makes ir         obvious-       0       0       1ft       1         pplication       #       1d       ½       Makes ir         obvious-       0       0       1ft       1         mass       0       1d       ½       0       1         aith       0       0       0       1       1       1         obvious-       0       1       ½       1       1       1         obvious-       0       1       ½       1       1       1       1         obvious-       0       1	le Cooler Evidence	ExemplaryAt StandardIn ProgressStill EmergingNo Evaluation(10)(8)(7)(6)(0)	signtful connections between ideas or events that might not be 	he Delivery Truck Evidence	ExemplaryAt StandardIn ProgressStill EmergingNo Evaluation(10)(8)(7)(6)(0)	sightful connections between ideas or events that might not be Makes general, abstract thinking evident (4 of 4)	art I: The Cooler Evidence	ExemplaryAt StandardIn ProgressStill EmergingNo Evaluation(10)(8)(7)(6)(0)	
7. Conclusion       #       wgt         pplication       #       wgt         onnecting       1d       ½       0         eas       1d       ½       0         pplication       #       wgt       0         pplication       #       wgt       0         onnecting       1d       ½       0         pplication       #       wgt       0         oass       1d       ½       0         oass       1d       ½       0         oass       1d       ½       0         oas       1d       ½       0         oass       1d       ½       0	1: The Cooler Evidence	Exemplary (10)	<ul> <li>Aakes insightful connections between ideas or evebvious—abstract thinking evident (4 of 4)</li> <li>The purpose is answered for which lake policilosing around to find more evidence and des looking around to find more evidence and des used to support the lake choice</li> <li>Evidence to support or not support the hypothevidence uses specific examples from the data evidence uses specific examples from the data than others at this point based on the evidence information? Any s than others at this point based on the evidence information? Make sure you say why!!</li> </ul>	II: The Delivery Truck Evidence	Exemplary (10)	<ul> <li>Aakes insightful connections between ideas or evebvious—abstract thinking evident (4 of 4)</li> <li>The purpose is answered for if the police will extract the sunken delivery truck from the lak volume of the airbag going over the maximum</li> <li>Specific data (evidence) is used to support the airbag will stay intact when the truck is retriefence to support or not support the hypoth truck evidence uses specific examples from th truck evidence uses specific examples from the truck evidence uses specific examples from the truck evidence are specific examples from the truck evidence uses specific examples from the evidence uses are point based on the evidence used on the evidence uses are point evidence used on the evidence uses are point evidence used on the evidence use are point evidence used on the evidence use are point evidence used on the evidence use are point evidence used are point evidence use are point evidence used are point evidence are point ev</li></ul>	ns-Part I: The Cooler Evidence	Exemplary (10)	
7. Conclusion         pplication         ass         onnecting         ld         onnecting         ld         onnecting         ld         eas         pplication         pplication         annecting         ld         pplication         pplication         pplication         ld         onnecting         ld         ld         onnecting         ld         onnecting         ld         ld         onnecting         ld	Part	wgt	1, z, o o	Part	wgt	<u>2</u> 0 <u>N</u>	estior	wgt	
7. Conclusi onnecting eas pplication pplication pplication Discussion	0U	#	Id	- <b>u</b> 0	#	Id	n Qu	#	
	IV. Conclusi	Application	Connecting Ideas	IV. Conclusi	Application	Connecting Ideas	V. Discussio	Application	

for this section missing, inaccurate, or vague overall (1 of 4) places—enough to confuse audience somewhat (2 of 4) insufficient, or vague in inaccurate, detailed—all basics evident (3 of 4) accurate and sufficiently audience understanding (4 of 4) data to explain why Questions #2 is answered correctly and answer is supported with Questions #3 is answered correctly and answer is supported with data to explain why Answers are written in complete sentences for all questions that require explanations data to explain why 

#### The Cooler and Delivery Truck Evidence

FORENSICS IN CHEMISTRY

37

Application # Supporting 3b Ideas	wgt	<u> </u>						
Supporting 3b Ideas		Ĩ	xemplary (10)	4	At Standard (8)	In Progress (7)	Still Emergi (6)	ng No Evaluatio (0)
	2	<ul> <li>Support used is varied, the best audience understanding (4 of 4)</li> <li>Questions #1 is answered, volume data to explain whi</li> <li>Questions #2 is answered, correct gas law and answe the graph shows the relations #3 is answered, correct gas law and answe the graph shows the relations #4 is answered, logical connections to the</li> </ul>	available, and strongly enhances correctly and answer is supported y correctly connecting the graph to cris supported with data to explai onship stated correctly connecting the graph to r is supported with data to explai onship stated correctly and answer is supported kinetic molecular theory to expla	s Suy d with suf acc acc acc acc bas in why of d with ain why	pport is urrate and ficiently ailed—all ics evident (3 4)	Support is insufficient, inaccurate, or vague in places—enough to confuse audience somewhat (2 of 4)	Support is missing, inaccurate, or vague overall ( of 4)	No work shown for this section
<b>Overall Evidenc</b>	e Re	port Formatting						
Application #	wgt	Ĥ	xemplary (10)	7	At Standard (8)	In Progress (7)	Still Emergi (6)	ng No Evaluatio (0)
Technology 1c Applications	1/2	Technology used is best availab research, data representation, in results. (4 of 4)	ole and appropriate for the require terpretation, and communication uter generated e Format uns is non-evident ctions required in the Lab Repor ubric	t Style con	Technology was used for the required research, data epresentation, erpretation, and mmunication of ssults. (3 of 4)	Technology used was insufficient for the required research, data representation, interpretation, and communication of results. (2 of 4)	Evidence o Technology u is missing an or insufficient of 4)	se for this section I/ (1
Content Recall								
Application #	wgt	Exemplary (10)	At Standard (8)	In Pr	rogress (7)	Still Emergi (6)	ing	No Evaluation (0)
Content Recall If	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	Recalls virtually all essential terms and factual information □ 0 Content Questions were asked to the instructor for the duration of this performance assessment	Recalls most essential terms and factual information $\Box$ 1 Content Question was asked to the instructor for the duration of this performance assessment	Recalls a min essential term information 2 Conten were ask the instr the dura this perf this perf assessm	imum of is and factual ant Questions eed to uctor for tion of ormance ent	Recalls virtually no essential terms and 1 information a 3 or more Cont Questions werv to the instructor for the duration this performan assessment	factual No tent sect e asked or n of ce	vork shown for this on
Some things I think Some things I still h	: I did 1ave g	well on this assessment al uestions about performan	re: ice assessments, lab report	ts, this class	s, etc. are:			
ff I graded myself o	in this	s, my score would be a	/120, then divide 1	that by 2 to	) get score out	of 60 because eac	ch section is	veighted by <sup>1</sup> /2.

#### **CHAPTER 3**

National Science Teachers Association

\_

38

INDEX

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

#### A

Acetaminophen, 7, 40, 41, 43, 46, 52, 57, 61, 113, 114, 115, 115, 118, 125–126, 128, 129, 132–135, 146, 149 Acids and bases, 1, 89, 148 Airbag deployment, 5, 6, 11, 14–16, 22–25, 23, 28, 30-31, 33-34, 36, 37, 145 Almond, 40, 46 Amount of chemical substance, 41–42, 48, 48–49, 53, 58-59,61 Applications of Learning (Illinois), 9–10, 151–152 Aspartame, 40, 46 Aspirin, 7, 8, 40, 41, 43, 46, 52, 55, 56, 60, 114, 115, 117, 118, 125, 126, 128, 129, 132, 133–135, 146, 149 Atmospheric pressure, 3, 160, 161, 165 Authentic assessment, 3

#### B

Beer's Law, 1, 65, 66, 69, 147 Beta decay calculations, 5, 68–70, 78, 83, 147 Blood stain analysis, 6, 8, 92, 94, 101–102, **101–102**, 106, 108, 110 Bone age analysis, 5, 7, 65, 67, 70, 71, 74–77, **75**, 82, 84 Bones, 2

#### C

Caffeine, 7, 8, 40, 43, 44, 113, **114**, 115, 118, 125, 126, 128, 132 extraction of, 6, 8, 114, 117, 118, 125, 126–128, 132–135, 137–138, 146, 149 Cake shop ingredients evidence, 42, 49, 59, 61 Carbon dating of bone fragments, 5, 7, 65, 67, 70, 74–77, **75**, 82, 84 Career opportunities in forensics, 2 *The Case of Kirsten K. See also* Forensics-based assessment curriculum chapter organization for, 9 chemical evidence for, 7, 39–64 complete scenario of, 6–9 cooler and delivery truck evidence for, 6–7, 11–38

descriptions of performance-based assessments for, 5 - 6development of forensics-based curriculum for, 1-3 drug lab evidence for, 8–9, 113–138 final assessment of, 139-144 flexibility of, 141 nuclear radiation evidence for, 7-8, 65-87 student excitement about, 3, 4 victim and suspect list for, 6 weapon analysis evidence for, 8, 89-112 Chemical evidence, 14, 39-64 case information for, 39-42 amount of chemical substance, 41-42 cake shop ingredients analysis, 42 delivery truck and crime scene evidence, 40-41 possible compound matches, 40, 40 suspect evidence, 41 chemistry concepts chart for, 146 chemistry content of, 39 national science education standards addressed by, 39 overview of, 7 performance-based assessment for, 45-64 amount of chemical substance, 48, 48-49 cake shop ingredients analysis, 49 delivery truck and crime scene evidence, 45, 45-47, 46 description of, 5 grading rubric, 62-64 student lab report example, 51-61 suspect evidence, 47, 47-48 suspect file B, 50 teacher guide for, 43-44 lab, 43 objectives, 43 preparation, 43 question guidelines, 43-44 teacher hints, 44 Chemistry concepts chart, 9, 145-149 Clinton Lake, 6–7, 8, 12, 18, 23 Cocaine, 7, 8, 40, 41, 43, 46, 52, 54, 56, 60, 84, 146 Codeine, 40, 46 Codron, Angela R., vii

#### INDEX ·

Cold Case, 2 Concentration, 65 Concept map, 132 Cooler and delivery truck evidence, 11-38 case information for, 11–14 cooler evidence, 11-14 delivery truck evidence, 14 chemistry concepts chart for, 145 chemistry content of, 11 national science education standard addressed by, 11 overview of, 6-7 performance-based assessment for, 18-38 cooler evidence, 18-21 delivery truck evidence, 22-25, 23 description of, 5 grading rubric, 35-38 student lab report example, 27-34 suspect file A, 26 teacher guide for, 15-17 lab, 16 materials, 17 objectives, 15 preparation, 15-16 question guidelines, 16 Court case scripts, 140–141, 141 CSI, 2 Curare, 40, 46

#### D

Data interpretation, 11 Dating bone fragments, 5, 7, 65, 67, 70, 71, 74–77, 75, 82,84 Delivery truck and crime scene evidence, chemical analysis of, 40-41, 45, 45-47, 46, 52, 54-55, 60 Delivery truck evidence and airbag deployment, 14, 22-25, 23, 28, 30-31, 33-34 Density, 5, 6, 11, 13–15, 16, 17, 18–21, 28, 29, 31–32, 35, 37, 145, 160, 161, 162, 164 Design-your-own project method, 139-140 Deslich, Barbara J., 2 Dimensional analysis, 11, 15, 63, 64, 145 Drug lab evidence, 40, 113–138 case information for, 113-116 caffeine extraction, 114 IR spectra analysis, 113–114, 114 thin layer chromatography of pen matching,

115-116 thin layer chromatography of unknown drug, 115 chemistry concepts chart for, 149 chemistry content of, 113 national science education standards addressed by, 113 overview of, 8-9 performance-based assessment for, 125-138 caffeine extraction, 126-128 description of, 6 grading rubric, 137-138 IR spectra analysis, 125–126 student lab report example, 132-136 suspect file E, 131 thin layer chromatography of pen matching, 129 - 130thin layer chromatography of unknown drug, 128-129 teacher guide for, 117-124 IR absorption frequencies chart, 120–121 IR spectra of chemical substances, 122-124 materials, 118 objectives, 117 preparation, 117-118 question guidelines, 118 table of IR absorbances for common organic functional groups, 119 teacher hints, 118-119 Drug log book, 9

#### E

Electrochemistry, 1, 89, 91, 111, 148 Empirical formula, 7, 39, 40, 43, 44, 47, 48, 55, 58, 59, 61, 125, 126, 133, 135, 146, 149 Evolution of final project, 139–141 what didn't work: PowerPoint mania and court case chaos, **140**, 140–141, **141** what worked: design-your-own project method, 139–140

#### F

Final assessment, 139–144 evolution of final project, 139–141 what didn't work: PowerPoint mania and court case chaos, **140**, 140–141, **141** what worked: design-your-own project method,

#### 174 National Science Teachers Association

139-140 final grading rubric, 142 flexibility of case, 141 Fingerprint analysis, 6, 8, 90, 91, 93, 94, 97-98, 105, 109 Fingerprint evidence chart, 96 Flexibility of case, 141 Forensic science career opportunities in, 2 obstacles to integrating into chemistry curriculum, 2 student interest in, 1, 2 television programs dealing with, 2 Forensic tags, 10, 12, 13, 66, 67, 67, 70, 157 Forensics-based assessment curriculum. See also The Case of Kirsten K. chapter organization of, 9 chemistry concepts chart for, 9, 145-149 complete scenario of, 6-9 development of, 1-3 final assessment of, 139-144 flexibility of, 141 funding for, 1 grading rubrics for, 9-10, 151-152 lab report style guide for, 10, 153-156 laboratories for, 3 performance-based assessments for, 3, 5-6 script for chemistry II forensic case, 95 student project examples for, 143-144

#### G

Funkhouser, John, 2

Gas laws, 3, 5, 11, 14, 15, 16, 25, 30, 31, 33, 35, 36, 38, 145, 160, 163, 165 Global climate change, 3 sample inquiry lab for, 159–171 Glyoxylic acid, 7, 44, 49, 59, 61, 92, 94, **106**, 146, 148 Grading rubrics for performance-based assessments of chemical evidence, 62–64 of cooler and delivery truck evidence, 35–38 of drug lab evidence, 137–138 final, 142 Illinois State Board of Education Applications of Learning, 9–10, 151–152 of nuclear radiation evidence, 86–87 of weapons analysis evidence, 111–112 Grams to moles calculations, 39, 54–58 Greenhouse gases, 3, 161–162, 164–165 Gun and bullet matching, 6, 8, 94, 91, 98–99, 106, 109 Gunshot residue, 6, 8, 91–92, 94, 99–100, **105**, 107, 109–110

#### Н

Half-life calculations, 65, 67-70, 76-78, 82, 85, 147

#### **|**

Ibuprofen, 40, 46 Illinois Science Teachers Association (ISTA), 1 Illinois State Board of Education (ISBE) Applications of Learning, 9–10, 151–152 Infrared (IR) spectra analysis, 6, 113–114, **114**, 117, 118, 122–126, 132–133, 135, 138 of chemical substances, 122-124 IR absorption frequencies chart, 120-121 table of IR absorbances for common organic functional groups, 119 Inquiry labs, 2, 3 on chemical evidence, 7, 39-64 on cooler and delivery truck evidence, 6-7, 11-38 on drug lab evidence, 8-9, 113-138 lab report style guide, 10, 153–156 on nuclear radiation evidence, 7-8, 65-87 preparing students for, 3-4 sample of, 10, 159–171 student lab report example, 2 for chemical evidence, 51-61 for cooler and delivery truck evidence, 27-34 for drug lab evidence, 132-136 for nuclear radiation evidence, 80-85 for weapon analysis evidence, 104-110 on weapon analysis evidence, 8, 89–112

#### K

Kinetic molecular theory, 11, 15, 16, 25, 34, 38, 145, 160

#### L

Lab reports. *See also* Inquiry labs student examples of, 2 for chemical evidence, 51–61 for cooler and delivery truck evidence, 27–34

#### INDEX

for drug lab evidence, 132–136 for nuclear radiation evidence, 80–85 for weapon analysis evidence, 104–110 style guide for, 10, 156–156 Lake Bloomington, 12, 18 Lake Springfield, 12, 18 Limiting reactants, 39, 42, 43, 44, 49, 59, 64, 146

#### Μ

Map of central Illinois with lake locations, 12 McCubbins, Sara A., vii, 1 Medical tracer evidence, 8, 68, 78, 82–83, 85 Molarity, 65, 89, 107, 147, 148

#### Ν

National science education standards, 9, 11, 39, 65, 89, 113 National Science Foundation (NSF), 1 National Science Teachers Association (NSTA), 1 Nitrates in soil samples, 5, 7, 66, 69, 72, 72–73, 81, 82, 83-84 Nitroglycerine, 7, 40, 43, 46, 52, 57, 61, 146 Nuclear equations, 65, 147 Nuclear radiation evidence, 12, 65-87 case information for, 65-68 bone age analysis, 67 crime scene soil sample evidence, 66 medical tracer evidence, 68 shoe print evidence, 66-67, 67 chemistry concepts chart for, 147 chemistry content of, 65 national science education standards addressed by, 65 overview of, 7-8 performance-based assessment for, 72-87 bone age evidence, 74–77, 75 crime scene soil sample evidence, 72, 72–73 description of, 5 grading rubric, 86-87 medical tracer evidence, 78 shoe print evidence, 73-74 student lab report example, 80-85 suspect file C, 79 teacher guide for, 69-71 materials, 70 objectives, 69

preparation, 69–70 question guidelines, 70 teacher hints, 70–71

#### 0

Organic functional groups, 6, 113, 117, 126, 149 infrared absorbances for, **119** 

#### Ρ

Partnership for Research in Science and Mathematics Education (PRISM), 1 Percent composition, 39, 40, 41, 46, 59, 146 Percent yield, 39, 42, 43, 44, 59, 146 Performance-based assessments (PBAs), 1, 3, 9 as authentic assessments, 3 for chemical evidence, 5, 39-64 chemistry concepts chart for, 9, 145-149 for cooler and delivery truck evidence, 5, 11–38 descriptions of, 5-6 for drug lab evidence, 6, 113–138 grading rubrics for, 9–10, 151–152 importance of, 3 for nuclear radiation evidence, 5, 65-87 timeframe for, 3 for weapon analysis evidence, 6, 89–112 pH range of blood, 6, 89, 92–95, 101–102, **106**, 108, 110, 148 Possible compound matches, 40, 40, 46, 46 PowerPoint presentations, 140

#### R

Radioactive isotope dating of bone fragments, 5, 7, 65, 67, 70, 74–77, **75,** 82, 84 Redox reactions, 89, 99, 111, 148 Reverse inquiry, 3 R<sub>f</sub> values, 113, 115, 129, 135, 137, 149

#### S

Sample inquiry lab, 10, 159–171
Science, technology, engineering, and mathematics (STEM) instruction, 2
Script for chemistry II forensic case, 95
Shoe print evidence, 5, 7, 8, 66–67, 67, 69–71, 73–74, 81, 84

Soil sample analysis, 5, 7, 66, 69, 70, 72, 72–73, 81, 82, 83-84 Solvents and solutions, 113, 115, 129, 130, 133, 149 Spectrophotometer (Spec-20), 5, 66, 69, 70, 72, 73, 83, 87 Stoichiometry, 1, 39, 43, 89, 146, 148 Student lab report example, 2 for chemical evidence, 51-61 for cooler and delivery truck evidence, 27-34 for drug lab evidence, 132-136 for nuclear radiation evidence, 80-85 for weapon analysis evidence, 104–110 Student project examples, 143-144 Surface tension, 11, 13, 15, 16, 27, 145 Suspect evidence, 41, 47, 47-48, 52, 56-58, 60-61 Suspect files, 6, 9, 26, 50, 79, 103, 131

#### Т

Teacher guide, 9 for chemical evidence, 43–44 for cooler and delivery truck evidence, 15–17 for drug lab evidence, 117–124 for nuclear radiation evidence, 69–71 for weapons analysis evidence, 93–96 Television programs about forensics, 2 Thin layer chromatography (TLC), 6, 113, 117, 128– 130, 132, 137, 149 of pen matching, 115–116, 129–130, 134, 136 of unknown drug, 115, **115**, 128–129, 133, 134, 135 Titrations, 6, 89, 91–94, 95, 99, 111, 112, 148 Trinitrotoluene, **40, 46** 

#### U

Unit conversions, 11, 145 grams to moles calculations, 39, 54–58

#### V

Vanilla, 7, **40**, 41–43, **46**, 49, 51, 52, 54, 56, 59, 60, 61, 64, 92, 94, **106**, 146

#### W

Weapon analysis evidence, 89–112 case information for, 89-92 blood stain analysis, 92 fingerprint analysis, 90, 91 gun and bullet matching, 91 gunshot residue, 91–92 chemistry concepts chart for, 148 chemistry content of, 89 national science education standards addressed by, 89 overview of, 8 performance-based assessment for, 97–112 blood stains analysis, 101-102, 101-102 description of, 6 fingerprint analysis, 97-98 grading rubric, 111–112 gun and bullet matching, 98–99 gunshot residue, 99-100 student lab report example, 104-110 suspect file D, 103 teacher guide for, 93–96 fingerprint evidence chart, 96 materials, 94 objectives, 93 preparation, 93-94 question guidelines, 94 script for chemistry II forensic case, 95 teacher hints, 94

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.



