Teenage Detectives

Bring the world of forensic investigation into your chemistry curriculum with the use of investigative labs and real world cases. What really happens in a crime lab? How do they obtain evidence to convict the bad guy?

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Introduction

Last summer I took part in the research experience for teachers (RET) program. During the summer I was assigned to work in the Materials Research Laboratory's polymer group. My project involved the study of diffusion characteristics for semicrystalline isotactic polystyrene. Some of these words were familiar, but they looked very strange in the same sentence. As I worked through the project, I began to understand a bit more about the structure of semicrystalline polymers and how diffusion takes place in these structures. I never had the feeling of complete understanding, but as I sit her a year and a half later, I am surprised at how much of the information I have retained.

This workshop is supposed to focus on what I have gained from my temporary experiences as a researcher and how I have worked them into my classroom. This was not an easy task considering that research was something that I had neither considered nor experienced before. Being new to the idea, it took me some time to relate this to my classroom. I tried to compare my initial reaction to the words "semicrystalline isotactic polystyrene" to those my students might have to various chemistry topics. Our confusion in confronting a new and broad topic seamed to be quite similar. The question then is how do I apply the path I took to understanding to my constantly confused.

For me what was unique in the research was the project nature of the experience. Everything was given to me at once instead of in small bits or sequentially like in a high school textbook. Right away I had a problem, an objective and a considerable amount of background information (an entire textbook and a couple of journal articles). Thankfully, part of my task was to decided what I needed to learn in order to complete my project. This seamed to be an "outside in" approach to learning rather than an "inside out."

As I considered the difference it seemed to me like a jigsaw puzzle. There are two ways to put together a puzzle. The first is piece by piece. You examine individual piece and fit it with others and build the picture from the inside out. The second is the box method. Looking at the picture on the outside of the box, you search through a jumbled mess of pieces for the right ones. Small pieces begin to take shape as you build the picture from the outside in.

This analogy helped me consider how my experiences applied to the classroom. Each approach seemed have its benefits. When teaching inside out, your students know the pieces, and it is easier to ensure which pieces are studied. This seams to be important when considering a list of standards that range from A-Z. The outside in approach emphasizes the connections between the various pieces and adds interest and reality to learning.

In this packet I have include a few labs and other activities that slightly modify a standard teaching approach. I have tried to make changes that make students first think of the use or purpose of what they are doing.

Chemistry CJA
Lab: Identification of Unknown Substance

Popular recording star 2 Shaggy Dog has been arrested. The arresting officer finds 500g of a powdery white substance in his possession. Shaggy insists that it is baking soda his mom asked him to borrowed from the neighbor. The substance is tested and found to actually be very high-grade cocaine.

Tests used to identify unknown substances range from the very simple to very expensive. You are going to develop a qualitative that can be used to identify cocaine. As shown in the data table below, four unknown solids will be tested with three different liquids.

Objective: Describe a test that can be used to determine if an unknown powder is cocaine. Determine where this test might be the most useful. Identify any drawbacks to this test.

Data Table:

Substance	**Reaction w/reagent 1**	**Reaction w/reagent 2**	**Reaction w/reagent 3**
A			
B			
C (Cocaine)			
D			

Due to certain state laws, we are unable to complete this experiment with actual controlled substances. Substitutions are made as follows: A=table salt, B=baking soda, C=baking powder, D=soluble starch, 1=water, 2=white vinegar, 3=2g I_2/6g KI in 100mL water

Chemistry CJA
Lab: Density of Glass Fragments

Escaping from the scene of a crime, a burglar drives his stolen vehicle into a tree. The man is thrown through the windshield and flees the scene on foot. Police later apprehend a suspect and search his house. They find a sweatshirt and pair of pants with many small fragments of glass stuck to them. Density determinations are to be done to match these samples to ones taken from the crime scene. Along with other physical evidence, this may place the suspect at the scene of the crime.

Forensics laboratories can determine the density of fragments as small as 1 mm wide by 3 or 4 mm long. We are just beginners, so we will be using much larger pieces of glass. Our objective is the same however; use density to determine if two sample of glass might have come from the same windshield.

The equation to calculate density is: $\text{Density} = \frac{\text{mass}}{\text{volume}}$. Mass will be measured in grams using an electronic balance. Volume will be measured using displacement in a 100 mL graduated cylinder. A table similar to the following is helpful in collecting the data.

Sample	**Mass**	**Initial Volume**	**Final Volume**	**Volume of sample**	**Density of Sample**
A					
B					
C					

Chemistry CJA
Lab: Soil Identification

DEA agents find a body in a shallow grave. The grave sight is fairly fresh, but the body is obviously not. It is suspected that the body was originally buried at another site before being moved and reburied. Samples of soil taken from the pockets of the body do not seem to match the soil at the grave sight. In order to piece together a complete picture of what happened, the investigators need to know where this dirt came from.

That's where you, the laboratory technician, come in. There are many options when analyzing soil. Soil is more than just plain dirt. Soil contains animal and plant materials as well as the standard geologic fare. A first option might be to describe and compare particle size, shape or composition. Particles may be large and granitic or small and basaltic. A second option might be to separate the soil using a density column like the one on page 35 of your textbook. Each type of soil would create its own signature pattern. Yet another might be to test the composition of the soil. This could mean testing for minerals like mica or feldspar, or elements like potassium or iron.

Your objective in this lab is to characterize the different soil samples using % iron. Percent iron = mass of iron removed ÷ initial mass of soil.

CHEMICAL RESIDUE – CHROMOTAGRAPY

In addition to the thousands of pieces of debris left behind after an explosion, something else gets left behind: chemical residue from the bomb itself.

Bomb specialists use a process called chromatography to discover the chemical components that were used in the making of the bomb.

Chromatography: A Means of Separation

The first thing bomb specialists do is collect the chemical residue from the explosion site. In the case of a large explosion, like the one at the World Trade Center, the residue can be found all over the blast site. More often, it is only on the pieces of the bomb itself.

Residue being gathered at the world Trade Center

Next, the residue is passed through a special material. The material attracts some molecules more strongly than other molecules. The molecules that are the least attracted separate from the material the fastest; those that are the most attracted take the longest to separate.

In the end, all like molecules line up together. This separation process is known as adsorption.

Adsorption: An Analogy

Let's say you mix together sawdust and tiny pieces of metal, and then pour them into a pile on a table. If you take a magnet and slowly wave it back and forth over the pile, the metal pieces will be attracted to the magnet and will stick to it. After a few passes the pile will only contain sawdust, and the magnet will hold all the metal. The reason this would happen is that sawdust is not attracted by a magnet, but metal is. This gives you some idea of how two different substances can be separated using a special material that attracts one of the substances more strongly than the other.

Color Separation Activity

Take a page of newspaper and cut off the top or bottom margins -- don't cut anything with type on it. The strips of paper should be about an inch wide and about six inches long. Fold the strips in half, lengthwise.

Next, pour two tablespoons of water into a glass, followed by two tablespoons of rubbing alcohol. Stir them together.

In a spoon, mix some drops of blue and red food coloring together until you have dark purple.

Now back to your paper strips. Dip a paintbrush, or toothpick, into the spoon, and paint a thin stripe of purple on one of the paper strips. The stripe of purple should be about 2 inches from one end. One a second paper strip, paint a thin stripe of green food coloring. Take the green food coloring straight from the container, and don't mix it with any other color.

Drape your paper strips over the side of the glass. The strips of paper should be positioned so that the stripes of purple and green are just above the liquid. Tape the far end of the paper strips to the side of the glass so they stay in place. Let everything sit for 20 minutes.

What happens?

Note: You can do this same experiment using water-based color markers instead of using food coloring. We suggest you use a black marker on one strip, and a green marker on the second strip. You can also use a coffee filter instead of newspaper strips. Twist one end of the filter and let that be the end that sits in the water-alcohol mixture. Paint your stripe of color just above where the twist begins to unfold.

Chemistry CJA
Scientific Measurements

Name ____________________
Date ____________________
Period ____________________

Scientific measurements are critical in the criminal justice field, especially in processing a crime scene. Accuracy, precision, and the ability to communicate information are key to this procedure. Suppose an evidence technician sketches a crime scene, including in his report numbers that were measured with a tape measure, and the resulting calculations. When expressing a measured number, how does the technician communicate the degree of precision in his measurement? After doing the resulting calculations, how does the technician determine where to round off his answer? Finally, if the measurement is extremely large or small, how does the technician express the number in an efficient way?

Significant figures (sig figs, of significant digits are used to communicate the degree of confidence one has when expressing a number. More significant figures communicate a more precise measurement. For example, the measurement "3.82 cm" communicates a better measuring tool than the measurement "3.5 cm". However, when zeros are involved, it is more difficult to determine whether the zeros are considered significant, and certain rules have been established to facilitate communication. In addition, rules have been established to provide guidelines for rounding the results of a calculation to the proper number of significant digits. When numbers become extremely large or small. Scientific notation can be used to express the number efficiently. This worksheet examines the rules for significant figures, rounding and scientific notation.

❑ Rules for Significant Figures

1. All nonzero digits are significant.
   371.2 mL ____________
2. Zeros between nonzero digits are significant.
   205 cm ____________
   2.05 cm ____________
   a woman's arm, measuring 61.09 cm, found in a lake. ____________
3. Zeros that precede the first nonzero digit are not significant. These zeros are used to locate a decimal point. (Zeros that are used as placeholders are NOT significant.)
   A pile of suspicious powder weighing 0.017 g ____________
   0.00108 g ____________
4. Zeros at the end of a number that includes a decimal point are significant.
   0.500 kg cocaine ____________ 25.160 kg cocaine ____________
   A trail of dried blood, 7.00×10^3 mm in length ____________
   A piece of broken glass weighing 1.00 g ____________
   20. kg ____________
5. Zeros at the end of a number without a decimal point are ambiguous and are not considered significant. (Zeros that are used as placeholders are NOT significant.)
   1000 m ____________ 590 m ____________
   A dead body with a volume of 84,950 cm^3 ____________

❑ Rules for Significant Figures in Multiplication and Division, Addition and Subtraction:

1. In calculations involving **multiplication or division**, the answer must contain the **same number of significant figures as in the measurement that has the least number of significant figures.**
   190.6 x 2.3 = ____________
   213.0 miles ÷ 4.20 hours = ____________
2. The results of an addition or a subtraction must be expressed to the same precision as the least precise measurement. The last digit retained in a **sum or difference** is determined by **the least number of digits after the decimal point** (because this is the most uncertain measurement). This means: in **addition and subtraction, count the number of digits after the decimal point; don't count sig. figs!**
   137.24 + 10.3 cm = ____________
   1,002.4609 g + 6.339 g = ____________
3. Exact numbers are treated as if they had an infinite number of sig figs. In other words, exact numbers do not limit the precision of your answer in a calculation.
4. When a calculation involves multiplying and dividing a series of numbers, round only at the end; do not round intermediate answers.