Teacher Guide: The Nuclear Radiation Evidence

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

Objectives

1. Students will solve a forensics case using their knowledge of chemistry (for performance assessment #3, this includes beer's law calculations, half-life determinations, isotopes, and beta decay).
2. Students will assemble their evidence and present their case at the end of the year.
3. Students will answer four questions:

Part I

Based on the nitrate soil samples, which suspects can be placed at or near the crime scene?

Part II

Based on the shoeprints, which suspects can likely be placed at or near the crime scene?

Part III

Using radioactive dating, which bone fragment could be from the victim?

Part IV

Using half-life calculations, what was the timeframe of the medical tracer and how much was given to the victim?

Preparation

Part I

You will need a Spec-20 to analyze the soil samples. If this is not available, you could make it more of a qualitative analysis, as the more concentrated the soil sample, the darker the color. You could then have students match the soil samples from the suspects to the soil sample from the crime scene. Students should use the equation for the line given on the graph in their handout to calculate the concentration from the absorbance reading given on the Spec-20. Note that this line is only for the calibration curve for Iron (III) Nitrate; if another nitrate compound is used, a different calibration curve will have to be made for that sample. When you are making up the samples from each of the suspects, make sure you make the non-matching suspects lower than 0.015M because that is on the high end of the trend line, and the Spec-20's can sometimes vary in their outputs of absorbance data.

Part II

Each shoe needs to be labeled with a Forensics Tag, which can be found in Appendix D. Make sure to label the locations for each of the shoes so that they fit well with the case and with your desired outcome. These locations are often arbitrary but might help link suspects together. For example, a shoe belonging to Suspect #3, Elizabeth G., might be found in the trunk of Suspect #4, Larry J.'s, car. To make the evidence shoeprints, first brush cocoa powder on the bottom of the shoe. Then, "walk" the shoe on the sticky side of some contact paper. Cut out a piece of poster board that is the same size as the contact paper and "preserve" the print by sticking the contact paper to the poster board. Make sure you leave room on the poster board to label the shoeprint with the suspect/victim information, or attach a Forensics tag to the print.

Part III

For this activity, students will need a chart of Parent and Daughter Isotopes so that they can match the isotopes to determine how old the bones are for each fragment. They will also need a half-life curve with the number of half-lives on the x-axis and the % parent on the y-axis. Both of these charts are given to the student in the performance assessment.

Part IV

No lab preparation needed for this assessment. Students will need a basic understanding of beta decay and half-life to do the calculations in this section.

Question Guidelines

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

Part I

Suspect #3, Elizabeth G., and Suspect #4, Larry J., had nitrate levels matching those at the crime scene.

Part II

Suspect #1, Harold M., was not at the crime scene, or he was wearing another suspect's shoes.

Part III

Bone Fragment #3 could belong to the victim but further testing is needed by the police.

Part IV

The timeframe is 24 days, and the amount of medical tracer found was 34.8 g, which is above the lethal dose of 30 grams.

Materials

Part I

- Suspect File C
- Student Guide
- Spec-20 and nitrate samples from suspects and victim
- Calibration Curve

Part II

- Contact paper
- White poster board
- Large paint brushes
- Suspect and victim shoes
- Crime scene shoeprints

Part III

- 4 bone fragments
- Baggies
- Forensics Tags

Teacher Hints

In an assessment such as this with multiple parts and equipment needed, I have students rotate each day from one station to another, that way there is less preparation time needed, as you are only making one set of soil samples and one set of shoes, etc.

Part I

- Students may not get exactly 0.015M for their concentration but the closer it is to that amount, then the more likely that soil sample matches the crime scene sample.
- Really only 2 nitrate soil sample solutions need to be made: one that matches the 0.015M concentration and one that does not. Use the 0.015M concentration one only for the suspects that you want to match being at the crime scene.

Part II

- Students will come up with their own procedure, but here is the correct procedure:
    - Use large paint brushes and cocoa powder in Petri dishes to dust the bottom of each suspect's shoe.
    - Lift the print off of the bottom of the shoe with contact paper.
    - Save the print by sticking the contact paper to a pre-cut piece of white poster board and label.
- Shoes can be purchased from Goodwill stores or ask friends/colleagues for old shoes they are not using anymore.

Part III

- To make this part of the assessment more exciting for students, I borrow finger bones from the old biology skeletons and place each one in four different baggies labeled with the forensic tags so students can actually see some bone fragments instead of just doing calculations.