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"The Chemistry of Coal"

I. Introduction:

As a chemistry teacher, I am always looking for ways to show the real-world applications of chemistry to my students. The periodic table and the ability to decipher its wealth of information has been such a huge part of my chemistry curriculum. So many times, it is easier to complete the book work and forget about real world applications. I want and expect more from my students than the reiteration of textbook knowledge.

In Eastern Kentucky, coal is a part everyday life. Each and every student is in some way affected by the coal industry. Because coal is a topic to which every student can relate, I decided to show my students that a piece of coal can be used to study the periodic table and other topics discussed in chemistry class.

The following objectives were addressed in this unit:

1. How is coal formed?
2. What are the everyday uses of coal?
3. How does the usage of coal affect our environment?
4. What elements are in a piece of coal?

The Kentucky Core Content covered in this unit consists of the following items:

> 1.5.1---The total energy of the universe is constant. Energy can be transferred in many ways, but it can neither be created nor destroyed.
>
> 2.2.1---Earth is a system containing essentially a fixed amount of each stable chemical atom or element. Each element can exist in several different reservoirs. Each element on Earth moves among reservoirs in the solid Earth, oceans, atmosphere, and organisms as part of geochemical cycles.
>
> 2.3.2---Techniques used to estimate geological time include using radioactive dating, observing rock sequences, and comparing fossils to correlate the rock sequences at various locations.

I surveyed the students to determine what they would like for this unit to address. A few suggested that we study deep mining which is a good idea. However, my overall goal was to address the unit with the periodic table and its relationship to coal, and not necessarily mining techniques. Other students suggested a field trip to a coal mine which affords many valuable learning experiences, but the cost of the event was determined to be impractical. For my long-term planning, a future unit relating chemistry to an underground mine is a possibility.

II. Description of Activities and Goals

Activity #1—Formation of Coal

This activity started with a lecture on the composition and formation of coal. Students were told about the components of coal and how dead plants and animals under certain conditions could transform into coal.

In organic chemistry, students are taught that carbon is the backbone of all living things; consequently, coal formation illustrates the real world connection between the once living organisms and the carbon backbone of coal. The amount of carbon and moisture content were then analyzed and students identified the types of coal (peat, lignite, bituminous, and anthracite). Amounts of energy produced were compared to the amount of carbon in the sample. Students then worked in groups and made posters that showed coal formation and classification.

Activity #2---Uses of Coal

Students were given various puzzles that dealt with the many uses of coal. They were very surprised to learn that items, such as perfume, dynamite, moth balls, paint thinner, etc., were products of the coal industry. I questioned adding the puzzles to the unit,

thinking that they may be too elementary for my high school students. I found out that my students loved the puzzles and that they turned out to be as educational as fun. Even after we had finished the ones in this unit, they asked for more.

Activity #3---The production of Coal Gas

This activity proved to be very fun and enjoyable for the students. Before going to the lab, we discussed the equipment set-up and that our objective was to produce coal gas by burning coal. In previous chemistry labs, we have produced hydrogen and carbon dioxide gas. Their presence was determined by the production of bubbles in liquid (not very exciting). Here, students were able to detect the gas by holding a match to the end of the glass tubing to see if it would burn. Students were able to burn the gas that they produced. After identifying the gas, coke and coal tar, the students were able to refer to their puzzles to determine what each by-product could be used for. Although this was a smelly project, the students ranked it as a favorite.

Activity #4—Simulation of the Emission of Mercury by Coal-Fire Power Plants

This is an activity authored by Jason McGraw that I adapted for my students. During the introduction of this lesson, students learn that coal contains oxygen, magnesium, sodium, potassium and phosphorus from the original organic matter in the plants and animals. It also introduces the fact that coal can be contaminated with mercury, arsenic, and sulfur by ground water or periods of floods.

The activity concentrates on the containment and how they affect the environment. In Part A, students read an article on mercury in an ecosystem and how the plants and animals are affected by this pollutant. This article identified coal combustion as a source of mercury in the environment. For Part B, students watched a video segment via the

Activity #6---Research Methods of Making Coal Usage Safer and Cleaner

This final activity required going to the computer lab and conducting research. Each student was given a scenario pertaining to a coal company or power plant opening near their home. After researching technologies currently being used to insure environmental safety, the student constructed a flyer or newsletter to distribute to the local community. The letter had to address the concerns of the citizens and inform them of the plans/techniques that would be used to protect their homes and air/water quality.

III. Summary:

Upon completion of this unit, I feel that my students obtained the knowledge and the real world application of my subject (chemistry) that I had hoped to accomplished from the study of this unit. My students saw that the periodic table is more than a chart that hangs on the wall. In class, we have learned information about it and through this coal study unit; we were able to show how it affects our daily lives.

In our area, following a coal truck on the highway is a daily event. However, most students never think about how the coal formed or the fact that it can be used for things other than heat and electricity. Now, I feel that my students have a greater appreciation for the coal industry and many misconceptions have been cleared. Our area tends to focus on negative misconception and relay those to our young people. We learned methods of insuring clean air and water in addition to environmental protection laws. I hope that my students will go into their communities and homes to inform people of these events. In order to burry these misconceptions, we must educate our young. They must help us educate the world.

internet titled "EPA Limits Mercury Emissions" which talks about methods and rules (CAIR) that the coal industry must implement to reduce the mercury oxide emissions by 2/3.

Part C was a perfect correlation to the periodic table. Using a bag of different colored beads to simulate a sample of coal's composition, students determined the percentage of various elements in their sample. Students used the element's atomic mass to calculate the number of moles present and the percent composition of carbon, hydrogen, oxygen, calcium, sodium, nitrogen, sulfur, arsenic, and mercury. The week before, we performed the same type of calculations, so this really proved the real world application of chemistry.

Students learned that coal can contain harmful elements even though their small in percentage. They also learned that the government and coal industry is taking measures to ensure that new methods are being administered to lower their percentages in the environment.

Activity #5---Sulfuric Rain Simulation

The objective of this activity was to show that coal that is treated before burning, produces less sulfur emissions, (hence acid rain) than coal that is not treated. Because I could not find any treated coal readily available, we tried to determine if the type of coal contributed to the pH of the rain produced in these areas. Students burned sample of coal, then collected some of the smoke in a test tube and added a small amount of water (rain). Universal indicator was added to the solution to determine it's pH. All types of coal produced a similar neutral pH. Although this activity was not successful, it did show that chemistry concepts can be applied to environmental issues.

Once the unit was completed, I asked my student to make a written, anonymous comment on the unit. I gave them suggestions such as:

(1) What did they like most, least?; (2) What should be changed?; and, (3) Should it be taught again? All responses indicated that the students enjoyed the unit, especially the puzzles and the lab activities. As most educators are aware, activities other than traditional book work are always popular with students, and this one was no exception. One student said that coal was a valuable resource for our community and that he/she felt that "it should be an important part of our curriculum."

Based on the experience of my students and my own perspective, I believe that this unit is worthy of teaching again. The only obstacle was supplies. I was given grant money, but most of my supplies did not arrive in time to teach the unit. I had to borrow from other colleagues, local businesses, and family members, repaying them once my supplies arrived. The acid rain simulation did not go as planned due to the fact that we did not have treated coal to compare to untreated coal. Until I can find treated coal, I would not teach this lesson again.

The unit allowed me to teach concepts that I normally cover with a different approach. Students usually don't think that they are learning if they are not using a book. I was able to teach about two topics (chemistry and coal) that students thought had no relationship what so ever, and illustrate the importance of both.

Resources:

http://www.teachcoal.org/

http://www.uky.edu/KGS/coal/coalkinds.htm http://www.coaleducation.org/

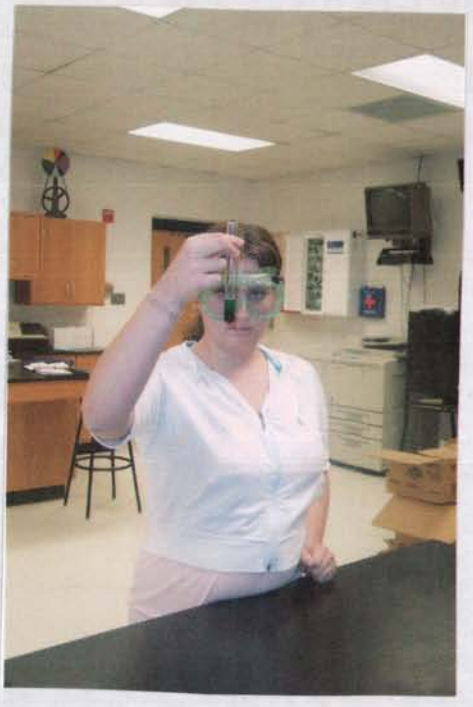
http://www.pbs.org/newshour/extra/teachers/lessonplans/science/mercury.html

Activity #1--- Students display the poster that they made diagramming coal formation and classification

Activity #2---Students work on puzzles that relate to the many uses of coal

Activity #3---Students watch as the coal gas burns that they produced in lab

Activity #4---Students count the number of colored beans that represent various elements found in a simulated bag of coal during the mercury emissions activity.



Activity #4--- A student looks at a test tube to determine the pH of the simulated acid rain

Activities #5---Students conduct research pertaining to technology used to make coal usage safer for the environment before designing a flyer.