Activities Guide

Workshop 3. Energetics and Dynamics

Comment

1. All activities have been peer-reviewed but not tested.
2. Some safety considerations are suggested in the activities. For full safety information, consult the MSDS sheets (go to http://msds.pdc.cornell.edu/) before doing the experiment.
3. A concise source book for further assignments, activities, and background information is *ChemSource,* version 2.1 (Orna, Mary Virginia, O.S.U.; Schreck, James O. & Heikkinen, Henry, eds.), 1998. Visit the Web site at http://intro.chem.okstate.edu/ChemSource/chemsource.html.

Colliding Particles Demonstration: Irene Walsh

Teacher's Guide

Goals

- To relate abstract topics to analogies that students can understand
- To help students visualize the concept of particles reacting

The Demonstration

In this class, students get a feeling of the world of particles and the collisions between them. They use analogies, which illustrate schematically the principles of molecular collisions. These analogies help them imagine and understand how particles collide and the factors which influence their collisions.

Materials

- 5 marbles

Lecture Notes

Write on the blackboard the reaction:

$4HBr + O_2 \rightarrow 2H_2O + 2Br_2$

Identify the reactants (R) and the products (P).

What did we say had to happen in order for a reaction to occur? We need collisions to occur.

How many particles are there on each side? (5R and 4P)

There are five particles colliding.

Demonstration

Call up five students and position them by a "demonstration table" (a higher table, if possible). Give each student a marble. Ask them to try to make all five marbles collide simultaneously, to get the feeling of the colliding particles in the reaction discussed. Try it several times. Collect the marbles.

Ask the students: What do you think that the probability is of this simultaneous collision happening? Very low.

Addition

Emphasize that this is a complex reaction and, like many others, follows a complex mechanism that comprises several steps. In each step only several particles collide, and thus the collision probability is higher (and depends on several other factors such as molecular geometry and electron distribution).

The actual mechanism of this reaction involves a series of consecutive bi-molecular reactions, thus raising the probability of effective collisions:

$HBr + O_2 \rightarrow HOOBr$

$HOOBr + HBr \rightarrow 2HOBr$

$2HOBr + 2HBr \rightarrow 2H_2O + 2Br_2$

And the overall reaction is:

$4HBr + O_2 \rightarrow 2H_2O + 2Br_2$

To sum up: this analogy can be used to promote the concept of reaction mechanism, and to describe its importance for chemical reactions.

Teaching Tips From Ms. Walsh

Very often the topics in chemistry are abstract, and we need to relate that to something that the students can understand: something that they can touch with their hands and say that what you're doing is making an analogy. And while you're doing it you want to look for good analogies and then build from there.

I think it is really important that the students visualize that these are particles that are reacting.

If the particles are the things that must collide when they react, when you're teaching, you have to get that idea down first, and then other things make sense.

I sort of likened that to Volkswagens colliding with each other. If you just have a little Volkswagen parked on an incline, and it slides into the other one, ask them to picture that vs. testing these: the car manufacturers having them going 60MPH, smashing into each other, and then I ask them the question:

> In which case do you get a bigger "Volkswagen rearrangement"?

In order for a reaction to occur you've got to get a rearrangement of the particles. The collision has to be that violent. So you get a rearrangement of the particles. That kind of thing is the activated complex, that's going to form. Then we start talking about the energy that is required, the minimum amount of energy, and that's activation energy.

Comment

The "colliding car" analogy serves best to describe the case where the reaction mechanism is: A + B -> AB, and does not directly refer to the role of the activated complex. However, in the reaction, it partially represents the concept of the dependence of rate on the velocity (temperature) of the reacting particles.

It is not simple, however, to find a good single analogy for a full chemical reaction, which represents the colliding reactants, the activated complex (which has a very short life, relatively) and the products. One idea might be to compare the reaction process to baking cookies.

The ingredients being the reactants, the "transition state" will be the dough on the tray just before and during baking, and the products are the cookies. This analogy lacks some important concepts such as vibrational modes of the activated complex, molecular geometry, and probability of collisions. But if you look closely, you still can extract some useful conclusions from it:

First, you put the reactants together (collisions), then, you form a short-lived, unstable, and odd-shaped form of cookie (transition state) and finally you collect the cookies (products).

You may also refer to energy: most reactants and the products are edible (low-energy) and relatively long-lived, whereas the "transition state" cookies are relatively short-lived and will cause a stomachache if eaten (high-energy). Also, to get from reactants to products, you must heat the system and overcome the "activation energy" for the process. Only when the cookies cool off ("stabilize"), can you eat them.

If you want to show the *probability* of a collision, you would need a whole different analogy, which takes into consideration things like cross-section for interaction, velocity, and mass. It is a physical process that might be well visualized just by drawing it on the board or by thinking about colliding (but not reacting) billiard balls.

The *reactivity* of colliding molecules, and the transition state are complex concepts which include concepts like molecular geometry, energy distribution within molecules, and vibrational modes. These concepts should be illustrated one by one, and only then can the whole picture be explained.

Reaction Rates Demonstration and Laboratory: Irene Walsh

Teacher's Guide

Goals

- To discuss how concentration influences the rate of reactions
- To help students visualize and assimilate the meaning of rate changes

The Demonstration

In this class period, students get a feeling of the world of particles and of the collisions between them. They use analogies, which illustrate schematically the principles of molecular collisions. These analogies help them to imagine and understand how particles collide and which factors influence their collisions.

Materials

- Overhead projector
- Three petri dishes containing three concentrations of HCl: 1 M, 3 M and 6 M HCl
- A piece of metal (either one of Cu, Zn, Fe, Al, Mg or Sn)
- Tweezers
- An empty beaker
- See also http://intro.chem.okstate.edu/ChemSource/chemsource.html. Click on "Acid-Base" for more.

SAFETY

Wear goggles and gloves during the entire demonstration!

HCl is corrosive. Handle with care!

Neutralize it with $NaHCO_3$ and rinse.

The released hydrogen gas is flammable. Work away from fire!

Instructions

1. Cover the overhead projector with clear transparent nylon.
2. Put the petri dishes with the acid on top of it.
3. Turn on the projector.
4. Put three pieces of the same metal into the dishes (one each) at the same time.
5. Watch what is happening and discuss the differences between the dishes.
6. Take out the metal with the tweezers and put in the empty beaker. Discard of the acid safely.

Lecture Notes

Is that what you expected? Why?

What is the theoretical basis for this? More collisions.

What did we say about reactions and collisions? You have to have a collision in order for the reaction to occur. The more particles that are there, the higher probability for a collision.

Addition

Try another or several other metals and compare. Write what you see in the table. Discuss the activity of metals in acid.

Metal	1M HCl	3M HCl	6M HCl	Comments
Mg				
Al				
Fe				
Cu				
Zn				
Sn				

The Laboratory

The Iodine Clock Reaction (ICR) is a reaction wherein a change of color suddenly appears some time after the beginning of the reaction. The period of time before the color appears, stems from the characteristics of two chemical reactions with very different rates. In this laboratory period, you will study the effect of the initial concentration of the reactants on the rate of the reaction.

Advanced

For advanced students who study physical chemistry, this laboratory could be modified, as suggested on the DoChem Web site shown below:

http://129.93.84.115/Chemistry/DoChem/DoChem114.html#Handout
A microscale version of the lab.

Materials for Each Group

- 50 ml of solution A (0.20M H_2SO_4, 0.088M H_2O_2)
- 50 ml of Solution B (0.0016M $Na_2S_2O_3$, 0.052M KI, starch)
- 6 test tubes (25 ml) in a rack
- A stopwatch
- 2 graduated cylinders of 10 ml
- A black marker

SAFETY

Wear goggles, aprons, and gloves throughout the laboratory! Hydrogen peroxide is irritating to skin and eyes. Handle with care! Iodine stains skin and fabric. Work on covered surfaces. At the end of the experiment, the remaining blue solution can be washed down the drain with water. Iodine can be destroyed by reaction with sodium thiosulfate solution.

Lecture Notes

The following processes occur during the reaction:

1. Oxidation of iodide ions by hydrogen peroxide to form triiodide ions:

$$3\ I^-_{(ab)} + H_20_2 + 2H^+_{(aq)} \longrightarrow I_3^-\ _{(aq)} + 2H_20\ _{(l)}$$

Reaction rate k1

2. Reduction of the triiodide ions back to iodide ions by thiosulfate ions:

$$I_3^-{}_{(aq)} + 2\ S_2O_3^{2-}{}_{(aq)} \longrightarrow 3I^-_{(aq)} + S_4O_6^{\ 2-}{}_{(aq)}$$

Reaction rate k2

3. Triiodide ions react with starch to form a blue complex of starch and pentaiodide

$$2I_3^-{}_{(aq)} + \text{starch} \longrightarrow \text{starch-}I^-_5\text{- complex} + I^-_{(aq)}$$

Mechanism

The reason for the sudden color change from colorless to blue, stems from the fact that the first two reactions have very different rates, such that k2>>k1. Thus, no I_3- ions can be found free in solution. Only when the thiosulfate in equation two is depleted, will triiodide ions accumulate and react with the starch to form the blue complex.

The time, required to form the blue complex, depends on the rates of the two initial reactions. If the first reaction is accelerated, the blue color will appear faster. Thus, increasing the concentration of iodide, hydrogen peroxide, or acid, which neutralizes the hydroxide ion, will shorten the time of the appearance of the blue color, whereas increasing the thiosulfate concentration will have the opposite effect.

Teaching Tips From Ms. Walsh

The students learn about enzymes and catalysts in biology. They understand that it changes the reaction's mechanism, since the activation energy is lowered.

A lot of things start to tie in during this experiment.

The clock reaction dramatically shows that changing the concentration changes the rate of reaction.

This is the first reaction that they have seen where it changes so dramatically. So if I could do only one reaction I would choose this one. Either that or I would do it as a demo.

I have seen it done with the William Tell Overture, but you should keep it timed so you get the color changes exactly with the music.

References: Links

http://www.chem.vt.edu/chem-ed/general/kinetics.html
A tutorial introducing reacting rates.

References: Readings

Bowers, P.G., Rubin, M.B., Noyes, R.M., and Andueza, D. (1997) "Carbon Dioxide Dissolution as a Relaxation Process: A Kinetics Experiment for Physical Chemistry," *Journal of Chemical Education,* Vol. 74, No. 12, p: 1455.

Creary, X., and Morris, K.M. (1999) "A New Twist on the Iodine Clock Reaction: Determining the Order of a Reaction," *Journal of Chemical Education,* Vol. 76, No. 4, p: 530.

Reaction Rates Demonstration and Laboratory: Irene Walsh

Students' Guide

Goals

- To discuss how concentration influences the rate of reactions
- To visualize and assimilate the meaning of rate changes

The Laboratory

The Iodine Clock Reaction (ICR) is a reaction wherein a change of color suddenly appears some time after the beginning of the reaction. The period of time, before the color appears, stems from the characteristics of two chemical reactions with very different rates. In this laboratory period, you will study the effect of the initial concentration of the reactants on the rate of the reaction.

Materials

- 50 ml of solution A (0.20M H_2SO_2, 0.088M H_2O_2)
- 50 ml of Solution B (0.0016M $Na_2S_2O_3$, 0.052M KI, starch)
- 6 test tubes (25 ml) in a rack
- A stopwatch
- 2 graduated cylinders of 10 ml
- A black marker

SAFETY

Wear goggles, aprons and gloves throughout the laboratory!

Hydrogen peroxide is irritating to skin and eyes. Handle with care!

Iodine stains skin and fabric. Work on covered surfaces.

At the end of the experiment, the remaining blue solution can be washed down the drain with water.

Iodine can be destroyed by reaction with sodium thiosulfate solution.

Instructions

1. Mark one cylinder A and the other B.
2. Measure 10 ml of solution A in one cylinder and 10 ml of solution B in the other one.
3. Carefully pour each of the solutions into a separate test tube.
4. Reset your stopwatch.
5. Mix the solutions in one of the test tubes, while starting the stopwatch.
6. Pour the mixture several times from one test tube to the other.
7. Record the time it took for the blue color to appear: ______________________________

8. Mix several other concentrations of solutions A and B, by diluting them in the graduated cylinder with water, but keeping the same final volume.
9. Measure the time of the appearance of the blue color and record your results in the table below:

Test No.	ml A	Conc. A	ml B	Conc. B	time
1	10		10		
2					
3					
4					
5					
6					
7					
8					

Explain your results in light of the following processes, which occur during the reaction:

1. Oxidation of iodide ions by hydrogen peroxide to form triiodide ions:

$$3\,I^{-}_{(ab)} + H_2 0_2 + 2H^{+}_{(aq)} \longrightarrow I_3^{-}{}_{(aq)} + 2H_2 0_{(l)}$$

Reaction rate k1

2. Reduction of the triiodide ions back to iodide ions by thiosulfate ions:

$$I_3^{-}{}_{(aq)} + 2\,S_2O_3^{2-}{}_{(aq)} \longrightarrow 3I^{-}_{(aq)} + S_4O_6^{\,2-}{}_{(aq)}$$

Reaction rate k2

3. Triiodide ions react with starch to form a blue complex of starch and pentaiodide

$$2I_3^{-}{}_{(aq)} + \text{starch} \longrightarrow \text{starch-}I^{-}{}_5\text{- complex} + I^{-}_{(aq)}$$

The Chemistry of Light Class: Al DeGennaro

Teacher's Guide

Goals

- To understand that different energies are associated with different photons
- To involve students in kinesthetic learning

The Class

Mr. DeGennaro demonstrates electronic transitions by letting students act out electrons, which give off light by throwing colored cards upon jumping from a higher electronic level. Thus they visualize the energy of light: the relationship between color and wavelength.

Lecture Notes

What is light made of?

We will use the same explanation that another famous scientist used; namely, Albert Einstein. He thought that light was made of photons.

Photons are tiny pieces of light.

Is visible light the only kind of light?

It's the only kind of light that people can see but there are other types of light (show the electromagnetic spectrum).

The lowest energy of light that we're going to deal with are radio waves.

When I turn the radio on, those radio waves are changed back to sound.

Do you realize that the radio waves from the radio transmitting station are going through your brains right now?

They have to be, because they're coming from Baltimore and going into my radio, and all of these people are in the way. Fortunately they have such low energy that you don't have to worry about it.

A more energetic light is the UV light. Where does the most famous UV light come from?

The sun gives off lots of UV light. Some of it gets through the atmosphere and hits the stuff on the ground.

Now, this is both bad news and some good news. Because if you have UV light which is far enough from visible light, then it is energetic enough to kill cells. We use it to kill germs which might be on our safety goggles. The cupboard has a lamp, which gives off UV.

What does this have to do with atoms?

Instructions

You will need several rigid buckets, or something similar, at different heights, and pieces of paper in different rainbow colors (red, blue, green, orange, yellow, etc.).

Organize the buckets, facing downwards, by their height.

Define each bucket to be an electronic level—the floor being the ground level 1S orbital, the shortest bucket will be the 2S orbital, the next one up is the 2P orbital, and so on.

Ask one student-electron to "excite himself"—by stepping up on top of the first bucket. Explain that if it was a real electron, you would have to add some energy for this transition to occur, such as heating. The student now represents an excited hydrogen atom, with a single electron at its 2S electronic level.

Make the student jump from the higher energy level to the floor and explain that if an electron has jumped to a lower energy level, then it must give off a photon. Since this transition has occurred from the lowest excited energy level, it gives off the least energy, and thus emits a low energy photon giving off red color.

Give the student a red (low-energy) piece of paper and "excite" the electron again. When the student jumps back to the floor, the student lets go of the red "photon," similar to light emission by real electrons.

Now ask the students to model an excited helium atom, where electrons are one in the 2S and one in the 2P orbitals.

If the 2S orbital of helium is higher in energy than that of the hydrogen atom, then the electron should give off a higher energy photon, i.e., orange "photon," for example. To jump from the 2P level would take a "green" photon, since its energy is even higher. And so on. Thus, the connection is made between energy difference and color, and the energy level structure is emphasized.

Comment

The transitions to 1S in the hydrogen atom are really so energetic, that they all appear in the UV spectrum, called the Lyman Series of spectral lines. Only the transitions to the n=2 (2S, 2P) level are found in the visible part of the spectrum (the Balmer Series). In advanced courses, this is the place to introduce quantum numbers and their relationships to energy levels.

Teaching Tips From Mr. DeGennaro

Teaching about light is no weirder than teaching about the elements.

Light and colors are interesting for kids.

I would like to spend more time on it [light]…but there are so many things that I have to do.

I used to have them watch my demonstrations about light and all they had to say is that it's green, and if it's green it can be potassium.

Now, I'm pushing it a step further, because we're talking about electron layers and they can actually understand that there are different energies associated with different photons.

There are kids that are kinesthetic learners, who must get up from their chairs and do something, even trivial, that relates to the subject. That helps them change their whole point of view about the subject.

References: Links

http://csep10.phys.utk.edu/astr162/lect/light/absorption.html
A brief illustrated tutorial on continuous spectra and emission spectra of atoms.

http://javalab.uoregon.edu/dcaley/elements/Elements.html
An interactive periodic table that shows the emission spectra of each element.

References: Readings

Minas da Piedade, M.E.; Berberan-Santos, M.N. (1998) "Atomic Emission Spectra Using a UV-Vis Spectrophotometer and an Optical Fiber Guided Light Source," *Journal of Chemical Education,* Vol. 75, No. 8, pp: 1013-1017.

Half-Life and M&Ms Activity: Kelly Rottmann

Teacher's Guide

Goals

- To understand the concept of half-life
- To have a useful analogy that helps students to actually "see" the decay process, a very abstract concept otherwise.

The Activity

M&Ms are used to simulate the decay of radioactive isotopes. Having two different sides, they represent the "radioactive" and the "decayed" elements. The decaying process is imitated by sequential discarding of the M&Ms, which fall "right side up" on the tabletop, until no M&Ms are left.

Materials for Each Group

- Lunch tray
- Styrofoam cup
- 100 M&Ms candies

Lecture Notes

In your cups, you should have 100 M&Ms. Make sure you have them all.

Make sure you have an M on one side, since it will affect your results.

If you need a replacement, come up, and take what you need.

About Half-Life

See the following sites:

> http://www.umich.edu/~radinfo/introduction/lesson/half.html
> A brief explanation of half-life.
>
> http://www.sciencecourseware.com/VirtualDating/files/RC_2.html
> An interactive on radiocarbon dating.

Half-life is the measure of the time it takes for a process (say, radioactive decay) to arrive at one half of its initial value. For example, the half-life of U238 is 4.5x109 years, and thus it still exists on earth in its radioactive form, whereas C11 is very short lived, relatively, since it has a half-life of only 20 minutes. Being an important isotope for medicine, it must be reformed every time it is used.

The decay sequence of Uranium-238:

U-238 comprises 99.3% of all uranium ores

=> Alpha =>Thorium-234 (4,510 million years)

=> Beta =>Protactinium-234 (24.1 days)

=> Beta =>Uranium-234 (6.75 hours)

=> Alpha =>Thorium-230 (247,000 years)

=> Alpha =>Radium-226 (80,000 years)

=> Alpha =>Radon-222 (1,620 years)

=> Alpha =>Polonium-218 (3.823 days)

=> Beta =>Bismuth-214 (26.8 mins)

=> Beta =>Polonium-214 (19.7 mins)

Branch: 99.98% Polonium-214 =>Alpha => Lead-210 (0.000164 secs)

=> Beta =>Bismuth-210 (21 years)

Branch: 81% Bismuth-210 =>Beta => Polonium-210 (5.01 days)

=> Alpha =>Lead-206 (138.4 days)

Lead-206 is stable

Taken from http://www.saveguard.co.nz/.

Teaching Tips From Ms. Rottmann

We spend about two weeks on nuclear chemistry. Half-life is just one aspect of our entire unit. We talk about the different types of radiation, sources of radiation, how radiation affects us.

Half-life is a difficult concept to understand because it is so abstract.

We're talking about radioactive isotopes and how they decay. We don't see it. And so we use M&Ms because it is something that they can physically manipulate.

They know how to calculate the half-life from their graphs.

So far we just looked at models of half-life. The true understanding will come when we do more problems and actually bring the radioisotopes into how scientists use half-life. It seems that they get the picture of what it is.

References: Links

http://www.lbl.gov/abc/ Extensive pages from Lawrence National Lab.
Be sure to click on "Basic Nuclear Science" and "Experiments."

References: Readings

Hughes, E.A., and Zalts, A. (2000) "Radioactivity in the Classroom," *Journal of Chemical Education,* Vol. 77, No. 5, pp: 613-614.

Half-Life and M&Ms Activity: Kelly Rottmann

Students' Guide

Goals

- To understand the concept of half-life
- To have a useful analogy that helps you to actually "see" the decay process, which is very abstract concept otherwise.

The Activity

M&Ms are used to simulate the decay of radioactive isotopes. Having two different sides, they represent the "radioactive" and the "decayed" elements. The decaying process is imitated by sequential discarding of the M&Ms, which fall "right side up" on the tabletop, until no M&Ms are left. A graph of the number of remaining candies vs. trial number should yield a measure of the "half-life."

Materials for Each Group

- Lunch tray
- Styrofoam cup
- 100 M&Ms candies

Instructions

Make sure you have 100 M&Ms with an M on one side of all candies, since it will affect your results.

Shake the M&Ms in the cup and dump them on the tray.

Remove all M&Ms which land with the M side up. Don't use them again.

Count the remaining candies. Record their number on your data chart, where it says Trial #1:

Trial #1	Trial #2	Trial #3	Trial #4	Trial #5	Trial #6	Trial #7	Trial #8	Trial #9	Trial #10

Put the remaining candies back in the cup, shake again, and repeat the process until you have zero candies left.

Graph the number of candies (y-axis) vs. the trial number (x-axis).

Determine the "half life" of the decay process: ____

____

Explain how you calculated it: ____

____

If the half-life of U_{238} is $4.5x10^9$, readjust your graph's scale for it and calculate how much U_{238} will be left after four half-lives: ____

____

Radioactive Sources Laboratory: Veatta Berry

Teacher's Guide

Goals

- To give the students information about radiation
- To give students some hands-on experience with radiation

The Activity

In this class period, students use radioactive sources in order to learn about radiation, its effects, and about ways to protect from it. Students use Geiger counters to study the effects of shielding materials and distances from the radioactive source on the measured radiation.

Materials for Each Group

- A series of radioactive sources
- A Geiger counter
- A series of blocking materials in different widths (teflon, lead, paper…)
- A meter stick
- Tongs
- Protective wear and shields

SAFETY

No student may work with any radioactive materials unless the work is carefully supervised by a certified staff member. For example guidelines, see the following:

> http://www.isbe.state.il.us/secondaryed/Science%20Ed/Guidebook%20Science%20Safety/ch10.pdf
> Guidelines from the State of Illinois. See especially 10.2 "Radioisotope Use."

Teaching Tips From Ms. Berry

Students have so many misconceptions about radiation. They don't realize that radiation is everywhere around us.

They find out that everything has radiation.

They see that radiation drops significantly as they move away from the radiation source.

It's important for our life to have that background about radiation.

It's one thing to tell them about these different things, but for them to actually see it and try it out with their own hands, they really get a feel for it.

One of the reasons that I talk to them about it, is that they are the decision makers of the future and they are the ones that are going to vote for the people who are going to decide whether nuclear reactors will be in their own back yards.

References: Readings

Hutchison, S.G., and Hutchison, F.I. (1997) "Radioactivity in Everyday Life," *Journal of Chemical Education,* Vol. 74, No. 5, pp: 501-504.

Radioactive Sources Laboratory: Veatta Berry

Students' Guide

Goals

- To give you information about radiation
- To give you some hands-on experience with radiation

The Activity

In this class, you will use radioactive sources in order to learn about radiation, its effects, and about ways to protect from it. You will use Geiger counters to study the effects of shielding materials and distances from the radioactive source on the measured radiation.

Materials for Each Group

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SAFETY

No student may work with any radioactive materials unless the work is carefully supervised by a certified staff member. For example guidelines, see the following:

> http://www.isbe.state.il.us/secondaryed/Science%20Ed/Guidebook%20Science%20Safety/ch10.pdf
> Guidelines from the State of Illinois. See especially 10.2 "Radioisotope Use."

Instructions

Turn the Geiger counter ON.

Allow it to stabilize and measure the background counts for the room: ________________________________

____

____

Measure the radiation of the provided alpha, beta and gamma sources and record their radiation (counts per minute) at a minimum distance from the detector (ZERO). Record your results in the following table.

Source	Zero	__cm	__cm	__cm	__cm	__cm	__cm
Alpha1							
Alpha1							
Beta1							
Beta1							
Gamma 1							
Gamma 2							

Use the meter stick to choose other distances of the source from the Geiger counter, and record your results for at least three sources (one each: alpha, beta, gamma).

Plot your results: radiation (y-axis) vs. distance (x-axis). Explain the effect of distance on the amount of radiation measured. What can you conclude? ____

____

____

____

Observe shielding effects. You have different shields made up from different materials and in different thicknesses. Put the different shields over the sources and see if the counts per minute drop with the presence of the shield. Compare the different kinds of sources with shields from different materials:

Source	Shield 1	Shield 2	Shield 3	Shield 4	Shield 5
Alpha1					
Alpha1					
Beta1					
Beta1					
Gamma 1					
Gamma 2					

Write down your conclusions: Which shield stops which radiation better? ______________________

Choose one source and measure its radiation with different shields at the same distance:

	Shield 1	Shield 2	Shield 3	Shield 4	Shield 5
Shield Thickness					
Counts/min Source A					

Plot your results, and discuss the effect of shield thickness on the measured radiation: ______________________

____

____

Think and imagine: If you had been a nuclear expert, what would be your considerations in protecting population from nuclear radiation? ____

____

____

Nuclear Submarine Class: Victor Smith and Dr. Michael Clarke

Teacher's Guide

Goals

- To help students understand what nuclear chemistry is
- To share real-life applications of nuclear chemistry

About the Class

Dr. Michael Clarke brings Victor Smith, a nuclear submarine expert, to class. He explains to the students about nuclear fission reactors and about the nuclear chemistry which yields power for producing electricity. Dr. Clarke hopes that bringing a real-life situation to class might help to make the connection between micro and macro processes in chemistry.

Lecture Notes—Victor Smith

When I say nuclear energy, what comes to mind?

Do you know what a nuclear reactor actually does? Produces power.

What types of nuclear reactors are there? Fusion and fission.

What are the differences between the two? Fusion: combine elements on the nuclear level, fuse them; Fission: split atoms and separate them into two different elements.

How many commercial fusion reactors are there in the world? Zero, this reaction occurs only in the sun. All commercial reactors are nuclear fission reactors.

What is the fuel for a nuclear fission reactor? Plutonium and uranium—U_{235}.

How powerful is U_{235}? Very powerful—on one tank of gas you can drive 300-400 miles, on one uranium pellet you can drive 5,000 miles.

How do we cause U_{235} to undergo fission? By adding neutrons to it, changing it to U_{236}. This is an unstable element that would undergo fission and become two different elements that are not always the same. We also get gamma ray radiation and 2-5 neutrons, which can get back into the reactor and begin the process again. We also get energy in the form of heat.

What is this process called? Chain reaction.

What kind of steam comes out of the reactor? Superheated steam. The steam can cut your arm off.

There are a lot of precautions we have to take to operate a nuclear reactor because it is very dangerous. This is why the Navy takes only top people for this.

Teaching Tips From Dr. Clarke

In nuclear chemistry, solve problems about balancing nuclear equations, mass-defect, and binding energy.

I want the students to understand that knowledge is universal and that the teacher is not the only source for knowledge.

I want them to talk with someone who actually works in nuclear chemistry, because for me as a teacher in the classroom it is not as real.

They didn't seem to transfer much of the knowledge that they discussed with me to the situation with the speaker, but this is why it is important to get different people in—so students can practice transfer of knowledge.

Knowledge they get in chemistry class is transferred to real life. That transfer is very important.

Someone who works in the field can tell stories of right and wrong. I can't tell them why the reactor exploded.

I think it is a good way for them to make the connection between the atomic world and the macro world. What happens within the atom, to the nucleus which is used, to generate electricity for a nuclear submarine. Hopefully they will see these connections.

References: Links

http://www.atomicarchive.com/
This excellent site has a wealth of information for students and teachers. Many of the pages are interactive. Some require Flash Player.

http://www.howstuffworks.com/nuclear-power1.htm
A brief tutorial on nuclear power with some simulations and links to related topics.

References: Readings

Olbris, D.J., and Herzfeld, J. (1999) "Nucleogenesis! A Game With Natural Rules for Teaching Nuclear Synthesis and Decay," *Journal of Chemical Education,* Vol. 76, No. 3, pp: 349-352.

Crippen, K.J., and Curtright, R.D. (1998) "Modeling Nuclear Decay: A Point of Integration Between Chemistry and Mathematics," *Journal of Chemical Education,* Vol. 75, No. 11, pp: 1434-1437.