Activities Guide

Workshop 1. Atoms and Molecules

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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.

Atomic Structure Class: Tom Pratuch

Teacher’s Guide

Goals
• To learn about the structure of the atom
• To use students’ misconceptions in order to teach correct concepts

The Class
In this class, Mr. Pratuch presents a common misconception about atomic structure which arose due to a wrong model of the atom on the school's banner. He shows it to the students on purpose to make them find the discrepancy, and thus strengthens their existing knowledge about the modern model of the atom.

Lecture Notes
When you initially came to Annandale, what was the first thing you saw about Annandale, or even knew, from middle school? Your school planner has an atom on its cover.

What’s wrong with that atom? List some things which are not realistic about it.

Where’s the nucleus? There is a big "A" in the middle—"A" for Atoms.

What do you think was, in previous years, the biggest mistake that people made when asked where the electrons, protons, and neutrons go (on the energy levels)?

They would say: How many orbitals do I have? Three (one each for protons, neutrons, and electrons). And they would not understand why they were failing chemistry.

Today, have we firmly established where the protons, neutrons, and electrons are? Well, perhaps some of you have gotten this point and still feel a little fuzzy about this?

Teaching Tips From Mr. Pratuch
I gave them a quote at the beginning of the year from Cardinal Woolsey that goes: “Be careful what you put into that head, because you will never, ever get it out.”

If they see the Annandale Atom a long time before I teach them chemistry, it takes a lot of work to get it out, as a model.

References: Readings
Periodic Trends Activity: Pernell Williams

Teacher’s Guide

Goals

• To learn to organize and classify the elements
• To build the periodic table of the elements from scratch

The Activity

In this activity, students use “Element Cards” in order to learn about the periodicity of the elements. Each card represents an element, with many of its properties listed, and the students organize several of the properties into graphs vs. the atomic mass of the elements. The students get a chance to acquaint themselves with periodic trends from first-hand experience.

Materials for Each Group

JUMP start—An orientation tool: Write the main topics of class on board; let students put it on paper.

Element Cards—cards which include data about elements 1-30.


SAFETY

No special safety considerations are required.

Lecture Notes

Start off with reading the JUMP start. Make sure you know what the activity is all about.

What sort of information does the periodic table contain?

Why do we use MP, BP, atomic mass, and density? Because they show clear trends and the information is available on the Web.

Divide into groups of five. You will be assigned a task according to your age: i.e. if you’re the youngest, you will list the elements by density. The fifth student will be the “boss” who graphs all the data and keeps time throughout the activity.

Spread the cards out on the table, write down the properties about whatever cards you find, then put them in numerical order.

Teaching Tips From Mr. Williams

I describe the periodic table as not absolutely necessary, but that’s what links the children to future knowledge in chemistry. Without it they’ll be lost in college.

Instead of just throwing columns at the children, you give them a chance to think about some qualities. When you move into qualities of compounds they make the connection.

It lets you introduce concepts like mass and density.
References: Links
http://chemlab.pc.maricopa.edu/periodic/periodic.html
A searchable periodic table. Clicking on an element produces a list of its properties, which may be used in
making the element cards in this activity.

Model your own periodic table in this activity from NASA’s Genesis Project. Requires Flash plug-in. Teacher’s
guide included.

http://www.uky.edu/Projects/Chemcomics/
For comic book fans, a whimsical look at elements in the comics.

References: Readings
1054-1058.

Abstract of Special Issue 25 on CD.
Periodic Trends Activity:  
Pernell Williams

Students’ Guide

Goals
• To learn to organize and classify the elements
• To build the periodic table of the elements from scratch

The Activity
In this activity, you will use “Element Cards” to learn about the periodicity of the elements. Each card represents an element, with many of its properties listed, and you will organize several of the properties into graphs vs. the atomic mass of the elements.

Materials for Each Group
Element Cards—cards which include data about elements 1-30.

SAFETY
No special safety considerations are required.

Instructions
1. Read the characteristics of the elements on the cards.
2. Pick one of the cards in front of you and write down the following:

   Element Name: _____________________________________________________________
   Atomic Mass: _____________________________________________________________
   Melting Point: _____________________________________________________________
   Boiling Point: _____________________________________________________________
   Density: ___________________________________________________________________

3. Spread the cards out on your table, so you can see them.
4. (About 20 minutes) Organize the cards by MP, BP, atomic mass, and density, from the lowest to the highest values (one property for each student). Draw a table in your notebook and write down the values you find (see example):

<table>
<thead>
<tr>
<th>Name of Element</th>
<th>Atomic Mass (AMU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>copper</td>
<td>63.54</td>
</tr>
</tbody>
</table>

5. Graph the boiling point, melting point, and density against atomic mass of all of the elements.

**Summary**
Describe the periodic trends that you see in your graphs. Note discrepancies, if any exist. What did you learn about the periodicity of the elements?  
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________

Compare to the Web site http://chemlab.pc.maricopa.edu/periodic/periodic.html, a searchable periodic table. Clicking on an element produces a list of its properties.

Write your comments:  
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________


Modeling Bonding Activity: Tom Pratuch

Teacher’s Guide

Goals
- To teach about atomic bonding
- To facilitate the understanding of bonding by interactive models

The Activity
Different methods are used to model bonding between atoms. These methods challenge various skills of the students in order to give them a deeper understanding.

Lecture Notes
Examples of Questions:
Why are there eight electrons in the oxygen atom?
Where are these electrons located?
How are the spins of the electrons organized?
How many electrons are there in the electron shell?
How many bonding/non-bonding electrons are there?

Teaching Tips From Mr. Pratuch
In teaching bonding, use three things:
1. **Marbles for the hands-on:** Call up students and let them actually build the atom with the marbles.
2. **The computer for the visual:** The software walks the students carefully through the notion of charges on the atom, what is truly happening on that level.
3. **Formula Rummy:** A card game for verbal interaction between students. It generates things that you can use. One can talk about how an ion is used up in the formula and the ratio between the ions.

In the game, students pick up cards with different positive/negative ions and match the charges. Then they try to find a multiplier. Thus they learn about the stoichiometry of bonding.

Try to make links between two things: the structure of the atom, and the resulting compounds, the molecules you get out of them.

The focus is on why we are looking for data, where we get the numbers from, and what it means.

References: Links
http://web.jjay.cuny.edu/~acarpi/NSC/5-bonds.htm
A tutorial on chemical bonding using Lewis dot structures.
**Periodic Table Hopscotch Laboratory:**
**Dr. Leslie Pierce**

**Teacher’s Guide**

**Goals**
- To visualize the concept of the mole
- To gain experience in calculating grams and moles

**The Activity**
In this activity, students visualize the concept of the mole using a mole of chalk as a model. They practice calculations of moles and grams, and end up with a better understanding of what a mole is and how chemists use it.

**Materials for Each Group**
- Data book and pencil
- Semi-analytical balance
- Students’ Guide
- A chunk of chalk
- Electronic balance, if available
- A table of atomic masses
- A calculator

**SAFETY**
No special safety considerations are required.

**Lecture Notes**
Get the masses before going outside and record in your databook.
Read the directions and follow them.
The main question you’re dealing with is how much chalk you leave out there, in grams or in moles.

**Teaching Tips From Dr. Pierce**
The activity gives the students something visual, coupled with the symbolic representation of the equation. Then they try to model the concept.
The lab is engaging and fun.
The students have to figure out what the molar mass of CaCO₃ is and they have to deduce how to do this, relative to the separate atoms from which it is made.
One can keep up with what the students are thinking much better on the worksheet.
Because chemistry is so abstract, if we can show the students different representations of the same idea, it helps them learn it.

**References: Links**
http://www.chemistrycoach.com/tutorials-2.htm
Click on "The Mole" to see a page of links to tutorials.

http://www.gcsechemistry.com/ximoles.htm
Explains what a mole is in chemistry and shows how to convert masses to moles. Other stoichiometric calculations are also shown.

**References: Readings**
Periodic Table Hopscotch Laboratory: 
Dr. Leslie Pierce

Students’ Guide

Goals
• Visualize the concept of the mole
• Gain experience in calculating grams and moles

The Activity
In this activity, you will visualize the concept of the mole using a mole of chalk as a model. You will practice calculations of moles and grams, and end up with a better understanding of what a mole is and how chemists use it.

Materials for Each Group
• Data book and pencil
• A chunk of chalk
• Semi-analytical balance
• Electronic balance, if available
• A table of atomic masses
• A calculator

SAFETY
No special safety considerations are required.

Instructions
1. Take a chunk of chalk and measure its mass on the balance: ________________________________
2. Go outside and draw something on the sidewalk.
3. Go back in class and weigh the unused chalk: ____________________________________________
4. Based on the initial mass of the chalk and the mass at the end, calculate how many grams of chalk you left out on the sidewalk: ________________________________________________________________
5. Write down the molecular formula of the chalk: ___________________________________________
6. Get the masses of the atoms: __________________________________________________________
7. Calculate the chalk’s molar mass: _______________________________________________________
8. Using this data, calculate:
   a. How many moles of chalk did you leave on the sidewalk? _______________________________
   b. How many molecules of chalk did you leave on the sidewalk? ___________________________
   c. How many atoms of calcium did you use? _____________________________________________
   d. How many atoms of carbon did you use? _____________________________________________
   e. How many atoms of oxygen did you use? _____________________________________________
Summary
How much does a mole of chalk weigh? __________________________________________________________
How many grams did you leave outside? __________________________________________________________
Is it (circle the correct answer):
1. less than a mole
2. equal to a mole
3. more than a mole
Define a mole, and explain its importance: ________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
____________________________________________________________________________________________
Building Molecules Laboratory: Sharon Walton

Teacher’s Guide

Goals
• To build a model showing molecular geometry using balloons
• To visualize shapes of the orbitals by the VSEPR theory

The Activity
The students build models of molecules from balloons, compare it to structures depicted by the VSEPR theory, and learn to make predictions about molecular structure.

Materials for Each Group
• Balloons
• String and scissors
• Worksheet

SAFETY
No special safety considerations are required.

Instructions
Inflate a number of balloons, according to the numbers of electron pairs, as described in the table. Tie the balloons together as tightly as you can using piece of string.

Fill in the geometric figures for all possible structures in the table by altering the number of non-bonding electron pairs for each electron configuration.

Draw, in the “configuration of bonds” column, the shape of the molecules you get from your balloons, including the central atom, the bonded atoms, and non-bonding pairs.

Give examples of molecules that fit into each category.

<table>
<thead>
<tr>
<th># of e-pairs</th>
<th>Config. of e-pairs</th>
<th># of nonbonding e-pairs</th>
<th>Class of molecule</th>
<th>Config. of bonds</th>
<th>Examples of molec.</th>
<th>Predicted bond angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Linear</td>
<td>0</td>
<td>AX₂</td>
<td>X-A-X</td>
<td>BeH₂, BeCl₂</td>
<td>180°</td>
</tr>
</tbody>
</table>

For full table, see a chapter about the VSEPR theory in any chemistry book or in the references on the following page.

Lecture Notes
Today we’re doing molecular geometry. We’ll learn the VSEPR theory and we’ll see the structure of molecules in 3D as opposed to the usual 2D.

Balloons model atoms well and you get real shapes that we see in the books.

You should tie the balloons as tight as you can with a piece of string, where each balloon represents a pair of electrons.
Fill in the geometric figures for all possible structures in the table by altering the number of non-bonding electron pairs for each electron configuration. Try to predict structures of molecules.

Fill out the worksheet to learn which shapes go with which atoms, and then you will be able to predict the shapes of other molecules.

Start with molecules of two atoms connected to the central atom. The type of molecule is denoted:

A—central atom
B—for bonding pairs

So a linear molecule is AB$_2$—we have two bonding pairs.

Do all the ones with no lone pairs, first.

See the triangular shape—see how it’s flat, that’s why they call it planar. Watch a ball and stick model, too.

Octahedron: It has six pairs of bonding electrons. It’s shaped like a square, with two atoms going out on both sides. It has eight faces—thus, it is called an octahedron.

**Summary**

Why do we learn this? We learned about polar covalent and non-polar covalent molecules. Now, we can see how they share their electron pairs.

If we have AB$_2$, do the atoms share the electrons equally?

It’s like a tug of war: similar atoms pull the electrons with the same amount of force. This bond is non-polar covalent. If the atoms are not the same, the bonds are polar covalent.

**Teaching Tips From Ms. Walton**

You can use different colors/sizes of balloons for bonding/non-bonding electron pairs. Get some extra balloons.

Balloons are cheap and available, and when they are tied together, one can really grasp the shapes, which are predicted by the VSEPR theory.

Try to show the students what basic shapes you can get and how it fits with the patterns of bonding/nonbonding electrons.

As you go on teaching, this activity is something you can refer to because the students remember it.

With balloons, it takes more imagination to see the central atom than with the ball and stick model.

The balloons make class interesting and the students understand.

**References: Links**

http://www.shef.ac.uk/chemistry/vsepr/
An excellent illustrated tutorial on VSEPR theory.

**References: Readings**


Building Molecules Laboratory:
Sharon Walton

Students' Guide

Goals
• To build a model showing molecular geometry using balloons
• To visualize shapes of the orbitals by the VSEPR theory

The Activity
You will build models of molecules from balloons, compare it to structures depicted by the VSEPR theory, and
learn to make predictions about molecular structure.

Materials for Each Group
• Balloons
• String and scissors
• Worksheet

SAFETY
No special safety considerations are required.

Instructions
Inflate a number of balloons, according to the numbers of electron pairs, as described in the table. Tie the balloons
as tight as you can using piece of string.

Fill in the geometric figures for all possible structures in the table by altering the number of non-bonding electron
pairs for each electron configuration.

Draw in the "configuration of bonds" column, the shape of the molecules you get from your balloons, including
the central atom, the bonded atoms, and non-bonding pairs.

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<tr>
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<td>Linear</td>
<td>0</td>
<td>AX₂</td>
<td>X-A-X</td>
<td>BeH₂, BeCl₂</td>
<td>180°</td>
</tr>
<tr>
<td>3</td>
<td>Equilateral Triangular</td>
<td>0</td>
<td>____</td>
<td>____</td>
<td>____</td>
<td>____</td>
</tr>
<tr>
<td>4</td>
<td>Tetrahedral</td>
<td>0</td>
<td>____</td>
<td>____</td>
<td>____</td>
<td>____</td>
</tr>
<tr>
<td>5</td>
<td>Trigonal Bipyramid</td>
<td>0</td>
<td>____</td>
<td>____</td>
<td>____</td>
<td>____</td>
</tr>
<tr>
<td>6</td>
<td>Octahedron</td>
<td>0</td>
<td>____</td>
<td>____</td>
<td>____</td>
<td>____</td>
</tr>
</tbody>
</table>
Summary
What can you say about the geometric properties of the different molecules?
Use the table to predict the structures of H2O, H3O+, PCl3, BCl3, SiH4, BH4-, H2S, SCl2, NH4+, BeH2, BeH4-2.