

# 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.
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>.

# 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

Giunta, C.J. (2001) "Using History to Teach Scientific Method: The Role of Errors," *Journal of Chemical Education*, Vol. 78, No. 5, pp: 623-627.

# 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.

See the Web site:

<http://www.dgs.oxon.sch.uk/depts/science/elements/data.htm>.

#### 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*.

#### Example of an "Element Card"

Name: Copper
Symbol: Cu
Atomic Number: 29
Atomic Mass: 63.546 amu
Melting Point: 1083.0°C
Boiling Point: 2567.0°C
Number of Protons/Electrons: 29
Number of Neutrons: 35
Classification: Transition Metal
Crystal Structure: Cubic
Density at 298K: 8.96gm/cm <sup>3</sup>
Color: Red/Orange

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### 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.

<http://www.genesismission.org/educate/scimodule/cosmic/ptable.html>

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

Laing, M. (2001) "Melting Point, Density, and Reactivity of Metals," *Journal of Chemical Education*, Vol. 78, No. 8, pp: 1054-1058.

Jerrold J. Jacobsen, Gordon Bain, Kara Bruce, and John W. Moore. (2000) "Chemistry Comes Alive!," Volume 4: *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.

Go to <http://www.dgs.oxon.sch.uk/depts/science/elements/data.htm>.

#### 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.

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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):

Name of Element	Atomic Mass (AMU)
copper	63.54

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? \_\_\_\_\_

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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: \_\_\_\_\_

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# 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  $\text{CaCO}_3$  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

Wakeley, D.M. (2000) "Developing an Intuitive Approach to Moles," *Journal of Chemical Education*, Vol. 77, No. 8, pp: 1007-1010.

# 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? \_\_\_\_\_

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### 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: \_\_\_\_\_

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# 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.

# of e-pairs	Config. of e- pairs	# of nonbonding e-pairs	Class of molecule	Config. of bonds	Examples of molec.	Predicted bond angle
2	Linear	0	AX <sub>2</sub>	X-A-X	BeH <sub>2</sub> , BeCl <sub>2</sub>	180°

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.

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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

Jones, M.B. (2001) "Molecular Modeling in the Undergraduate Chemistry Curriculum," *Journal of Chemical Education*, Vol. 78, No. 8, pp: 867-868.

Parker, J. (1997) "VSEPR Theory Demo," *Journal of Chemical Education*, Vol. 74, No. 7, p: 776.

Hanson, D. reviews "Orbitals in Chemistry: A Modern Guide for Students," (Victor M. Gil, author), *Journal of Chemical Education*, Vol. 78, No. 9, p: 1184.

Martin, J.D. (2001) "From the Wood-Shop to Crystal Engineering: Teaching Three-Dimensional Chemistry," *Journal of Chemical Education*, Vol. 78, No. 9, pp: 1195-1197.

# 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.

Give examples of molecules that fit into each category.

# of e-pairs	Config. of e- pairs	# of nonbonding e-pairs	Class of molecule	Config. of bonds	Examples of molec.	Predicted bond angle
2	Linear	0	AX <sub>2</sub>	X-A-X	BeH <sub>2</sub> , BeCl <sub>2</sub>	180°
3	Equilateral Triangular	0	—	—	—	—
—	—	1	—	—	—	—
4	Tetrahedral	0	—	—	—	—
—	—	1	—	—	—	—
—	—	2	—	—	—	—
—	—	3	—	—	—	—
5	Trigonal Bipyramid	0	—	—	—	—
6	Octahedron	0	—	—	—	—

### Summary

What can you say about the geometric properties of the different molecules?

Use the table to predict the structures of  $\text{H}_2\text{O}$ ,  $\text{H}_3\text{O}^+$ ,  $\text{PCl}_3$ ,  $\text{BCl}_3$ ,  $\text{SiH}_4$ ,  $\text{BH}_4^-$ ,  $\text{H}_2\text{S}$ ,  $\text{SCl}_2$ ,  $\text{NH}_4^+$ ,  $\text{BeH}_2$ ,  $\text{BeH}_4^{2-}$ .

(Taken from Gillespie, R.J., Humphreys, D.A., Baird, N.C., Robinson, E.A. (1986), Chemistry, Allyn & Bacon, Inc., London, p: 309.)