Hands on Periodic Table: Visualizing the Unseen

5th Grade

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National Science Standards

Teaching Standard A: Teachers of science plan an inquiry-based program for their students. In doing this, teachers

- Select science content, adapt and design curricula to meet the interests, knowledge, understanding, abilities, and experiences of students.
- Select teaching and assessment strategies that support the development of student understanding, and nurture a community of science learners.

Teaching Standard B: Teachers of science guide and facilitate learning. In doing this, teachers

- Focus and support inquiries while interacting with students.
- Orchestrate discourse among students about scientific ideas.

Teaching Standard C: Teachers of science engage in ongoing assessment of their teaching, and of student learning. In doing this, teachers

- Use multiple methods and systematically gather data about student understanding and ability.
- Guide students in self-assessment.

Teaching Standard E: Teachers of science develop communities of science learners that reflect the intellectual rigor of scientific inquiry, the attitudes, and social values conducive to science learning. In doing this, teachers

- Nurture collaboration among students.

Content Standard B: As a result of their activities in grades 5 – 8, all students should develop an understanding of

- Properties and changes of properties in matter.

Materials:

- 4 (s-, p-, d-, f-) blocks of the periodic table, laminated (computer files available at http://www.csupomona.edu/~ceemast/science/scienceLessonPlans.htm OR *www.rialtoschools.org [Navigation directions: click "Group Pages" → click "Curriculum & Technology" → click "Elementary Math & Science" → click "SMART 5th grade Science Training" folder]*
- 120 1.5" Styrofoam balls or 120 ping pong balls
- 5/8" Velcro dots w/ sticky backs, one for each Styrofoam ball
- Styrofoam/plastic glue
- 10 different acrylic colors, 1 choice being a metal color (preferably silver)
- Chenille stems: 2 different colors (66 12" stems of color 1; 100 12" stems of color 2, each cut into quarters)
- One 6" Styrofoam ball cut in half
- Two pkgs. beads of 2 different colors (one of each)
- Beading wire or thread and small needle (for stringing beads)
- 1 pkg. quilting pins
- 1 class set of individual illustrated periodic charts, laminated (Periodic Table of the Elements (11 x 18 inches), 100 pk available at http://www.acs.org)
- Chart paper and markers
- Bags of assorted buttons – enough for each student group (see Final Assessment)

Styrofoam balls are not very durable. After approximately 5 uses, the Styrofoam around the glue joint begins to fail and will need to be glued again. If this set of atoms will see extensive use, you may want to use ping pong balls. Should this be the case, you will need to make holes in the ping pong balls with a push-pin to accommodate the chenille stems.

Navigation instructions for illustrated periodic charts: choose "Natl. Chem. Week" under "quick finds" in left hand column of the page. Click on "Online Store" in left hand column, then click on "Search" in left hand column. Type "periodic table" into keyword box.

5 - 6 class periods of 1 hour

Pre-lesson preparation:

Periodic Table:
You will need to print (or make) a huge periodic table whose boxes are 5-6 inches square. Each block of the periodic table [s (left two columns), p (right hand 6 columns), d (10 columns across the middle), and f (14 columns at the bottom)] is on a separate sheet of paper. Each square contains the elemental number, but no other information. We used butcher paper and then laminated the separate parts. Once laminated, you can write on them with water soluble markers. Computer files of the Periodic Table "skeleton" are available at http://www.csupomona.edu/~ceemast/science/lessons

Atoms:
Painting the Atoms -
Styrofoam balls are used to represent atoms. The different atoms belonging in each column of the s- and p-blocks (main group elements) are painted a different color. Extra 1 and 7 columns atoms are needed for making binary compounds in Lesson 1. For the d-block, silver balls are used for each atom regardless of "family" (column or number of electrons). You will need a total of 10 colors; unpainted white works for one of the choices. See Table 1 for the numbers of Styrofoam balls of each color needed.

Table 1: Numbers of Styrofoam Balls of Each Color

Number of Balls Needed	Color	Column	Block
24	1	1	s
6	2	2	s
6	3	3	p
6	4	4	p
6	5	5	p
6	6	6	p
24	7	7	p
6	8*	8	p
1	9*	8	p
40 (metal color)	10		d

*We suggest that color 9 be a variation of color 8 (e.g. a lighter shade of the same color). The one "atom" that is painted color 9 represents He, a noble gas; the atoms painted with color 8 will also be noble gases.

Adding the Outer Valence Electrons -
Each "atom" has its valence electrons explicitly displayed. We've used one color of pipe cleaner for unpaired electrons and another for the paired electrons. (This is a management tip; all electrons are the same)

The H and He atoms have only one “house” (orbital) to hold electrons; each “house” can hold a maximum of 2 electrons. Therefore, the two electrons of He are paired. The rest of the atoms in the s- and p-blocks have four electron “houses” (orbitals); the atoms with 5 electrons have 1 pair of electrons and three that are unpaired. Because electrons are all negative in charge, they are as far away from each other as possible. Illustrations of the geometries of each type of atom in these blocks an be found at: www.chemistry.wustl.edu/~edudev/vseprtable.pdf; or www.shef.ac.uk/chemistry/vsepr/jmol/geometries.html [For more information about the geometries adopted by the electrons in these orbitals, please see an introductory chemistry text such as Atkins and Jones, Valence Shell Electron Pair Repulsion (VSEPR) discussion[1].] The atoms belonging to the d-block have six electron “houses” (orbitals); the atoms with 7 electrons have 1 pair of electrons and 5 unpaired electrons. Table 2 informs you how many chenille stems are needed for each atom.

Table 2: Number of Chenille Stems For Each Styrofoam Ball

Number of Balls	Paint Color	# Chenille Stem Color 1[a]	# Chenille Stem Color 2 [b]	Angle[c]	Geometry[d]
Main Group (s- and p-block) Elements					
22	1	1	0		
6	2	2	0	180°	linear
6	3	3	0	120°	trigonal planar
6	4	4	0	109.5°	tetrahedral
6	5	3	2	109.5°	tetrahedral
6	6	2	4	109.5°	tetrahedral
21	7	1	6	109.5°	tetrahedral
6	8*	0	8	109.5°	tetrahedral
1	9*	0	2	109.5°	tetrahedral
Transition Metals (d-block) Elements					
4	10	3	0	120°	trigonal planar
4	10	4	0	109.5°	tetrahedral
4	10	5	0	two at 180°; three on “equator” at 120°	trigonal bipyramid
4	10	6	0	90°	octahedral
4	10	5	2	90°	octahedral
4	10	4	4	90°	octahedral
4	10	3	6	90°	octahedral
4	10	2	8	90°	octahedral
4	10	1	10	90°	octahedral
4	10	0	12	90°	octahedral

[a]Chenille stem color 1 is used to represent unpaired electrons; each occupies one "space" on the Styrofoam ball. [b]Chenille stem color 2 is used to represent paired electrons; two are used in each "space" on the Styrofoam ball. [c]It is not necessary to measure the angles exactly; "eyeballing" the angles should be sufficient. [d]These are the "base" geometries used to describe the orientation of the electrons.

Glue on the Velcro Dot -
Glue a 5/8" Velcro dot (loops) onto each Styrofoam ball (use glue for Styrofoam or plastic to hold them on!); the hook half (scratchy side) gets put onto the periodic table. We used sticky Velcro dots and only needed to use glue on the Styrofoam balls.

Divide the s- and p-block atoms into bags, one for each group of students. Each bag should have a variety of atoms with different numbers of valence electrons. Do the same for the d-block atoms making sure that each bag has different atoms with different numbers of valence electrons. You should now have two sets of bags - one with the main group atoms (all different colors) and another set with the T-metal atoms of just color #10.

6" Styrofoam Ball -
Cut in half the 6" Styrofoam ball. Use one half to make a cut-away model of an oxygen atom, and the other half to make another model of a different element with more inner electrons (e.g. bromine). For oxygen there will be two inner electrons, and six valence electrons with 2 sets being paired and 2 electrons unpaired. Use quilting pins to represent the core or inner electrons. Then place the correct number of valence electrons on the outside surface of the ball using pipe cleaners.

Atomic Nuclei -
You will also need a class set, one per table group, of atomic nuclei. Use small beads to represent the nucleus with the correct number of neutrons and protons. For oxygen string 8 beads of each color alternately while drawing the string or wire through beads multiple times to end up with a ball of beads. The two colors of beads represent protons and neutrons found in the nucleus of the atom. Place the beads in the center of the cut ball.

Note: this model is not to scale. If the atom was 6" across, the nucleus of the atom would be too small to see. A more accurate scale as an example for students would be to describe the nucleus as a period in the center of a football stadium. [The atom is actually about 10^5 times larger than the nucleus.]

Lesson Construction:
This lesson is written as a series of questions (guided inquiry) instead of as a lecture so that students are more actively engaged in thinking during the lesson, thus constructing their own understanding. Feel free to add or modify the questions to accommodate your students' needs. Please share additional questions with us so we can add them to subsequent revisions of this script.

We also have included embedded assessments (ongoing or formative assessments) that allow you to determine whether or not the students have gotten the idea along with helpful hints (usually in the form of a question) to help your students along in the thought process.

Lastly, we have made use of different fonts to make visible the teacher voice from possible student responses.

Class Period 1: **Introduction to Atoms and Molecules**

California Science Content Standards:

1. *Elements and their combinations account for all the varied types of matter in the world.*

1b. Students know all matter is made of atoms, which combine to form molecules.
1h. Students know living organisms and most materials are composed of just a few elements.
6g. Record data by using appropriate graphic representations (including charts, graphs, and labeled diagramming) and make inferences based on those data.

Lesson 1 Concepts:

- Chemists use a specific form of notation to record chemical reactions.
- Atoms combine to form molecules according to the number of valence electrons available on each atom.

Materials:

Chart paper and markers are ready for each group to record
Laminated illustrated periodic tables for students or pairs of students to use
s- and p-block atoms are divided and in bags, one bag per group
Questions for think-pair-share are on chart paper and posted

ENGAGE, EXPLORE, EXPLAIN!

Prior activities: KWL chart on periodic table
Introductory research on periodic table
Reading; Harcourt Science: Chapter 2, pp.C36 - C54

Small group: Distribute illustrated periodic tables. In a think-pair-share have the groups answer the following questions. Questions should be charted for students to use.

1. What is the title of what you are seeing?

2. What do you see on the table?
3. Do you notice any patterns?
4. What do the letters in the boxes represent? (elements)
5. What information do the boxes contain? (Atomic number = number of protons, elemental symbol; atomic mass is mainly the mass of the protons and neutrons found in the nucleus. A proton's mass is 2000 times the mass of an electron)
6. What do you know about elements? (**Element** = a collection of atoms that all have the same number of protons in their nucleus, building blocks of matter, living organisms and most materials are composed of just a few of these elements. The majority of earth's crust is made up of 8 elements: O, Si, Al, Fe, Ca, Na, K, and Mg; living organisms are mostly composed of O, C, H, N, S, and P.)
7. Do you see any familiar elements on the table?
8. What are the elements used for?
9. If elements are made of atoms, what are atoms made of? (**atoms**, the smallest part of matter that cannot be broken down further ***by chemistry***, are made of **protons, neutrons, and electrons**)
10. Where are the parts of the atom located? (protons and neutrons are located in the central nucleus while the electrons are on the outside of the nucleus)
11. Why do you think the solid sawtooth line is there on the right side of the periodic table?

EXPLAIN, EVALUATE!

Whole group:
Share out from think-pair-share, reinforce vocabulary, any organizational patterns in periodic chart.

(Teacher should note any misconceptions the students might have. Misconceptions are difficult to dislodge. One of the best ways is to introduce new information that may not fit into their idea of how the world works (discrepant events). These lessons as a whole are designed to address many of the misconceptions that your students may have. You may need to clarify and define terms, discuss atomic structure, etc. It is important to know what your students know before launching into a lesson that may be well beyond them at the moment. Please take the time to make sure that <u>all</u> students understand the basics before moving on to another topic.
– see for example "California Journal of Science Education: Dealing with Science Misconceptions, Vol. V, Issue 2, Spring 2005), p.159 – 167, published by CSTA.)

Show cut-away model of Oxygen atom.

1. Can you find oxygen on the periodic table? (#8)

2. What is the symbol for oxygen? (O)
3. Where is it? (Third column from right edge)
4. How many protons does it have? (8)
5. How many neutrons in the nucleus? (8)
6. How do we know how many neutrons are in a nucleus?
7. What is the mass number of oxygen?
8. What makes up the mass number? (Protons and neutrons, proton is 2000 times the mass of an electron, neutrons are about the same mass as a proton.)
9. Where do you think most of the atom's mass is? (Nucleus, 99.9%)
10. How many electrons does it have (8)? How do you know?
11. Can someone count the electrons in this model?
12. Do some atoms have more protons and electrons than others? (Yes, different elements are defined by the number of protons and electrons. Refer to periodic table and the atomic number.)
13. Are all electrons at the same distance from the nucleus? (No, we can think about the atoms as if they were onions, with sets of electrons in each onion layer).

Show using the oxygen atom model (6" cut away), notice the inner layer of electrons, and the outer layer of valence electrons.

14. How many outer electrons does it have? (6)
15. How many inner electrons? (2)
16. How are the 6 outer electrons arranged? (2 are alone, two are pairs of electrons)

ENGAGE, EXPLORE, EXPLAIN

Today's lesson will focus on the behavior of the electrons on the outside of the atom. These electrons are called the valence electrons. They are the only ones available for doing chemistry. The valence electrons are represented by hooks so they can hook-up with other atoms which also have unpaired valence electrons. Electrons that are already paired are unavailable to do chemistry.

Here is another cut-away model of an atom. (Show it to everyone.)

1. What do you notice about this model? [6 inch Styrofoam ball cut in half with a nucleus and core electrons depicted by heads of quilting straight pins.] (**Note:** this model is not "realistic" because it is not to scale – nucleus is too large for atom; all electrons are equal regardless of position; core electrons are "hidden" inside and are not visible from the outside; and the nucleus is too small to see. A more accurate scale could be represented by a period (the nucleus) in a stadium (the entire atom).)

Ask students to compare and contrast oxygen atom model to other model.

2. How are the 2 atom models different? (different number of electrons)

3. What is similar between the two atoms? (nucleus + core electrons + valence electrons)

Small group:

Distribute atoms: Bags of main group (s- and p-block) atoms to student groups.

Each group should now have a collection of atoms on their desks. Examine the atoms you have.

1. What can you say about them? (one color of pipe cleaners represents electrons are internally paired, the other color represents unpaired electrons, atoms have between 1 and 8 electrons, they have different colors, they are spherical, they have Velcro dots, all balls are same size. [**Note:** although two different colors of chenille stems are used to represent paired and unpaired electrons, all electrons are exactly the same. Note also that atoms are not all the same size, are not colored, and do not have Velcro dots on them.])
2. What do the pipe cleaners represent?
3. Why are the valence electrons of each atom spread away from one another?
4. Count the valence electrons. How many are there?
5. Where are the rest of the electrons? (inside the atom and they are unavailable for making chemical bonds, only valence electrons do chemistry)
6. Why are some of the valence electrons occupying the same space?
7. Do you think electrons of the same atom want to be paired up? (not unless they have to, they have the same charge, and like charges repel each other)

But these atoms only have 4 electrons houses (orbitals), each of which can hold a maximum of 2 electrons.

8. So what do electrons do if an atom has 5 electrons and only 4 spaces? (2 must pair up!)

Pair up all of your valence electrons that are in the same house.

9. How many pairs of electrons are there?
10. How many lone electrons are there?
11. How many total electrons are there? (There are the outside valence electrons and there are also electrons paired inside the atom which are not available to do chemistry.)

(This model makes it appear as if there are 2 types of electrons – this is not true, all electrons are the same!)

Electron Behavior:

- The electrons want to be paired; but they only pair internally when forced to do so.
- Unpaired electrons (lone ones) are what we call “reactive”. They need to find external partners.
- Making new electron-electron pairings is what we call **chemistry** or a **chemical reaction**.

Small Group:

Before we do any chemistry, we need to be sure we are safe! (Put on goggles - joke!) Now, let's do some chemistry and make some new **bonds** (or new electron-electron connections) between two atoms.

Have students make **molecules** (chemicals that have two or more atoms bonded together) from only two types of atoms, or binary compounds (**binary compounds** = molecules with 2 different types of atoms).

Rules:

- Use only two differently colored (or two types of) atoms to connect the unpaired electrons - use as many as you need.
- You are all done when all unpaired electrons have a single partner and none are left unpaired.

Now go ahead and see what sorts of binary compounds your group can make.

Whole Group: Have students share out the types of compounds made.

1. What combinations did you make?
2. What atomic ratios did you find in your binary compounds?
3. How many of each type of atom did you have to use?

Chart responses: 2 yellow + 3 green $\Rightarrow$ 2Y+3G $\Rightarrow Y_2G_3$ "expert" chemical writing. This is the shorthand way chemists use to describe chemicals compounds, chemical formulae, or combining ratios.

Now make another new chemical with three different types of atoms. (Double and triple bonds/connections between atoms are allowed, but not quadruple bonds because it is physically/geometrically impossible to do so.)

4. How many of each atom did you use? Chart responses.
5. Did anyone use the atoms that have 8 electrons? How?

6. Why not? (all electrons are paired; there are no single electrons available for chemistry)
7. What can be said about the paired electrons?

Ask students to unhook the atoms and place them back in the into the bags for the next lesson.

TAKE HOME MESSAGE:

- Electrons have the same charge, but not all electrons are the same distance from the nucleus.
- The outer valence electrons want to be paired; but they only pair internally when forced to do so. Unpaired electrons (lone ones, or valence electrons) are what we call "reactive". They need to find external partners.
- Making new electron-electron pairings is what we call chemistry or a chemical reaction. When all electrons are paired the molecule is said to be stable.
- Chemists use a specific notation for recording chemical reactions.

Lesson 2: Organization of the Periodic Table

California Science Content Standards:

1. *Elements and their combinations account for all the varied types of matter in the world.*

1b. Students know all matter is made of atoms, which combine to form molecules.
1d. Students know that each element is made of one kind of atom, and that the elements are organized in the periodic table by their chemical properties.

6a. Students will classify objects in accordance with appropriate criteria.
6g. Record data by using appropriate graphic representations (including charts, graphs, and labeled diagramming) and make inferences based on those data.

Lesson 2 Concepts:

- The periodic table is organized so elements are arranged in columns based on the number of electrons available for chemical reactions (only the outer or valence electrons are available to do chemistry). Therefore, the elements in any column have similar chemical behavior because they have the same number of ***valence*** electrons.
- Electrons are added to the atoms (not the same atom, but atoms with increasing numbers of protons) in layers – with each row of the periodic table representing a different layer. Elements in lower rows have more total electrons, but the same number of valence electrons as those above them in the column.

Materials:

4 s-, p-, d-, and f- blocks laminated and hanging up in the classroom
Main group atoms (s- and p-block) divided into bags, one per group of students

Preparation: Lesson begins with empty, huge periodic table on the wall. The s-block has two columns with the number 1 in the top left box, and should be placed on the left side of the wall. Next place the d-block (10 columns wide with the number 21 in the upper left box) to the right of the s-block so that the box containing 21 lines up with the box containing 20. The p-block containing 6 columns (and has the number 2 in the top right box) is then placed to the right of the d-block so that the box with 31 lines up with the box containing 30. Now place the f-block (14 columns wide with two rows) across the bottom of your periodic table.

ENGAGE, EXPLORE, EXPLAIN!

Prior Activities:

KWL
Discuss examples of “everyday” classification

Reading (Harcourt Science: Chapter 2; Lesson 2: pp. C48 – C54)
Debrief from Lesson 1: Introduction to Atoms and Molecules

Small Group: Hand out bags of s- and p-block atoms.
Tell students: You have a bunch of data in front of you – different atoms! Remember, you do not know what is inside each one. Chemists are only concerned with the valence electrons. (Ask the students to break any bonds between the atoms that may have been left from Lesson 1.)

Examine the atoms in front of you as collected data.
How do the atoms compare to one another?
Discuss in your groups how you might organize/classify these atoms.

You might have noticed the periodic table on the wall. This is just an organizing chart for the data you have in front of you - the atoms! From your group discussion, how might you organize your data on this organizing chart?

WAIT! only a part of the Periodic Table is needed for this task.
So let's remove the parts we are going to ignore [f and d blocks for a start].
RIPPPPPP! Now move the p-block over so that it is next to the s-block → so you have a chart that is 8 squares across. See Figure 1.

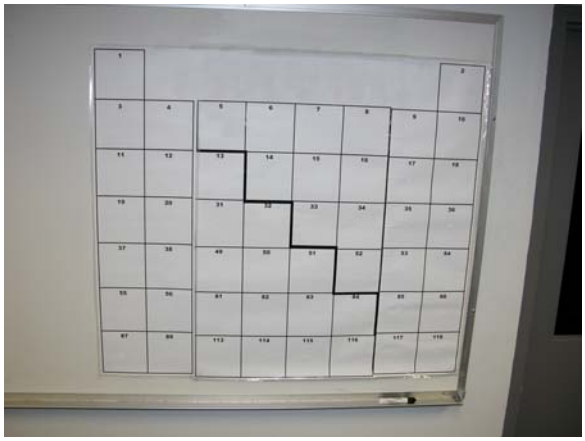

Figure 1: Periodic Table s- and p-blocks with d- and f-blocks removed.

These atoms fit onto the parts of the periodic table on the wall in front of the room. Your job is to organize the atoms so that they fit into the boxes of the periodic table. What are you going to use to as the basis of the organization? How will you do it?

Talk among yourselves for a couple of minutes about how you might organize your data knowing that the entire chart needs to be filled with data when you are done.

Come place your atoms on the periodic table as your group chose to organize them. (Use the Velcro on the atoms to stick to the Velcro on the table).

Note about misconceptions:
Students may confuse atomic number with numbers of valence electrons. Tell students: All the data needs to go on the periodic table.

Leading questions/hints to ask students to if they fail to organize the data properly:

Is there a repeating pattern?
Every box needs to be filled.
Does it look organized?
How many rows do I have?
How many columns do I have?
How many different types of atoms do I have?

To see what the periodic table looks like when the data is sorted correctly, see Figure 2.

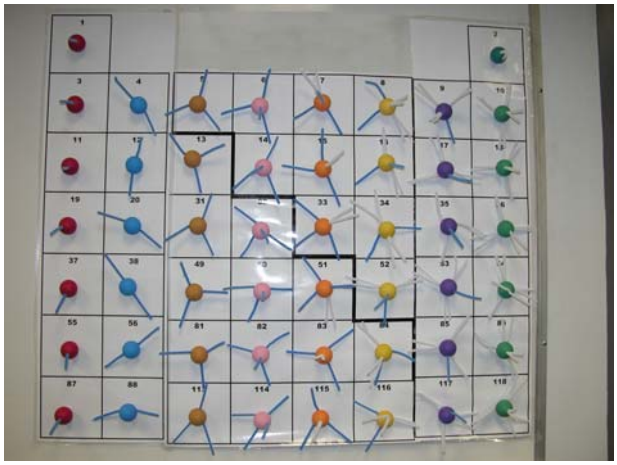

Figure 2: Atoms placed correctly on the s- and p-blocks of the Periodic Table.

EXPLORE, EXPLAIN, EVALUATE!

Whole group:

1. Compare and contrast the different ways the groups organized their data.
2. Did you all agree with the placement?

3. What would you like to change?

Allow groups to make changes.

4. How did you decide how to organize the data this way?
5. What do you notice about the organization of the atoms? (atoms in each column are all the same color and have the same number of valence electrons)
6. Are there other possible arrangements that might make sense? (yes - for instance atoms could be arranged 8-1 valence electrons from left to right)
7. How do you think you could decide which might be the correct one? (perhaps the number of the boxes in a row provide a clue?)
8. What sorts of information might you need in order to decide?
9. Do you think that these atoms are placed correctly? What do you base your opinion upon?

If chart is organized continue with the questions, if not keep questioning until students organize the table according to the number of valence electrons.

Remember, you do not know what is inside the model atoms, and that the valence (outside) electrons are responsible for the chemistry.

10. What do the atoms in any given column have in common? What does this mean? (All of the atoms in a column have the same number of valence electrons. We do not know how many electrons are in the "center" of the atoms, nor do we know which element it actually is, but because the atoms have the same number of valence electrons they must do similar chemistry. In reality, scientists use highly sophisticated equipment to tell the different elements apart because each element has a different mass and a total number of electrons)
11. If the electrons are responsible for the chemistry, which electrons do you think are the ones doing the chemistry? (valence - and only those that are unpaired)
12. What can you predict about the properties of each column?
13. What can you say about the chemistry of the atoms in any given column? Give a reason for this conclusion. (If only valence electrons are responsible for the chemistry, their chemical behavior should be similar.)
14. What are the differences between the atoms in a column? (different numbers of electrons)
15. What about moving across a row, do you see any patterns? (Each atom as you move across has one more electron.)
16. How does the first atom on the row differ from the fifth atom in the row? The last atom in the row?
17. After a row has been completed, where does the next row begin?
18. How can that next layer be described?
19. Can you predict the general size of an atom by looking at the rows? (each row is another layer, like an onion)

20. If each row is another layer, what can be said about the distance of the valence electrons from the nucleus?
21. What happens to atoms as you move down through the column? (The atoms react faster because the valence electrons are further away from the nucleus)
22. Why might the atoms react faster? (Atoms in lower rows have more total electrons, more protons and more neutrons. They will react faster because the electrons are further from the nucleus and more likely to be attracted to an external partner. An analogy: think about your "unfocused" students. Would you rather have them sit up front close to you or at the back of the room? Why?)
23. Is it possible to make predictions on how many atoms of various elements one would need to make a compound? How?
24. Can anyone give another example?

EVALUATE!

Independent work: In journals have students answer the following question.
What are the different ways chemists read data on the periodic chart?

Across a row
Down the column
Linear as in the atomic number
The staircase divides metals from non-metals

TAKE HOME MESSAGE:

There is a repeating pattern as you go across = **periodic behavior**

- Periodic behavior: Moving across the periodic table, each row or layer begins with one valence electron until all the houses are filled with paired electrons in that particular layer, then a new layer/row starts again. With each new layer the outer electrons move further away from the nucleus.

Atoms in a column or **family** have similar chemical behavior

- Moving down the column each element has the same number of valence electrons. Chemistry involves the outer layer of electrons only, called the valence electrons. The number of valence electrons is a chemical property.

- When all of the valance electrons are paired, the molecule is said to be stable.

Class Period 3: Bonding

California Science Content Standards:

1. *Elements and their combinations account for all the varied types of matter in the world.*

1a. Students know that during chemical reactions the atoms in the reactants rearrange to form products with different properties.

1b. Students know all matter is made of atoms, which combine to form molecules.

1d. Students know that each element is made of one kind of atom, and that the elements are organized in the periodic table by their chemical properties.

1i. Students know the common properties of salts, such as sodium chloride (NaCl).

6a. Students will classify objects in accordance with appropriate criteria.

6g. Record data by using appropriate graphic representations (including charts, graphs, and labeled diagramming) and make inferences based on those data.

Lesson 3 Concepts:

- The periodic table can be used to make some predictions about chemical compounds. A column 1 atom bonded to column 7 atom, does so in a 1:1 ratio; this makes a salt.
- The periodic table can be used to make predictions about which compounds will have ionic bonds. Not all ionic bonds dissolve in water, but ionic compounds that do dissolve in water carry an electric current are salts.
- The periodic table can be used to make predictions about combining ratios to make different compounds.

Materials: s- and p-block parts of periodic table, and atoms for s- and p-blocks
s- and p-blocks should be up and filled with atoms where all atoms in a column have the same number of valence electrons.
Chart paper and markers
Extra s-and p-block atoms not placed on the large periodic chart

ENGAGE, EXPLORE, EXPLAIN!

Prior Activities: Go over organizational patterns of periodic chart. Students in groups can share journal entries. Whip around the room, chart organizational patterns.

Whole group:

We can make predictions about the chemical behavior of atoms by examining their placement on the periodic table. Let's go back and examine the combining ratios of atoms from different columns. (This was already done when the students made binary compounds with the atoms before they placed the atoms on the periodic table. Show chart with written chemical expressions from Lesson 1)

Binary Compound ratios:	
Column 1 (alkali metals) with column 7 (halogens)	1:1
Column 1 with column 6 (oxygen family)	2:1
Column 2 (alkali earth metals) with column 6	1:1
Column 3 (boron family) with column 5 (nitrogen family)	1:1
Column 4 (carbon family) with column 6	1:2

Have students make some of the binary compounds with s- and p- block atoms

1. Can you find a binary compound combining ratio that is 2:3, or 3:4?
2. Which columns are involved? How many from each column to make the compound?
3. Is it stable? Are there any unpaired electrons?

During questioning use the large periodic chart and the atoms to model what is being discussed by being explicit as to the columns used and the number of atoms from each column.

1. If the atoms in the right hand column do not do any chemistry, what does this tell you about atoms that have nothing but paired electrons? (They are stable)
2. How do you know this? (In order to be "stable", all atoms need to have the same electron configuration as noble gases. Atoms can do this in one of two ways. They can gain or lose electrons to become ions (atoms that do not have the same number of protons and electrons), or they can share electrons with other atoms so that all available houses have two electrons. Interact with the atoms (by demonstrating ion formation-chenille stems are easy to pull out of or add to the Styrofoam balls) on the Periodic Table as students answer the following questions.*)*
3. If we were able to add or subtract electrons from atoms, do you think the atoms in the left hand column 1 would rather take in more or lose what they have? (The atom would rather lose the one they have to become a positive ion. Ions do not have the same number of protons and electrons. The ions have either gained or lost an electron which changes the balance of the number of protons in the nucleus to the number of electrons for that particular element.)
4. Why? (The atom would lose the electron because then it would have the same appearance as a noble gas, also it takes less energy)
5. What about the atoms in column 7, will they want to lose 7 electrons or gain 1? (They would take in one electron to make a negative ion.) Why? (They would have the same number of electrons as a noble gas, and again it will take less energy.)
6. So, which atoms do you think might want electrons more than others? Is there a pattern/trend? (Atoms on the right side of the periodic table "hog" the electrons more because they want to appear as having the stable arrangement of electrons like a noble gas {higher electronegativity}, while the atoms on the left side of the periodic table are likely to give up their electrons so that they too appear to have a stable

electron arrangement as a noble gas {electropositive,or having a lower electronegativity})

7. In a compound the atoms from which columns would share electrons most unevenly? (Those with atoms from the left column and those from the second to the right column would share most unevenly. These are termed ionic compounds - compounds where the electron actually "defects" from the atom in the left hand column to the atom in the 7th column)

Let's explore ionic bonding, and the results in more detail. *Model the following process using atoms from the Periodic Table.*

Ionic bonding: Bonds between a metal and a non-metal

- Model with atoms. When Na combines with Cl, the electron from Na is removed and added to unpaired electron on Cl to form an electron pair.
- The defection of the electron from one atom to the other changes the charge on both atoms. Na now has a positive charge because it lost an electron, where Cl has a negative charge from taking an electron from Na.
- Atoms from column 1 with atoms from column 7 form ionic compounds where there is a defection of an electron. Ionic compounds that dissolve in water are salts. The ions formed when salts dissolve can carry an electric current.

Make a model of water (H_2O) and show it.
In addition, the oxygen atom in water has two lone pairs of electrons. The result is that there is much more negative charge around the oxygen atom in water making the molecule itself polar (but it is not ionic!). This means that water acts like a magnet with the more negative oxygen "end" being attracted to positive ions and positive sides of other polar molecules, and the more positive hydrogen "end" being attracted to negative ions and the negative sides of other polar molecules.

Interactions of salts with water:
Salts are compounds with ionic bonds. NaCl is table salt. Let's examine what happens when NaCl dissolves in water.

1. Which atom in positively charged? (Na)
2. Which atom is negatively charged? (Cl)
3. Which end of water is negatively charged? (O)
4. Which end of water is positively charged? (H)

Collect the "extra" alkali metal and halogen atoms and make a salt crystal. Then demonstrate using your water molecule model that the oxygen end of water begins to solvate a Na (it takes a minimum of 4 water molecules to completely solvate either Na or Cl and cart them off into the bulk liquid), while the hydrogen end of water will

approach and begin to solvate a Cl. Once the ions are surrounded by at least 4 water molecules and distributed in the bulk liquid, the salt has “dissolved”.

The fact that there are ions in solution results in two other properties of NaCl – one is that it tastes “salty”, the other is that the solution can carry a current (moving charges are a current – it is not just electrons that can do this). A web animation is available at: http:/ /www.mhhe.com/physsci/chemistry/essential chemistry/flash/molvie1.swf

TAKE HOME MESSAGES:

- Combinations of metals with a non-metal make an ionic compound; a salt is a compound that when dissolved in water becomes ionic, and tastes salty. Not all ionic compounds dissolve in water. A salt does dissolve in water.
- Combinations between atoms in columns 1 & 7 make ionic compounds that are salts. There is a complete defection of the electron from the atom in column 1 to the atom in column 7
- When a salt dissolves in water it forms ions which can carry an electric current.
- Combinations between atoms in columns 2 & 7 make ionic compounds that could be a salt
- Atoms on the right side hog where atoms on the left side of the table are more likely to give up electrons.
- In forming ions, whether the atom loses or gains an electron, the goal is to look like a noble gas, or to be stable.

Class Period 4: Properties of Metals

California Science Content Standards:

1. *Elements and their combinations account for all the varied types of matter in the world.*

1b. Students know all matter is made of atoms, which combine to form molecules.

1c. Students know metals have properties in common, such as high electrical and thermal conductivity. Some metals, such as aluminum (Al), iron (Fe), nickel (Ni), copper (Cu), silver (Ag), and gold (Au), are pure elements; others, such as steel and brass, are composed of a combination of elemental metals.

1d. Students know that each element is made of one kind of atom, and that the elements are organized in the periodic table by their chemical properties.

6a. Students will classify objects in accordance with appropriate criteria.

6g. Record data by using appropriate graphic representations (including charts, graphs, and labeled diagramming) and make inferences based on those data.

Lesson 4 Concepts:

- Metals have a special set of properties because they share their electrons differently (communal sharing of electrons) than the main group elements, including salts.
- Transition metals are organized on the Periodic Table in a similar way as the main group elements.
- Metals are ductile and malleable.

Materials:

d- and f-block laminated charts
One bag per student group with d-block atoms divided equally

Preparation: Add the d-block (10 across) portion to the Periodic Table. In bags have the d-block atoms with valence electrons 3 - 12 divided up equally, one per student group.

Prior Activities:

KWL
Review organization of s- and p-blocks. Review types of bonding.
Review/discuss physical properties of metals. (This should have been a previous lab where students explored the physical properties of metals, or a lab should follow.)

Small Group: Pass out transition-metal balls (the ones with 3-12 electrons and metallic colored). Explain to the students that the atoms they have also belong on the periodic table. The students are to discuss in their groups how to organize this new data. After a consensus is reached, they are to place their atoms on the newly added portion of the periodic table.

The new atoms I have given you also belong on the Periodic Table I have just added. Discuss in your groups how to organize this data, and then place your data on the newly added portion of the Periodic Table.

Figure 3 illustrates what the periodic table looks like when the atoms are sorted and placed correctly.

Figure 3: Periodic Table with all of the atoms.

Whole Group:

1. Do you all agree with the placement of the data?
Come make changes.
2. How did you decide on the organization?
3. What do you notice about the organization of the data?
4. How many electron "houses" do these atoms have? (6)
5. How do you know? (12 total electrons, first pair of electrons appears for atoms with 6 electrons)

People Movers Activity: A kinesthetic demonstration of malleability and ductility.
A "dance" in three parts:

1) Demonstration of ductility - this is the ability to draw materials (metals) through a small hole to make a wire. You will need to make an "orifice" through which you will "draw" the students. You can do this by laying down tape so that students can only pass through in single file. Line up the students in rows and columns to simulate a metal crystal. Ask them to "touch" those around them, but they will be free to move when they are "pushed" or "pulled" by you as long as they maintain touch. Explain that they cannot pass through a solid wall and must stay in the "open space" of the orifice you have laid out. Take one student by the hand and "pull" them through the "orifice". Since the other students need to maintain "touch" contact, this will eventually draw all students through the "orifice" in single file as if they were a wire.

2) Demonstration of malleability - Do this “dance” against a “wall” or place tape on the ground and explain that this is a wall through which they cannot pass. Then arrange students in rows and columns. Now hold a large circle (paper, Frisbee, etc.) and explain that you are the hammer that is going to pound on them - the piece of metal. As you gently “push” at some part of the metallic crystal, the students should move out of the way by spreading out against the “wall”, while maintaining touch contact. Since they cannot go through the wall, all they can do is “spread”. A material that can change its shape upon pounding without breaking is malleable.

3) How are salt crystals different from metals? “Reset” your crystal of rows and columns of students. This time the bonding is different. The students in every other row places their hands on the students in front of and behind them while the other students place their hands on the students beside them in both direction. Now, they are not allowed to “let go” of those they are touching. What happens as you try to “hammer” them? The only thing that can happen is that the crystal (if it reacts at all) it to cleave or shatter.

TAKE HOME MESSAGE:

- Metal to metal bonds are different than ionic bonds which can make salts. Ionic (electrons completely defect to the atom further to the right hand side of the periodic table) bonds are between non-metals and metals. Metallic bonding is much more communal – all electrons are shared across all of the atoms.
- Metal to metal bonds are where the electrons are shared communally because of this metals have special physical properties of ductility, malleability, magnetism, thermal conductivity, and electrical conductivity.

EXTEND AGAIN!

Add the f-block to the periodic table. Have students predict what would be the organizational pattern. This is done without the benefit of actual atomic models to place on the periodic table.

1. If you had atoms how could they be arranged in this new block I have added? (14 squares across; starts with 3 electrons goes through 16 electrons, 8 electron houses or orbitals)
2. How many houses do think would be on one of these atoms?
3. What would be the total number of valence electrons if they were all paired?
4. On which atom would all of the houses have one atom, and another atom would have to share a house?

5. Do you see a pattern between the s- and p-block, the d-block, and now the f-block?

Final Assessment: **A culminating exercise (either now or later):**

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1. *Elements and their combinations account for all the varied types of matter in the world.*

1b. Students know all matter is made of atoms, which combine to form molecules.

1d. Students know that each element is made of one kind of atom, and that the elements are organized in the periodic table by their chemical properties.

6a. Students will classify objects in accordance with appropriate criteria.

6g. Record data by using appropriate graphic representations (including charts, graphs, and labeled diagramming) and make inferences based on those data.

Materials:

Class set of Illustrated Periodic Tables
Several bags with a variety of buttons

Ask the students to use the buttons to represent something they know about the data represented on the periodic table by placing buttons on your periodic table. This is a group project.

Have the groups do a museum walk to see what other groups have done.
Then have one group share about how another group organized their buttons on the periodic chart. Whip around the room having each group share another group's organization.

1. What do you notice about how another group chose to place their buttons?
2. What were they representing?
3. Did they represent more than one pattern?

Continue the questions with each group until every group has shared and been shared about.

4. Did any group have something they represented that has not been pointed out?

TAKE HOME MESSAGE:

- Periodic chart organizes the elements in a variety of ways.
- Chemists use the chart to make predictions about chemical properties and reactions.

Acknowledgements

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