CHEMICAL BONDING

Grade Level: 7th Grade

Presented by: Rod and Denice Sandefur, Naturita Middle School, Naturita, CO

Length of Unit: 5 lessons

I. ABSTRACT

A. This unit focuses on a review of atomic structure and chemical bonding both of which are instrumental in driving the laws of nature. Chemicals bond because of the mutual attractions for the outermost valence electrons and result in chemical reactions characterized by patterns of change, stability unity and diversity. Students will demonstrate a comprehension of ionic, covalent and metallic bonding, outer shell stability and molecular formation and structure.

II. OVERVIEW

A. Two general **concepts** guide the unit

1. Concept One: Understand that everything that exists and has mass is matter and that matter can be defined by the interaction of electrons.
2. Concept Two: Understand that chemical bonding and chemical reactions resulting from that bonding are driven by reactant composition and characteristics toward a predictable outcome.

B. **Content**

1. The following unit focuses on a student development of understanding and application of atomic structure and how it pertains to chemical bonding.
2. Lesson Sequence:
   a. Lesson One: What is Matter
   b. Lesson Two: Characteristics of Matter
   c. Lesson Three: Electron Configuration
   d. Lesson Four: Introduction to Chemical Bonding
   e. Lesson Five: Student Culminating Activity

C. Specific **skills** to be addressed in this unit are:

1. The student will develop background knowledge in how atoms achieve stable outer shells of electrons.
2. The student will demonstrate how chemical reactions rearrange the atoms and electrons in elements and compounds to form chemical bonds.
3. The student will compare and contrast ionic, covalent and metallic bonding.
4. The student will list how atoms combine with themselves or other atoms to form molecules.
5. The student will compare and contrast oxidation/reduction reactions with acid/base reactions.
6. The student will predict chemical bonding based on their knowledge of electron configuration.

III. BACKGROUND KNOWLEDGE

A. For the teacher:

1. *Chemistry*, Chisholm, Jane and Johnson, Mary
2. *Chemistry of Matter*, by Maton, Anthea, et.al.
3. Beckworth, Rowan, http://www.ChemCenter.org/wondrnet/welcome.htm
4. Blaber, Michael, "Chemical Equations", http://wine1.sb.fsu.edu/chm1045/notes/Stoich/Equation/Stoich01.htm

B. For the student:

1. Teacher-assigned readings from Internet selections listed above.

2. Core Knowledge fourth, fifth and sixth grade curriculum for review purposes and seventh grade curriculum.

IV. RESOURCES

A. For the teacher:

1. *Chemistry,* Chisholm, Jane and Johnson, Mary
2. *Chemistry of Matter,* by Maton, Anthea, et.al.
3. *Chemistry, Investigations in Science,* by Parratore, Phil M.
4. Beckworth, Rowan, "Basic Atomic Structure" http://www.users.senet.com.au/~rowanb/chem/atstruct.html
5. Beckworth, Rowan, "Chemical Bonding Information", http://www.users.senet.com.au/~rowanb/chem/chembond.htm
6. Beckworth, Rowan, http://www.ChemCenter.org/wondrnet/welcome.htm
7. Blaber, Michael, "Chemical Equations", http://wine1.sb.fsu.edu/chm1045/notes/Stoich/Equation/Stoich01.htm
8. Blaber, Michael, "Metals, Nonmetals and Metalloids", http://wine1.sb.fsu.edu/chm1045/notes/Periodic/Metals/Period06.htm

B. For the student:

1. Teacher-assigned readings from Internet selections listed above.

V. LESSONS

Lesson One - What is Matter?

A. **Daily Objectives**

1. Lesson Content
   a. A review of atomic structure (Core Knowledge- 4th grade science curriculum) as it pertains to matter.
2. Concept Objectives
   a. The student will understand as they review again the concept that atoms are the basic unit of matter and that matter makes up everything.
3. Skill Objectives
   a. The student will compare and contrast the parts of an atom.

B. **Materials**

1. pencil and paper
2. poster board
3. periodic table
4. markers

C. **Key Vocabulary**

1. Atoms – the basic building block of matter.
2. Proton – a positively charged sub-atomic particle found in the nucleus of an atom.
3. Electron – a negatively charged subatomic particle found in orbit around the nucleus.
4. Neutron – a neutral-charged subatomic particle found within the nucleus of an atom.
5. Nucleus – the dense central portion of an atom.
6. Periodic table – a table listing all of the known elements of the universe arranging according to specific properties and characteristics.

D. **Procedures/Activities**

1. Make a list of known substances on the chalkboard.
2. Lead the students through a discussion of each substance's composition:
   a. Water – composed of hydrogen and water.

b. Sugar - composed of carbon, hydrogen and oxygen.
c. Salt – composed of sodium and chlorine.
d. Carbon dioxide – composed of carbon and dioxide.

3. Re-introduce the student to the periodic table by handing out copies of the periodic table. See resource list – *Chemistry,* Usborne. Pg. 14-15.
4. Discuss the symbols and atomic structure of common elements.

E. **Evaluation/Assessment**

1. The student will be given five elements to locate on the periodic table by symbol.
2. As homework, the student will pick one element from the first three rows of the periodic table and draw its atomic structure including the nucleus, protons, electrons and neutrons.

F. **Standardized Test Connections**

1. This lesson relates to standard 2.1, The students know that matter has characteristic properties which are related to its composition and structure, from the Colorado Model Content Science Standards.

Lesson Two – Characteristics of Matter

A. **Daily Objectives**

1. Lesson Content
   a. The student performs a series of lab procedures designed to augment the previous day's lesson concerning atomic structure as it pertains to matter. These procedures include dissolving sugar and salt in water and seeing how some of the characteristics carry through even in phase changes.
2. Concept Objectives
   a. The student will understand that certain elements and compounds have observable and identifying characteristics.
3. Skill Objectives
   a. The student will identify characteristics specific to salt and sugar that carry through in combination with other compounds.

B. **Materials** (per team)

1. beaker
2. water
3. watch glasses
4. sugar
5. salt
6. measuring spoon – teaspoon
7. measuring cup

C. **Key Vocabulary**

1. Properties – characteristics that identify certain elements or compounds.
2. Phase change – the different forms of the same substance – exp. Solid, liquid and gas.

D. **Procedures/Activities**

1. Have students group into teams of two.
2. Place ½cup water into a beaker.
3. Into water add 3 teaspoons of sugar and stir until sugar disappears into the water completely.
4. Observe for any color changes in the water.
5. Taste the water.
6. Have students record observations in lab notebook.
7. Place 2 teaspoons of sugar solution in a watch glass and set aside to dry overnight.

8. Repeat steps 2 – 7 with salt.
9. Each team needs to culminate the activity by comparing and contrasting their observations in their lab notebooks.

E. **Evaluation/Assessment**
1. Have students compare their observations with other students to determine whether or not similar observations were found.
2. Quiz students with the following questions:
   a. Describe one property of salt that still existed in the salt water.
   b. Describe one property of sugar that still existed in the sugar water.
   c. Predict the characteristics of the substances in the watch glasses after drying overnight.

F. **Standardized Test Connections**
1. This lesson correlates with standard 2.1, the students know that matter has characteristic properties which are related to its composition and structure.

Lesson Three – Electron Configuration

A. **Daily Objectives**
1. Lesson Content
   a. Through guided classroom discussion, the student will be introduced to the concept of electron configuration and how it determines the characteristics of chemical bonding.
2. Concept Objectives
   a. The student will recognize the characteristics of electron configuration and its effect on chemical bonding.
3. Skill Objectives
   a. When prompted, the student will be able to describe a particular element's electron configuration.
   b. The student will utilize the electron configuration to locate an element on the periodic table.
   c. The student will predict a possible chemical bonding of two elements based on their knowledge of electron configuration.

B. **Materials**
1. periodic table
2. corkboard
3. scissors
4. pushpins or tacks of different colors
5. ruler

C. **Key Vocabulary**
1. Energy level (electron shell) – referring to the level an electron occupies around the nucleus of an atom.
2. Electron configuration – the arrangement of the electrons in the energy levels.
3. Valence electrons – electrons occupying the outer most positions in the energy levels.
4. Chemical bonding – the combining of atoms to form new substances.

D. **Procedures/Activities**
1. Give lecture utilizing the summary of information listed below.
   a. Everything around us is made up of matter – the air we breathe, the trees we rest beneath on hot summer days, the clouds that threaten storms above those trees and the umbrellas we also take shelter beneath. In addition each tiny part of humans is composed of matter. This matter all has one thing in common even as diverse as this matter is – it is all

composed of tiny building blocks called atoms, the basic structure of matter.

b. Atoms then compose elements which in turn make up matter and there are only 109 elements, the simplest type of substance. These 109 elements are each made of specific types of atoms and atoms of elements combine with one another to produce new and different substances called compounds. Compounds contain more than one kind of atom chemically joined together.

c. Atoms are composed of subatomic particles called electrons, protons and neutrons. The protons and neutrons are found within the densely packed nucleus at the center of the atom and the electrons are found within orbit in energy levels surrounding this nucleus. Protons are positively charged subatomic particles, neutrons are neutral and electrons carry a negative charge. The number of outer shell electrons is what determines the reactivity of the element and thus its bonding behavior, chemically speaking.

d. It is important to remember that even though elements and matter is all different it is still all composed of electrons, protons and neutrons. In other words all atoms are basically the same but the manner in which they are arranged differs creating the diversity in matter.

2. Demonstrate on the board the atomic structure of the following elements.
   Hydrogen Helium Lithium

   Sodium Carbon Chlorine

3. Do the activity as outlined below.
   a. Cut a thin piece of corkboard into a circle 50 cm in diameter to represent an atom.
   b. Insert a colored pushpin or you can use a colored tack to represent the nucleus.
   c. Draw three concentric circles around your nucleus to represent the energy levels of the atom. The inner circle should be 20 cm in diameter, the second circle, 30 cm in diameter, and the third, 40 cm in diameter.
   d. Using your pushpins or tacks of an alternative color to represent the electrons, construct the following atoms: hydrogen (H), helium (He), fluorine (F), neon (Ne), and argon (Ar).
   e. Are any of these elements in the same family? If so, which ones? How can you tell?

E. **Evaluation/Assessment**

1. The student should complete an accurate depiction of the atoms as outlined above. Helium, neon and argon all belong to the same family based on the number of valence electrons (electrons in the outer most shell) they have.

F. **Standardized Test Connections**

1. This lesson correlates to standard 2.1, students know that matter has characteristic properties, which are related to its composition and structure, of the Colorado Model Content Science Standards.

Lesson Four – Introduction to Chemical Bonds

A. **Daily Objectives**

1. Lesson Content
   a. The following lesson offers an introduction to the different types of chemical bonding chiefly ionic bonding, covalent bonding and metallic bonding.
   b. The student will understand the differences between the different types of bonding and apply them accordingly.
2. Concept Objectives
   a. The student will understand that when electrons are transferred by atoms the resulting chemical bond is ionic.
   b. The student will recognize that atoms sharing electrons form covalent bonds.
   c. The student will understand that atoms of metals form metallic bonds in which the outer electrons form an electron cloud.
3. Skill Objectives
   a. The student will identify common compounds held by an ionic bond.
   b. The student will predict the resulting charge when electrons are added or removed from a specific atom.
   c. The student will predict which atoms will engage in covalent bonding.
   d. The student will identify common molecules held together by covalent bonding.
   e. The student will be able to describe the properties of a metal.
   f. The student will identify elements participating in metallic bonding.

B. **Materials**

1. Periodic table
2. Practice sheet of electron-dot diagrams (Appendix A)
3. Heat conduction activity (Appendix B)

C. **Key Vocabulary**

1. Ionic bonding – the bonding involving the transfer of electrons.
2. Ion – a charged atom.
3. Ionization – the process of removing electrons and forming ions.
4. Electron affinity – the tendency of an atom to attract electrons.
5. Covalent bonding – the bonding resulting from the sharing of electrons.
6. Electron-dot diagram – a diagram that uses chemical symbols for an element surrounded by a series of dots to represent the sharing of electrons.
7. Diatomic elements – an element whose atoms can form covalent bonds with another atom of the same element.
8. Molecule – a combination of atoms formed by a covalent bond.
9. Polyatomic ion – a group of covalently bonded atoms acting like a single atom in combination with other atoms.
10. Sea of electrons – the common distribution of electrons occurring throughout a metallic crystal.
11. Metallic bond – the bond formed by atoms of metals in which the outer electrons of the atoms form a common electron cloud.
12. Metals – elements that give up electrons easily.

D. **Procedures/Activities**

1. Lead the class in a discussion utilizing a brief summary of content material listed below.
    a. Atoms will bond with other atoms in order to achieve stability, which means for both atoms to get complete outermost energy levels. This can be achieved through sharing, transferring or commonly distributing the electrons between the atoms.
    b. Ionic bonding involves the transfer of electrons and gets its name from the word ion, which means a charged atom. An atom is neutral but becomes charged if there is a transfer of electrons. Because ionic bonding involves the transfer of electrons, one atom gains electrons and the other loses electrons. Therefor within each atom the negative and positive charges no longer balance. The atom that gains an electron gains with it the negative charge the electron carries. And the atom that loses an electron then carries a positive charge because it has "lost" some of its negativity in the form of the electron lost.
    c. Bonding often occurs between atoms that have high ionization energies and high electron affinities. This means that neither atom loses electrons easily but both atoms attract electrons and in such cases there can be no transfer of electrons between atoms. Instead, these atoms "share" electrons. This type of bonding is called covalent bonding. The word covalent suggests sharing through its prefix as in the word cooperate. By sharing electrons, each atom fills up its outermost energy shell and the shared electrons are in the outermost energy level at the same time thus achieving stability. Remember that in covalent bonding, the positively charged nucleus of each atom simultaneously attracts the negatively charged electrons that are being shared. This attraction between the nucleus and the shared electrons holds the atom together.
    d. Covalent bonding often takes place between atoms of the same element forming a molecule referred to as a diatomic element. Examples of this are chlorine, oxygen and bromine. A molecule is the smallest particle of a covalently bonded substance. This means that 1 molecule of water for example has all the characteristics of a glass of water, a bucket of water or a swimming pool of water. But, break the molecule of water down into atoms of its elements – oxygen and hydrogen – and the atoms would no longer have the properties of water.
    e. A polyatomic ion is one in which a group of covalently bonded atoms act like a single atom when combining with other atoms. Examples are hydroxides, phosphates and nitrates.
    f. Metals are common to the lay person as copper, silver, gold and iron and have been important to mankind throughout the ages. Metals are elements that give up their electrons easily. In a metallic solid, or a solid made entirely of one metallic element contain only atoms of that particular metal, there are no other atoms to accept the electrons the metal easily gives up. These atoms form metallic bonds in which the outer electrons of the atoms form a common electron cloud. This common distribution of electrons occurs throughout the metallic crystal. And in a sense the electrons become the "property" of the all the atoms sharing electrons. In this situation the positive nuclei of atoms in metals are surrounded by free-moving electrons that are all attracted by the nuclei at the same time creating a "sea of electrons". This accounts for

the many different properties of metals such as its ability to be pulled apart or stretched thin.

g. In summary, remember that when atoms combine to form new substances their characteristics change because of the bonding that occurs.

2. Do the activity on ionic bonding as outlined below.
   a. Use the marker board to write examples that show all Group 1 metals form one-to-one ratios with Cl, LiCl, NaCl, KCl, and so on. Have volunteer students use the marker board to show the valence levels of Li, Na, and K then ask:
      1) How many valence electrons are found in Group 1 metals?
      2) Would it be easier for those metals to attract 7 new valence electrons from other elements, or would it be easier to have some other element take the 1 outer level electron? Why?
   b. Point out that elements which have nearly a full outer level are likely to gain 1 or 2 electrons (rather than give up) to complete that outer level. (Columns 6 and 7 on the periodic table qualify for this distinction.) Stress to students that the consequence of giving up or obtaining additional electrons is to become charged. Electrons have a negative chare – when an atom gains an electron, the atom becomes negative.
3. Provide the students with guided practice using an activity sheet of electron-dot diagrams (Appendix A).
4. Guide the students through the heat conduction la (Appendix B).

E. **Evaluation/Assessment**

1. The student will answer correctly 8/10 of the following questions.
   a. How many electrons are in the outermost energy level of lithium? (1)
   b. How many electrons are in the outermost energy level of fluorine? (7)
   c. How would you predict that lithium would combine with another atom to fill its outermost energy level? (It would lose 1 electron)
   d. Can you make a prediction about what would happen if lithium and fluorine and were combined chemically with each other? (They would form an ionic bond in which lithium would give up an electron to fluorine)
   e. Use the equation - $Mg + O_2 \rightarrow MgO + energy$ - on the board for the following questions:
      1) What two elements are the reactants in this equation? (magnesium and oxygen)
      2) What are the symbols for these symbols? (Mg and O)
      3) Does the O look strange to you as a symbol for oxygen? (It should – free oxygen is represented as O_2 indicating a molecule of oxygen containing 2 oxygen atoms)
      4) What is the product in this reaction? (Magnesium oxide)
      5) What does this formula tell you about the composition of a molecule of magnesium oxide? (It contains 1 atom of magnesium and 1 atom of oxygen)
   f. Cooking an egg until it's hard-boiled involves a chemical reaction. Cutting a piece of paper into a hundred little pieces on the other hand does not involve a chemical reaction. Explain the difference.

VI. BIBLIOGRAPHY

A. Chrisholm, Jane & Johnson, Mary. *Chemistry*. Saffron Hill, London, England: Usborne Publishing Ltd., 1993 ISBN # 0-86020-709-9

B. Maton, Anthea et al. *Chemistry of Matter*. Upper Saddle River, New Jersey: Prentice Hall, 1997 ISBN# 0-13-423120-1

C. Parratore, Phil M. *Chemistry, Investigations in Science*. Cypress, CA: Creative Teaching Press, Inc. 1995

D. Beckworth, Rowan "Basic Atomic Structure" Yahoo [on line]. URL: http://users.snet.com.au/~rowonb/chem/abstruct.hml

E. Beckworth, Rowan "Chemical Bonding Information" Yahoo [on line]. URL: http://users.snet.com.au/~rowonb/chem/chembond.hml

F. Beckworth, Rowan "Chemistry Central" Yahoo [on line]. URL: http://www.ChemCenter.org/wondrnet/welcome.hml

APPENDIX A

ELECTRON-DOT DIAGRAMS

Introduction: Electron-Dot diagrams are a system used to demonstrated how one atom is sharing an electron (covalent bonding) with another atom. Hydrogen and Carbon are two of the most common atoms to bond by sharing electrons.

Practice:

The electron-dot diagram of a hydrogen atom is: H representing

The electron-dot diagram of a carbon atom is: C representing

The covalent bond of a single carbon and hydrogen bond is represented by:

Using the electron-dot diagram represent the following compounds:

CH_4 C_2H_6 H_2O

APPENDIX B

HEAT CONDUCTION AND METALLIC BONDING

Introduction:

The special characteristics of metallic bonding allow metals to have special characteristic. One of the special properties of metallic bonding is heat conduction. Metals generally much faster than other substances.

Materials:
Several utensils (spoons or forks) made of different materials
500 ml beaker
Hot water
Frozen or cold butter or margarine
Beads or popcorn kernels

Procedures:

1. Press a small amount of cold butter on the end of each utensil.
2. Press a bead or kernel into the butter on each of the utensils.
3. Stand the utensils around the edge of the beaker carefully so they are not touching each other.
4. Carefully add hot water enough to cover half of the utensil. Be careful not to melt the butter.
5. Observe and record your observations.