Chemical Bonds

Throughout the guide, teaching tips are in red.

Activity Description & Estimated Class Time

Students use cards labeled with element names and the valence numbers to investigate chemical bonds and compounds. This lesson takes one 50-minute period.

Objectives

Students will demonstrate knowledge and understanding of the following ideas and content:

- Compounds are a chemical joining of two or more elements based on giving or sharing electrons between atoms.
- The location of an element in the periodic table gives a clue about how it will form compounds.

Students demonstrate this knowledge and understanding by creating compounds using a simple valence number model. They find the elements of the compound in the periodic table and use the atomic model to explain bonding tendencies.

Correlations to North Carolina Science Standards

8.P.1.1 Classify matter as elements, compounds, or mixtures based on how the atoms are packed together in arrangements.

8.P.1.2 Explain how the physical properties of elements and their reactivity have been used to produce the current model of the periodic table of elements.

Brief Science Background

Chemical reactions involve rearranging electrons among different atoms. Atoms can donate or share electrons. An element's reactivity is based on the available or active electrons in unfilled outer electron shells. The least reactive elements, the noble gases on the far right of the Periodic Table, have full outer electron shells. As a result, they are chemically inactive. The valence number of an element is generally regarded as the maximum number of bonds that element can form. However, elements are not always constant in this number. The elements and valence numbers used in this activity were selected as general models for simple ionic (giving and accepting electrons) and covalent bonds (sharing electrons). The nomenclature of these interactions can be confusing. A compound is formed by chemical bonds between two or more different atoms. An element is a substance composed of just one kind of atom. A molecule is the combination by chemical bonding of any two or more atoms. O_2 is a molecule but, by definition, not a compound. A mixture is just that, a mixture of matter without chemical bonds that can usually be separated by mechanical means.

Chemical Bonds (one 50-minute session)

Materials

Materials for the whole class

- large version of the periodic table (supplied by teacher) or photocopied versions for pairs of students

Materials for groups of 2 students

- a set of valence cards
- science notebook

Preparation

1. Check valence card sets to make sure they are complete. Shuffle them. Each set should contain the following 27 cards:

4 Hydrogen	1 Sodium	1 Calcium
1 Lithium	1 Magnesium	1 Zinc
1 Carbon	2 Aluminum	1 Bromine
1 Nitrogen	2 Silicon	2 Iodine
3 Oxygen	3 Chlorine	1 Mercury
1 Fluorine	1 Potassium	

Procedure

1. Pass out the card sets to pairs of students and ask them to look at them. Ask students for their observations of what is on the card. They should note that there are element names on the card and a mention of what that element does with its electrons. With regard to electrons, explain: "Chemists figured out that when elements are involved in a chemical reaction, electrons are the active part of the atoms."
2. Ask the students to organize the cards by what the elements like to do with electrons. Ask them to find the elements in their groups on the periodic table. Challenge the students to make some general rules about their observations. Students will notice that elements that like to do the same thing with electrons are in the same group. They will also note that electron donators are on the left and electron acceptors are on the right side of the table.
3. Say, "Somebody tell me a chemical formula name for a compound that everybody knows." Somebody will say, "H_20." When they do, take a little time to talk about such a formula and what the 2 signifies (2 hydrogen atoms, not 2 oxygen atoms).
4. Ask the students to find one Oxygen card and two Hydrogen cards, and have a student read the electron affinity on each card. Explain that math is used here: if two hydrogens want to give up an electron each, that makes a +2, and if the oxygen wants to accept two electrons, that makes a matching -2. Therefore, the water molecule adds up to zero and is balanced.

Procedure Cont.

5. Ask students to try another compound that we all use, which is salt, or NaCl. Have them check the math and see if it comes out to 0.
6. Challenge students to use the element cards to create compounds with two or more different atoms. Ask them to record their compounds in their science notebooks. Inform students that they have to be able to keep track of how many of each atom are in the compound and that they indicate this by writing the number as a subscript to the right of the element as in H_2O. Most of the possible combinations are listed in BLM 1: Sample Compounds.
7. Ask students to write their largest compound on the board and ask the class to check them for a zero balance.
8. Display the following formulas and ask the students to figure out if they can exist based on the idea of a zero molecule total: $NaHCO_3$ (sodium bicarbonate) and $H_2Al_2Si_2O_8$ (kaolin clay). They will not have enough of some of the cards so they will need to work mathematically.

Wrap-Up

Start with the simple compounds H2O and NaCl, and ask students to locate the elements they contain in the periodic table. Explain that early chemists realized that different elements could combine to make compounds, but they didn't know why some combinations were possible but others were not. After the development of the periodic table, though, the actual ways different elements combined (or didn't combine) started to make sense. This was because some elements, the ones in the same group, behaved chemically in one way, while other elements in a different group acted another way. The development of atomic theory and the understanding of how electrons behaved explained what people had noticed for a long time. For example, the ends of the rows (or periods) of the periodic table contained elements that had no active electrons because their outer shells were filled. With no electrons to either donate or accept, they could not form bonds with other elements.

Guided Practice

Guided Practices are similar to typical tests, but require students to reveal their thinking about content. They serve as a practice before a test and should not be graded. They are intended to expose misconceptions *before* an assessment and to provide opportunities for discussion, re-teaching, and for students to justify answers. They are best given as individual assignments without the manipulatives used in the activity. In that context, pose the following "test items" to the class. Ask them to write responses in notebooks.

1. Give the class the following statement from a student: A student said that any atom of an element in the first column of the periodic table can only react with the elements in the next-to-last column (reading left to right) to form a compound. When they react, only one atom of the element in the first column combines with exactly one atom of the element in the next-to-last column. This is

because elements in the first column want to donate one electron and elements in the next-to-last column want to accept one electron.

2. Ask the class: “What is wrong with this statement?” Take all answers, then use them to prompt a discussion.

Answer Key

The second part of the explanation is correct but the first part is not. As everyone saw when working with the cards, the elements in both of these columns can combine with other elements that are not in these columns. For example, H_2O, $Na_2(CO_3)$ or $CaCl_2$. When they make these combinations, it is not as a one-to-one compound, but in multiples (e.g. two hydrogens to one oxygen or two chlorines to one calcium).

BLM 1 Sample Compounds

Two elements, one atom each

Hydrogen Chloride (Hydrochloric Acid) .... HCl
Hydrogen Fluoride (Hydrofluoric Acid) .... HF
Lithium Bromide .... $LiBr$
Lithium Chloride .... $LiCl$
Calcium Oxide (Quicklime) .... CaO
Magnesium Oxide (Magnesia) .... MgO
Mercury Oxide (Mercuric Oxide) .... HgO
Potassium Bromide .... KBr
Potassium Chloride .... KCl
Potassium Fluoride .... KF
Potassium Iodide .... KI
Sodium Bromide .... $NaBr$
Sodium Chloride (Table Salt, Halite) .... $NaCl$
Sodium Fluoride .... NaF
Sodium Iodide .... NaI
Zinc Oxide .... ZnO

Two elements, more than one atom each

Calcium Chloride .... $CaCl_2$
Magnesium Chloride .... $MgCl_2$
Mercury Chloride (Mercuric Chloride) .... $HgCl_2$
Mercury Iodide (Mercuric Iodide) .... HgI_2
Silicon Dioxide (Quartz, Sand) .... SiO_2
Zinc Chloride .... $ZnCl_2$
Aluminum Chloride .... $AlCl_3$
Aluminum Oxide .... Al_2O_3

Three elements

Ammonium Chloride .... NH_4Cl
Calcium Carbonate (Lime, Limestone) .... $CaCO_3$
Magnesium Carbonate .... $MgCO_3$
Potassium Hydroxide .... KOH
Sodium Hydroxide (Lye, Caustic Soda) .... $NaOH$
Sodium Nitrite .... $NaNO_2$
Ammonium Hydroxide (Ammonia) .... NH_4OH

Four elements

Potassium Bicarbonate .... $KHCO_3$
Sodium Bicarbonate (Baking Soda) .... $NaHCO_3$
Kaolin clay .... $H_2Al_2Si_2O_8$

Appendix

Common Student Preconceptions About This Topic

Children have difficulty distinguishing between elements, compounds, atoms, and molecules for reasons having to do with basic language. For example, elements are described as "pure" substances, meaning "made of only one thing." For many children, the term "pure" means "without harmful contents," or "clean, bright, and as-it-should-be." In addition, children have difficulty with the idea of "substance." For example, some middle school children see ice and water as different substances. In general, most children understand matter in a macroscopic way, not at a microscopic level. As a result, they tend to view chemical combination as a kind of mixing, with only a hazy idea of microscopic internal chemical bonds. For example, many think that burning is like evaporation, only faster because of the heat. Although they know that oxygen is necessary for combustion, they have little or no sense that it is interacting with the material that is burning.