

Activity 5 - Compounds and Their Formulas

Goals

- Identify the elements and number of atoms in the formula of a compound.
- Compare some physical properties of a compound with the properties of the elements from which it was formed.
- Determine the subscripts in the formula of a compound.
- Describe the types of elements in ionic and covalent compounds.
- Identify the bonding in a compound as ionic or covalent.

Pre-lab Questions *(answer these on a separate sheet using complete sentences)*

1. Why are color, texture, state, density, and melting point considered physical properties?
2. Why do the physical properties of the elements change when they combine to form a compound?
3. How is the number of atoms in a molecule indicated in the formula?
4. Why do compounds of metals and nonmetals consist of ions?
5. What is a covalent bond?
6. What compound in toothpaste is a preventative for cavities?

Concepts to Review

Formulas

Ions

Ionic and covalent bonds

Formation of ionic and covalent compounds

Naming ionic and covalent compounds

Introduction

Almost everything you see around you is made of compounds. A compound consists of two or more different elements that are chemically combined. Although there are currently (as of 2015) 118 elements known, there are millions of different compounds.

In a compound, there is a definite proportion of each element. This is represented in the formula, which gives the lowest whole number ratio of each kind of atom. For example, water has the formula H_2O . This means that two atoms of hydrogen and one atom of oxygen are combined in every molecule of water. Every water molecule is represented by this, and only this, formula.

A mixture consists of two or more substances (elements or compounds), which are not chemically combined. Thus, the components maintain their original physical properties, and they can be separated by physical methods such as use of a magnet, filtration, or evaporation.

Properties of Elements and Compounds

When we observe a compound or an element, we can describe physical properties such as color and luster. We can measure other physical properties such as density, melting point and boiling point. When elements undergo chemical combination, the physical properties change to the physical properties of the new compound, which is a novel substance different from its components. For example, when silver tarnishes, the physical property of the shiny silver metal changes to a dull gray color as silver combines with sulfur to form tarnish, Ag_2S . A chemical change has occurred when the reaction between the elements has caused a change in their physical properties.

Types of Bonds in Compounds

Atoms form compounds to become more stable, usually by forming octets in their outer shells. The attractions between the atoms in a compound are called *chemical bonds*. For example, when a metal combines with a nonmetal, the metal loses electrons to form a positive ion and the nonmetal gains electrons to form a negative ion. The attraction between the positive ions and the negative ions is called an *ionic bond*. When two nonmetals form a compound, they share electrons and form *covalent bonds*. The combinations of atoms in covalent compounds are called *molecules*.

Table 1. A selection of compounds and their corresponding bonding type.

Compound	Types of Elements	Characteristics	Type of Bonding
NaCl	Metal, nonmetal	Ions, (Na^+ , Cl^-)	Ionic
CCl_4	Two nonmetals	Molecules	Covalent
MgBr_2	Metal, nonmetal	Ions, (Mg^{2+} , Br^-)	Ionic
NH_3	Two nonmetals	Molecules	Covalent

Safety

Wear safety glasses at all times!

Act in accordance with the laboratory safety rules of Cabrillo College.

Avoid contact with all chemical reagents and dispose of those used in experiments in appropriate waste containers.

Caution: Acids are corrosive; they will cause chemical burns to your skin. Know the location of solid sodium bicarbonate (NaHCO_3) in the lab as well as the aqueous solution of sodium bicarbonate. Use either the solid or the solution of sodium bicarbonate to neutralize any spills of the 6 M $\text{HCl}_{(\text{aq})}$ solution. Should you happen to spill the acid solution on your skin, use the sodium bicarbonate solution to neutralize it right away and rinse off with water. Have a classmate notify the instructor immediately.

Caution: To sample the odor of a gas, first fill your lungs with fresh air and hold it while you use your hand to fan some of the vapors from the reaction tube toward you. Carefully note the odor.

Materials:

A selection of elements and compounds as identified on your experimental pages, samples of iron (Fe) filings, sulfur (S), iron filings and sulfur mixture (Fe + S), iron (II) sulfide (FeS), and 6 M HCl (hydrochloric acid).

Equipment: bar magnet, spatula, dropper, test tubes and test tube rack.

Experimental Procedure

A. Interpreting Formulas of Compounds

Observe the compounds in the laboratory display. Describe the physical properties of each compound. Write the formula for each compound. From the formula of each compound, state the number of atoms of each element present in that compound. From the display of elements, observe and record some of the physical properties of the individual elements.

B. Physical Properties of FeS and its Elements

1. Your instructor may do this part of the experiment as a demonstration. Obtain samples of Fe, S, a mixture of Fe and S, and FeS. These may be in prepared test tubes or sample containers. Describe the physical properties of each sample.
2. Using a chemistry handbook (Chemical Rubber Company—CRC), look up the density, melting and boiling points of Fe, S, and FeS. Record these values.
3. Test each of the samples for magnetic attraction by running a bar magnet under the sample in each container. (*Do not place the magnet directly into the samples!* The attracted particles cling to the magnet and make it difficult to clean.) If there is magnetic attraction, you will see particles follow the magnet. Record your observations.
4. (Optional) This part of the experiment involves a reaction that produces H₂S gas, which is toxic in more than trace amounts. Check with your instructor before proceeding. Place a small amount of each sample (enough to cover the tip of a spatula) in a test tube. **WORKING IN THE HOOD**, slowly add 15 drops of 6 M HCl (**corrosive**) into each test tube. Observe any reaction. **CAREFULLY** note any odor.
5. Describe each sample as an element, mixture, or compound.

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Name _____

Section _____ Date _____

Exercise A. Interpreting Formulas of Compounds

1. Complete the following table using the samples placed around the room.

Formula of compound	Physical properties of compound	Number of atoms of each element	Physical properties of the elements
<i>Example:</i> CuSO ₄	Deep blue crystals	1 Cu, 1 S, 4 O	Cu - shiny, copper metal; S - yellow chunks; O - colorless gas

2. When elements combine to form compounds, are the physical properties of the compound the same as those of the elements? Explain.

3. Does the formula of a compound vary or is matter constant in composition? Explain your answer.

Exercise B. Physical Properties of FeS and Its Elements

1. Complete the following table from your observations of FeS and its elements.

Sample	Physical properties (color, state, luster?)	Density-d (g/mL)	M.P. (°C)	B.P. (°C)	Magnetic attraction	Reaction with HCl? Odor?	Description of Sample (element, mixture, compound)
Fe							
S							
Fe + S							
FeS							

Use the results in your chart to answer the following questions:

2. How does the attraction to the magnet differ for the elements, mixture, and compound? Explain.
3. Why do the physical properties of Fe and S differ from those of FeS?
4. Can the elements in the Fe + S mixture and the compound FeS be separated using the same methods? Explain.

Questions and Problems

1. Complete the table for the given compounds

Compound	Units in compound (ions or molecules)	Type of bonds (ionic or covalent)
LiBr	ions	ionic
CaCl ₂		
CCl ₄		
NH ₃		
K ₂ S		
MgO		

2. List the number of atoms of each kind of element in the following formulas:

Formula	Number and Kind of Atoms in the Compound
H ₂ O	2 atoms H and 1 atom O _____
CuCl ₂	_____ _____
Al ₂ S ₃	_____ _____
Ba(NO ₃) ₂	_____ _____
C ₆ H ₁₂ O ₆	_____ _____

3. Write formulas of the following compounds from the number of atoms given. The elements are listed in the order in which they appear in the formula.

1 atom of C and 2 atoms of O	CO ₂ _____
1 atom of N and 3 atoms of H	_____ _____
1 atom of C and 4 atoms of Cl	_____ _____
2 atoms of Fe and 3 atoms of O	_____ _____
1 atom of Ba, 1 atom of S, 4 atoms of O	_____ _____

4. Identify the elements in each compound as a metal and nonmetal, or two nonmetals. Indicate the bonding in each as ionic or covalent.

	Elements	Type of Bonding
BaCl ₂	<u>metal and nonmetal</u>	<u>ionic</u>
C ₃ H ₈	_____	_____
Li ₂ O	_____	_____
PCl ₃	_____	_____
NaBr	_____	_____
SO ₃	_____	_____

Indicate whether each of the following is a chemical or physical change:

tearing a piece of paper in two	_____
burning a match	_____
grinding pepper	_____
rusting iron nail	_____
freezing water for ice cubes	_____