Sweet 16 Chemical Formulas Tournament

FLINN SCIENTIFIC CHEM FAX!

Do your students eagerly fill out their "March Madness" tournament brackets? Have some fun and inspire your students with March Madness chemistry! This activity combines the popularity of "bracketology" with a review of writing chemical formulas. Knowledge of ion charges, polyatomic ions, subscripts, and formula writing will help students determine the winner of the Sweet 16 Chemical Formulas Tournament!

Concepts

- Chemical formulas
- Ion charges
- Polyatomic ions

Tournament Rules

The rules for filling out the tournament bracket are summarized below.

- First round: Write the charge of each ion next to its name. The first pair has been done for you.
- Second round: Write the formula of the ionic compound formed by each pair of ions. The compound with the *higher* cation (+) charge advances to the semifinals. In case of a tie, the *lower* charge on the anion (–) wins.
- Semifinals: Count how many total atoms are in each formula. The formula with the greater number of atoms advances to the finals.
- Final round: The compound with a polyatomic ion is declared the winner!

NGSS Alignment

This laboratory activity relates to the following Next Generation Science Standards (2013):

Disciplinary Core Ideas: Middle School
MS-PS1 Matter and Its Interactions
PS1.A: Structure and Properties of Matter

Disciplinary Core Ideas: High School
HS-PS1 Matter and Its Interactions
PS1.A: Structure and Properties of Matter

Science and Engineering Practices
Asking questions and defining problems
Analyzing and interpreting data

Crosscutting Concepts
Patterns
Structure and function

Tips

- Remind students that the number one is not written as a subscript, but should be counted in the semifinals.
- Student should be familiar with both monatomic and polyatomic ions, ion charges, and writing formulas. Use the *Background* information for review if needed.

Background

The *chemical formula* of a compound indicates the kinds of atoms and the relative number of each atom that is combined together to form the compound. *Subscripts* are the numbers written after the chemical element symbols and are used to indicate the number of atoms of each element in the compound. Water, the most abundant chemical on Earth, has the chemical formula H_2O and has a whole-number hydrogen:oxygen atom ratio of 2 to 1.

Some compounds such as sodium chloride, which is common table salt, are composed of *ions*. Ions are atoms or groups of atoms that have a positive or negative charge. *Cations* are atoms or groups of atoms with a positive charge, such as Cu^{2+} or NH_4^+, while *anions* are atoms or groups of atoms with a negative charge, such as O^{2-} or NO_3^-. Atoms of metallic elements tend to form cations while atoms of nonmetallic elements tend to form anions. Ions join together because of an oppositely-charged or electrostatic attraction between a positive cation and a negative anion resulting in an *ionic bond.* Compounds held together by ionic bonds are *ionic compounds.*

For cations, the name of the ion is exactly the same as the name of the element. Thus a lithium atom (Li) forms a lithium

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cation (Li^+) and a magnesium atom (Mg) forms a magnesium cation (Mg^{2+}). The name of an anion, on the other hand, is not the same as the element name. Instead, the anion uses the first part of the element name then ends in *-ide*. Thus a sulfur atom (S) forms a sulfide anion (S^{2-}) and a chlorine atom (Cl) forms a chloride anion (Cl^-).

The metals in Groups 1, 2, and 3 of the periodic table lose electrons to form cations with 1+, 2+, and 3+ charges, respectively. Notice that the ionic charge is positive and is numerically equal to the group number. The transition metals, in contrast, may have more than one common ionic charge. For example, copper forms two common cations, Cu^+ and Cu^{2+}. The two metals in Group 14 of the periodic table, tin and lead, also have more than one common ionic charge, both forming a 2+ (Sn^{2+} and Pb^{2+}) and a 4+ (Sn^{4+} and Pb^{4+}) cation.

A common method for naming cations with more than one common ionic charge is called the *Stock system*. A Roman numeral in parentheses is used as part of the name of the element to indicate the numerical value of the charge. Thus the cation Cu^+ is the copper(I) ion and is read as the "copper one" ion, while Cu^{2+} is the copper(II) ion and is read as the "copper two" ion.

Ions consisting of single atoms are called monatomic ions. Unlike the monatomic ions, polyatomic ions are covalently-bonded groups of atoms that behave as a unit and carry a net charge. The nitrate anion, for instance, is composed of four atoms—one nitrogen atom and three oxygen atoms. The nitrate ion has a $^-1$ charge and is written NO_3^-. Many polyatomic anion names end in *–ite* or *–ate*. However, there are two important exceptions to this rule—the cyanide anion (CN^-) and the hydroxide anion (OH^-), which both end in *–ide*. The most common polyatomic cation is NH_4^+, which is called the ammonium ion.

Although composed of ions, ionic compounds are electrically neutral, i.e., the total positive charge is equal to the total negative charge. The chemical formula indicates the smallest whole-number ratio of each element in the network of ions and is called a *formula unit*. For example, magnesium chloride has the chemical formula $MgCl_2$. The magnesium cation (Mg^{2+}) and chloride anions (Cl^-) combine in a 1:2 ratio to form $MgCl_2$. The overall charge on the resulting ionic compound is zero. Thus the final compound is composed of two Cl^- ions for each Mg^{2+} ion. Calcium cations, Ca^{2+}, in the presence of polyatomic nitrate anions, NO_3^-, will combine in a ratio of two nitrate ions for every calcium ion in order to balance the positive and negative charges and achieve electrical neutrality. Thus the formula for calcium nitrate is written as $Ca(NO_3)_2$, showing that for every calcium ion there are two nitrate ions. Notice that the polyatomic ion is put in parentheses as a unit with the subscript on the outside of the parentheses.

Writing formulas for ionic compounds may be simply determined by following the steps below:

1. The cation is always written first; the anion is written second.
2. The overall charge for an ionic compound is always zero. The charges of the individual ions are never included in the compound's formula.
3. Subscripts are used to indicate the number of atoms of each element in the compound.
4. Parentheses are used around polyatomic ions with subscripts greater than one to show that the subscript pertains to the polyatomic ion as a whole.
5. Assumed subscripts of one are omitted when writing chemical formulas.

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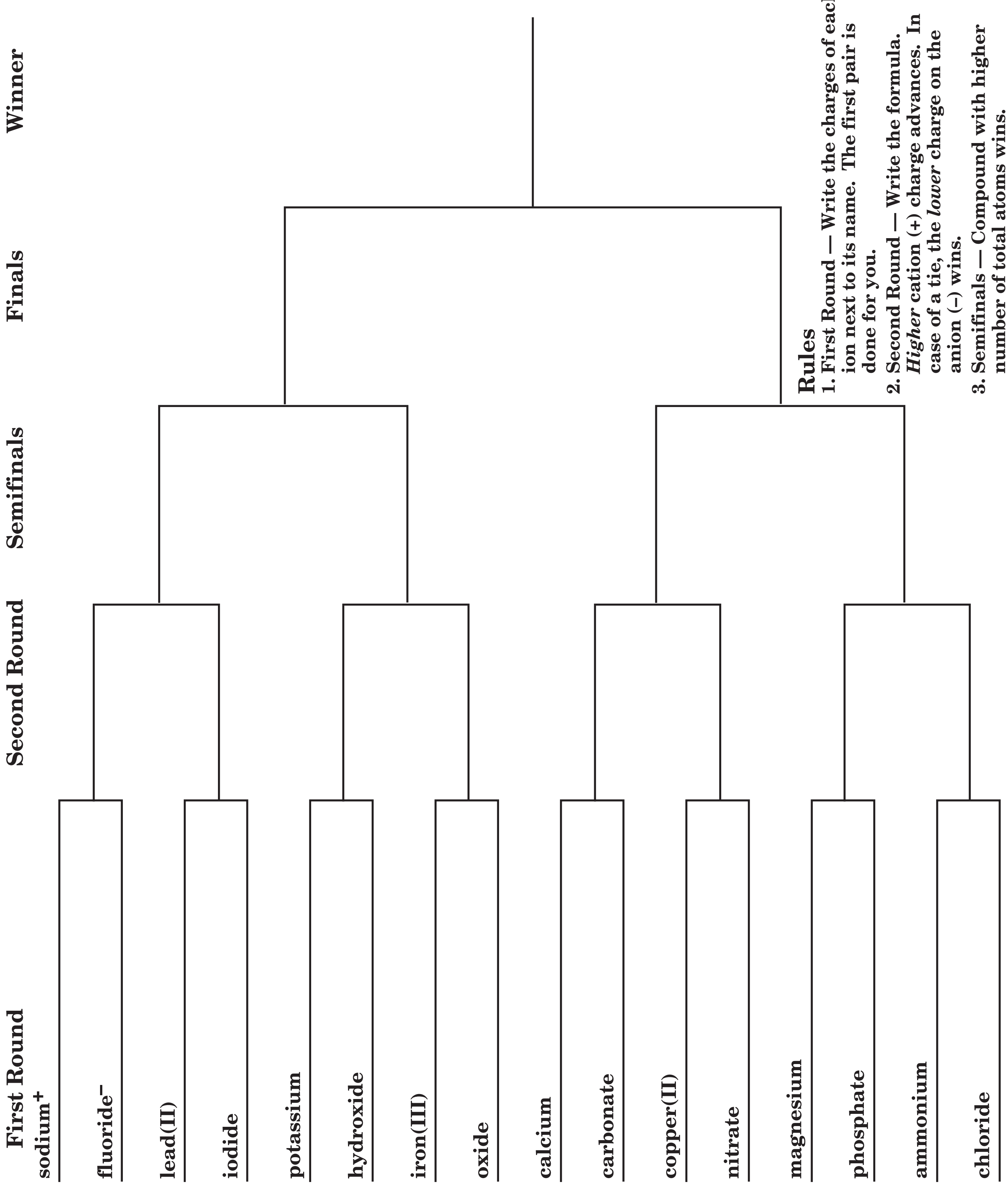

Rules

1. First Round — Write the charges of each ion next to its name. The first pair is done for you.
2. Second Round — Write the formula. *Higher* cation (+) charge advances. In case of a tie, the *lower* charge on the anion (–) wins.
3. Semifinals — Compound with higher number of total atoms wins.
4. Finals — The compound with the polyatomic ion is the winner!