Taylor University
Pillars at Taylor University

Chemistry Student Scholarship

Chemistry and Biochemistry

Summer 2018

Educational Resources: Ionic Matching

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Ionic Matching

The entire point of this piece is simply to introduce balancing charges in ionic compounds. This is a simpler method to get students thinking about the idea, which also makes it suitable for pre-high school students. It gives a visual representation of how charges balance and how cations pair with anions. At this level, it is very similar to least common denominator calculations.

Relevant Indiana State Standards

7.PS.1 Draw, construct models, or use animations to differentiate between atoms, elements, molecules, and compounds.

- Specifically identifying ionic compounds

8.PS.2 Illustrate with diagrams (drawings) how atoms are arranged in simple molecules. Distinguish between atoms, elements, molecules, and compounds.

- Identifying ionic compounds

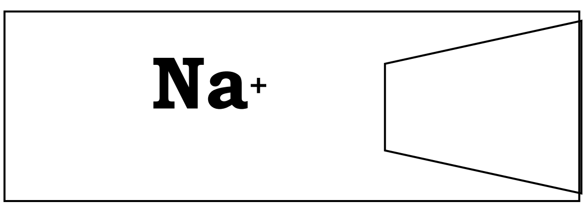
ICP.6.1 Distinguish between elements, mixtures, and compounds based on their composition and bonds and be able to construct or sketch particle models to represent them.

- Coming up with the empirical formula for ionic compounds for identification

C.3.4 Write chemical formulas for ionic compounds and covalent compounds given their names and vice versa.

Supplies

- Printed out ion puzzle pieces (3 of each type per student/group)
    - Each piece has a number of tabs/notches to equal its charge. For example, O^{2-} has 2 tabs
    - Cations (connect on the right with a notch)



        - Al^{3+} (aluminum)
        - Ca^{2+} (calcium)
        - Fe^{2+} (iron II)
        - Fe^{3+} (iron III)
        - Na^{+} (sodium)
        - NH_4^{+} (ammonium)
    - Anions (connect on the left with a tab)

        - F^{-} (fluorine, because of ionic naming rules becomes fluoride when named)
        - N^{3-} (nitrogen, because of ionic naming rules becomes nitride)

        - O^{2-} (oxygen, because of ionic naming rules becomes oxide)
        - OH^- (hydroxide)
        - PO_4^{3-} (phosphate)
        - SO_4^{2-} (sulfate)
    - Note: for younger students who haven't started learning anything about the periodic table, the element/polyatomic ion names could be written on the back of the pieces to make the process easier.
- Optional: a larger set

Pre-activity questions

- Do you know any chemical formulas?

Discussion topics/topics to know

- Ionic compounds/formulas
    - Ionic compounds are substances like table salt/sodium chloride (NaCl), iron (III) oxide (Fe_2O_3), or calcium carbonate ($CaCO_3$).
    - They are commonly made of a metal and a non-metal or polyatomic ion.
        - Metals: elements like iron or sodium. On the left side/in the middle of the periodic table.
        - Nonmetals: On the right side of the periodic table. Elements such as chlorine, oxygen, or nitrogen
        - Polyatomic ions: Specific groups of atoms that create ions (groups with a charge
    - Unlike covalent molecules (like sugar), ionic compounds are identified by empirical formula, like the least common denominator.
    - Essentially, all of the charges need balanced. So, for NaCl, the ionic formula has 1 Na and 1 Cl because Na carries a +1 charge and Cl has a -1 charge. Iron (III) oxide is Fe_2O_3 because Fe has a +3 charge and O has a -2 charge. So, to have the charges balanced we need Fe^{3+} x 2 (3*2=6) and O^{2-} x 3 (2*3=6), giving us a neutral compound.
    - Ionic compounds are labeled by empirical formula because, unlike covalent compounds with specific bonds, ionic compounds form a crystal lattice.
        - A crystal lattice is just a basic scaffolding of an ionic compound. Instead of forming individual molecules, like water, ionic compounds all go into orderly rows and columns because of their charges.
- Cation: positive ion (ion that lost an electron)
    - Some metals, such as iron, can form more than one stable cation
- Anion: negative ion (ion that gained an electron)
- Element symbols (ex. Fe=iron, Na=sodium, Cl=chlorine, etc.)
- Basic naming of compounds
    - Ionic compounds are named [name of metal/polyatomic cation] [name of non-metal ending in –ide/name of polyatomic anion]
        - Ex. Sodium + chlorine=sodium chloride
        - Ammonium + hydroxide=ammonium hydroxide

Instructions

1. Give every student or group a set of the ion puzzle pieces.
2. Have students form compounds of increasing difficulty.
    a. Give them the name and/or symbols of the components and allow students to create the actual formula based on balancing the charges.

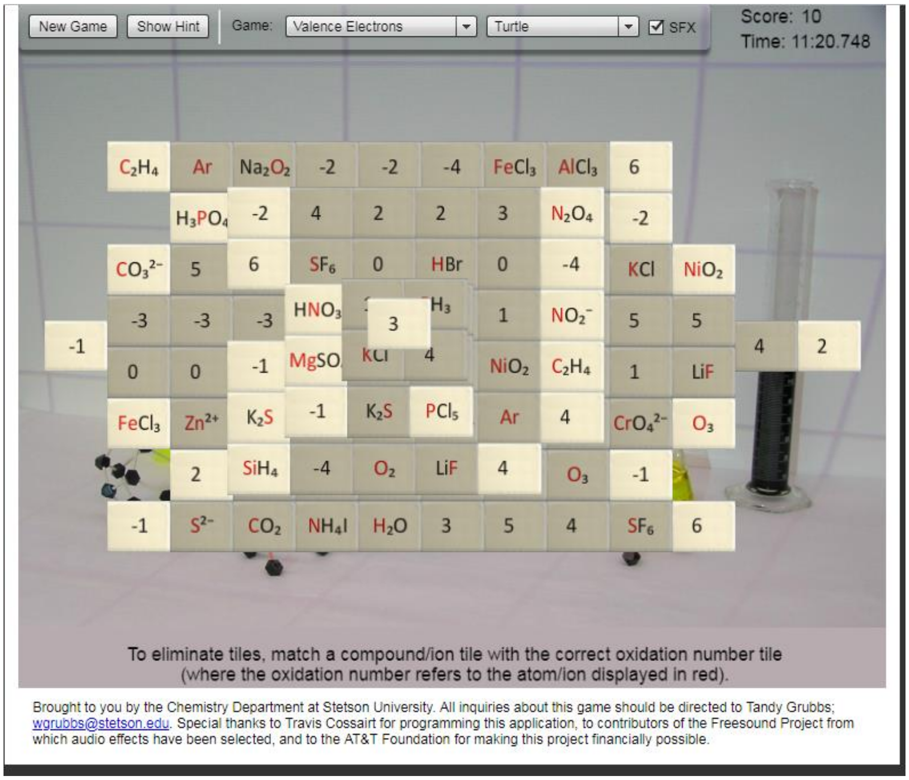
    b. It's very unlikely that students below high school will know the polyatomic ions, so make sure to specify those.
3. Suggested compounds to have students make with their uses. The formulas are given here, but should not be shown to the students.
    a. The 1:1 molecules
        i. **Sodium fluoride** = NaF, often used to add fluoride to water to prevent cavities
        ii. **Calcium sulfate** = $Ca(SO_4)$, which, with the right amount of water/treatment, is plaster of Paris/gypsum plaster (the stuff in original plaster casts and used on some theatrical sets)
        iii. **Aluminum phosphate** = $Al(PO_4)$, also a rare mineral called Berlinite
    b. These use the +/-1 charges to make some nice even charges while still not having the 1:1 ratio.
        i. **Calcium hydroxide** = $Ca(OH)_2$, or slaked lime. It's partially used in pickling and making paper.
        ii. **Ammonium nitrate** = $(NH_4)_3(SO_4)$, a heavy-nitrogen fertilizer and a large component in the industrial explosive ANFO/fertilizer bombs
    c. And here's the mixing of +/-2 and +/-3 charges, which is when charges don't line up as nicely.
        i. **Aluminum oxide** = Al_2O_3, the product of aluminum reacting with air (oxidizing). It is also the mineral corundum. Impurities in corundum create rubies (from chromium impurities) or sapphires (from various transition metals).
        ii. **Calcium nitrate** = Ca_3N_2, used as a small part of some fertilizers, in some cold packs, and in waste water treatment for odor emission prevention.
    d. Finally, the iron ones. Iron is interesting because it appears as both iron (II) and iron (III) in the environment, so it can form two different charges. Make sure to specify which one is being used in the formula. This section also shows that the applications of the different charges are also different.
        i. **Iron (III) oxide** = Fe_2O_3, which is just common rust.
        ii. **Iron (II) sulfate** = $FeSO_4$, normally blue-green, a component in iron supplements and one of the two components of iron gall ink.
        iii. **Iron (III) sulfate** = $Fe_2(SO_4)_3$, normally yellow, a mordant (mordant means dye fixer)

Post-Activity Questions

- Make your own ionic compound out of the puzzle pieces.

Possible extensions

- Pair this with an activity about building covalent molecules when students start learning more in-depth about this. A common activity involves using toothpicks and marshmallows to build the structures.
- Have students build their own ionic compound from the pieces here and research its applications.
- https://www2.stetson.edu/mahjongchem/



- Students match the oxidation number with the red highlighted ion. More suitable for high school+ students, although it could be incorporated at lower levels. The game can also match polyatomic ions, molecular vs ionic compounds, valence electrons, acids and bases, basic elemental symbols, and more.
- To change the settings, go into the drop down menus at the top, select the settings, and hit “New Game”
- Warning: This game is more complicated than it appears. You might want to try playing different configurations before having students play.