Finding Compound Formulas with LEGO Bricks

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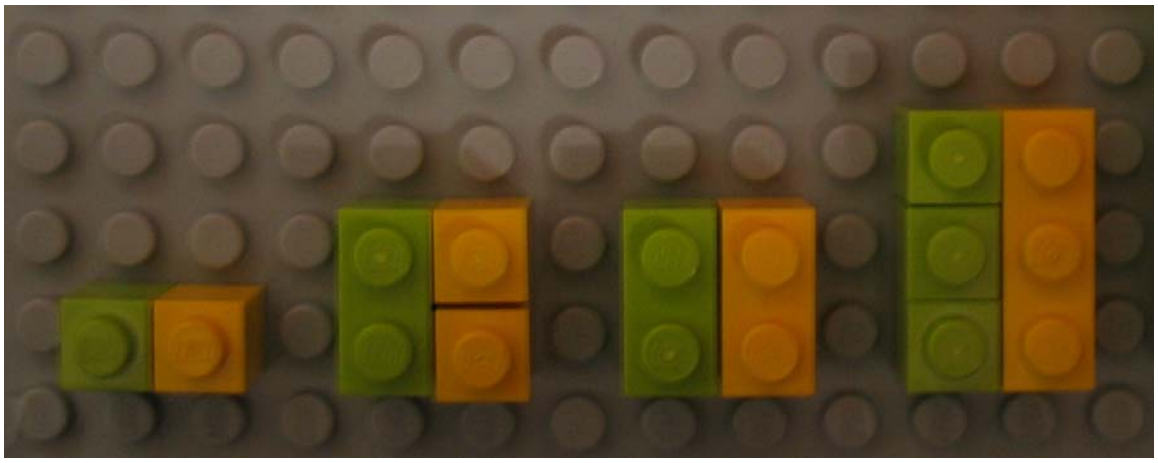
Matter is made of atoms. An element is matter which has all the same kind of atoms. A compound is matter which has a specific relative amount of elements. For example, water is a compound that is one part of the element oxygen and two parts of the element hydrogen. Ionic compounds are compounds that are made of ions – atoms that have an electrical charge. Positively charged ions are called cations and negatively charged ions are called anions. Even though the ions have an electrical charge, the compounds that they form have no electrical charge and are called electrically neutral. The charges of the ions determine how many cations must combine with how many anions to make a neutral compound. LEGO bricks can be used to figure out these combinations to get the proper formula of ionic compounds by arranging rows of bricks representing cations and bricks representing anions so that the rows must be of equal length. The following table gives an example of how this works:

Cation	Green brick	Anion	Yellow brick
+1 (like sodium, Na^{+})	1 peg long	-1 (like chloride, Cl^{-})	1 peg long
+2 (like calcium, Ca^{2+})	2 pegs long	-2 (like oxide, O^{2-})	2 pegs long
+3 (like aluminum, Al^{3+})	3 pegs long	-3 (like phosphide, P^{3-})	3 pegs long



Example 1 Example 2 Example 3 Example 4

Example 1 - sodium chloride (also known as table salt): A green one-peg brick represents the positively charged sodium ion and the yellow one-peg brick represents the negatively charged chloride ion. In order to match these bricks up with each other in (short) rows of equal length, you need exactly one of each. There is one sodium ion for every chloride ion, and this combination of sodium and chloride can be expressed as NaCl.

Example 2 - calcium chloride: A green two-peg brick represents the positively charged calcium ion and the yellow one-peg brick represents the negatively charged chloride ion. In any compound, the amount of positive charge from the cations must match the amount of negative charge from the anions. In order to match these bricks up with each other in

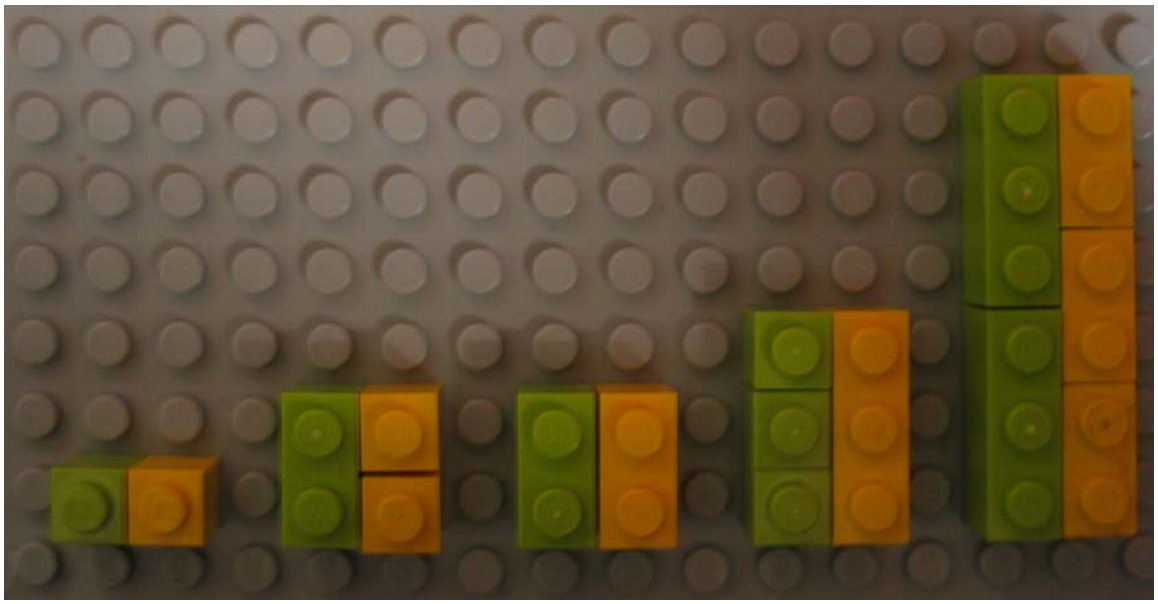
rows of equal length, you need one calcium ion two-peg brick and two chloride ion one-peg bricks. There is one calcium ion for every two chloride ions, and this combination of calcium and chloride can be expressed as $CaCl_2$.

Example 3 - calcium oxide: A green two-peg brick represents the positively charged calcium ion and the yellow two-peg brick represents the negatively charged oxide ion. In order to match these bricks up with each other in rows of equal length, you need one calcium ion two-peg brick and one oxide ion two-peg brick. There is one calcium ion for every oxide ion, and this combination of calcium and oxide can be expressed as CaO.

Example 4 – sodium phosphide: A green one-peg brick represents the positively charged sodium ion and the yellow three-peg brick represents the negatively charged phosphide ion. In order to match these bricks up with each other in rows of equal length, you need three sodium ion one-peg bricks and one phosphide ion one-peg brick. There are three sodium ions for every phosphide ion, and this combination of sodium and phosphide can be expressed as Na_3P.

Challenge: What would be the formula of aluminum oxide?

Answer:



NaCl $CaCl_2$ CaO Na_3P Al_2O_3

NOTE: More than a year after this was posted online, a nice article about LEGO® stoichiometry was published: Ruddick, K. R.; Parril, A. L. *J. Chem. Educ.*, **2012,** *89*, 1436-1438.