

CHEMICAL FORMULAS AND FORMULA WEIGHT CALCULATIONS

1. THE MEANING OF A CHEMICAL FORMULA

A chemical formula is a shorthand method of representing the elements in a compound. The formula shows the formulas of the elements in the compound and the ratio of the elements to one another. For example, the formula for sodium chloride:



tells us that the compound is composed of the elements sodium, Na, and chlorine, Cl, in a one-to-one ratio. That is, one atom of sodium combines with one atom of chlorine.

When elements combine in different ratios, subscripts are added, following the element symbol, to indicate that the number of atoms of that element in the compound is greater than one. The subscript refers only to the element it immediately follows. For example, the formula for magnesium bromide:



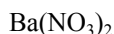
tells us that two bromine atoms combine with one magnesium atom.

Some elements form stable groups, or polyatomic ions, that combine with other elements to form compounds. An example of this is the sulfate polyatomic ion in the compound calcium sulfate:



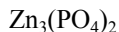
In this compound, the SO_4 is called a *sulfate* group. It consists of one sulfur atom combined with four oxygen atoms. The sulfate group cannot exist by itself and must be combined with another element. The compound CaSO_4 consists of one calcium atom combined with one sulfate group. Counting atoms, calcium sulfate consists of one calcium atom, one sulfur atom, and four oxygen atoms.

Another example of an atom combined with a polyatomic ion is barium nitrate:



This compound consists of a barium atom combined with two nitrate groups. Since NO_3 is readily identified as a nitrate group, and barium combines with two nitrates, parentheses are placed around the nitrate and the subscript 2 indicates two nitrate groups. Changing the subscripts in the nitrate to N_2O_6 would change the meaning of the formula and is incorrect. Counting atoms, barium nitrate consists of one barium atom, two nitrogen atoms, and six oxygen atoms.

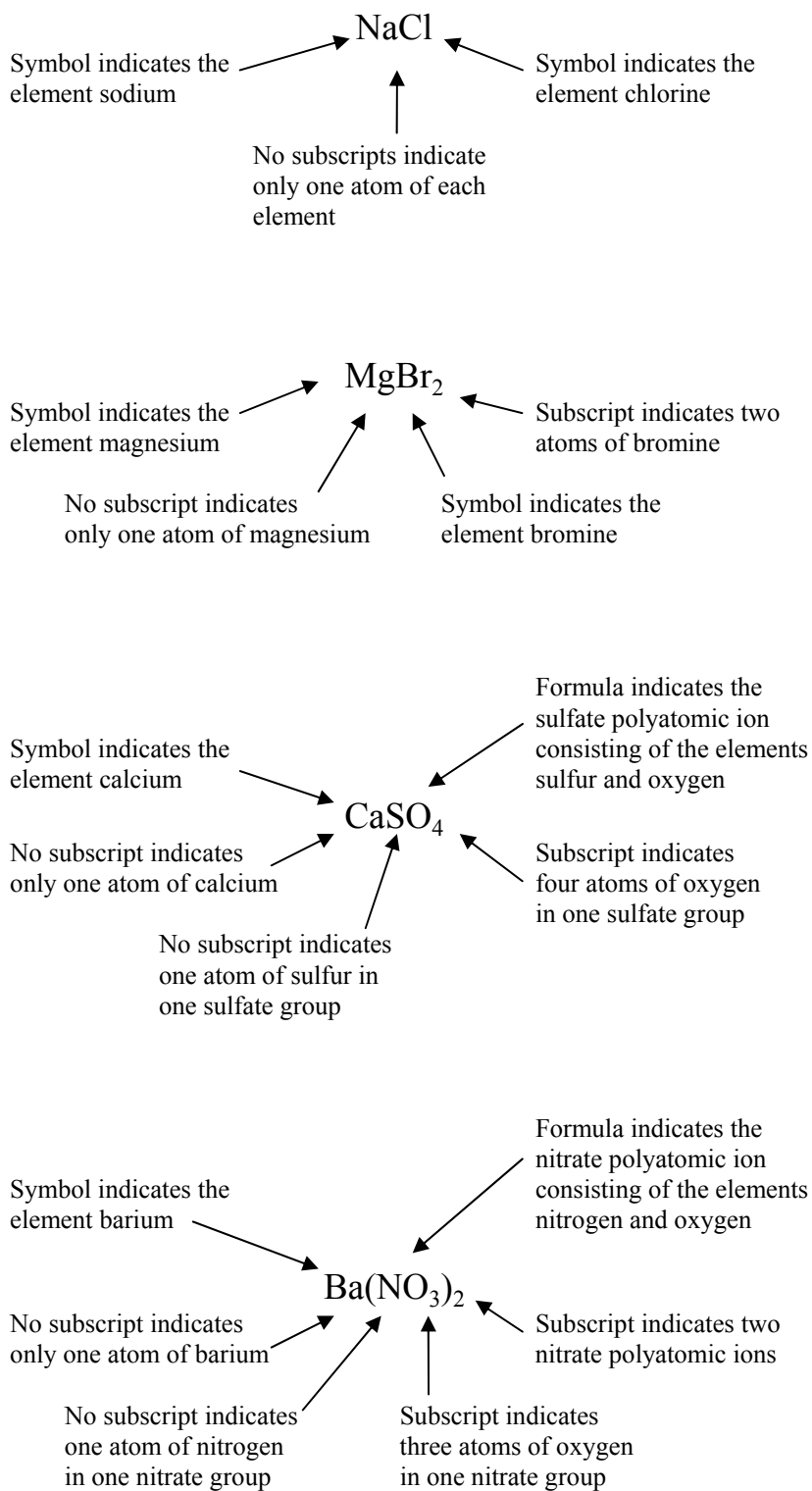
In the compound zinc phosphate:

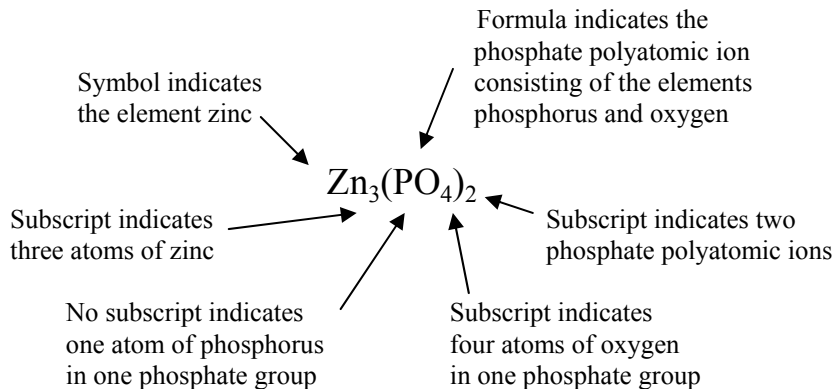


we encounter another polyatomic ion, phosphate, PO_4 . In this example, three atoms of zinc combine with two phosphate groups. Counting atoms, there are three atoms of zinc, two atoms of phosphorus, and eight atoms of oxygen.

The meaning of these formulas are summarized in Figure 1.

Figure 1. The meaning of some chemical formulas.





2. CALCULATING A FORMULA WEIGHT OR MOLECULAR WEIGHT

The **formula weight** of a substance (element or compound) is the sum of the atomic weights of all the atoms in the chemical formula of the substance. A **molecular weight** of a substance is the sum of all the atomic weights of all the atoms in a molecule of a molecular substance. The terms formula weight and molecular weight are often used interchangeably, but formula weight includes simple or empirical formulas of compounds, as well as, molecular formulas.

To calculate the formula weight or molecular weight of a compound, set up a table:

1. List the elements in the compound
2. Determine the number of atoms of each element in the compound
3. Look up the atomic weight of each element and place them in the appropriate column
4. Multiply the number of atoms times the atomic weights to get the total mass of each element
5. Add the total masses of all the elements.

Examples:

1. Calculate the formula weight of sodium chloride, NaCl.

Answer:

Set up a table listing the elements in the compound, the number of atoms of each element, and the atomic weight of each element.

Elements in the compound	Number of atoms of each element	Atomic Weight
Na	1	23.0
Cl	1	35.5

Multiply the number of atoms times the atomic weight to get the total mass of each element. Then add the total masses.

Elements in the compound	Number of atoms of each element	Atomic Weight	Total Mass
Na	1	x 23.0	= 23.0
Cl	1	x 35.5	= 35.5
			Formula weight = 58.5

Although there are no units of the atomic and formula weights, the atomic weights are expressed in amu (atomic mass units) for single molecules or grams for laboratory quantities.

2. Calculate the formula weight of magnesium bromide, MgBr_2

Answer:

Set up a table similar to the one used in example 1.

Elements in the compound	Number of atoms of each element		Atomic Weight	Total Mass
Mg	1	x	24.3	= 24.3
Br	2	x	79.9	= 159.8
Formula weight				= 184.1

3. Calculate the formula weight of calcium sulfate, CaSO_4

Answer:

Elements in the compound	Number of atoms of each element		Atomic Weight	Total Mass
Ca	1	x	40.1	= 40.2
S	1	x	32.1	= 32.1
O	4	x	16.0	= 64.0
Formula weight				= 136.3

4. Calculate the formula weight of barium nitrate, $\text{Ba}(\text{NO}_3)_2$

Answer:

Elements in the compound	Number of atoms of each element		Atomic Weight	Total Mass
Ba	1	x	137.3	= 137.3
N	2	x	14.0	= 28.0
O	6	x	16.0	= 96.0
Formula weight				= 261.3

5. Calculate the formula weight of zinc phosphate, $\text{Zn}_3(\text{PO}_4)_2$

Answer:

Elements in the compound	Number of atoms of each element		Atomic Weight	Total Mass
Zn	3	x	65.4	= 196.2
P	2	x	31.0	= 62.0
O	8	x	16.0	= 128.0
Formula weight				= 386.2

Problems: Calculating formula weights

Calculate the formula weights of the following compounds.

