

IONIC CHARGES, FORMULAS, AND COMPOUNDS

1. DEFINITIONS:

- An **ion** is an individual atom, or a cluster of bonded atoms, that has gained or lost electrons.
- A **cation** has a positive electrical charge resulting from the loss of one or more electrons by an atom or a group of bonded atoms.
- An **anion** has a negative electrical charge resulting from the gain of one or more electrons by an atom or a group of bonded atoms.
- A **monatomic ion** is an ion formed from electron gain or loss by a single atom.
- A **polyatomic ion** is an ion formed from electron gain or loss by a cluster of bonded atoms.

EXAMPLES: Al^{3+} is a monoatomic cation. NH_4^+ is a polyatomic cation.
 S^{2-} is a monoatomic anion. CO_3^{2-} is a polyatomic anion.

2. PREDICTING THE CHARGE OF MONATOMIC IONS OF REPRESENTATIVE ELEMENTS:

It is possible to use location in the Periodic Table to predict the charges of the monatomic ions formed from some of the representative elements. Since cations of different charges can often be formed from the same transition metal, the charge on a particular transition metal ion generally cannot be predicted solely from the element's location in the Periodic Table.

- For monatomic cations formed from metals in Groups IA, IIA, or IIIA, the cation charge is the group number ($C = G$).

<u>Group</u>	<u>Ionic Charge</u>	<u>Examples</u>
IA	+1	Li^+ , Na^+ , K^+
IIA	+2	Mg^{2+} , Ca^{2+} , Ba^{2+}
IIIA	+3	Al^{3+}

- For monatomic anions formed from nonmetals in Groups VA, VIA, or VIIA, the anion charge is the group number minus eight ($C = G - 8$).

<u>Group</u>	<u>Ionic Charge</u>	<u>(Calculation)</u>	<u>Examples</u>
VA	-3	$(5 - 8 = -3)$	N^{3-}
VIA	-2	$(6 - 8 = -2)$	O^{2-} , S^{2-} , Se^{2-}
VIIA	-1	$(7 - 8 = -1)$	F^- , Cl^- , I^-

- Some transition elements & metals have a fixed charge, Zn^{+2} , Ag^{+1} , Cd^{+2} , Al^{+3} , Ga^{+3}

3. PREDICTING THE CHARGE OF POLYATOMIC IONS:

The ionic charges of many polyatomic ions can be reliably predicted from an understanding of the chemical behavior of the elements involved, but memorization is probably the easiest and best way for beginning students to learn the ionic charges

4. WRITING CHEMICAL FORMULAS FOR IONIC COMPOUNDS

The chemical formula for an ionic compound gives the smallest whole number ratio of each type of ion in the compound. Chemical formulas that give only the ratio of elements are typically referred to as empirical formulas. If the ionic charge of the cation and anion is known for an ionic compound, the empirical formula can be readily determined.

EXAMPLES:

- a. Write the chemical formula for the ternary ionic compound containing Fe^{3+} and CO_3^{2-} .
 - The ionic charge is known for both the cation and anion.
 - For ions with these charges, determine the smallest number of cations and anions that will yield total positive and negative charges of equal absolute value.
 - In this case it is 2 cations for a total positive charge of +6 and 3 anions for a total negative charge of -6.
 - Thus, the correct chemical formula is $\text{Fe}_2(\text{CO}_3)_3$.

- b. Write the chemical formula for the binary ionic compound containing Sr and Br.
 - The ionic charge is not given, but it can be determined from a Periodic Table (see #2 above).
 - The ionic charges can be determined to be +2 for Sr^{2+} and -1 for Br^- .
 - The fewest cations and anions that will yield total positive and negative charges of equal absolute value are: 1 cation for a total positive charge of +2 and 2 anions for a total negative charge of -2.
 - Thus, the correct chemical formula is SrBr_2 .