 Name: _____

Nomenclature for ionic compounds

Nomenclature is a system of naming. This worksheet presents a widely used system of nomenclature for ionic compounds.

There are two types of metal cations with different naming conventions discussed separately.

- fixed charge (single charge) cations (Never use a Roman numeral)
- variable charge (multiple charge) cations (Always use a Roman numeral)

Cations with a single, fixed charge

Cations have a positive charge. They are formed from metals, which lie on the left side of the periodic table. The main group (Groups 1-8) metals form cations with a single, fixed charge. The charge is the same as the Group (column) number on the periodic table. The cation name is formed by adding the word "ion" after the element name. For example, the element sodium (Na) is found in Group 1. It ionizes to form the "sodium ion" represented as Na^+. The charge is +1 because it is in Group 1.

Anions have a negative charge. They are formed from nonmetals, which lie on the right side of the periodic table. The negative charge is found using the **Octet Rule** as eight (8) minus the Group number. Anions always have a single, fixed charge. The anion name is formed by changing the element name suffix to "-ide" and adding the word "ion" after the element name. For example, the element chlorine (Cl) is found in Group 7. It ionizes to form the "chloride ion" represented as Cl^-. The charge is -1 because it is in Group 7, and 8 - 7 = 1.

Ionic compounds are formed by cation-anion pairs in electrically neutral ratios. They are named using the cation name first, followed by the anion name, excluding the word "ion." For example, sodium ion (Na^+) and chloride ion (Cl^-) form the compound sodium chloride. Its formula is NaCl, which is electrically neutral because sodium ion is +1 and chloride ion is -1. As a second example, magnesium chloride has the formula $MgCl_2$. The subscripts indicate 2 chloride ions (Cl^-) per 1 magnesium ion (Mg^{2+}). The subscript "1" is always implied and never written.

Note: There is <u>never</u> any charge indicated in the name of a compound having a cation with a single, fixed charge. The single, fixed charge is obvious to a chemist.

 Name: _____

Exercise 1. Provide the name or formula for each ion:

___	__chloride ion_____	Li^+	_____
___	__bromide ion_____	Na^+	_____
F^-	_____	K^+	_____
S^{2-}	_____	Mg^{2+}	_____
O^{2-}	_____	Ca^{2+}	_____
N^{3-}	_____	Al^{3+}	_____
P^{3-}	_____	___	__barium ion_____
C^{4-}	_____	___	__boron ion_____

Exercise 2. Complete the table of neutral ionic compounds with the formulas and names for each cation-anion pair.

	Cl^-	I^-	S^{2-}	O^{2-}	Br^-	N^{3-}
Na^+						
K^+						
Mg^{2+}						
Al^{3+}						

Cations with a variable/multiple charges

Some transition metals have multiple possible cation charges. A roman numeral (I, II, III, IV, V, …) must be used in the cation and ionic compound naming system to distinguish between the charges. For example, iron (Fe) can form the iron (II) ion and also the iron (III) ion, denoted Fe^{2+} and Fe^{3+}, respectively. Iron (II) oxide and iron (III) oxide are distinct compounds, with electrically neutral formulas FeO and Fe_2O_3, respectively.

Exercise 3. Provide the formula for each compound.

iron (II) oxide _____

iron (III) oxide _____

lead (II) chloride _____

lead (IV) iodide _____

cobalt (II) chloride _____

cobalt (III) chloride _____

Mixed cation types

The first step in naming an ionic compound is to determine whether or not the cation can exhibit multiple charges. This requires memorization. Learn the following procedure.

1. The main group (Groups 1-8) elements always have a single charge, determined by the column on the periodic table.
2. Silver and zinc are the only transition metals with a single charge. Memorize the ionic charges for Ag^{+} and Zn^{2+}.
3. All other transition metals have multiple charges. Use a roman numeral to indicate the cation charge, which can be figured out from the given information.

Exercise 4. Provide the name for each compound.

FeO _____

$NaCl$ _____

$CuBr_2$ _____

ZnO _____

K_3P _____

CaS _____

Ag_2S _____

CoI_3 _____

Be_3N_2 _____

Polyatomic ions

Polyatomic ions are charged groups of atoms. An example is ammonium ion, NH_4^+. It has five atoms (one nitrogen and four hydrogens) that share a charge of +1. The polyatomic ions remain intact, and parentheses may be required when using subscripts. For example, ammonium chloride is NH_4Cl and ammonium sulfide is $(NH_4)_2S$. Ammonium is the only polyatomic cation. Common anions are shown in Table 1.

Table 1. Polyatomic ions

Ion name	Ion Formula
ammonium	NH_4^+
cyanide	CN^-
hydroxide	OH^-
perchlorate	ClO_4^-
chlorate	ClO_3^-
chlorite	ClO_2^-
hypochlorite	ClO^-
bromate	BrO_3^-
iodate	IO_3^-
nitrate	NO_3^-
sulfate	SO_4^{2-}
carbonate	CO_3^{2-}
hydrogen carbonate (bicarbonate)	HCO_3^-
phosphate	PO_4^{3-}
hydrogen phosphate	HPO_4^{2-}
dihydrogen phosphate	$H_2PO_4^-$
permanganate	MnO_4^-
chromate	CrO_4^{2-}
dichromate	$Cr_2O_7^{2-}$
acetate	$C_2H_3O_2^-$ *or* $CH_3CO_2^-$

There are many polyatomic anions. Many occur in **families of names**.

Start by learning the polyatomic ions ending with "-ate" such as chlorate (ClO_3^-), nitrate (NO_3^{--}), sulfate (SO_4^{2-}), carbonate (CO_3^{2-}), and phosphate (PO_4^{3-}).

The corresponding "-ite" ion name has one less oxygen and the same charge. For example, chlorite ion is ClO_2^-. Less commonly used names are the "per__-ate" and "hypo__-ite" forms to indicate different numbers of oxygen.

Key in on the chlorate family in Table 1 to construct names for other ions. For example, sulfite (not in the table) would be SO_3^{2-}, because it has the same charge and one less oxygen than sulfate (SO_4^{2-} in the table).

Sometimes "bi-" indicates H^+ has attached. For example, bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}).

Hydroxide, cyanide, permanganate, acetate, and chromate/dichromate are common polyatomics that do <u>not</u> occur in families.

 Name: _____

Exercise 5. Complete the table of neutral ionic compounds with the formulas and names for each cation-anion pair, similar to Exercise 2.

	SO_4^{2-}	NO_3^-	PO_4^{3-}	CO_3^{2-}	ClO_3^-	OH^-
Na^+						
Al^{3+}						
Ba^{2+}						
NH_4^+						
Cu^+						

Exercise 6. Provide the formula for each compound.

sodium sulfate _____

sodium bisulfate _____

sodium sulfite _____

sodium sulfide _____

copper (I) sulfate _____

copper (II) sulfite _____

copper (II) sulfide _____

 Name: _____

Exercise 7. Provide the formula for each compound.

nickel (III) carbonate _____

calcium nitrate _____

copper (II) acetate _____

potassium phosphate _____

silver acetate _____

zinc chromate _____

tin (II) nitrate _____

tin (II) nitrite _____

ammonium bicarbonate _____

copper (II) sulfite _____

sodium hydroxide _____

potassium cyanide _____

potassium phosphide _____

Exercise 8. Provide the name for each compound.

CuCN _____

FeO _____

ZnO _____

Al_2O_3 _____

AgCl _____

NH_4NO_3 _____

$NaNO_3$ _____

$NaNO_2$ _____

$Ca(NO_2)_2$ _____

$FeCrO_4$ _____