You should be able to write names and the corresponding chemical formulas for binary molecular compounds, ionic compounds involving both monatomic and polyatomic ions, and both binary and oxoacids. The rules of chemical nomenclature that we will follow were laid down by the International Union of Pure and Applied Chemists (IUPAC), and will lead you to establishing the systematic or IUPAC names of compounds. ***NOTE*****:** There are really only 2 compounds that we will refer to by their common names: H_2O, water and NH_3, ammonia.

Before we can engage in a productive discussion of nomenclature, we must first discuss the characteristics of molecular vs. ionic compounds.

Molecular Compounds	**Ionic Compounds**
• composed of molecules	• composed of ions
• molecule: neutral groups of atoms bonded together	• ions: single atoms (*monatomic*) or groups of atoms bonded together (*polyatomic*) that carry positive or negative charge
• the smallest piece of a molecular compound that has the same physical and chemical properties of that compound is a single molecule	• monatomic ions formed by gain or loss of electrons
• atoms within a molecule are held together by covalent (shared electron) bonds •	• cation: positively charged ion; formed by loss of electrons; metals like to lose electrons and form cations
• molecular compounds can be identified by their constituent elements; they are composed of nonmetals only (or nonmetal and semimetal)	• anion: negatively charged ion; formed by gain of electrons; nonmetals like to gain electrons and form anions
• binary molecular compounds: only 2 elements present (i.e. PF_5, SO_3, $SiCl_4$)	• ions carry charge, but an ionic compound is electrically neutral
•	• an ionic compound must have both cations and anions; cations and anions are held together by "ionic bonds" – the electrostatic attraction of oppositely charged species
•	• smallest piece of an ionic compound that has the same physical and chemical properties of that compound is a formula unit (given by the chemical formula)
•	• ionic compounds can be identified by their constituent elements; they are composed of metals (cations) and nonmetals (anions)
• structurally a molecular compound is a collection of individual, discrete molecules	• structurally an ionic compound has a long range, repeating 3-dimensional order with precise arrangement of cations and anions

Naming Cations:

- recall that metals prefer to lose electrons and form cations

- for main group metals, maximum – and frequently only – positive charge (cation charge) is equal to the element's group number: i.e. for Al (group 3A) ➔ Al^{3+}

- there are two types of metals: Type I metals are those that form only one cation (of one charge) and Type II metals are those that can form more than one cation (with more than one charge)

- Type I metals (relatively small group – ***KNOW THEM AND THEIR CHARGE***):
 alkali earth metals – group 1A metals – are always +1: Li^+, Na^+, K^+, Rb^+, Cs^+
 alkaline earth metals – group 2A metals – are always +2: Be^{2+}, Mg^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}
 miscellaneous others – charge always = group number: Al^{3+}, Ga^{3+}, Y^{3+}, Sc^{3+}, La^{3+}, Zn^{2+}, Cd^{2+}, Ag^+

- to name a Type I metal ion: Na^+, sodium ion; Ca^{2+}, calcium ion; Ga^{3+}, gallium ion; etc.

- Type II metals include most heavier main group metals and transition metals. If a metal is ***NOT*** a Type I metal it is, by default, a Type II metal.

- to name a Type II metal ion you must indicate the ion's charge using a stock number – a roman numeral equal to the charge in parentheses after the element's name: Ni^{2+}, nickel (II) ion; Ni^{3+}, nickel (III) ion; Pb^{2+}, lead (II) ion; Pb^{4+}, lead (IV) ion; etc.

- there are really only 2 polyatomic cations that you will need to know: NH_4^+, ammonium ion; H_3O^+, hydronium ion

- see Table 1 for the names, formulas and charges of Type I metals and the 2 common polyatomic cations

Naming Anions:

- recall that nonmetals prefer to gain electrons and form anions

- for monatomic nonmetal anions, the maximum – and only – negative charge (anion charge) is equal to the element's group number minus 8: i.e. for S (group 6A) ➔ S^{2-}

- to name a monatomic anion, add the suffix *–ide* to the stem of the element name: S^{2-}, sulf*ide* ion; Br^-, brom*ide* ion; P^{3-}, phosph*ide* ion; etc.

- see Table 2 for names and charges of monatomic anions

- there are ***MANY*** polyatomic anions that you need to know
 for polyatomic anions, know name, formula and charge
 rules for polyatomic oxoanions (anions with oxygen) exist, but cannot be applied without a fairly comprehensive familiarity with the anions; in short – ***MEMORIZE THEM***

- basic rule for naming oxoanions, add the suffix *–ate* to the stem of the element name: SO_4^{2-}, sulf*ate* ion; PO_4^{3-}, phosph*ate* ion; ClO_3^-, chlor*ate* ion; NO_3^-, nitr*ate* ion; etc.

- for elements that form more than one oxoanion, add the suffix *–ite* to the stem of the element name to indicate fewer oxygens: SO_3^{2-}, sulf*ite* ion; ClO_2^-, chlor*ite* ion; NO_2^-, nitr*ite* ion; etc.

- Cl, Br, and I form a series of 4 oxoanions with 1 – 4 oxygens. Use per–______–ate to name the ion with 4 O's and hypo–______–ite to name the ion with 1 O: ClO_4^-, *per*chlor*ate* ion; ClO^-, *hypo*chlor*ite* ion; etc.

- for protonated oxoanions (oxoanion with 1 or more H^+ ion), add the word *hydrogen* to the oxoanion name: HSO_4^-, *hydrogen* sulfate ion; HSO_3^-, *hydrogen* sulfite ion; HPO_4^{2-}, *hydrogen* phosphate ion; $H_2PO_4^-$, *dihydrogen* phosphate ion; etc. ***NOTE:*** for protonated oxoanions the anion charge changes in addition to the name and formula.

- some miscellaneous anions that don't fit with the groups listed above: OH^-, hydroxide ion (really a protonated oxide ion); $C_2H_3O_2^-$, acetate ion; $C_2O_4^{2-}$, oxalate ion; MnO_4^-, permanganate ion; CrO_4^{2-}, chromate ion; $Cr_2O_7^{2-}$, dichromate ion; $S_2O_3^{2-}$, thiosulfate ion; CN^-, cyanide ion

- see Table 3 for names, formulas and charges of the more common polyatomic anions

Names and Formulas of Substances
I have broken this down into name ➔ formula and formula ➔ name sections for molecular compounds, ionic compounds, binary acids, and oxoacids.

Binary Molecular Compounds: (see Table 4 for prefixes to indicate "how many")

name ➔ formula	**formula ➔ name**
• identify the elements present, and number of atoms of each element present from name	• name the elements in the order that they appear in the chemical formula
• elements will appear in the chemical formula in the same order as they are written in the name	• use the appropriate prefixes to indicate how many atoms of each element are present in the formula
• write the chemical formula using symbols for the elements and numerical subscripts to indicate how many atoms of each element present	• add the suffix *–ide* to the stem of the 2nd element name
• *example*: sulfur trioxide ➔ SO_3	• *example*: SF_6 ➔ sulfur hexafluoride

Ionic Compounds:

name ➔ formula	**formula ➔ name**
• identify the cation and anion from the given name, including identification of each ion's symbol or formula and charge	• the name is written with the cation first and the anion second
• write the chemical formula with the cation 1st and the anion 2nd	• identify whether the cation is a Type I metal, a Type II metal, or a polyatomic cation and then name it appropriately
• determine how many cations and anions will be in the formula based on their charges; remember that the ionic compound is neutral overall	• name the anion appropriately; remember that a monoatomic anion name will end with *–ide* while an oxoanion name will end with *–ate* or *–ite*
• to indicate more than one polyatomic ion, put parentheses around the ion formula with a subscript outside of the ( )	• ***DO NOT*** use prefixes (*like those in Table 4*) to indicate how many cations or anions are present; this can be determined based on the charges of the individual ions and knowing that the compound must be neutral overall
• *example*: ammonium sulfate ➔ NH_4^+ and SO_4^{2-} ➔ $(NH_4)_2SO_4$	• *examples*: $Ni(NO_3)_2$ ➔ nickel (II) nitrate; vs. KBr ➔ potassium bromide

Acids:

Let me make a few general comments about acids.

- At this point we will be considering the aqueous acids – meaning compounds that are dissolved in water to produce an aqueous solution. This is indicated with *(aq)* written after the chemical formula.

- You will be able to recognize an acid by its formula as a compound with one or more H^+ ion(s) bonded to an anion.
  Binary acids have H^+ and a monatomic anion (names and formulas included in Table 2 as appropriate).
  Oxoacids have H^+ with an oxoanion (names and formulas included in Table 3 as appropriate).

- Acids are composed of H^+ ion(s) and anions but are electrically neutral overall. Therefore, knowing the charge on the anion allows you to determine the number of hydrogen ions that must be in the acid's chemical formula.

Binary Acids:

name ➔ formula	**formula ➔ name**
• if the acid name follows this formula: hydro–______–ic acid, it is a binary acid (H^+'s with monatomic anion); ***the prefix hydro– is the big identifier here***	• if the acid is a binary acid there will be only 1 element in addition to hydrogen in the formula
• identify the anion and its charge	• to name a binary acid, use this formula: hydro–______–ic acid
• determine the number of H^+ ions required for a neutral compound	• the stem of the element name (other than H) goes in the blank
• write the chemical formula; H appears first	•
• *example*: *hydro*sulfur*ic* acid ➔ anion is S^{2-} ➔ therefore 2 H^+'s required ➔ H_2S (aq)	• *example*: HI (aq) ➔ *hydro*iod*ic* acid

Oxoacids:

name ➔ formula	**formula ➔ name**
• if the acid name follows the formulas: _______*–ic* acid or ______*–ous* acid, it is an oxoacid (H^+'s with an oxoanion)	• if the acid is an oxoacid there will be H, O and 1 other element in the chemical formula
• if the name of the acid is ______*–ic* acid, then the oxoanion name ends in *–ate*; if the name of the acid is ______*–ous* acid, then the oxoanion name ends in *–ite*	• identify and name the oxoanion in the chemical formula
• identify the oxoanion; write its formula with charge	• if the oxoanion name ends in *–ate*, then the corresponding oxoacid is named using the formula: ______*–ic* acid
• determine how many H^+ ions are required for a neutral compound	• if the oxoanion name ends in *–ite*, then the corresponding oxoacid is named using the formula: ______*–ous* acid
• write the chemical formula; H appears first	•
· *examples*: sulfur*ic* acid ➔ acid of the sulf*ate* ion ➔ SO_4^{2-} ➔ 2 H^+'s required ➔ H_2SO_4 (aq) vs. chlor*ous* acid ➔ acid of the chlor*ite* ion ➔ ClO_2^- ➔ 1 H^+ required ➔ $HClO_2$ (aq)	• *examples*: HNO_3 (aq) ➔ acid of NO_3^- ➔ nitr*ate* ion ➔ therefore nitr*ic* acid vs. HNO_2 (aq) ➔ acid of NO_2^- ➔ nitr*ite* ion ➔ therefore nitr*ous* acid

Table 1: Names, Formulas , and Charges for Type I and Polyatomic Cations

	formula and charge	name
Group 1A:	Li^+	lithium ion
	Na^+	sodium ion
	K^+	potassium ion
	Rb^+	rubidium ion
	Cs^+	cesium ion
Group 2A:	Be^{2+}	beryllium ion
	Mg^{2+}	magnesium ion
	Ca^{2+}	calcium ion
	Sr^{2+}	strontium ion
	Ba^{2+}	barium ion
Others:	Al^{3+}	aluminum ion
	Ga^{3+}	gallium ion
	Y^{3+}	yttrium ion
	Sc^{3+}	scandium ion
	La^{3+}	lanthanum ion
	Zn^{2+}	zinc ion
	Cd^{2+}	cadmium ion
	Ag^+	silver ion
Polyatomic Cations:	NH_4^+	ammonium ion
	H_3O^+	hydronium ion

Table 2: Names and Charges for Monatomic Anions (and formulas of corresponding acids where appropriate)

	formula and charge	name	corresponding acid	acid name
Group 5A:	N^{3-}	nitride ion	----	----
	P^{3-}	phosphide ion	----	----
	As^{3-}	arsenide ion	----	----
Group 6A:	O^{2-}	oxide ion	H_2O	water
	S^{2-}	sulfide ion	H_2S	hydrosulfuric acid
	Se^{2-}	selenide ion	H_2Se	hydroselenic acid
	Te^{2-}	telluride ion	H_2Te	hydrotelluric acid
Group 7A:	F^-	fluoride ion	HF	hydrofluoric acid
	Cl^-	chloride ion	HCl	hydrochloric acid
	Br^-	bromide ion	HBr	hydrobromic acid
	I^-	iodide ion	HI	hydroiodic acid

Table 3: Names, Formulas and Charges for Common Polyatomic Anions (and formulas of corresponding acids where appropriate)

	formula and charge	name	corresponding acid	acid name
Group 4A:	CO_3^{2-}	carbonate ion	H_2CO_3	carbonic acid
	HCO_3^-	hydrogen carbonate ion		
	SiO_3^{2-}	silicate ion	----	----
Group 5A:	NO_3^-	nitrate ion	HNO_3	nitric acid
	NO_2^-	nitrite ion	HNO_2	nitrous acid
	PO_4^{3-}	phosphate ion	H_3PO_4	phosphoric acid
	HPO_4^{2-}	hydrogen phosphate ion	----	----
	$H_2PO_4^-$	dihydrogen phosphate ion	----	----
	AsO_4^{3-}	aresenate ion	H_3AsO_4	arsenic acid
	SbO_4^{3-}	antimonate ion	----	----
Group 6A:	SO_4^{2-}	sulfate ion	H_2SO_4	sulfuric acid
	HSO_4^-	hydrogen sulfate ion	----	----
	SO_3^{2-}	sulfite ion	H_2SO_3	sulfurous acid
	HSO_3^-	hydrogen sulfite ion	----	----
	SeO_4^{2-}	selenate ion	H_2SeO_4	selenic acid
	SeO_3^{2-}	selenite ion	H_2SeO_3	selenous acid
	TeO_4^{2-}	tellurate ion	H_2TeO_4	telluric acid
	TeO_3^{2-}	tellurite ion	----	----
Group 7A:	ClO_4^-	perchlorate ion	$HClO_4$	perchloric acid
	ClO_3^-	chlorate ion	$HClO_3$	chloric acid
	ClO_2^-	chlorite ion	$HClO_2$	chlorous acid
	ClO^-	hypochlorite ion	$HClO$	hypochlorous acid
	BrO_4^-	perbromate ion	$HBrO_4$	perbromic acid
	BrO_3^-	bromate ion	$HBrO_3$	bromic acid
	BrO_2^-	bromite ion	$HBrO_2$	bromous acid
	BrO^-	hypobromite ion	$HBrO$	hypobromous acid
	IO_4^-	periodate ion	HIO_4	periodic acid
	IO_3^-	iodate ion	HIO_3	iodic acid
	IO_2^-	iodite ion	HIO_2	iodous acid
	IO^-	hypoiodite ion	HIO	hypoiodous acid
Organic Anions:	$C_2H_3O_2^-$	acetate ion	$HC_2H_3O_2$	acetic acid
	$C_2O_4^{2-}$	oxalate ion	$H_2C_2O_4$	oxalic acid
Miscellaneous:	OH^-	hydroxide ion	----	-----
	MnO_4^-	permanganate ion	----	----

	CrO_4^{2-}	chromate ion	----	----
	$Cr_2O_7^{2-}$	dichromate ion	----	----
	$S_2O_3^{2-}$	thiosulfate ion	----	----
	CN^-	cyanide ion	----	----
	CNO^-	cyanate ion	----	----
	CNS^-	thiocyanate ion	----	----

Table 4: Numerical Prefixes for Naming Molecular Compounds

number	prefix
1*	mono–*
2	di–
3	tri–
4	tetra–
5	penta–
6	hexa–
7	hepta–
8	octa–
9	nona–
10	deca–
11	undeca–
12	dodeca–

* *mono–* is rarely used to indicate one atom of an element in a formula; the most common use of mono– is in carbon *mon*oxide

** Note: frequently a prefix ending in a– before oxide be truncated with the a– being dropped; i.e. N_2O_4 is named dinitrogen *tetr*oxide instead of dinitrogen *tetra*oxide. This is called an elision.