Writing and Naming Inorganic Compounds

Naming

IUPAC is an agency that makes rules for naming chemicals
Many compounds also have common names

Inorganic compounds

Compounds that do not contain carbon, EXCEPT
CO_2 and CO_3^{2-} are considered inorganic
CO_2 is carbon dioxide
CO_3^{2-} is carbonate ion

Ionic Compounds – Definitions and examples

Contain at least one metal and at least one nonmetal
Form salts consisting of formula units

Binary Ionic compounds – contain two different atoms

KCl is potassium chloride – contains two different atoms, K, Cl
The cation is potassium ion, K^+
The anion is chloride, Cl^-
$CaCl_2$ is calcium chloride – contains two different atoms Ca, Cl
The cation is calcium ion, Ca^{2+}
The anion is chloride, Cl^-

Ternary Ionic compounds – contain three different atoms

Na_2SO_4 is sodium sulfate – contains three different atoms, Na, S and O
The cation is sodium ion, Na^+
The anion is sulfate, SO_4^{2-}
K_3PO_4 is potassium phosphate. It contains three different atoms, K, P, O
The cation is potassium ion, K^+
The anion is phosphate PO_4^{3-}

Covalent Compounds – Definitions and examples

Contain two or more nonmetals
Form molecules held together by covalent bonds

Binary Molecular compounds – two different nonmetal atoms

Examples with common names
NH_3 – ammonia

H_2O – water
N_2H_4 - hydrazine
Examples with systematic names
CO_2 – carbon dioxide
CO – carbon monoxide
N_2O – dinitrogen monoxide

Aqueous Acids

Note that acids often start with an H, but not all compounds that start with H are acids.
Acids form an aqueous solution when dissolved in water.
Indicate aqueous acids by placing an (aq) after the formula.
The two acid categories below are for writing and naming aqueous acids.

Binary aqueous acids

Consist of two different atoms, where the first atom is H.
HF(aq) – hydrofluoric acid
HCl(aq) – hydrochloric acid
HBr(aq) – hydrobromic acid
HI(aq) – hydroiodic acid

Ternary aqueous acids

Made up of three different atoms, one is hydrogen, one is oxygen
H_2SO_4(aq) – sulfuric acid
HNO_3(aq) – nitric acid
H_3PO_4(aq) – phosphoric acid
H_2CO_3(aq) – carbonic acid

Ionic compounds – Writing and Naming

Ions

An ion is an atom or group of atoms with a charge
A polyatomic ion is a group of atoms with a charge
Cation – ion with a positive charge.
Examples: K^+ (potassium ion), NH_4^+ (ammonium ion)
Anion – ion with a negative charge.
Examples: F^- (fluoride ion), SO_4^{2-} (sulfate ion)

Naming Cations

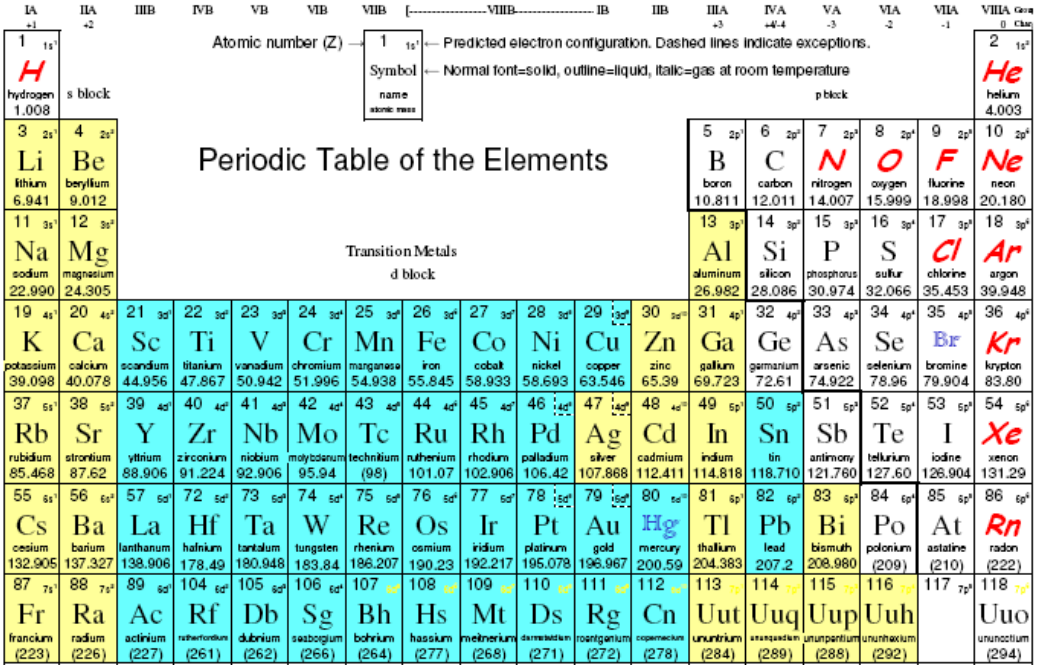
For monatomic (one atom) cations that form ions with only one charge, use the name of the metal followed by the word 'ion.'

Cations named using this system include the main group metals (except cations of Sn and Pb) as well as the transition metal ions Ag^+, Zn^{2+}, and Cd^{2+}.

All the metals named with this system are highlighted yellow in the periodic table below.
Examples:
K^+ is potassium ion
Ca^{2+} is calcium ion
Al^{3+} is aluminum ion
Ag^+ is silver ion
Zn^{2+} is zinc ion
Cd^{2+} is cadmium ion
As discussed previously, \
Group IA metals form +1 ions
Group IIA metals form +2 ions
Group IIIA metals form +3 ions

For monatomic (one atom) cations that form ions with more than one charge, use the Stock system of naming a Roman numeral gives the charge.

Use the name of the metal, a Roman numeral in parentheses, and the word 'ion'
Cations named using this system include the transition metal ions (except Ag^+, Zn^{2+}, and Cd^{2+}), as well as the main group metal ions of Sn and Pb.
All the metals named with the Stock system are highlighted blue in the periodic table below.
Transition metals form multiple ions, except for Ag, Zn, and Cd
Fe^{2+} is called the iron(II) ion
Fe^{3+} is called the iron(III) ion
Ti^{4+} is called the titanium(IV) ion
Cr^{6+} is called the chromium(VI) ion
Mn^{7+} is called the manganese(VII) ion
(Note: a few other metals form multiple ions, but not for this course)
Most transition metals form a +2 ion as well as others
The 2s valence electrons are lost when forming a +2 ion



Polyatomic (more than one atom) cations

There is only one polyatomic cation used in this course, NH_4^+ (ammonium ion). The ammonium ion forms compounds that are ionic in behavior (and naming).

Naming Anions

Monatomic (one atom) anions (nonmetals usually form anions)

Drop the ending of the name of the element and add the suffix '-ide'

The red indicates the portion that is dropped

Cl- is called chloride (chlorine)

O^{2-} is called oxide (oxygen)

N^{3-} is called nitride (nitrogen)

Se^{2-} is called selenide (selenium)

Group VIIA nonmetals form -1 ions

Group VIA nonmetals form -2 ions

Group VA nonmetals form -3 ions

Polyatomic (more than one atoms) anions

Many polyatomic anions contain oxygen – called oxyanions

Oxyanions have names that end in '-ate' or '-ite'

Examples of '-ate' oxyanions

The oxyanion NO_3^- is nitrate

The oxyanion SO_4^{2-} is sulfate
The oxyanion PO_4^{3-} is phosphate
The oxyanion ClO_3^- is chlorate
Examples of '-ite' oxyanions
Take away 1 oxygen and keep the same charge
The oxyanion NO_2^- is nitrite
The oxyanion SO_3^{2-} is sulfite
The oxyanion PO_3^{3-} is phosphite
The oxyanion ClO_2^- is chorite
Two polyatomic anions sound like elements
These have an '-ide' ending but they are not elements
The polyatomic anion CN^- is cyanide
The polyatomic anion OH^- is hydroxide

Examples of Writing and Naming Ionic Compounds

A *formula unit* is the simplest representation of an ionic compound
Total charge on the compound must be zero = cations + anions
Name the cation (usually metal or ammonium ion) first and then the anion
Charges must be balanced
$Na^+ + Cl^-$ forms NaCl – sodium chloride, where +1 + -1 = 0
$Ca^{2+} + Cl^-$ forms $CaCl_2$ – calcium chloride, where +2 + 2(-1) = 0
$Ca^{2+} + S^{2-}$ forms CaS – calcium sulfide, where +2 + -2 = 0
$Li^+ + S^{2-}$ forms Li_2S – lithium sulfide, where 2(+1) +-2 = 0
Notice the crossover rule:
Charge on the metal becomes the subscript on the nonmetal
Charge on the nonmetal becomes the subscript on the metal
Remember to reduce the result
Use parenthesis to indicate more than one polyatomic ion
$Al^{3+} + SO_4^{2-}$ forms $Al_2(SO_4)_3$ – aluminum sulfate
$NH_4^+ + PO_4^{3-}$ forms $(NH_4)_3PO_4$ – ammonium phosphate
$Ca^{2+} + O^{2-}$ forms CaO – calcium oxide (remember to reduce)
$Ti^{4+} + O^{2-}$ forms TiO_2 – titanium(IV) oxide (remember to reduce!)

Calculating charges for metals that form more than one ions

The total charge of the ions in an ionic compound must sum to zero
Calculate the charge on iron in Fe_2S_3
S is -2 because it is a nonmetal in Group VIA
The total charge on 3 S atoms is 3(-2) = -6
The total positive charge must be +6
The +6 charge goes to 2 iron atoms
Charge on each iron atom must be +6 / 2 or +3

Charge on each iron atom is +3
The stock name is iron(III) sulfide
Use the (III) because iron is a transition metal other than Ag, Cd, or Zn

What is the Stock name of Hg_2O?
O is -2 because it is a nonmetal in Group VIA
The total positive charge must be +2 because the overall charge must be 0
Charge on each Hg must be +2 / 2 = +1
The Stock name is mercury(I) oxide

What is the formula for Manganese(IV) oxide?
Oxide is -2
Manganese is +4
The correct formula is MnO_2 (remember to reduce!)

What is the formula for chromium(III) sulfate?
Sulfate, SO_4^{2-}, is -2
Chromium is +3
The correct compound is $Cr_2(SO4)_3$

Name Na_2CO_3 – sodium carbonate
Name $Cr(SO_4)_2$ – chromium(IV) sulfate (transition metal)

Covalent Compounds – Writing and Naming

A molecule is the simplest representation of a molecular compound

Binary Molecular Compounds

Use prefixes to indicate the number of atoms in a molecular compound

1	mono-	2	di-
3	tri-	4	tetra-
5	penta-	6	hexa-
7	hepta-	8	octa-
9	nona-	10	deca-

Name the first atom, using a prefix if needed
Note that the last ‘a’ or ‘o’ in the prefixes is dropped if the element name starts with a vowel
If there is only one of the *first* atom, skip the prefix ‘mono’
Name the second atom, using a prefix if needed, and adding the suffixe ‘-ide’
CO_2 is called carbon dioxide (skip prefix mono for first atom)
CO is called carbon monoxide (skip prefix ‘mono-‘ for first atom, dropped ‘o’ before oxide)
SF_6 is called sulfur hexafluoride (skip prefix ‘mono-‘ for first atom)
P_4O_6 is called tetraphosphorous hexoxide (note: ‘a’ is dropped from hexa)

P_4S_6 is called tetraphosphorous hexasulfide
PO_5 is called phosphorous pentoxide(note: ‘a’ is dropped from penta)
PS_5 is called phosphorous pentasulfide

Binary Aqueous Acids

Aqueous acids are dissolved in water
HF(aq) – hydrofluoric acid
HCl(aq) – hydrochloric acid
HBr(aq) - hydrobromic acid
HI(aq) – hydroiodic acid

Ternary Aqueous Acids

Aqueous acids are dissolved in water
HNO_3(aq) is nitric acid
HNO_2(aq) is nitrous acid
H_2SO_4(aq) is sulfuric acid
H_2SO_3(aq) is sulfurous acid
H_3PO_4(aq) is phosphoric acid
H_3PO_3(aq) is phosphorous acid