Ch. 8: Nomenclature

Naming of compounds

- Metals and non-metals combine to form ionic compounds

- Non-metals and non-metals combine to form molecular compounds

Binary Compounds – composed of only two elements, though may have more than two atoms:

$NaCl$, KF, $CaCl_2$, CO, CO_2, H_2O, C_6H_{14}, HCl, …

Naming Ions:

●Cation (metal) – name is the same as the element, + 'ion'

●Fixed charge cations – metals that only form one cation (such as Group 1 and 2 metals):

$Li^{+1} \rightarrow$ lithium ion, $Ca^{+2} \rightarrow$ calcium ion

●Variable charged cations – metals that may form different cations (most transition metals). Use Roman numerals to show the charge:

$Fe^{+2} \rightarrow$ iron (II) ion

$Fe^{+3} \rightarrow$ iron (III) ion

TABLE 8.3 Comparison of Roman Numeral and Suffix System Names for Selected Metal Ions

Element	Ions	Preferred Name	Old System Name
Copper	Cu^{+}	copper(I) ion	cuprous ion
	Cu^{2+}	copper(II) ion	cupric ion
Iron	Fe^{2+}	iron(II) ion	ferrous ion
	Fe^{3+}	iron(III) ion	ferric ion
Tin	Sn^{2+}	tin(II) ion	stannous ion
	Sn^{4+}	tin(IV) ion	stannic ion
Lead	Pb^{2+}	lead(II) ion	plumbous ion
	Pb^{4+}	lead(IV) ion	plumbic ion
Gold	Au^{+}	gold(I) ion	aurous ion
	Au^{3+}	gold(III) ion	auric ion

- Anion (non-metal) – use the root of the element name, change the ending to 'ide', + 'ion':

$S \rightarrow S^{-2}$

sulfur → sulfide ion

$N \rightarrow N^{-3}$

nitrogen → nitride ion

$O \rightarrow O^{-2}$

oxygen → oxide ion

TABLE 8.2 Names for the More Common Nonmetal Ions

Element	Stem	Name of Ion	Formula
Bromine	brom-	bromide ion	Br^-
Carbon	carb-	carbide ion	C^{4-}
Chlorine	chlor-	chloride ion	Cl^-
Fluorine	fluor-	fluoride ion	F^-
Hydrogen	hydr-	hydride ion	H^-
Iodine	iod-	iodide ion	I^-
Nitrogen	nitr-	nitride ion	N^{3-}
Oxygen	ox-	oxide ion	O^{2-}
Phosphorus	phosph-	phosphide ion	P^{3-}
Sulfur	sulf-	sulfide ion	S^{2-}

Naming Binary Ionic Compounds:

- List the cation first, then the anion
- Do not include 'ion' in the name
- Names must be distinctive, in order to distinguish between similar compounds, such as with variable-charged metals

NaCl – sodium chloride

CaF_2 – calcium fluoride

FeI_2 – iron (II) iodide

FeI_3 – iron (III) iodide

For variable charged ionic compounds:

- Basically, all metals are variable charged, except for:
Group 1, Group 2, Ag^{+1}, Zn^{+2}, Cd^{+2}, Al^{+3}, Ga^{+3}

- For all other metals, the Stock System (Roman Numerals) must be used:

Cu_2O – copper (I) oxide

CuO – copper (II) oxide

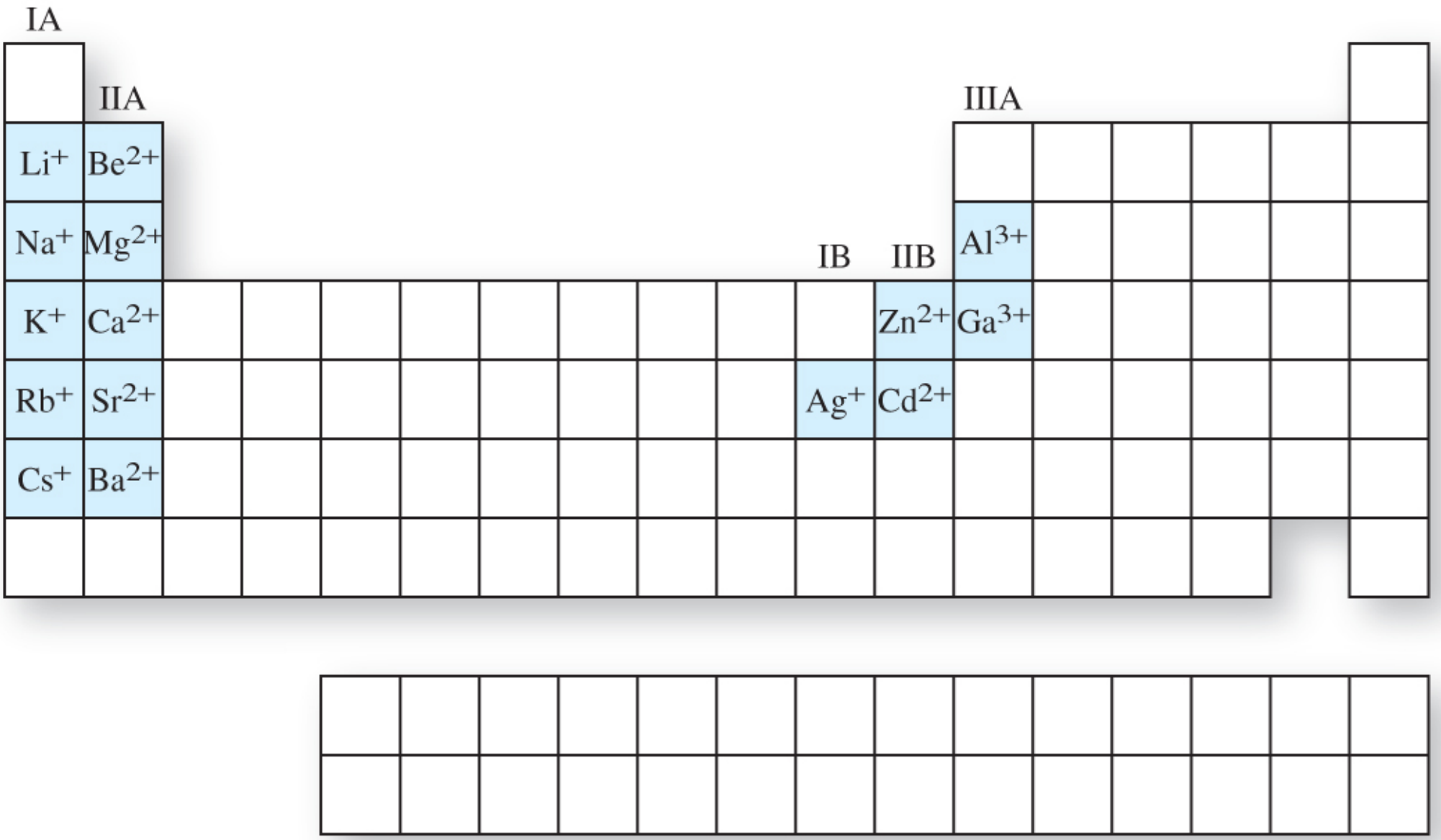

TABLE 8.1 Ionic Charges Associated with Ions of the More Common Variable-Charge Metals

Element	Ions Formed
Chromium	Cr^{2+} and Cr^{3+}
Cobalt	Co^{2+} and Co^{3+}
Copper	Cu^{+} and Cu^{2+}
Gold	Au^{+} and Au^{3+}
Iron	Fe^{2+} and Fe^{3+}
Lead	Pb^{2+} and Pb^{4+}
Manganese	Mn^{2+} and Mn^{3+}
Tin	Sn^{2+} and Sn^{4+}

To determine the charge on a variable charge cation, treat the formula as an algebraic expression:

To determine the iron charge in Fe_2O_3

- let Fe = x and O = y (x and y are ionic charges)
- the charges of the ions must add up to the overall charge, which is 0 in this case, so

$2x + 3y = 0$

- we know that y = -2 (oxide ion)

$2x + 3(-2) = 0$

$x = +3$

- so Fe_2O_3 is named iron (III) oxide

Writing formulas for binary ionic compounds:

- The formula shows a ratio of one ion to the other.
- The ionic charges must cancel out so that the overall charge is neutral
- Always list the metal first, then the non-metal
- Select subscripts to balance charges
- Reduce subscripts if needed to obtain the lowest whole number ratio between ions

Polyatomic Ions

These are covalently bonded atoms with an overall charge (an ionic molecule):

NO_3^{-1} – nitrate ion
ClO_3^{-1} – chlorate ion
$C_2H_3O_2^{-1}$ – acetate ion
OH^{-1} – hydroxide ion
SO_4^{-2} – sulfate ion
CO_3^{-2} – carbonate ion
PO_4^{-3} – phosphate ion
H_3O^{+1} – hydronium ion
NH_4^{+1} – ammonium ion (NH_3 – ammonia)

Oxyions

Polyatomic ions containing oxygen and another non-metal

- Most common forms end in 'ate'
- One less oxygen ends in 'ite'
- Two less oxygens, 'hypo' prefix and 'ite' suffix
- One more oxygen, 'per' prefix and 'ate' suffix

ClO^{-1} – hypochlorite ion

ClO_2^{-1} – chlorite ion

ClO_3^{-1} – chlorate ion

ClO_4^{-1} – perchlorate ion

TABLE 8.4 Formulas and Names of Some Common Polyatomic Ions

Key Element Present	Formula	Name of Ion
Nitrogen	NO_3^-	nitrate ion
	NO_2^-	nitrite ion
	NH_4^+	ammonium ion
	N_3^-	azide ion
Sulfur	SO_4^{2-}	sulfate ion
	HSO_4^-	hydrogen sulfate (bisulfate ion)**
	SO_3^{2-}	sulfite ion
	HSO_3^-	hydrogen sulfite (bisulfite ion)**
	$S_2O_3^{2-}$	thiosulfate ion
Phosphorus	PO_4^{3-}	phosphate ion
	HPO_4^{2-}	hydrogen phosphate ion
	$H_2PO_4^-$	dihydrogen phosphate ion
	PO_3^{3-}	phosphite ion
Carbon	CO_3^{2-}	carbonate ion
	HCO_3^-	hydrogen carbonate (bicarbonate ion)**
	$C_2O_4^{2-}$	oxalate ion
	$C_2H_3O_2^-$	acetate ion
	CN^-	cyanide ion
	OCN^-	cyanate ion
	SCN^-	thiocyanate ion
Chlorine	ClO_4^-	perchlorate ion
	ClO_3^-	chlorate ion
	ClO_2^-	chlorite ion
	ClO^-	hypochlorite ion
Oxygen	O_2^{2-}	peroxide ion
Boron	BO_3^{3-}	borate ion
Hydrogen	H_3O^+	hydronium ion*
	OH^-	hydroxide ion
Metals	MnO_4^-	permanganate ion
	CrO_4^{2-}	chromate ion
	$Cr_2O_7^{2-}$	dichromate ion

Naming Binary Molecular Compounds

- For the first element, use the elemental name
- For the second, change the ending to 'ide'
- To determine which element is listed first:
  - Lower group first
  - If both elements are in the same group, then the largest number period is first

  Exceptions:
  - Hydrogen goes between groups 15 and 16
  - Oxygen is between F and Cl, for naming order

Element	B	Si	C	Sb	As	P	N	H	Te	Se	S	I	Br	Cl	O	F
Group	IIIA	IVA		VA					VIA			VIIA				

- The formula name must indicate the subscripts
- use prefixes to show subscripts
- The prefix 'mono' is not used on the first element listed
- Remember that molecules have fixed numbers of atoms linked together, so DO NOT reduce coefficients to lower ratios

TABLE 8.5 Common Numerical Prefixes from 1 to 10

Prefix	Number
Mono-	1
Di-	2
Tri-	3
Tetra-	4
Penta-	5
Hexa-	6
Hepta-	7
Octa-	8
Nona-	9
Deca-	10

TABLE 8.6 Some Binary Molecular Compounds that Have Common Names

Compound Formula	Accepted Common Name
H_2O	water
H_2O_2	hydrogen peroxide
NH_3	ammonia
N_2H_4	hydrazine
CH_4	methane
C_2H_6	ethane
PH_3	phosphine
AsH_3	arsine

Naming Acids

- Acids are molecules that split apart in water to form H^{+1} (H_3O^{+1}) ions and an anion
- The acidic H(s) is usually listed first in the formula
- If the name of the anion formed:
  - ends in 'ide'
    - 'hydro' + stem of anion + 'ic' + 'acid'
      $HCl \rightarrow$ hydrochloric acid
  - ends in 'ate'
    - stem of anion + 'ic' + 'acid'
      $HClO_3 \rightarrow$ chloric acid
  - ends in 'ite'
    - stem of anion + 'ous' + 'acid'
      $HClO_2 \rightarrow$ chlorous acid

TABLE 8.7 The Dual Naming System for Molecular Compounds Containing Hydrogen and a Nonmetal Other Than Oxygen

Formula	Name of Pure Compound	Name of Water Solution
HF	hydrogen fluoride	hydrofluoric acid
HBr	hydrogen bromide	hydrobromic acid
HI	hydrogen iodide	hydroiodic acid
H_2S	hydrogen sulfide	hydrosulfuric acid*

**For acids involving sulfur, ur from sulfur is reinserted in the acid name for pronunciation reasons.*