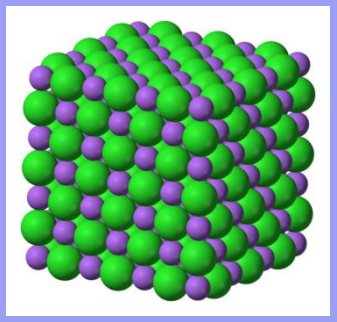
4.2 Names and Formulas of Compounds

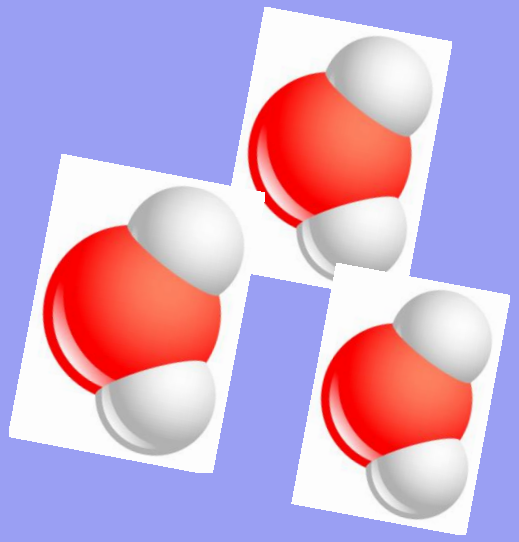
- **Ionic compounds are made up of positive and negative ions.**
  - **All of the positive and negative ions organize in a pattern.**
    - **Negative-positive attract.**
    - **Negative-negative and positive-positive repel.**
  - **Ionic compounds form from the inside out as solid crystals.**
  - **Ionic compounds are like a solid stack of bricks.**
    - **A salt shaker contains thousands of small pieces of NaCl.**



Salt, NaCl

See pages 184 - 185

- **Covalent molecules share electrons.**
  - **There is generally no order to the formation of covalent molecules.**
  - **These molecules clump together as solids, liquids or gases.**
  - **http://www.youtube.com/watch?v=NgD9yHSJ29I**



Water, H_2O

- Turn to page 185
- Get into partners
- On a seperate piece of paper complete the following
  - What to do #1-4
  - What did you find out # 1-4

  - You have 10 minutes to complete

The Chemical Name and Formula of an Ionic Compound

- **Ionic compounds are composed of positive ions and negative ions.**
  - **The name of an ionic compound = positive ion (metal) + negative ion(non mental) *-ide.***
    - ***The suffix "ide" is added on to the negative ion***
  - **For example, an ionic compound forms between magnesium and oxygen.**
    - **The positive ion is the first part of the name, magnesium.**
    - **The negative ion forms part of the ending of the name, oxygen.**
    - **Add *-ide* to the end of the name to form magnesium oxide.**

Magnesium oxide is used as a drying agent.

See pages 186 - 187

- Lets try to name some compounds
  - Pg 187 odds (a, c, e, g etc)

Table 4.5 Naming Ionic Compounds Containing Two Elements

Steps	Examples	
	CaI_2	Na_3P
1. Name the metal ion.	• The metal ion is Ca^{2+}. • The ion's name is given in the periodic table as calcium.	• The metal ion is Na^{+}. • The ion's name is given in the periodic table as sodium.
2. Name the non-metal ion by ending the element name with the suffix "ide."	• The non-metal ion is I^{-}. The element's name is iodine. • Changing the name to end with the suffix "-ide" gives iodide.	• The non-metal ion is P^{3-}. The element's name is phosphorus. • Changing the name to end with the suffix "-ide" gives phosphide.
3. Write the name of the compound.	calcium iodide	sodium phosphide

Practice Problems

Write the names of the following ionic compounds.

1. (a) Li_3N (b) $MgBr_2$ (c) Ag_2O (d) RbF (e) AgI (f) $AlBr_3$ (g) CaI_2 (h) GaI_3 (i) Ag_3N (j) MgSe (k) Ca_3P_2 (l) Na_2O (m) CdS (n) Sr_3P_2 (o) CsF

- **Ionic formulas are based on the ions of the atoms involved.**
  - **Remember the naming principles above.**
  - **For example, what is the name of Ca_3N_2?**
    - **Ca, the positive ion, is calcium.**
    - **N, the negative ion, is nitrogen.**
    - **Drop the end of the anion and add *-ide.***
    - **Calcium nitride**
- **The subscript gives the ratio of each type of ion in the compound. In ionic compounds this is always in lowest terms.**
  - **In the above example there are 3 calciums for every 2 nitrogens**
  - ********* LOWEST TERMS ONLY FOR IONIC COMPOUNDS*************

The Chemical Name and Formula of an Ionic Compound (continued)

- **Writing formulas for ionic compounds:**
  - In an ionic compound, the positive charges balance out the negative charges.
    - The overall charge will be **zero**
  - The ratio of positive:negative charges gives the proper formula.
    - The ratio is always written in reduced form.
  - For example, what is the formula for magnesium phosphide
    - Mg 2+ P3-
    - Lowest common multiple of 2 and 3 is 6
  - Try the formula for calcium oxide.

Calcium oxide, also known as "quicklime" was once produced by cooking limestone in ancient kilns.

See page 188

- calcium is Ca^{2+} oxygen is O^{2-}
- 1 Ca^{2+} ion and 1 O^{2-} ions
- Ca_2O_2, which is simplified and written as CaO

Crossover method

- **Refer to Handout**

- **Practice problems**
  - **Page 188**
    - **#1 evens**
    - **#2 odds**

Steps	Examples	
	aluminum fluoride	magnesium nitride
1. Identify each ion and its charge.	aluminum: Al^{3+} fluoride: F^-	magnesium: Mg^{2+} nitride: N^{3-}
2. Determine the total charges needed to balance positive with negative.	Al^{3+}: $= +3$ F^-: $-1\ -1\ -1 = -3$	Mg^{2+}: $+ 2 + 2 + 2 = +6$ N^{3-}: $-3\ -3 \quad = -6$
3. Note the ratio of positive ions to negative ions.	1 Al^{3+} ion for every 3 F^- ions	3 Mg^{2+} ions for every 2 N^{3-} ions
4. Use subscripts to write the formula. A "1" is not shown in the subscripts.	AlF_3	Mg_3N_2

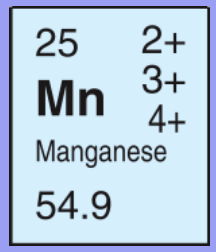
Practice Problems

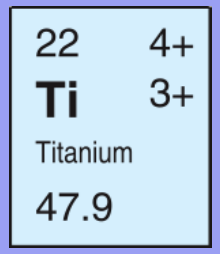
1. Write the formulas of the compounds containing the following ions.
   (a) Na^+ with Br^-
   (b) Zn^{2+} with I^-
   (c) K^+ with S^{2-}
   (d) Al^{3+} with S^{2-}
   (e) Ca^{2+} with O^{2-}
   (f) Al^{3+} with P^{3-}

2. Write the formulas of the following ionic compounds.
   (a) strontium nitride
   (b) lithium oxide
   (c) silver sulfide
   (d) barium phosphide
   (e) sodium nitride
   (f) potassium selenide
   (g) cesium sulfide
   (h) aluminum nitride
   (i) zinc oxide
   (j) aluminum iodide
   (k) lithium fluoride
   (l) sodium sulfide
   (m) zinc phosphide
   (n) magnesium chloride
   (o) rubidium bromide

Formula of an Ionic Compound with a Multivalent Metal

- Some transitional metals are multivalent, meaning they have more than one ion form.
  - On the periodic table, the most common form of the ion is listed on top.
  - In the name of the compound, **Roman numerals** are used following the positive ion to indicate which ion was used.
  - For example, what is the formula manganese (III) sulphide?
    - This manganese is Mn^{3+}. sulfur is S^{2-}





  - Try the name for TiF_4
    - titanium is Ti^{4+} or Ti^{3+} fluorine is F^-
    - 1 Ti^{4+} ion and 4 F^- ions
    - titanium (IV) fluoride

See pages 189 - 191

- Lets try some
  - Page 190
    - Practice problems
      - Evens

Table 4.9 Writing Formulas of Compounds Containing a Multivalent Metal

Steps	Examples	
	manganese(IV) sulfide	cobalt(III) oxide
1. Identify each ion and its charge.	manganese(IV): Mn^{4+} sulfide: S^{2-}	cobalt(III): Co^{3+} oxide: O^{2-}
2. Determine the total charges needed to balance positive with negative.	Mn^{4+}: $= +4$ S^{2-} : $-2\ -2 = -4$	Co^{3+}: $+\ 3\ +\ 3\ = +6$ O^{2-}: $-2\ -2\ -2 = -6$
3. Note the ratio of positive ions to negative ions.	1 Mn^{4+} ion for every 3 S^{2-} ions	2 Co^{3+} ions for every 3 O^{2-} ions
4. Use subscripts to write the formula. A "1" is not shown in the subscripts.	MnS_2	Co_2O_3

Practice Problems

1. Write the formulas of the following compounds containing multivalent metals.

(a) copper(I) nitride
(b) iron(II) phosphide
(c) manganese(II) oxide
(d) manganese(IV) oxide
(e) chromium(II) bromide
(f) chromium(III) bromide
(g) lead(IV) chloride
(h) iron(III) phosphide
(i) tin(II) sulfide
(j) tin(II) nitride
(k) tin(IV) nitride
(l) mercury(II) fluoride
(m) copper(I) iodide
(n) copper(II) iodide
(o) copper(II) selenide

- Page 191
  - Practice problems
    - odds

Table 4.10 Naming Ionic Compounds Containing a Multivalent Metal

Steps	Examples	
	Au_3N	PdS_2
1. Identify the metal.	gold (Au)	palladium (Pd)
2. Verify that it can form more than one kind of ion by checking the periodic table.	Au^+ and Au^{3+}	Pd^{2+} and Pd^{4+}
3. Determine the ratio of the ions in the formula.	Au_3N means 3 gold ions for every 1 nitride ion.	PdS_2 means 1 palladium ion for every 2 sulfide ions.
4. Note the charge of the negative ion from the periodic table.	The charge on the N^{3-} ion is 3−.	The charge on the S^{2-} ion is 2−.
5. The positive and negative charges must balance out. Determine what the charge needs to be on the metal ion to balance the negative ion.	Each of the 3 gold ions must have a charge of 1+ to balance the 1 nitride ion with a charge of 3−. Therefore the name of the gold ion is gold(I).	The 1 palladium ion must have a charge of 4+ to balance the 2 sulfide ions that each have a charge of 2−. Therefore, the name of the palladium ion is palladium(IV).
6. Write the name of the compound.	gold(I) nitride	palladium(IV) sulfide

Practice Problems

Each of these compounds contains a multivalent metal ion. That means that the name of the metal ion will contain a Roman numeral, which you will need to determine. Write the names of the following compounds.

1. (a) Fe_2O_3
(b) PbF_4
(c) FeI_2
(d) HgI_2
(e) Hg_3N_2
(f) Sn_3P_4
(g) MnS
(h) MnS_2
(i) VCl_5
(j) Ni_2S_3
(k) NiS
(l) Mo_2O_3
(m) UCl_6
(n) ReF_7
(o) TiS_2

Polyatomic Ions

- **Some ions, called polyatomic ions, are made up of several atoms joined together with covalent bonds.**
  - **The whole group has a + or − charge, not the individual atoms.**
  - **What is the formula of sodium sulphate?** Na^+ and SO_4^{2-} Na_2SO_4
  - **What is the name of the compound KClO?** K^+ = potassium ClO^- = hypochlorite

potassium hypochlorite

Table 4.11 Names, Formulas, and Charges of Some Polyatomic Ions

Positive Ions	Negative Ions		
NH_4^+ ammonium	CH_3COO^- acetate	HCO_3^- hydrogen carbonate, bicarbonate	NO_2^- nitrite
	CO_3^{2-} carbonate	HSO_4^- hydrogen sulfate, bisulfate	ClO_4^- perchlorate
	ClO_3^- chlorate	HS^- hydrogen sulfide, bisulfide	MnO_4^- permanganate
	ClO_2^- chlorite	HSO_3^- hydrogen sulfite, bisulfite	PO_4^{3-} phosphate
	CrO_4^{2-} chromate	OH^- hydroxide	PO_3^{3-} phosphite
	CN^- cyanide	ClO^- hypochlorite	SO_4^{2-} sulfate
	$Cr_2O_7^{2-}$ dichromate	NO_3^- nitrate	SO_3^{2-} sulfite

See pages 192 - 193

Lets Practice

- **Page 193**
  - **#1 Evens**
  - **#2 Odds**

Table 4.12 Writing the Formula of a Compound with Polyatomic Ions

Steps	Examples	
	manganese(III) chlorate	ammonium sulfate
1. Identify each ion and its charge.	manganese(III): Mn^{3+} chlorate: ClO_3^-	ammonium: NH_4^+ sulfate: SO_4^{2-}
2. Determine the total charges needed to balance positive with negative.	Mn^{3+}: $= +3$ ClO_3^-: $-1\ -1\ -1 = -3$	NH_4^+: $+1\ +1 = +2$ SO_4^{2-}: $= -2$
3. Note the ratio of positive ions to negative ions.	1 Mn^{3+} ion for every 3 ClO_3^- ions	2 NH_4^+ ions for every 1 SO_4^{2-} ion
4. Use brackets around ions to correctly show the ratio of ions.	$(Mn)(ClO_3)_3$	$(NH_4)_2(SO_4)$
5. Use subscripts and brackets to write the formula. Omit brackets if only one ion is needed.	$Mn(ClO_3)_3$	$(NH_4)_2SO_4$

Practice Problems

Refer to Table 4.11, Names, Formulas, and Charges of Some Polyatomic Ions, as you do these problems.

1. Write the names of the following compounds with polyatomic ions.

(a) KCH_3COO
(b) $Ca(CH_3COO)_2$
(c) $(NH_4)_3P$
(d) $(NH_4)_3PO_4$
(e) $Al(OH)_3$
(f) $Fe(OH)_3$
(g) K_2CrO_4
(h) $K_2Cr_2O_7$
(i) $Ca(HCO_3)_2$
(j) $Mg_3(PO_4)_2$

2. Write the formulas of the following compounds with polyatomic ions.

(a) potassium permanganate
(b) sodium chromate
(c) ammonium nitrate
(d) lithium hydroxide
(e) aluminum hydroxide
(f) lead(II) perchlorate
(g) iron(III) hydrogen sulfide
(h) vanadium(V) nitrate
(i) magnesium acetate
(j) tin(II) cyanide

Names and Formulas of Covalent Compounds

- **Covalent compounds, also called molecules, rely on the chemical formula to reveal the components of the molecule.**

  - **Covalent compounds are made up of two or more non-metals.**
  - **Names may reveal the components, but often they do not.**
  - **Subscripts mean something different in covalent compounds**
    - **Ionic compounds subscripts show the smallest whole-number ratio between the ions in the compound.**
    - **Covalent molecules have subscripts that show the actual number of atoms in the molecule.**

  - **Nitrogen monoxide vs dinitrogen dioxide**

See page 193

Naming Binary Covalent Compounds

- **Binary covalent compounds (two non-metal atoms) use a system of prefixes.**
  - Covalent compounds may have many or few atoms sharing electrons.
    - CH_4 = methane and $C_{25}H_{52}$ = candle wax
  - Prefixes are often used before the atom name to indicate the number of atoms in the molecule.
  - If there is only one of the first atom, no prefix is needed (ONLY FOR FIRST ATOM)
    - CO = carbon monoxide, CO_2 = carbon dioxide
  - Write the most metallic atom (farthest left) first
    - Add *-ide* to theend of the second atom's name
  - What is the chemical formula for the molecule trinitrogen tetrachloride?
    - N_3Cl_4
  - What is the name of the molecule Si_3P_6?
    - Trisilicon hexaphosphide

Table 4.13 Prefixes Used in Naming Binary Covalent Compounds

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

See pages 194 - 195

Practice

- Page 195
  - # 1 Evens
  - #2 Odds

Table 4.14 Writing the Names of Binary Covalent Compounds

Steps	Examples	
	CO	N_2O_3
1. Name the left most element in the formula first.	• The first element is C (carbon).	• The first element is N (nitrogen).
2. Name the second element, making sure the element name ends with the suffix "ide."	• The second element is O (oxygen). • It becomes oxide.	• The second element is O (oxygen). • It becomes oxide.
3. Add a prefix to each element's name to indicate the number of atoms of each element in the compound. Exceptions to rule 3: • If the first element has only one atom, do *not* add a prefix. • The prefix "mono-" is shortened to "mon-" if it is placed before "oxide."	• Do not use a prefix when there is only one atom of the first element. • The compound's name is carbon monoxide.	• There are two (di-) nitrogen atoms and three (tri-) oxygen atoms. • The compound's name is dinitrogen trioxide.

Table 4.16 Hints for Writing Names of Binary Covalent Compounds

Formula	Name	Hints for Writing Names
CS_2	carbon disulfide	Do not use a prefix when there is only one atom of the first element.
CCl_4	carbon tetrachloride	Do not use a prefix when there is only one atom of the first element.
P_4O_{10}	tetraphosphorus decaoxide	Do not reduce the name to diphosphorus pentoxide.

Practice Problems

1. Write the names of the following compounds.
   (a) N_2O
   (b) CO_2
   (c) PI_3
   (d) PCl_5
   (e) SO_2
   (f) N_2O_4
   (g) P_4S_{10}
   (h) S_2F_{10}
   (i) NI_3
   (j) NO
2. Write the formulas of the following compounds.
   (a) nitrogen tribromide
   (b) sulfur hexafluoride
   (c) dinitrogen tetrasulfide
   (d) oxygen difluoride
   (e) carbon tetraiodide
   (f) sulfur trioxide
   (g) phosphorus pentabromide
   (h) diiodine hexachloride
   (i) dichlorine monoxide
   (j) xenon hexafluoride

Comparing Ionic and Covalent Compounds

- **To determine whether a compound is ionic or covalent:**
  1. **Examine the formula.**
     - **Ionic compounds start with a metal or the ammonium ion.**
     - **Covalent compounds start with a non-metal.**
  2. **If the compound is ionic:**
     - **Check the metal to see if it is multivalent (add a Roman numeral if it is multivalent). Naming starts with the name of the metal atom.**
     - **If it ends with a single non-metal, naming will just end in *-ide.***
     - **If it ends in a polyatomic ion, look up the name/formula.**
  3. **If the compound is covalent:**
     - **Use the prefix system of naming if the compound is binary and does not start with hydrogen.**
     - **If there are more than two different elements, or it starts with H, there is probably a different, simpler name for the covalent molecule.**

See pages 196 - 197

Take the Section 4.2 Quiz

Practice

- **Page 197**
  - **#1 Evens**
  - **#2 Odds**

Practice Problems

1. Identify each of the following compounds as either ionic or covalent.
   (a) $(NH_4)_2S$
   (b) OCl_2
   (c) $SnCl_2$
   (d) $NaNO_3$
   (e) N_2O_3
   (f) SCl_2
   (g) NBr_3
   (h) FeF_2

2. The compounds in each group below have similar–looking formulas. However, they may have very different names. Some in each group are ionic, while others are covalent. Classify and name each compound.
   (a) VO_2
   NO_2
   (b) $CrBr_2$
   $CdBr_2$
   SBr_2
   (c) $Na_2Cr_2O_7$
   Na_2CrO_4
   Cr_2O_3
   N_2O_3
   (d) SO_3
   Li_2SO_3
   Li_2SO_4
   SO_2
   (e) OCl_2
   BeF_2
   FeF_2
   (f) CO_2
   $NaHCO_3$
   $PbCO_3$

HOMEWORK

- **Workbook Questions.....** ☺
- **68-71, 73**