Ionic and Covalent Compounds

$$\text{metal} + \text{metal} \longrightarrow \text{metal}$$

$$\text{non-metal} + \text{non-metal} \longrightarrow \text{non-metal or covalent molecule}$$

$$\text{metal} + \text{non-metal} \longrightarrow \text{ionic salt}$$

The periodic table can be used to predict the formulas for ionic compounds and the structure of covalent molecules. In molecules, every non-metallic element has a preferred number of bonds. The following periodic table is labeled to show the rules for both types of compounds, based on the column of the table each element is in.

												Ideal number of bonds					
1 (H only)												4	3	2	1	0	
H																He	
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
+1	+2	+?	+?	+?	+?	+?	+?	+?	+?	+?	+?	+3	–	-3	-2	-1	0

Charges in Ionic Compounds

Polyatomic Ions

In addition to simple binary ionic compounds (combinations of a single type of metal with a single type of non-metal), ionic compounds can also contain polyatomic ions. Polyatomic ions are a covalently-bonded combination of atoms that has a charge and acts as a single unit. For example, baking soda is sodium bicarbonate and contains sodium ions (Na^{+1}) and bicarbonate ions (HCO_3^{-1}) in a 1:1 ratio, $NaHCO_3$.

Common Polyatomic Ions

Name	**Formula**		**Name**	**Formula**		**Name**	**Formula**
Hydroxide	OH^{-1}		Phosphate	PO_4^{-3}		Nitrate	NO_3^{-1}
Carbonate	CO_3^{-2}		Perchlorate	ClO_4^{-1}		Nitrite	NO_2^{-1}
Bicarbonate	HCO_3^{-1}		Chlorate	ClO_3^{-1}		Ammonium	NH_4^{+1}
Sulfate	SO_4^{-2}		Chlorite	ClO_2^{-1}		Acetate	CH_3COO^{-1}
Sulfite	SO_3^{-2}		Hypochlorite	ClO^{-1}			

Sample Problems

1. Determine the expected formulas for each of the following molecules.

   (a) Li and Cl
   (b) Li and O
   (c) Ca and Br
   (d) Mg and O
   (e) Al and O
   (f) Li and sulfate
   (g) Mg and nitrate
   (h) Ca and phosphate

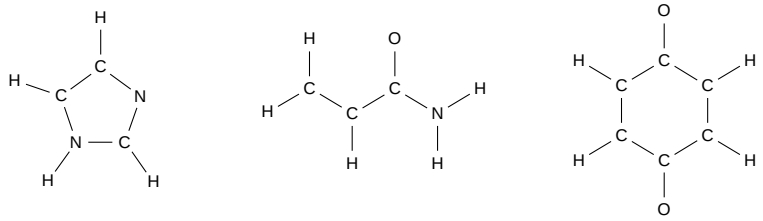
2. Determine the charge of the metal in the following molecules.

   (a) $ReBr_3$
   (b) $TiCl_4$
   (c) WO_3
   (d) Nb_2S_5
   (e) $RuPO_4$
   (f) $Ti(OH)_4$
   (g) $Co_2(SO_4)_3$
   (h) $Cu_3(PO_4)_2$

3. Draw reasonable structures for each of the following molecules.

   (a) CCl_4
   (b) CH_2O
   (c) $HClO$
   (d) C_2H_4
   (e) HCN
   (f) N_2H_2
   (g) N_2H_4

4. Add the necessary bonds to complete the following structures.



5. Add the necessary H atoms to complete the following structures.

Answers to Sample Problems

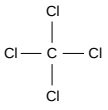
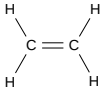
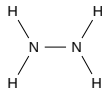
1. Expected formulas.

   (a) $LiCl$
   (b) Li_2O
   (c) $CaBr_2$
   (d) MgO
   (e) Al_2O_3
   (f) Li_2SO_4
   (g) $Mg(NO_3)_2$
   (h) $Ca_3(PO_4)_2$

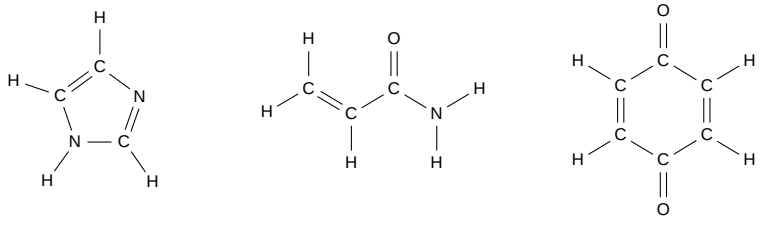
2. Charges of metals.

   (a) Re = +3 in $ReBr_3$
   (b) Ti = +4 in $TiCl_4$
   (c) W = +6 in WO_3
   (d) Nb = +5 in Nb_2S_5
   (e) Ru = +3 in $RuPO_4$
   (f) Ti = +4 in $Ti(OH)_4$
   (g) Co = +3 in $Co_2(SO_4)_3$
   (h) Cu = +2 in $Cu_3(PO_4)_2$

3. Draw reasonable structures for each of the following molecules.

   (a) 
   (b) 
   (c) H–O–Cl
   (d) 
   (e) H–C≡N
   (f) H–N=N–H
   (g) 

4. Add the necessary bonds to complete the following structures.



5. Add the necessary H atoms to complete the following structures.