Compounds (structure and naming)

Compounds

Ionic (made of ions)
Composed of a Metal (left side) and a Nonmetal (right side)
One element from the left side and one from the right side of the Periodic Table
NaCl or MgF₂

On the left side of Periodic Table they lose electrons (become +)
On the right side of Periodic Table they receive electrons (become -)

H is on left side but is nonmetal – sometimes acts like H⁺ and sometimes like H⁻

Covalent (made of molecules or networks of atoms)
Composed of a Nonmetal and a Nonmetal
Both come from right side of periodic table
NO₂ or HCl (H on left side but is a nonmetal)

Compounds can be decomposed into elements
Compounds are composed of two or more types of atoms
Molecules are collection of atoms that are building blocks of some compounds

The fantastic knowledge that comes from Chemistry is used
to both understand the world and for many practical applications

Chemical Formulas (some common examples given below)

<table>
<thead>
<tr>
<th>Chemical Formula</th>
<th>Name</th>
<th>Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>O₂</td>
<td>Oxygen gas</td>
<td>Necessary for animal life</td>
</tr>
<tr>
<td>CO</td>
<td>Carbon monoxide</td>
<td>Prevents you from getting O₂ because CO binds to Fe in the Hemoglobin (in red blood cells)</td>
</tr>
<tr>
<td>CO₂</td>
<td>Carbon dioxide</td>
<td>Necessary for plant life to produce sugars</td>
</tr>
<tr>
<td>CH₄</td>
<td>Methane gas</td>
<td>Natural gas, burn for energy</td>
</tr>
<tr>
<td>H₂O</td>
<td>Water</td>
<td>need for living things</td>
</tr>
<tr>
<td>C₆H₁₂O₆</td>
<td>Fructose</td>
<td>One type of sugar made by plants from CO₂ and H₂O</td>
</tr>
<tr>
<td>Chemical Formula</td>
<td>Substance</td>
<td>Notes</td>
</tr>
<tr>
<td>------------------</td>
<td>--------------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>C₆H₁₂O₆</td>
<td>Glucose (same formula different molecule)</td>
<td>Sugar commonly used for energy by human body</td>
</tr>
<tr>
<td>CH₃OH</td>
<td>Methanol</td>
<td>Type of alcohol that can cause blindness or death if ingested</td>
</tr>
<tr>
<td>C₂H₅OH</td>
<td>Ethanol</td>
<td>Type of alcohol found in all alcoholic beverages</td>
</tr>
</tbody>
</table>

American Chemical Society keeps track of all compounds assigns each a special number called registry number. Over 20 million known compounds are known.

Chemical Reaction shown by balanced chemical equation

Burning natural gas:

\[
\text{Methane} + \text{Oxygen} \rightarrow \text{Carbon Dioxide} + \text{Water}
\]

\[
\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}
\]

The number preceding the compound is known as the coefficient.

Lighter flame:

\[
\text{Butane} + \text{Oxygen} \rightarrow \text{Carbon Dioxide} + \text{Water}
\]

\[
2\text{C}_4\text{H}_{10} + 13\text{O}_2 \rightarrow 8\text{CO}_2 + 10\text{H}_2\text{O}
\]

The equation is balanced if the number of atoms on left (reactants) and right (products) are the same.

(Reactants) (Products) for butane lighter reaction

\[
\begin{array}{ccc}
8 & \text{C} & 8 \\
20 & \text{H} & 20 \\
36 & \text{O} & 36
\end{array}
\]

Matter and Changes

Chemistry is study of matter and changes matter can undergo

Change:

1) Physical Change – identity is the same but properties different
   - Ex: separate mixture – divide sugar and salt
   - Change state – ice \( \rightarrow \) water \( \rightarrow \) steam
   - Do NOT create new chemical species

2) Chemical Change – create new chemical species
   \( 2\text{H}_2\text{O} \rightarrow \text{H}_2 + \text{O}_2 \)

Strike match – chemical change
Break a match – physical change
Dissolve table sugar – physical change
sucrose molecules($C_{12}H_{22}O_{11}$) spread out in water
Dissolve table salt – chemical change
$NaCl \rightarrow Na^+ + Cl^-$ ions form and spread out in water

Matter:
Mixture (more than one substance mixed together)
1) Homogenous – same throughout
   ex: salt water is same throughout
2) Heterogeneous – not same everywhere
   ex: oil-water has two different layers

Pure Substance (same composition and proportion of elements)
1) Pure element such as $Na, Cl_2, H_2, O_2$
2) Pure compound such as $NaCl$ or $H_2O$ or $C_6H_{12}O_6$

Matter and Change:
elements can be combined to make compound
compound can be decomposed to produce elements
compounds can be combined to produce new compounds

Naming Scheme

Ionic Compounds can be either cations (left) + or anions (right) –
Cations can be either
monatomic with either a unique or variable charge
polyatomic

Anions then can be either
monatomic (ide ending)
polyatomic with either (ide ending ) or if with oxygen (ate, ite)

Covalent Compounds Nomenclature
(left) either monatomic or polyatomic
(right) either monatomic or polyatomic

Cation (+ ion)
Monatomic ion:
Unique charge
One type of cation refer to name of metal
$Na^+$ Sodium
Mg$^{2+}$ Magnesium  
Al$^{3+}$ Aluminum  
need to know that always Group IA (group 1) = +1   Group IIA (group 2) = +2   Al = +3

Variable Charge – More than one type of cation

<table>
<thead>
<tr>
<th>Cation</th>
<th>Modern</th>
<th>Old</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cu$^+$</td>
<td>Copper (I)</td>
<td>Cuprous</td>
</tr>
<tr>
<td>Cu$^{2+}$</td>
<td>Copper (II)</td>
<td>Cupric</td>
</tr>
<tr>
<td>Fe$^{2+}$</td>
<td>Iron (II)</td>
<td>Ferrous</td>
</tr>
<tr>
<td>Fe$^{3+}$</td>
<td>Iron (III)</td>
<td>Ferric</td>
</tr>
</tbody>
</table>

Expected to know modern scheme and just be aware of old system.  
Modern system uses Roman number to designate charge.  
Older system uses latin names and ous = lower and ic =higher endings for higher and lower of two possible charges.

Polyatomic
Cation atoms held together by covalent bonds but have overall positive charge

NH$_4^+$ Ammonium  
Hg$_2^{2+}$ Mercury (I) Mercurous  
H$_3$O$^+$ Hydronium

Anions

Monatomic  
replace ending of nonmetal with ide

Cl$^-$ Chloride  
O$_2^-$ Oxide  
N$^{3-}$ Nitride  
S$^{2-}$ Sulfide

Know  
VIIA (group 17) = -1 (can include H as sometimes acts like H$^+$)  
VIA (group 16) = -2  
VA (group 15) = -3
Polyatomic

CN¹⁻ Cyanide
OH⁻ Hydroxide
O₂²⁻ Peroxide

Other polyatomic with oxygen end with ate or ite

ClO⁴⁻ Perchlorate
ClO³⁻ Chlorate
ClO²⁻ Chlorite
ClO⁻ Hypochlorite

NO₃⁻ Nitrate
NO₂⁻ Nitrite

Learn Common Polyatomic Ions in textbook

Naming Examples
Ammonium sulfide   (NH₄)₂S
Iron (III) oxide     Fe₂O₃
Iron (II) oxide      FeO
Copper (II) cyanide  Cu(CN)₂

* Use parenthesis if more than one polyatomic ion

THINK IONS
see this Al₂O₃ and think of the ions Al³⁺  O²⁻ name aluminum oxide
see this Na₂O and think of the ions Na⁺  O²⁻ name sodium oxide
see this Cu(NO₃)₂ and think of ions Cu²⁺ NO₃⁻ name copper(II) nitrate
see this copper(II) nitrate and think of ions Cu²⁺ CN⁻ and then write Cu(CN)₂
Name does not give combining ratio – have to determine from ion charges!

Naming with hydrogen
(H is nonmetal but often named as if H⁺ cation)

H₂S   hydrogen sulfide
HCl   hydrogen chloride
HBr   hydrogen bromide
H₂O₂  hydrogen peroxide O₂⁻⁻  peroxide named like ionic
PCl₅  phosphorous pentachloride
UF₆   uranium hexafluoride (some metal-nonmetals are more covalent than ionic)
HClO₄ hydrogen perchlorate (hydrogen like positive ion)
HClO₃ hydrogen chlorate
HClO₂ hydrogen chlorite
HClO  hydrogen hypochlorite

HNO₃  hydrogen nitrate
HNO₂  hydrogen nitrite
H₂SO₄  hydrogen sulfate
H₂SO₃  hydrogen sulfite
H₃N  hydrogen nitride

LiH  lithium hydride (ionic: hydrogen like negative ion)

**Binary Covalent Compounds Nomenclature**
These are made of nonmetals

**Systematic**
Use Greek prefixes if more than one atom

1 – mono (omit for first element, omit for second if only one possibility)
2 – di
3 – tri
4 – tetra
5 – penta
6 – hexa
7 – hepta
8 – octa
9 – nona
10 – deca

Add ide ending on second element (name like ion)

O₂F₂  dioxygen diflouride
HCL  hydrogen chloride
NO  nitrogen monoxide  (old name: nitric oxide)
N₂O  dinitrogen monoxide  (old name: nitrous oxide)
NO₂  nitrogen dioxide
N₂O₃  dinitrogen trioxide
N₂O₅  dinitrogen pentoxide  (drop final o or a in prefix if element begins with vowel)

**Trivial Names**

H₂O  water
NH₃  ammonia
N₂H₄  hydrazine
PH₃  phospine
Acid Nomeclature
Naming Inorganic Acids
these names are used only if compound dissolved in water to make acid
Acid – releases $H^+$ ion (attaches to water to form $H_3O^+$ hydronium)

Acids without Oxygen
Binary or binary related acids hydro___ic acid
Ex:

<table>
<thead>
<tr>
<th>Compound Name</th>
<th>Acid Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCl</td>
<td>hydrochloric</td>
</tr>
<tr>
<td>H$_2$S</td>
<td>hydrosulfuric</td>
</tr>
<tr>
<td>HCN</td>
<td>hydrocyanic</td>
</tr>
</tbody>
</table>

Acids WITH Oxygen
Tenary oxoacids
Compounds ending acid ending
ate ------------------ ic
ite ------------------ ous

Ex:

<table>
<thead>
<tr>
<th>Compound Name</th>
<th>Acid Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>HClO$_4$</td>
<td>perchloric</td>
</tr>
<tr>
<td>HClO$_3$</td>
<td>chloric</td>
</tr>
<tr>
<td>HClO$_2$</td>
<td>chlorous</td>
</tr>
<tr>
<td>HCl</td>
<td>hypochlorous</td>
</tr>
<tr>
<td>H$_2$SO$_4$</td>
<td>sulfurous</td>
</tr>
<tr>
<td>H$_2$SO$_3$</td>
<td>sulfurous</td>
</tr>
<tr>
<td>HNO$_3$</td>
<td>nitric</td>
</tr>
<tr>
<td>HNO$_2$</td>
<td>nitrous</td>
</tr>
<tr>
<td>HC$_2$H$_3$O$_2$</td>
<td>acetic</td>
</tr>
<tr>
<td>H$_2$CO$_3$</td>
<td>carbonic</td>
</tr>
<tr>
<td>H$_3$BO$_3$</td>
<td>boric</td>
</tr>
<tr>
<td>HIO$_2$</td>
<td>iodous</td>
</tr>
</tbody>
</table>
Naming review and everyday uses

Examples:

NaCl  sodium chloride (table salt, used in solutions for contact lens)
ZnO  zinc oxide (used in some sunscreens and diaper rash ointment)
NaF  sodium fluoride (active ingredient in toothpaste)
SeS  selenium sulfide (in selsium blue shampoo)
NaNO₂ sodium nitrite (preservation in meat such as bacon)
NaClO sodium hypochlorite (bleach)
N₂O  dinitrogen oxide (laughing gas used for some dental work)
NaHCO₃ sodium bicarbonate (baking soda)

Look on boxes or bottles used around your home
and see if you recognize names of the inorganic ingredients.