Compounds, Bonds, and Nomenclature

Compounds

- Composed of more than one type of atom chemically bonded.
- A pure substance, meaning its properties are the same throughout the substance.
- Separated chemically not physically
- No overall charge; they are electrically neutral.
- Total number of protons equals the total number of electrons.

» "The atoms in compounds combine in simple whole number ratios."

» "In chemical reactions, atoms are combined, separated, or rearranged."

John Dalton's Atomic Theory

Molecular Formula

- Identifies which atoms and how many of these atoms will be found in each molecule.
- The atomic symbols identify the atoms and a subscript will identify the number of that atom.

Molecular Formula Example 1

- H_2O → Water
- 2 hydrogen atoms and 1 oxygen atom.
- Since there is only 1 oxygen atom a 1 will not be written.

Molecular Formula Example 2

- H_2SO_4 → Sulfuric acid
- 2 hydrogen atoms, 1 sulfur atom and 4 oxygen atoms.

Ions

- An ion is an atom or group of atoms with an uneven number of protons and electrons.
- This particle is charged.
- Uneven number of protons and electrons.
- Ions with a positive charge are named cations and ions with a negative charge are named anions.

Ion Example

- Sodium Chloride
- The sodium atom gives its electron to the chlorine atom.
- The atoms were neutrally charged, with equal protons and neutrons.
- Sodium has one more proton than electrons and the chlorine has one more electron than protons.
- The charge of the sodium is +1, and the chlorine is –1; each is now called an ion. The symbols for these ions are Na^+ and Cl^-. The charge is indicated by a plus or minus and a number superscripted. The number 1 is not written, if there is a charge written 1 is assumed unless another number is written.

- The charge of the sodium is +1

- The charge of the chlorine is –1

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Ion Example Cont

Polyatomic Ion

- Composed of many atoms - the overall particle is charged.
- An example: Phosphate Ion → PO_4^{-3}
- This ion has 3 more total electrons than it does protons.
- Total of 47 protons, which means there must be 50 electrons.

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Formula	Name	Formula	Name
NO_3^-	Nitrate	ClO_4^-	perchlorate
NO_2^-	Nitrite	ClO_3^-	chlorate
CrO_4^{2-}	Chromate	ClO_2^-	chlorite
$Cr_2O_7^{2-}$	Dichromate	ClO^-	hypochlorite
CN^-	Cyanide	IO_4^-	periodate
SCN^-	Thiocyanate	IO_3^-	iodate
MnO_4^-	Permanganate	IO_2^-	iodite
OH^-	Hydroxide	IO^-	hypoiodite
O_2^{2-}	Peroxide	BrO_4^-	perbromate
NH_2^-	Amide	BrO_3^-	bromate
SO_4^{2-}	Sulfate	BrO_2^-	bromite
SO_3^{2-}	Sulfite	BrO^-	hypobromite
PO_3^{3-}	Phosphite	CO_3^{2-}	carbonate
PO_4^{3-}	Phosphate	HCO_3^-	hydrogen carbonate
HPO_4^{2-}	hydrogen phosphate	HSO_4^-	hydrogen sulfate
$H_2PO_4^-$	dihydrogen phosphate	HSO_3^-	hydrogen sulfite
$C_2H_3O_2^-$	Acetate	HS^-	hydrogen sulfide
CH_3COO^-	Acetate	NH_4^+	ammonium

Common Polyatomic Ion

Ionic Bonds

- Occur between a cation and an anion.
- The molecule is formed because of the electrostatic attractive forces of the positive and negative ions
- The overall charge for the molecule is zero. Meaning the positive charge must cancel out the negative charge.
- Ionic bonds form between metals and nonmetals.

» If the difference in electronegativity is greater than 1.9, the bond is considered ionic.

Electronegativity Values for the Elements

<1.0	2.0 – 2.4
1.0 – 1.4	2.5 – 2.9
1.5 – 1.9	3.0 – 4.0

1 H 2.1																
3 Li 1.0	4 Be 1.5											5 B 2.0	6 C 2.5	7 N 3.0	8 O 3.5	9 F 4.0
11 Na 1.0	12 Mg 1.2											13 Al 1.5	14 Si 1.8	15 P 2.1	16 S 2.5	17 Cl 3.0
19 K 0.9	20 Ca 1.0	21 Sc 1.3	22 Ti 1.4	23 V 1.5	24 Cr 1.6	25 Mn 1.6	26 Fe 1.7	27 Co 1.7	28 Ni 1.8	29 Cu 1.8	30 Zn 1.6	31 Ga 1.7	32 Ge 1.9	33 As 2.1	34 Se 2.4	35 Br 2.8
37 Rb 0.9	38 Sr 1.0	39 Y 1.2	40 Zr 1.3	41 Nb 1.5	42 Mo 1.6	43 Tc 1.7	44 Ru 1.8	45 Rh 1.8	46 Pd 1.8	47 Ag 1.6	48 Cd 1.6	49 In 1.6	50 Sn 1.8	51 Sb 1.9	52 Te 2.1	53 I 2.5
55 Cs 0.8	56 Ba 1.0	57 La 1.1	72 Hf 1.3	73 Ta 1.4	74 W 1.5	75 Re 1.7	76 Os 1.9	77 Ir 1.9	78 Pt 1.8	79 Au 1.9	80 Hg 1.7	81 Tl 1.6	82 Pb 1.7	83 Bi 1.8	84 Po 1.9	85 At 2.1
87 Fr 0.8	88 Ra 1.0	89 Ac 1.1														

Electronegativity

- Covalent bonds are formed between two nonmetals.
- Every one of the halogens bonds to itself to form a diatomic atom.
- The molecule F_2 is a classic example of a covalent bond.

Covalent Bonds

» An oxidation number is the charge that an ion is carrying.

	+1	+2											+3	+/-4	-3	-2	-1	0
	1	2											13	14	15	16	17	18
	1A	2A											3A	4A	5A	6A	7A	8A
1	1 H																	2 He
2	3 Li	4 Be	3	4	5	6	7	8	9	10	11	12	5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg	3B	4B	5B	6B	7B	8B	8B	8B	1B	2B	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	*57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	82 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	*89 Ac	104 Rf	105 Ha	106 Sg	107 Ns	108 Hs	109 Mt	110 Ds								

Electronegativity›

NaCl

- Oxidation number of sodium ion is +1
- Oxidation number of chlorine atom is -1.

$MgCl_2$

- Magnesium has an oxidation number of +2
- Chlorine’s oxidation number is -1.

Electronegativity Examples

	Element(s)	Oxidation #	Exceptions
6	Group I	+1	None
7	Group II	+2	None
8	F	-1	None
9	H (with metals and B)	-1	None
10	H (with non-metals)	+1	None
11	O	-2	-1 in peroxides or with F
12	Halogens (group VII)	-1	with oxygen or halogens higher in column

Special Rules

- $AlCl_3$ is an ionic compound.
  - Al is a metal
  - Cl is a non-metal
- Al^{+3}: The Al atom will form a +3 ion
- Cl^{-}: The Cl will form a -1 ion.
- The Al has a +3 charge we will need 3 Cl ions.

- So, the oxidation number of Al is +3 and the oxidation number of Cl is -1.

Oxidation Examples

- The oxidation number for an element in its elemental form is 0. This holds true for isolated atoms and elemental substances that bond identical atoms: e.g. Cl_2 or S_8.
- The oxidation number of a monatomic ion is the same as its charge. For example, the oxidation number of Na^+ is $^+1$, and that of S^{-2} is $^-2$.
- In binary compounds, a compound composed of two different elements, the element with greater electronegativity is assigned a negative oxidation number equal to its charge in simple ionic compounds of the element.

Oxidation Rules

» The sum of the oxidation numbers is zero for an electrically neutral compound. For example, water has no overall charge.

» The sum of the oxidation numbers of a polyatomic ion equals the overall charge for the polyatomic ion. For example, the sum of phosphorous and oxygen in the polyatomic ion PO_4^{-3} must total $^{-}3$.

Oxidation Rules

Oxidation Rules

- Alkali metals exhibit only an oxidation state of $^{+}1$ in compounds.
- Alkaline earth metals exhibit only an oxidation state of $^{+}2$ in compounds.
- Fluorine always has a -1 oxidation number within compounds.
- Oxygen always has an oxidation number of $^{-}2$, with 2 exceptions:
  - 1) when it is in the form of peroxide where the oxidation number is $^{-}1$
  - 2) it takes on whatever number it must when in a compound with fluorine, which is always $^{-}1$.

- All halogens, besides fluorine, have a $^{-}1$ oxidation number in compounds, except when with oxygen or other halogens where their oxidation numbers can be positive.

- Hydrogen is always assigned a $^{+}1$ oxidation number in compounds, except when it is in a hydride form, where its charge is $^{-}1$.

Oxidation Rules

» The naming of compounds is referred to as nomenclature.

» The nomenclature of all types of bonds are different.

» Simple ionic compounds, those compounds consisting of only two elements, are referred to as binary compounds.

Nomenclature of Molecules

- The nomenclature for molecular compounds is very easy if you know the meanings of the following Latin prefixes.
- Add the suffix "ide" to the second element.

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

Formula	Name
CO	carbon monoxide
PCl_5	phosphorous pentachloride
N_2O_5	dinitrogen pentaoxide
SF_6	sulfur hexafluoride

Nomenclature of Molecules