###### Unit 5: Bonding and Inorganic Nomenclature

 **Chemical Bonding**

* ***Ionic Bonds***: atoms give up or gain e– and are attracted to each other by coulombic attraction

Na loses an e– Cl gains an e–

Na 🡪 Na1+ + e– Cl + e– 🡪 Cl1–

ionic compounds = salts Na1+ + Cl1– 🡪 NaCl

K1+ + NO31– 🡪 KNO3

where NO31– is a polyatomic ion: a charged group of

atoms that stay together

***Properties of Salts***

 1. very hard – each ion is bonded to several

 oppositely-charged ions

 2. high melting points – many bonds must be

broken

3. brittle – with sufficient force, like atoms are

brought next to each other and repel

* ***Covalent Bonds***

 …atoms share e– to get a full valence shell

 C 1s2 2s2 2p2 (4 v.e–)

 F 1s2 2s2 2p5 (7 v.e–)

 both need 8 v.e– for a full outer shell (octet rule)

Lewis structure: a model of a covalent molecule that

shows all of the valence e–

1. Two shared e– make a single covalent bond, four

make a double bond, etc.

2. unshared pairs: pairs of unbonded valence e–

3. Each atom needs a full outer shell, i.e., 8 e–.

Exception: H needs 2 e–

carbon tetrafluoride (CF4)

**o**

C

**o**

 **o**

 **o**

**x**

**x**

**x**

**x**

**x**

**x**

F

 **x**

**o**

C

**o**

**o**

 **o**

**x**

**x**

**x**

**x**

**x**

**x**

F

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**x**

**x**

F

 **x**

 **x**

**x**

**x**

**x**

**x**

F

 **x**

 **x**

methane (CH4)

C

H

H

H

H

**x**

H

**o**

C

**o**

**o**

 **o**

H

 **x**

 **x**

H

**x**

H

**x**

H

**o**

C

**o**

 **o**

 **o**

nitrogen triiodide (NI3)

**o**

N

**x**

**x**

**x**

**x**

**x**

**x**

I

**x**

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**x**

I

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**o**

**x**

**x**

**x**

**x**

**x**

**x**

I

 **x**

carbon dioxide (CO2)

**o**

C

**o**

 **o**

 **o**

**x**

**x**

**x**

**x**

**x**

O

 **x**

**x**

**x**

**x**

**x**

**x**

O

 **x**

**x**

**x**

**x**

**x**

**x**

O

 **x**

**o**

C

**o**

 **o**

 **o**

O = C = O

 **x x**

 **x x**

 **x x**

 **x x**

covalent compounds = molecular compounds

-- have lower melting points than do ionic compounds

* ***Metallic Bonds***

In metals, valence shells of atoms overlap, so v.e– are free to travel between atoms through material

 ***Properties of Metals***

 conduct heat and electricity; ductile; malleable

* ***Other Types of Bonds***

dipole-dipole forces, hydrogen bonds, London dispersion forces; & ion-dipole forces (solutions)

 **Writing Formulas of Ionic Compounds**

chemical formula: has neutral charge;

shows types of atoms and how many of each

To write an ionic compound’s formula, we need:

 1. the two types of ions

 2. the charge on each ion

 Na1+ and F1– NaF

 Ba2+ and O2– BaO

 Na1+ and O2– Na2O

 Ba2+ and F1– BaF2

criss-cross rule: charge on cation / anion

 “becomes” subscript of anion / cation

 \*\* Warning: Reduce to lowest terms.

Al3+ and O2– Ba2+ and S2– In3+ and Br1–

 Al2 O3 Ba2 S2 In1 Br3

 Al2O3 BaS InBr3

* ***Writing Formulas w/Polyatomic Ions***

Parentheses are required only when you need more than one “bunch” of a particular polyatomic ion.

Ba2+ and SO42– BaSO4

Mg2+ and NO21– Mg(NO2)2

 NH41+ and ClO31– NH4ClO3

 Sn4+ and SO42– Sn(SO4)2

 Fe3+ and Cr2O72– Fe2(Cr2O7)3

 NH41+ and N3– (NH4)3N

 **Inorganic Nomenclature**

* ***Ionic Compounds (cation/anion combos)***

Single-Charge Cations with Elemental Anions

 The single-charge cations are:

 groups 1, 2, 13, and Ag1+ and Zn2+

A. To name, given the formula:

1. Use name of cation.

2. Use name of anion (it has the ending “ide”).

 NaF sodium fluoride

 BaO barium oxide

 Na2O sodium oxide

 BaF2 barium fluoride

B. To write formula, given the name:

 1. Write symbols for the two types of ions.

 2. Balance charges to write formula.

 silver sulfide Ag1+ S2– Ag2S

 zinc phosphide Zn2+ P3– Zn3P2

 calcium iodide Ca2+ I1– CaI2

Multiple-Charge Cations with Elemental Anions

 The multiple-charge cations are: Pb2+/Pb4+,

Sn2+/Sn4+, transition elements (not Ag or Zn)

A. To name, given the formula:

1. Figure out charge on cation.

2. Write name of cation.

Stock System

of nomenclature

3. Write Roman numerals in ( )

to show cation’s charge.

4. Write name of anion.

 FeO Fe? O2– iron (II) oxide

 Fe2O3 2 Fe? 3 O2– iron (III) oxide

CuBr Cu? Br1– copper (I) bromide

 CuBr2 Cu? 2 Br1– copper (II) bromide

B. To find the formula, given the name:

 1. Write symbols for the two types of ions.

 2. Balance charges to write formula.

 cobalt (III) chloride Co3+ Cl1– CoCl3

 tin (IV) oxide Sn4+ O2– SnO2

 tin (II) oxide Sn2+ O2– SnO

Traditional System of Nomenclature

 …used historically (and still some today) to name

compounds w/multiple-charge cations

To use: 1. Use Latin root of cation.

 2. Use ***-ic*** ending for higher charge;

 “ ***-ous*** “ “ lower “

 3. Then say name of anion, as usual.

Element Latin root ***-ic -ous***

gold, Au aur- Au3+ Au1+

 lead, Pb plumb- Pb4+ Pb2+

 tin, Sn stann- Sn4+ Sn2+

 copper, Cu cupr- Cu2+ Cu1+

 iron, Fe ferr- Fe3+ Fe2+

Write formulas: Write names:

cuprous sulfide Pb3P4 3 Pb? 4 P3–

Cu1+ S2– Cu2S plumbic phosphide

auric nitride Pb3P2 3 Pb? 2 P3–

Au3+ N3– AuN plumbous phosphide

ferrous fluoride SnCl4 Sn? 4 Cl1–

Fe2+ F1– FeF2 stannic chloride

Compounds Containing Polyatomic Ions

Insert name of ion where it should go

in the compound’s name.

Write formulas:

iron (III) nitrite Fe3+ NO31– Fe(NO3)3

ammonium phosphide NH41+ P3– (NH4)3P

ammonium chlorite NH41+ ClO21– NH4ClO2

zinc phosphate Zn2+ PO43– Zn3(PO4)2

lead (II) permanganate Pb2+ MnO41– Pb(MnO4)2

Write names:

(NH4)2S2O3 ammonium thiosulfate

AgBrO3 silver bromate

(NH4)3N ammonium nitride

U(CrO4)3 U? 3 CrO42– uranium (VI) chromate

Cr2(SO3)3 2 Cr? 3 SO32– chromium (III) sulfite

* ***Covalent Compounds***

-- contain two types of nonmetals

 Key: FORGET CHARGES

What to do:

 Use Greek prefixes to indicate how many atoms of

each element, but don’t use “mono” on first element. 1 – mono 6 – hexa

 2 – di 7 – hepta

 3 – tri 8 – octa

 4 – tetra 9 – nona

 5 – penta 10 – deca

EXAMPLES:

carbon dioxide CO2

CO carbon monoxide

dinitrogen trioxide N2O3

N2O5 dinitrogen pentoxide

carbon tetrachloride CCl4

NI3 nitrogen triiodide

* ***Acid Nomenclature***

binary acids: acids w/H and one other element

**Binary Acid Nomenclature**

 1. Write “hydro.”

 2. Write prefix of the other element,

followed by “-ic acid.”

HF hydrofluoric acid

 HCl hydrochloric acid

 HBr hydrobromic acid

 hydroiodic acid HI

 hydrosulfuric acid H2S

oxyacids: acids containing H, O, and one other

element

Common oxyanions (polyatomic ions that contain

oxygen) that combine with H to make oxyacids:

BrO31– NO31–

CO32– PO43–

ClO31– SO42–

IO31–

**Oxyacid Nomenclature**

Write prefix of oxyanion, followed by “-ic acid.”

 HBrO3 bromic acid

 HClO3 chloric acid

 H2CO3 carbonic acid

 sulfuric acid H2SO4

 phosphoric acid H3PO4

Above examples show “most common” forms of the oxyacids. If an oxyacid differs from the above by the # of O atoms, the name changes are as follows:

 one more O = per\_\_\_\_\_ic acid

**“most common” # of O = \_\_\_\_\_ic acid**

 one less O = \_\_\_\_\_ous acid

 two fewer O = hypo\_\_\_\_\_ous acid

HClO4 perchloric acid

HClO3 chloric acid

HClO2 chlorous acid

HClO hypochlorous acid

phosphorous acid H3PO3

hypobromous acid HBrO

persulfuric acid H2SO5

 **Empirical Formula and Molecular Formula**

lowest-terms formula shows the true number

and type of atoms in a

molecule

|  |  |  |
| --- | --- | --- |
| **Compound** | **Molecular Formula** | **Empirical****Formula** |
| glucose | C6H12O6 | CH2O |
| propane | C3H8 | C3H8 |
| butane | C4H10 | C2H5 |
| naphthalene | C10H8 | C5H4 |
| sucrose | C12H22O11 | C12H22O11 |
| octane | C8H18 | C4H9 |