Ionic Nomenclature

Model 1

When an atom gains or loses electrons, it becomes an ion. Above are the most common ions formed by each element.

Q1. Using another periodic table for guidance, draw the staircase onto the periodic table in Model 1 that separates metals from non-metals. What do you notice about ions on one side of this staircase versus ions on the other side?

Q2. According to the table in Model 1, sodium becomes Na\(^+\) ion. What ion (give chemical symbol and charge) is formed by:

a) Mg
b) O
c) Br

Q3. In addition to the charges shown in the table, there are 3 more ions you should memorize. Using a periodic table to guide you, fill in the table in Model 1 with the following ions:

\[
\begin{array}{ccc}
\text{Zn}^{2+} & \text{Cd}^{2+} & \text{Ag}^+ \\
\end{array}
\]
**Model 2**

Ionic compounds form when a positively charged ion(s) combines with a negatively charged ion(s) in such a way that their total charge equals zero.

- **MgO**
- **K₂O**

The chemical formula K₂O tells us that there are two potassium ions to one oxygen ion.

**NOTE:** Ionic compounds have structures where many of these ions are packed together to form a crystal lattice. In these pictures, only one formula unit is shown for simplicity.

Q4. Draw a picture of each of the following ionic compounds (as in Model 2). Confirm that each one has an overall charge of zero.

- **NaCl**
- **MgCl₂**
- **Al₂O₃**

Q5. Predict the chemical formula obtained by combining the following elements:

a) Ca and Cl

b) Ag and O

c) Zn and N
**Information**
The elements that are not given charges in Model 1 are left blank because they usually form more than just one kind of ion.

Example: Iron can become Fe$^{2+}$ or Fe$^{3+}$ ions.

These metals are called “variable charged” and are usually (but not limited to) the transition metals.

Q6. Draw each of the following compounds (as you did in Q4, showing both the element and the charge). Can you figure out the charge of the metal (based on knowing the charges of the non-metals)?

[Diagrams of CuS, FeCl$_2$, Cr$_2$O$_3$]

**Model 3**

Q7. In Model 3, does the -2 charge on the polyatomic ion, sulfate, appear to be on one atom or on the group of atoms?

Q8. Find the polyatomic ion, carbonate, in your list of polyatomic ions (page 4 of your lab manual or page 130 in Tro). Draw a picture of it (as in Model 3) of what carbonate looks like. Show the charge.
Q9.  a) How many sodium ions will combine with one hydroxide? With one sulfate? With one carbonate?

b) Give a chemical formula to each compound that forms from the combinations in Part a.

Q10.  a) How many hydroxides are required to combine with one aluminum ion?
      Draw a picture of this combination.

b) Which is more correct for its chemical formula, AlOH₃ or Al(OH)₃? Explain.

**Part 2. Information**

All of the chemical formulas you’ve encountered can be cut into 2 parts: the positive ion and the negative ion.

To name a compound:

Full name of the positive ion + Binary ending (-ide) of negative ion (or polyatomic name, if appropriate)

Example:  K₂O   potassium oxygen oxide
          Al(OH)₃   aluminum hydroxide

*You may wish to refer to Tro p.128 Table 5.4 for the anion names (with binary endings) and p.130 Table 5.6 for the names of the polyatomic ions.*

Q11. In the names given above, is there any reference to the numbers contained within the chemical formula?

Q12. Looking at Table 5.4 and 5.6 in Tro, what is the difference between these 3 terms:
      nitride     nitrite     nitrate
Q13. Give names to the compounds in Q4, Q5, Q6, and Q9b. You may write them next to your previous answers or you may write them in the space below.

**Information**

To name compounds with variable charged metals, a roman numeral is needed.

For example, for Q6 a) FeCl₂

*did you say that the name is “iron chloride”?*

Since iron is a variable charged metal, the charge on the iron must be stated in the name. Since Fe²⁺ is in FeCl₂, the name becomes iron (II) chloride. Fix your answers to the rest of Q6 to include the roman numeral.

Q14. How can you tell which metals are variable charged (and will need to be followed by a roman numeral)? Refer to Model 1, which you will eventually need to memorize.

Q15. Why do you think the roman numeral is needed for variable charged metals?

**Exercises**

This activity covers material in Tro, Chapter 5.3-5.7. Refer to this chapter for more information and for practice problems.

1. Try problems from Chapter 5 (Tro): 29-35(odd); 47-63(odd).

2. Try the following worksheets attached to this activity (the answer key is included).

3. Try your lab manual: p. B15-B17 (problems on B-17; the answer key is included).

**PRACTICE IS ESSENTIAL TO LEARNING THIS MATERIAL!!!**
PRACTICE PROBLEMS FOR IONIC COMPOUNDS

Name    Key    Section
Sn(II) phosphate  Sn(PO₄)₂
zin oxide  ZnO
barium sulfate  BaSO₄
lithium nitride  Li₃N  * note: nitride is N³⁻  nitrate is (NO₃)⁻
silver fluoride  AgF
barium hydroxide  Ba(OH)₂
lead(II) iodide  PbI₂
mercury(II) chloride  HgCl₂
cobalt(II) nitrate  Co(NO₃)₂
lithium bromide  LiBr

AlBr₃  aluminium bromide  * variable charge  * Roman numerals
FeS  iron(II) sulfide
(NH₄)₃PO₄  ammonium phosphate  * note: sulfide = S²⁻  sulfite = (SO₃)²⁻
Hg(NO₃)₂  mercury(II) nitrate  sulfite = (SO₃)²⁻
Ag₂S  silver sulfide
K₂MnO₄  potassium permanganate
MgCl₂  magnesium chloride
Cr₂O₃  chromium(III) oxide  * note: phosphide = P³⁻  phosphite = (PO₃)⁻
K₃P  potassium phosphide
TiCl₂  titanium(II) chloride

B-17
Writing formulas for ionic compounds

Exercise 1: Write the formula for each combination of ions below. Then write the name of the compound underneath.

<table>
<thead>
<tr>
<th>Ion</th>
<th>Cl(^{-})</th>
<th>HCO(_3)(^{-})</th>
<th>PO(_4)(^{3-})</th>
<th>CO(_3)(^{2-})</th>
<th>S(^{2-})</th>
<th>OH(^{-})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na(^{+})</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fe(^{3+})</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ca(^{2+})</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Sn(^{4+})</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zn(^{2+})</td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Exercise 2: Write the formulas for each of the following compounds:

1. ammonium iodide
2. lithium sulfate
3. cobalt (II) carbonate
4. zinc nitride
5. magnesium phosphate
6. selenium dibromide
7. sodium bromide
8. iron (II) cyanide
9. copper (II) chloride
10. beryllium nitrate
11. calcium nitrite
12. tin (II) fluoride
13. potassium sulfide
14. silver oxide
15. aluminum bicarbonate
16. zinc hydroxide
17. chromium (III) oxide
18. lead (IV) bromide
19. nickel (II) sulfate
20. aluminum nitrite
**PRACTICE WITH NAMING IONIC COMPOUNDS**

These are binary ionic compounds (two ions involved). The second ion carries a binary ending of -ide.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>BeS</td>
</tr>
<tr>
<td>2.</td>
<td>CaH₂</td>
</tr>
<tr>
<td>3.</td>
<td>NaI</td>
</tr>
<tr>
<td>4.</td>
<td>MgO</td>
</tr>
<tr>
<td>5.</td>
<td>AlBr₃</td>
</tr>
<tr>
<td>6.</td>
<td>Li₂S</td>
</tr>
<tr>
<td>7.</td>
<td>ZnF₂</td>
</tr>
<tr>
<td>8.</td>
<td>K₂N</td>
</tr>
<tr>
<td>9.</td>
<td>AgCl</td>
</tr>
<tr>
<td>10.</td>
<td>AlN</td>
</tr>
<tr>
<td>11.</td>
<td>BeCl₂</td>
</tr>
<tr>
<td>12.</td>
<td>CaCl₂</td>
</tr>
<tr>
<td>13.</td>
<td>KF</td>
</tr>
<tr>
<td>14.</td>
<td>MgBr₂</td>
</tr>
<tr>
<td>15.</td>
<td>Ag₂S</td>
</tr>
<tr>
<td>16.</td>
<td>ZnO</td>
</tr>
</tbody>
</table>

These are ternary ionic compounds (they involve a polyatomic ion). First, recognize which ion is used. Then use your ion chart to name the compound.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>17.</td>
<td>NH₄Br</td>
</tr>
<tr>
<td>18.</td>
<td>Al(OH)₃</td>
</tr>
<tr>
<td>19.</td>
<td>Li₂PO₄</td>
</tr>
<tr>
<td>20.</td>
<td>Mg(C₂H₃O₂)₂</td>
</tr>
<tr>
<td>21.</td>
<td>Zn(HSO₄)₂</td>
</tr>
<tr>
<td>22.</td>
<td>(NH₄)₂CO₃</td>
</tr>
<tr>
<td>23.</td>
<td>NaClO₃</td>
</tr>
<tr>
<td>24.</td>
<td>Ca(CN)₂</td>
</tr>
<tr>
<td>25.</td>
<td>KHC₂O₃</td>
</tr>
<tr>
<td>26.</td>
<td>Mg₃(PO₄)₂</td>
</tr>
<tr>
<td>27.</td>
<td>Al(NO₃)₃</td>
</tr>
<tr>
<td>28.</td>
<td>Ag₂SO₄</td>
</tr>
</tbody>
</table>

These are binary or ternary and involve a variable charged metal (you must indicate the charge as a roman numeral in the name).

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>29.</td>
<td>Cr₂O₃</td>
</tr>
<tr>
<td>30.</td>
<td>CoN</td>
</tr>
<tr>
<td>31.</td>
<td>Fe₃</td>
</tr>
<tr>
<td>32.</td>
<td>Co(HSO₄)₂</td>
</tr>
<tr>
<td>33.</td>
<td>Cu₂O</td>
</tr>
<tr>
<td>34.</td>
<td>Hg(ClO₃)₂</td>
</tr>
<tr>
<td>35.</td>
<td>NiBr₂</td>
</tr>
<tr>
<td>36.</td>
<td>CuSO₃</td>
</tr>
<tr>
<td>37.</td>
<td>Ni(NO₃)₂</td>
</tr>
<tr>
<td>38.</td>
<td>Fe(C₂H₃O₂)₂</td>
</tr>
</tbody>
</table>
### Writing formulas for ionic compounds

Exercise 1: Write the formula for each combination of ions below. Then write the name of the compound underneath.

<table>
<thead>
<tr>
<th>Cl⁻</th>
<th>Na⁺</th>
<th>HCO₃⁻</th>
<th>PO₄³⁻</th>
<th>CO₃²⁻</th>
<th>S²⁻</th>
<th>OH⁻</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na⁺</td>
<td>Na⁺</td>
<td>NaHCO₃</td>
<td>Na₂PO₄</td>
<td>Na₂CO₃</td>
<td>Na₂S</td>
<td>NaOH</td>
</tr>
<tr>
<td>Fe³⁺</td>
<td>Fe⁺⁺⁺</td>
<td>Fe₂(HCO₃)₃</td>
<td>FePO₄</td>
<td>Fe₂(CO₃)₃</td>
<td>Fe₂S₃</td>
<td>Fe(OH)₃</td>
</tr>
<tr>
<td>Ca²⁺</td>
<td>Ca⁺⁺⁺</td>
<td>Ca(HCO₃)₂</td>
<td>Ca₃(PO₄)₂</td>
<td>Ca₃(CO₃)₂</td>
<td>CaS</td>
<td>Ca(OH)₂</td>
</tr>
<tr>
<td>Sn⁴⁺</td>
<td>Sn⁺⁺⁺⁺</td>
<td>Sn₂(HCO₃)₃</td>
<td>Sn₃(PO₄)₂</td>
<td>Sn₃(CO₃)₂</td>
<td>SnS</td>
<td>Sn(OH)₄</td>
</tr>
<tr>
<td>Zn²⁺</td>
<td>Zn⁺⁺</td>
<td>Zn(HCO₃)₂</td>
<td>Zn₃(PO₄)₂</td>
<td>Zn₂CO₃</td>
<td>ZnS</td>
<td>Zn(OH)₂</td>
</tr>
</tbody>
</table>

### Exercise 2: Write the formulas for each of the following compounds:

1. ammonium iodide \( \text{NH}_₄\text{I} \)
2. lithium sulfate \( \text{Li}_₂\text{SO}_₄ \)
3. cobalt (II) carbonate \( \text{Co}_₂\text{CO}_₃ \)
4. zinc nitride \( \text{Zn}_₃\text{N}_₂ \)
5. magnesium phosphate \( \text{Mg}_₃\text{PO}_₄ \)
6. selenium dibromide \( \text{Se}_₂\text{Br}_₄ \)
7. sodium bromide \( \text{NaBr} \)
8. iron (II) cyanide \( \text{Fe}(\text{CN})₃ \)
9. copper (II) chloride \( \text{CuCl}_₂ \)
10. beryllium nitrate \( \text{Be}(\text{NO}_₃)_₂ \)
11. calcium nitrite \( \text{Ca}(\text{NO}_₂)_₂ \)
12. tin (II) fluoride \( \text{Sn}_₂\text{F}_₃ \)
13. potassium sulfide \( \text{K}_₂\text{S} \)
14. silver oxide \( \text{Ag}_₂\text{O} \)
15. aluminum bicarbonate \( \text{Al}(\text{HCO}_₃)_₃ \)
16. zinc hydroxide \( \text{Zn}(\text{OH})₂ \)
17. chromium (III) oxide \( \text{Cr}_₂\text{O}_₃ \)
18. lead (IV) bromide \( \text{PbBr}_₄ \)
19. nickel (II) sulfate \( \text{Ni}_₂\text{SO}_₄ \)
20. aluminum nitrite \( \text{Al}(\text{NO}_₂)_₃ \)
These are binary ionic compounds (two ions involved). The second ion carries a binary ending of -ide.

1. BeS  beryllium sulfide
2. CaH$_2$  calcium hydride
3. NaI  sodium iodide
4. MgO  magnesium oxide
5. AlBr$_3$  aluminum bromide
6. Li$_2$S  lithium sulfide
7. ZnF$_2$  zinc fluoride
8. K$_3$N  potassium nitride
9. AgCl  silver chloride
10. AlN  aluminum nitride
11. BeCl$_2$  beryllium chloride
12. CaCl$_2$  calcium chloride
13. KF  potassium fluoride
14. MgBr$_2$  magnesium bromide
15. Ag$_2$S  silver sulfide
16. ZnO  zinc oxide

Tip: All of these can be divided into 2 parts — the (+) ion or the (-) ion. Just name each part. (Inorganic identifying polyatomic ions)

17. NH$_4$Br  ammonium bromide
18. Al(OH)$_3$  aluminum hydroxide
19. Li$_2$O$_2$  lithium peroxide
20. Mg(C$_2$H$_3$O$_2$)$_2$  magnesium acetate
21. Zn(HCO$_3$)$_2$  zinc bicarbonate or zinc hydrogen sulfite
22. (NH$_4$)$_2$PO$_4$  ammonium carbonate
23. NaClO$_3$  sodium chlorate
24. Ca(CN)$_2$  calcium cyanide
25. KHCO$_3$  potassium bicarbonate
26. Mg$_3$(PO$_4$)$_2$  magnesium phosphate
27. Al(NO$_3$)$_3$  aluminum nitrate
28. Ag$_2$SO$_4$  silver sulfate

These are binary or ternary and involve a variable charged metal (you must indicate the charge as a roman numeral in the name)

29. Cr$_2$O$_3$  chromium (II) oxide
30. Co$_3$N  cobalt (III) nitride
31. Fe$_3$S  iron (II) iodide
32. Co(HSO$_4$)$_2$  cobalt(II) bisulfate
33. Cu$_2$O  copper (I) oxide
34. Hg$_2$(ClO$_4$)$_2$  mercury (II) chlorate
35. NiCl$_2$  nickel (II) bromide
36. CuSO$_4$  copper (II) sulfate
37. Ni(NO$_3$)$_3$  nickel (III) nitrate
38. Fe(C$_2$H$_3$O$_2$)$_2$  iron (II) acetate