Nomenclature & Formula Writing 4

Writing Formulas & Names for Polyatomic Compounds

INFORMATION

Polyatomic ions, as their name suggests, are ions containing more than one atom.

Unlike the atoms combined in binary ionic compounds, the atoms in polyatomic ions are molecules – atoms joined by **covalent bonds**. The nature and properties of covalent bonds are discussed in a later activity, but for now it is important to know that the atoms in the polyatomic ion *collectively behave like an ion for the purpose of forming ionic compounds*.

> The atoms in a polyatomic ion collectively behave like an ion for the purpose of forming ionic bonds.

The charges of polyatomic compounds are fixed, a result of the nature of the bonds between the atoms in them and the number of electrons in those bonds. Valences for polyatomic ions are not determined by patterns, like with representative elements. *Each polyatomic ion has a fixed charge based on its **structure*** (structure indicated the connections between atoms and the molecule's configuration in space – the structure of molecules will also be investigated at a later time). These charges are determined by looking up the ion on a table of polyatomic ions, or by memorizing the ions and their charges.

Polyatomic ions are just that – ions – and therefore always have a charge associated with them. Whenever a polyatomic ion is written as a chemical formula (as opposed to part of a compound), the charge must accompany it. For example, the polyatomic anion *nitrate* is written as $\mathbf{NO_3^{-1}}$.

In later activities, the charge of polyatomic ions will be determined by the application **valence bonding theory** – the governing principles that drive valence bonding. For now, the charges of polyatomic ions will be provided in the reference table mentioned above.

Understanding Oxyanions

Oxyanions are polyatomic anions containing one or more oxygen atoms, but no hydrogen atoms. Many oxyanions have the special property that the root element remains the same as the number of oxygen atoms changes, but the charge stays the same.

> *Hypochlorite (ClO^{-1}), chlorite (ClO_2^{-1}), chlorate (ClO_3^{-1}), and perchlorate (ClO_4^{-1}) are all related (they have a chlorine root), and even though they have different numbers of oxygen atoms, they all have a charge of -1.*

The suffix *-ite* indicates one fewer oxygen than a compound ending in *-ate*. The prefix *hypo-* indicates one less than *-ite*, and the prefix *per-* indicates one more than *-ate*.

The increasing order for the prefixes is hypo-, -ite, -ate, per-.

Writing Formulas for Polyatomic Compounds

The formula writing and naming of polyatomic ionic compounds is similar to the process for binary compounds. For example, making a compound using aluminum metal and nitrate yields:

$$Al^{+3} \quad NO_3^{-1}$$

$$Al^{+3} \quad NO_3^{-1}$$

$$Al(NO_3)_3$$

Key Questions

1. What is the purpose of the parentheses in the compound magnesium cyanide, $Mg(CN)_2$?

2. Why are the 3's not simplified in the aluminum nitrate formula, above?

3. In the compound potassium oxalate, $K_2(C_2O_4)$, why are the 2's and the 4 not simplified?

4. Create a chart that demonstrates how to determine the names and numbers of oxygen atoms present in the oxyanions of a particular oxyanion series.

5. For the following polyatomic anions, write the names and formulas for all of the oxyanions associated with them.
   a. Chlorate, ClO_3^{-1}
   b. Bromate, BrO_3^{-1}
   c. Iodate, IO_3^{-1}
   d. Sulfate, SO_4^{-2}

Exercises

6. Write the formulas for the following compounds:
   a. Sodium chlorate
   b. Strontium sulfate
   c. Lithium hypoidodite
   d. Aluminum phosphate
   e. Ammonium iodide
   f. Indium hydroxide
   g. Rubidium hydrogen carbonate
   h. Potassium tartrate

INFORMATION

Naming Polyatomic Compounds

Naming polyatomic compounds is similar to naming binary compounds (except, of course, for the presence of the polyatomic anion instead of a monatomic anion). Examine the following examples:

1. Magnesium cyanate, $Mg(OCN)_2$
2. Beryllium chlorate, $Be(ClO_3)_2$
3. Ammonium nitrate, NH_4NO_3
4. Ammonium nitride, $(NH_4)_3N$
5. Aluminum hexafluorosilicate, $Al_2(SiF_6)_3$
6. Strontium gallate, $Sr_3(GaO_3)_2$
7. Sodium hydroxide, NaOH
8. Ammonium chloride, NH_4Cl

Key Questions

7. In grammatically correct English, write detailed procedures for a) writing polyatomic formulas and b) naming polyatomic compounds. Assume that the procedures will be used by someone who has no prior knowledge of this material.

Exercises

8. Write names for the following polyatomic compounds:
   a. $NaCrO_2$
   b. $Al_2(MoO_4)_3$
   c. $Sr(HSO_3)_2$
   d. $K_4(P_2O_7)$
   e. $Na_2C_4H_4O_6$
   f. $LiMnO_4$
   g. $GaPO_4$
   h. $CaCr_2O_7$

Student Name: _____ Pd. _____ Date: _____

Supplementary Exercises
Polyatomic Compound Naming and Formula Writing

Write the correct name for the following compounds.

1. $AlPO_4$
2. KNO_2
3. $NaHCO_3$
4. $CaCO_3$
5. $Mg(OH)_2$
6. Na_2CrO_4
7. $Ba(CN)_2$
8. K_2SO_4
9. NaH_2PO_4
10. NH_4NO_3
11. $KClO_3$
12. $Al(MnO_4)_3$
13. $Mg_3(PO_4)_2$
14. $CaHPO_4$
15. Na_2CO_3
16. $Ba(HC_2O_4)_2$
17. CsIO
18. $Sr(N_3)_2$

Write the correct formula for the following compounds.

19. potassium hydrogen phosphate
20. aluminum hydroxide
21. sodium hydrogen carbonate
22. calcium acetate
23. potassium permanaganate
24. calcium perchlorate
25. lithium carbonate
26. magnesium hydrogen sulfite
27. sodium hypochlorite
28. potassium perchlorate
29. aluminum sulfate
30. barium iodate
31. magnesium dihydrogen phosphate
32. ammonium sulfate
33. ammonium nitrate
34. francium cyanate
35. potassium perchlorate
36. barium dichromate
37. sodium arsenite
38. radium pyrophosphate
39. lithium sulfate
40. calcium hypochlorite