Nomenclature & Formula Writing 5

Writing Formulas & Names with Multivalent Metals

INFORMATION

Transition metals are elements that do not fall into the category of representative elements. A transition metal is one that, due to the way its electrons are arranged in the various shells within it, does not conform to the "group number = valence electrons" rule used for representative elements.

Transition metals have many special properties, one of which is that many of them are capable of forming bonds in more than one proportion; that is, they can have more than one valence, or charge, depending on the conditions under which they form bonds. Transition metals capable of having different charges and forming compounds in different proportions are called **multivalent metals**, or **multiple-charge cations**. Several representative metals in groups 3 and 4 can also have multiple charges – though they are not strictly transition metals, they are multiple-charge cations.

Oxidation States

Every element, with the exception of the noble gases, is capable of achieving at least one **oxidation state**, whether it is a metal or nonmetal, representative element, or transition metal. Strictly speaking, oxidation states are the possible charges an atom can attain assuming that all of its bonds are completely ionic (more about ionic bonds later). For the purpose of this activity, they are simply representative of the various valences that an element can have.

Many transition metals have more than one oxidation state. Each of those oxidation states represents a valence that the metal can have when it forms bonds.

Important Note: Many nonmetals can have more than one oxidation state when forming covalent bonds, as well. However, understanding these is a topic for later discussion, beyond the scope of this activity. For now, nonmetals still use the "group number = valence electrons" rule.

Key Questions

1. Using your periodic table, locate the oxidation states of some of the "single-valent" representative metals you have already worked with. What pattern do you notice?

2. Does the law of definite proportions apply to multivalent metals? If not, propose a law that applies to them and explain your reasoning. Both your law and your explanation must be written in grammatically correct English.

3. Iron is a multivalent metal; therefore, it can form bonds with oxygen in more than one proportion. Fe_2O_3 and FeO are both legitimate formulas for the compounds formed by these two elements. What problem would arise when determining names for these compounds?

INFORMATION

Naming and Formula Writing for Multivalent Metals

Since multivalent metals can often form multiple compounds with the same anion, a means is required to differentiate between multiple compounds with the same constituent elements (like the iron and oxygen compounds in question 3, above) when writing formulas for multivalent metal compounds.

Similarly, it is important to determine if a metal is multivalent and then to determine its valence before its name can be written.

The law that arises from the relationship between the different species that can be formed is known as the **law of multiple proportions**.

Key Question

The names of several multivalent compounds are listed below:

Fe_2O_3	iron (III) oxide	$Ni_2(SO_4)_3$	nickel (III) sulfate
FeO	iron (II) oxide	$AuCl_3$	gold (II) chloride
MnS_2	manganese (VI) sulfide	$Cu(OH)_2$	copper (II) hydroxide

4. Given a formula and no other information, is it possible to determine the charge on a multivalent metal? Explain how to do this in grammatically correct English.

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

6. Use what you now know about multivalent metal compounds to determine how the law of multiple proportions might be stated in a textbook or reference manual. Write your answer in grammatically correct complete sentences.

Student Name: _____ Pd. _____ Date: _____

Supplementary Exercises
Multivalent Cation Compound Naming and Formula Writing

Write the correct name for the following compounds.

1. Cu_2SO_4
2. $Sn(OH)_2$
3. Cu_2O
4. PbO_2
5. CuS
6. $PbBr_4$
7. $Pb(NO_3)_2$
8. FeO
9. SnO_2
10. Hg_2O
11. HgO
12. $HgCr_2O_7$
13. $Cu(ClO_3)_2$
14. Fe_2O_3
15. CuBr
16. PbO
17. Fe_2S_3
18. $MnSiO_4$
19. Co_2S_3
20. AuF
21. $CrBr_2$
22. $AuCl_3$
23. $Fe(IO)_2$
24. Sn_3P_4
25. MnO
26. $CrCl_3$
27. CoO

Write the correct formula for the following compounds.

28. iron (II) arsenate
29. tin (II) oxide
30. chromium (III) oxide
31. gold (I) iodide
32. manganese (VI) oxide
33. cobalt (III) phosphate
34. lead (II) bromide
35. tin (IV) iodide
36. mercury (II) fluoride
37. tin (IV) oxide
38. chromium (II) chloride
39. lead (IV) nitride
40. cobalt (II) phosphide
41. tin (II) sulfide
42. copper (II) iodide
43. manganese (III) dichromate
44. chromium (II) nitride
45. iron (III) chloride
46. copper (I) sulfide
47. lead (IV) superoxide
48. copper (II) sulfide
49. tin (II) iodite
50. mercury (I) bromide
51. mercury (I) sulfide
52. gold (III) bromide
53. manganese (II) oxide
54. tin (IV) sulfate
55. iron (II) phosphide