Ionic Hydrates

• An ionic hydrate is a compound that has water associated with it. Water is part of its crystalline structure.

• Bluestone contains five water molecules per copper(II) ion and sulfate ion in the crystal

• Its formula is CuSO$_4$· 5 H$_2$O.

• Its IUPAC name is copper(II) sulfate pentahydrate.
The term anhydrous means without water, thus the name for anhydrous compound is simply copper(II) sulfate, and the molecular formula is CuSO$_4$.

A hydrate, like rock salt, sodium chloride monohydrate (NaCl · $\text{H}_2\text{O}$), can be formed when a salt water lake dries up leaving behind solid salt. However, not all of the water evaporates. Some water molecules became part of the salt crystals giving rise to hydrated crystals.

Writing Chemical Formulas for Ionic Hydrates:

• The name of an ionic hydrate can be distinguished from the names of other ionic compounds by the presence of the term hydrate.

• For example, the IUPAC name for bluestone is copper(II) sulfate pentahydrate.

• In order to convert IUPAC names for ionic hydrates into chemical formulas, you will need to remember the prefix system.

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Value</th>
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<tbody>
<tr>
<td>mono</td>
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<td>di</td>
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<td>octa</td>
<td>8</td>
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<td>nona</td>
<td>9</td>
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<td>deca</td>
<td>10</td>
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Sodium thiosulfate pentahydrate

1. Break the name down into three parts:
   A. The -ate ending in thiosulfate suggests that the anion is polyatomic:
      thiosulfate is $S_2O_3^{2-}$
   B. Sodium is a member of Group 1 and has a 1+ charge:
      $Na^+$
   C. The hydrate is pentahydrate which means five water molecules:
      pentahydrate is $\cdot 5\, H_2O$
2. Balance the ion charges:
   two $Na^+$ ions are needed for each $S_2O_3^{2-}$ ion
3. Putting all this together, you get:
   $Na_2S_2O_3 \cdot 5\, H_2O$
4. Notice that a dot separates water from the rest of the formula.

Cobalt (II) chloride dihydrate

1. Break the name down into three parts:
   A. Chloride is a simple ion of chlorine (gr. 17), it has a 1- charge.
      $Cl^-$
   B. Cobalt(II) is a cobalt ion with a 2+ charge.
      $Co^{2+}$
   C. The hydrate is dihydrate which means two water molecules.
      $\cdot 2\, H_2O$
2. Balance the ion charges:
   one $Co^{2+}$ ion is needed for each $Cl^{-}$ ion
3. Putting all this information together, you get:
   $CuCl_2 \cdot 2\, H_2O$

Again, notice that a dot separates water from the rest of the formula.
Write formulas for the following:

1. Zinc sulphate heptahydrate
2. Potassium sulphate decahydrate
3. Cadmium (II) nitrate tetrahydrate

Writing Names for Ionic Hydrates:

Converting a chemical formula for an ionic hydrate into a name is a reversal of the steps you do to write the formula.

1. Begin with the anion, find it’s name and charge.
2. Next identify the cation and it’s charge
3. Find the prefix and add it to “hydrate.”
4. Combine the parts of the name.
Ni$_3$(PO$_4$)$_2$ · 8 H$_2$O

Break the chemical formula into three parts:

1. Begin with the anion. Locate "PO$_4$" in the polyatomic ions table.
   
   
   
   PO$_4^{3-}$ is the phosphate ion

   
   
   
   Since each phosphate ion has a 3- charge, the total negative charge in the formula is $(2 \times 3-) = 6-$; therefore, the charge on each of the three nickel ions must be $2^+$ $(6 ÷ 3 = 2)$.

2. Next identify the cation and its charge.
   
   
   
   the nickel ion is nickel(II)

3. Finally, ·8 H$_2$O means eight water molecules per formula. Find the prefix for eight and write the hydrate name:
   
   
   
   ·8 H$_2$O is octahydrate

4. Combine the three parts of the name:
   
   
   
   nickel(II) phosphate octahydrate


Fe(OH)$_3$ · 3 H$_2$O

Break the chemical formula into three parts.

1. Begin with the anion. Locate "OH" in the polyatomic ions table.
   
   
   
   OH$^-$ is the hydroxide ion

   
   
   
   Since hydroxide has a 1- charge, and since there are three of them in the formula, the charge on each iron ion must be 3+.

2. Next identify the cation and its charge.
   
   
   
   the iron ion is iron(III)

3. Finally, ·3H$_2$O means three water molecules per formula. Find the prefix for three and write the hydrate name:
   
   
   
   ·3H$_2$O is trihydrate

4. Combine the three parts of the name:
   
   
   
   iron(III) hydroxide trihydrate
Give the name for each of the following:

1. AlCl$_3$ · 6 H$_2$O
2. MgSO$_4$ · 7 H$_2$O
3. CuSO$_4$ · 5H$_2$O