So.....What’s Really in a Name?
An Introduction to Chemical Nomenclature
Bill C. Ponder

Why is nomenclature important?

Innovation and discovery are born from the concentrated arrangement and dynamic review of numerous and seemingly unrelated ideas. Genius or inspiration fuses these ideas into powerful new creations of cultural and technological development. A multitude of representative examples, spanning the last 5,500 years, are found in the areas of invention, art, literature, government, engineering, science, music, philosophy, etc. However, the cultural and technological sophistication of humanity remained decidedly stone-age for tens of thousands of years prior to 5,500 years ago. The exchange and accumulation of ideas during pre-history was severely restricted by spatial distance (human populations were small and widely dispersed) and temporal distance (ideas that were not readily adopted or widely disseminated died with their creators). With the development of a writing system 5,500 years ago, ideas generated at different locations and times could be collected and concentrated into a common place and moment in the form of written text. Interestingly, this time-point also marks the beginning of humanity’s rapid cultural and technological advancement, and within a flash of time relative to all the years previous (Figure 1), humans were transported from the stone-age to the current “information” age. The invention of writing systems is perhaps the most significant occurrence in all of human existence, outside of the development of spoken language – which leads to the next, very obvious point – the existence of spoken language is a prerequisite for the development of a writing system.

Figure 1. The invention of writing systems accelerated human development.
What does any of this have to do with chemistry?

The descriptions, explanations and examples of this assignment comprise an introduction to chemical nomenclature: the rules governing the spoken language (i.e. naming of compounds) and the writing system of chemistry. These rules are used for effective communication, accumulation, review and application of chemical knowledge. Applied chemistry is a primary contributor to the diversified array of infrastructure (Table 1) associated with the modern world. Those fluent in naming and literate in reading and writing of chemistry will certainly have an advantage as the frontier of technological innovation moves forward.

<table>
<thead>
<tr>
<th>computing</th>
<th>aerospace</th>
<th>communication</th>
</tr>
</thead>
<tbody>
<tr>
<td>microchip manufacturing, heat dissipation</td>
<td>high performance metal alloys, ultra strong adhesives</td>
<td>fiber optic cables, liquid crystal displays</td>
</tr>
<tr>
<td>transportation</td>
<td>biotechnology</td>
<td>medicine</td>
</tr>
<tr>
<td>lightweight structural composites, long-lasting lubricants</td>
<td>genome mapping, microfluidic diagnostics</td>
<td>pharmaceuticals, targeted chemotherapeutics</td>
</tr>
<tr>
<td>construction</td>
<td>energy</td>
<td>commerce</td>
</tr>
<tr>
<td>engineering plastics, high-strength low-density concrete</td>
<td>photovoltaics (solar cells), bio-fuels</td>
<td>packaging materials, printing</td>
</tr>
</tbody>
</table>

Table 1. Areas of modern infrastructure with specific examples where knowledge of chemistry is particularly important.

At this level of study, you are probably already familiar with many of the names used in this exercise, such as sodium, nitrogen, chlorine, phosphorous, magnesium and calcium. In addition, the meanings you have developed for these names may be more nuanced than perhaps they were at the beginning of the term. For example, the names above are no longer just “chemicals” but are “elements”, “a Group 1 metal”, “a halogen” or “elements with five valence electrons”. These subtleties reflect a growing sophistication in your view of the world, and you need a way to express your view.

However, a group of names and meanings does not constitute a language. For example, the arrangement of words - “tour history space in first” - is quite nonsensical, though each of the words is familiar. Using generally accepted rules governing the arrangement of words relative to each other, the phrase - “the first space tour in history” - conveys clear meaning. Therefore, the arrangement of words also provides the framework (or context) within which the meanings of the words operate.

As you learn the language and writing system of chemistry, try to remember that chemical nomenclature is far more than names for symbols and symbols for names. Focus on what the chemical names and chemical formulas are telling you about atomic and molecular structure.

The naming rules introduced within this laboratory exercise are maintained by the International Union of Pure and Applied Chemistry (IUPAC) and can be found within “The Rules of Inorganic Nomenclature” (also known as “The Red Book”), an IUPAC publication. More information can be found at http://www.iupac.org/

Association of the names of elements to their respective symbols in the periodic table is a necessary requirement for chemical literacy. The use of a periodic table containing both element names and

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Assignment Definitions

- **Chemical Formula** – written combinations of at least one symbol for an element, numbers and other punctuation to indicate the relative amounts of elements comprising a chemical compound or molecular element such as H₂.
- **Ion** – An electrically charged atom or molecule resulting from unequal numbers of electrons and protons within the atom or molecule (e.g. Na⁺ or Cl⁻).
- **Polyatomic Ion** – A molecule composed of more than one element and also possessing either negative or positive charge (e.g. SO₄²⁻).
- **Cation** – An ion possessing more protons than electrons (positively charged, e.g. Na⁺).
- **Anion** – An ion possessing more electrons than protons (negatively charged, e.g. Cl⁻).
- **Oxidation State** (also called oxidation number) – For atomic cations, describes the number of electrons removed to produce the resulting cation.
- **Binary Compounds** – Ionic compounds and covalent compounds composed of only two elements (e.g. NaCl, H₂O, PCl₃, Al₂O₃). Binary compounds are further classified into Type I, Type II and Type III binary compounds.
  - **Type I Binary Compounds** – Ionic binary compounds containing metals that commonly exhibit only one oxidation state. Calcium, for example, commonly exhibits only a 2+ oxidation state (Ca²⁺). Calcium is not found within compounds while possessing a 1+, 3+ or higher oxidation state. These metals are called Type I metals.
  - **Type II Binary Compounds** – Ionic binary compounds containing metals that commonly exhibit more than one oxidation state. For example, copper is commonly found in 1+ (Cu⁺) or 2+ (Cu²⁺) oxidation states. These metals are called Type II metals.
  - **Type III Binary Compounds** – Binary covalent compounds containing two nonmetals (e.g. HCl).

**Type I Binary Compounds**

- The first part of the name will indicate the metal cation. The metal is ALWAYS the cation.
- The second part of the name will indicate the anion. The anion’s name is derived by modifying the ending of the element name with -ide. It is ALWAYS a nonmetal.
- The group number of the cation will indicate its oxidation state (i.e. its charge). Cations are formed by the loss of electrons. The loss of electrons will occur so that the resulting cation has 8 electrons in its outer (valence) shell which resembles a noble gas valence shell.
- For anions, by subtracting 18 from the Group #, the charge can usually be calculated. Anions are formed by gaining electrons, so that the resulting anion has a noble gas configuration.
- Within the chemical formula, cations and anions come together in such a way as to balance the positive and negative charge. Therefore, the chemical formula represents the number of cations and anions needed to result in no overall charge.

Example:

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<table>
<thead>
<tr>
<th>First part of name,</th>
<th>Second part of name and ends with -ide, nonmetal anion,</th>
</tr>
</thead>
<tbody>
<tr>
<td>metal cation, Group 1,</td>
<td>with -ide, nonmetal anion,</td>
</tr>
<tr>
<td>1+ oxidation state</td>
<td>Group 16, has charge of 2⁻</td>
</tr>
<tr>
<td>potassium sulfide</td>
<td></td>
</tr>
</tbody>
</table>
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K has a 1+ charge,
S has a 2- charge
Therefore two K⁺ are needed to balance one S²⁻