The United States Supreme Court has the unenviable task of deciding what the law is. This responsibility can be a major challenge when there is no clear principle involved or where there is a new situation not encountered before. Chemistry faces the same challenge in extending basic concepts to fit a new situation. Drawing of Lewis structures for polyatomic ions uses the same approach, but tweaks the process a little to fit a somewhat different set of circumstances.

### Polyatomic Ions

Recall that a **polyatomic ion** is a group of atoms that are covalently bonded together and which carry an overall electrical charge. The ammonium ion, \(\ce{NH_4^+}\), is formed when a hydrogen ion \(\ce{H^+}\) attaches to the lone pair of an ammonia \(\ce{NH_3}\) molecule in a coordinate covalent bond.

![Figure 9.6.1: The ammonium ion. (CC BY-NC; CK-12)](image)

When drawing the Lewis structure of a polyatomic ion, the charge of the ion is reflected in the number of total valence electrons in the structure. In the case of the ammonium ion:

\[
\begin{align*}
1 \ \ce{N} \ \text{atom (}= 5) \ \text{valence electrons} \\
4 \ \ce{H} \ \text{atoms (}= 4 \times 1 = 4) \ \text{valence electrons}
\end{align*}
\]

subtract 1 electron for the \(1^+\) charge of the ion

\[
\text{total of 8 valence electrons in the ion}
\]

It is customary to put the Lewis structure of a polyatomic ion into a large set of brackets, with the charge of the ion as a superscript outside the brackets.

Example 9.6.1

Draw the Lewis electron dot structure for the sulfate ion.

**Solution:**

*Step 1: List the known quantities and plan the problem*
Known

molecular formula of sulfate ion: $\ce{SO_4^{2-}}$

- 1 $\ce{S}$ atom $\times 6 = 6$ valence electrons
- 4 $\ce{O}$ atoms $\times 6 = 24$ valence electrons
- add 2 electrons for the $2-$ charge of the ion
- total of 32 valence electrons

The less electronegative sulfur atom is the central atom in the structure. Place the oxygen atoms around the sulfur atom, each with a single covalent bond. Distribute lone pairs to each oxygen atom in order to satisfy the octet rule. Count the total number of atoms. If there are too many electrons in the structure, make multiple bonds between the $\ce{S}$ and $\ce{O}$.

Step 2: Solve

![Figure 9.6.2: The sulfate ion.](image)

Step 3: Think about your result

The Lewis structure for the sulfate ion consists of a central sulfur atom with four single bonds to oxygen atoms. This yields the expected total of 32 electrons. Since the sulfur atom started with six valence electrons, two of the $\ce{S-O}$ bonds are coordinate covalent.

Summary

- Lewis structures for polyatomic ions follow the same rules as those for other covalent compounds.

Contributors

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