Group 16 Elements

Group 16 elements are also known as the chalcogens, which “derives from the Greek word for bronze, and refers to the association of sulfur and its congeners with copper” (Atkins & Shriver, 2006, pg376). The group is comprised of oxygen, sulfur, selenium, tellurium, and polonium. At standard temperature and pressure oxygen is the only member of the group that’s a gas, the rest are solids. Sulfur and selenium exist as nonmetals, tellurium as a metalloid, and polonium as a radioactive metal.

The group follows the major trends of the periodic table. The atomic radius increases down the period of elements, with oxygen the smallest and polonium the largest. The electronegativity and the ionization energy decrease down the period. This leads to the uniqueness principle of the second row, which is displayed by oxygen. A clear example of this principle is that the melting and boiling points increase down period with only oxygen having negative values.

Oxygen is the second most electronegative element in periodic table, making it the most reactive of the group. The high electronegativity of oxygen leads to polarity in bonding. For example, the high polarity of oxygen in water produces hydrogen bonding between the lone pair electrons on oxygen and other hydrogens in solution. Due to the lack of d-orbitals, which follows the uniqueness principle, oxygen has an oxidation state of -2.

Oxygen, the most abundant element of the group, is found as two allotropes, dioxygen (O2) and ozone (O3). Dioxygen’s ground state is triplet oxygen. Dioxygen also has a state
of higher energy, known as the singlet state oxygen. The triplet state follows Aufbau’s Principle for filling orbitals, with the two remaining electrons in different orbitals with the same spin. In the singlet state, the two remaining electrons are in the same orbital with opposite spin, increasing the energy. This phenomenon of oxygen switching between the two states can be seen in Aurora Borealis. To overcome the energy difference between the two states energy from the sun is required. Electrons and charged particles that are given off by the sun can hit triplet state oxygen, exciting it into the singlet state. When the electron falls back to the ground state, visible light is emitted, producing the different colors. Colors seen are determined by the altitude and energy at which the collisions between particles and electrons are taking place. This phenomenon occurs at poles because charged particles are channeled by Earth’s magnetic field lines which go into the poles.

Sulfur, the second element in the group, is commonly found as an 8-membered ring. Unlike oxygen, sulfur has poor pi-orbital overlap due to larger atomic size, hindering double bonding with itself. Due to the availability of d-orbitals, it can form stable compounds with oxidation states ranging between -2 and +6, the most common states being -2, +4, and +6. Sulfur forms a similar structure with hydrogen as it does with oxygen, but the differences in electronegativity make H2S less polar and therefore less likely to hydrogen bond. Sulfur was the basis for mustard gas, Cl-CH2-CH2-S-CH2-CH2-Cl, a cancer causing weapon used in World War I. By changing the structure of the gas and substituting nitrogen for sulfur, N-mustard is formed, which is used to fight Hodgkin’s Disease and many types of cancer.

Selenium and tellurium are both large elements with similar properties. They exhibit oxidation states similar to sulfur that also range from -2 to +6. Their commonly found structures are different. Like sulfur, selenium is found as an 8-membered ring, whereas
tellurium crystallizes in a chain-like form. Selenium and tellurium combine with most elements although not as readily as the more electronegative members of the group, oxygen and sulfur. Selenium exhibits both photovoltaic and photoconductive actions and therefore is used in the production of photocells and solar cells.

Polonium, a radioactive element, is rarely found in nature. It’s made in small quantities by a nuclear reaction with bismuth. There are 29 known radioisotopes and more known isotopes than any other element. Polonium crystallizes in a cubic structure. Due to large atomic size, Pi orbital overlap becomes difficult, therefore rarely forms double bonds. Following the trend, it’s the least electronegative of the group, yet combines directly with most elements.

In November 2006, a Russian spy named Alexander Litvinenko was poisoned with a lethal dose of $^{210}\text{Po}$. It is believed that he consumed less than a microgram. Only a very small amount was needed because polonium decays through alpha emission. An alpha emission is a $^4_2\text{He}$, which is a large emission that heavily damaged his vital organs.
References


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WebElements™, the periodic table on the WWW, URL: http://www.webelements.com/

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