Photochemical smog is a type of air pollution due to the reaction of solar radiation with airborne pollutant mixtures of nitrogen oxides (NOx) and volatile organic compounds (hydrocarbons). Smog is a byproduct of modern industrialization. Due to industry and the number of motor vehicles, this is more of a problem in large cities that have a warm, sunny and dry climate.

- **Oxidation**: Photochemical smog is also referred to as oxidizing smog. Oxidation reactions have been defined several ways. In terms of oxygen transfer, oxidation is a gain of oxygen. Oxidation can also be defined as a loss of hydrogen. The most important use of oxidation is described in terms of electron transfer. Oxidation can be described as an increase in oxidation number or loss of electrons. Oxidation numbers represents a distribution of charge. In other words, oxidation numbers represent the charge of the atom if the compound was composed of ions. (Oxidation Numbers – [Rules and Practice Problems](#)).

- **Reduction**: Reduction can involve the gain of hydrogen or loss of oxygen. Reduction can refer to the gain of electrons, which results in a decrease in oxidation number.

### Formation of Photochemical Smog

**Step 1**: People begin driving in the morning, nitrogen is burned or oxidized

\[ \text{N}_2 + \text{O}_2 \rightarrow 2\text{NO} \]

- Oxidation number of N₂ is 0. The nitrogen in NO has acquired an oxidation number of +2.

**Step 2**: After a few hours, NO combines with O₂, in another oxidation reaction

\[ 2\text{NO} + \text{O}_2 \rightarrow 2\text{NO}_2 \]

- The nitrogen in NO has an oxidation number of +2. The nitrogen in NO₂ has an oxidation number of +4.

**Step 3**: Nitrogen dioxide absorbs light energy, resulting in a reduction reaction

\[ \text{NO}_2 \rightarrow \text{NO} + \text{O} \]

- The nitrogen in NO₂ has an oxidation number of +4 and the nitrogen in NO is +2.

**Step 4**: In sunlight, atomic oxygen combines with oxygen gas to form ozone

\[ \text{O} + \text{O}_2 \rightarrow \text{O}_3 \]

**Step 5**: Reaction is temperature and sunlight dependent

\[ \text{O}_3 + \text{NO} \rightarrow \text{NO}_2 + \text{O}_2 \]

### Alternative Reactions

NO and NO₂ can also react with the hydrocarbons instead of ozone to form other volatile compounds known as PAN.
(peroxyacetyl nitrate). The accumulation of ozone and volatile organic compounds along with the energy from the sun forms the brown, photochemical smog seen on hot, sunny days. Panoramic view of Santiago covered by a layer of smog on May 10, 2006. The Metropolitan Region of Santiago facing the driest autumn last 28 years due to lack of rainfall, which coupled with poor air circulation, causes an increase in smog.

From ChemPRIME: 11.15: Oxidation Numbers and Redox Reactions

References


Contributors

• Ed Vitz (Kutztown University), John W. Moore (UW-Madison), Justin Shorb (Hope College), Xavier Prat-Resina (University of Minnesota Rochester), Tim Wendorff, and Adam Hahn.