Chapter 7
Atmospheric Chemistry:
An Overview – Ozone, Acid Rain, and Greenhouse Gases

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ABSTRACT

The complex chemistry and basic physics of Earth's atmosphere will be reduced to three main sections within the context of the chemical reactivities of predominant chemical species and the additional role of photochemistry from solar radiation. The three areas of chemical interactions and photochemical reactions in the atmosphere discussed are (1) the reactivities and relationships between chemical species that can affect tropospheric and stratospheric ozone concentrations, (2) reactions between chemical species that create acid rain, and (3) the chemical species, sources, and reactions that are believed to be contributing to climate change. These three areas in atmospheric dynamics will comprise this chapter along with some of the documented effects on ecological systems, human health, and infrastructure.

INTRODUCTION

In 1994, physicist and astronomer, Carl Sagan, referred to the earth as a "pale blue dot" (Sagan, 1994, p. 7). His reference was from a National Aeronautics and Space Administration (NASA) photograph taken of Earth at his request by a receding Voyager 1 spacecraft as it approached the outer reaches of the solar system four billion miles from Earth. Earth appeared as one pale blue pixel in Saturn's rings. Images of Earth taken from space all reveal a sapphire blue sphere surrounded by a

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gaseous envelope that is as essential for almost all lifeforms as liquid water. Earth's atmosphere is a blanket of gases about 375 miles high, but about 99% of the gases and aerosols of the atmosphere are confined to the first 20 miles of altitude in regions of the atmosphere called the troposphere and stratosphere. The first studies of gases began with Boyle, Charles, Gay-Lussac, and Avogadro who each discovered fundamental relationships between gas properties of pressure, temperature, volume, and the quantity of gaseous atoms or molecules. With advances in atomic theory and chemistry by Dalton, Lavoisier, Priestly, and others, the birth of the new science of atmospheric chemistry occurred in the mid-18^{th} and 19^{th} centuries (Kotz, Treichel, Townsend, & Treichel, 2015).

Earth's Atmosphere: General Descriptions

The regions of the atmosphere all have particular properties which are based on such factors as pressure, temperature, radiant flux, latitude, seasons, gas density, turbulence, mobility, the Coriolis effect, particulates, diurnal cycle, and the chemical species. The mean radius of the Earth is about 3,965 miles (midway between the equatorial and polar radii). Using the mean radius to calculate the volume of the atmosphere, v_{atm}, to about 375 miles above the surface would be equal to the total volume of the planet including the atmosphere, v_t, minus the volume of the earth: $v_{atm} = v_t - v_{\text{earth}}$. The volume of a sphere is: $\frac{4\pi r^3}{3}$, thus,

$$v_{atm} = \frac{4\pi}{3}(4,340\,\text{miles})^3 - \frac{4\pi}{3}(3,965\,\text{miles})^3 = 3.424\text{E+11 miles}^3 - 2.611\text{E+11 miles}^3$$

This gives an estimate for the volume of the atmosphere to 375 miles above the surface of 8.13×10^{10} cubic miles or about 81.3 billion cubic miles. The atmospheric volume of the first 20 miles where almost all gases are found is about 1% of the total volume or about 813 million cubic miles.