Exercise 11.4
Nonmetal Oxides as Acids

1. When coal or oil containing sulfur compounds is burned, sulfur dioxide is produced. The sulfur dioxide reacts with nitrogen dioxide (another pollutant) to give sulfur trioxide and nitrogen monoxide. All of these pollutants are gases.

    Sulfur trioxide reacts with water to give sulfuric acid. When this happens in the atmosphere, acid rain forms.

(a) In the mid-1990s, fossil fuel combustion (power plants, vehicles, etc.) and industry were releasing sulfur oxides containing 70 Tg S per year. (1 Tg = 1 million tonnes = 10^{12} g).

    Calculate the mass of each of the following:

    i. SO_2 containing 70 Tg S

    ii. SO_3 containing 70 Tg S

    iii. H_2SO_4 containing 70 Tg S

(b) Draw a balanced chemical equation for the reaction of sulfur trioxide with water (using Lewis diagrams not molecular formulas). Use curly arrows to show the movement of electrons in the first step on this reaction. *You do not have to show how the H moves.*

(c) Sulfur trioxide is behaving as what type of acid in this reaction?

(d) What are the oxidation states of sulfur in sulfur trioxide and sulfuric acid?

(e)   A cap-and-trade scheme has significantly reduced the amount of sulfur oxides released into the atmosphere; however, we are still releasing substantial amounts of a different nonmetal oxide – carbon dioxide. In 2010, annual global emissions were 33 618 Tg CO_2. 30-40% of this carbon dioxide is dissolved in the oceans.

Describe the consequences of continuing to dissolve substantial amounts of CO_2 in the ocean every year (considering that many creatures at the base of the ocean food web have shells made of $CaCO_3$). Use chemical equations where appropriate.