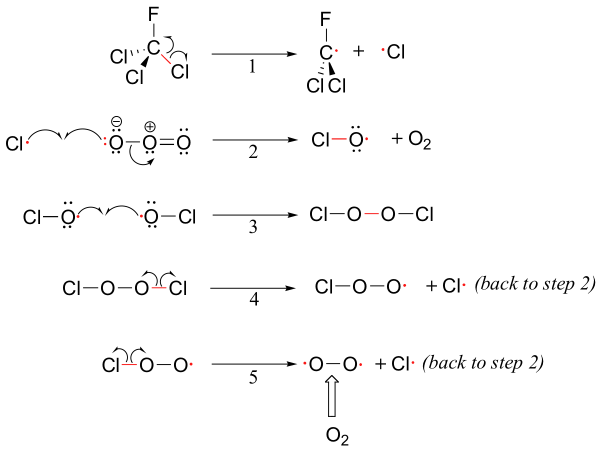
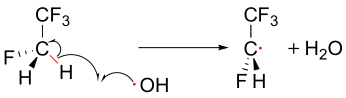
13.9: Application- The Ozone Layer and CFCs

The high reactivity of free radicals and the multiplicative nature of radical chain reactions can be useful in the synthesis of materials such as polyethylene plastic - but these same factors can also result in dangerous consequences. You are probably aware of the danger posed to the earth's protective stratospheric ozone layer by the use of chlorofluorocarbons (CFCs) as refrigerants and propellants in aerosol spray cans. Freon-11, or $CFCl_3$, is a typical CFC that was widely used until fairly recently. It can take months or years for a CFC molecule to drift up into the stratosphere from the surface of the earth, and of course the concentration of CFCs at this altitude is very low. Ozone, on the other hand, is continually being formed in the stratosphere. Why all the concern, then, about destruction of the ozone layer - how could such a small amount of CFCs possibly do significant damage? The problem lies in the fact that the process by which ozone is destroyed is a chain reaction, so that a single CFC molecule can initiate the destruction of many ozone molecules before a chain termination event occurs.

Although there are several different processes by which the ozone destruction process might occur, the most important is believed to be the chain reaction shown below.



To address the problem of ozone destruction, scientists are developing new organohalogen refrigerant compounds that are less stable than the older CFCs like Freon-11, in the hope that the new compounds will break down in the lower atmosphere before they reach an altitude where they can harm the ozone layer. Most of the new compounds contain carbon-hydrogen bonds, which are subject to homolytic cleavage initiated by hydroxide radicals present in the lower atmosphere.



This degradation occurs *before* the refrigerant molecules have a chance to drift up to the stratosphere where the ozone plays its important protective role. The degradation products are quite unstable and quickly degrade further, by a variety of mechanisms, into relatively harmless by-products. The hydroxide radical is sometimes referred to as an atmospheric 'detergent' due to its ability to degrade refrigerants and other volatile organic pollutants which have escaped into the atmosphere.

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