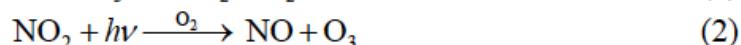


1) Problem 11.2 “[Sources of Tropospheric O₃](#)” in Jacob textbook

2) Chemical regimes in the upper troposphere.

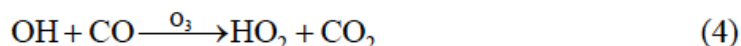
Aircraft emissions of NO_x may increase ozone concentrations in the upper troposphere where it is an efficient greenhouse gas. We examine here the sensitivity of ozone to NO_x in the upper troposphere under different conditions.

The NO_x radicals (NO_x ≡ NO + NO₂) cycle through the reactions:



Assume that the [NO]/[NO₂] ratio is determined solely by reactions (1)-(2) (a reasonable approximation in the upper troposphere). For the rest of this problem, write [NO] = α[NO_x] and [NO₂] = (1-α)[NO_x] where α is a coefficient assumed constant.

The HO_x radicals (HO_x ≡ OH + HO₂) in the upper troposphere are produced at a rate $P(\text{HO}_x)$ that we assume to be constant. They cycle and are consumed principally by the following reactions:



- 6.1 Identify four different HO_x sinks in the above mechanism.
- 6.2 We can distinguish four different chemical regimes in the upper troposphere depending on the dominant reaction for HO_x loss. Let us model each of these regimes by considering the limiting case where loss of HO_x is exclusively by the dominant reaction. Further assume that the HO_x radicals are in chemical steady state, and that HO_x cycling is efficient so that the HO_x cycling reactions are much faster than the HO_x loss reactions. For each regime, determine the dependence of the ozone production rate on [NO_x].
- 6.3 Which of the four regimes applies to very low NO_x concentrations? to very high NO_x concentrations? Plot qualitatively the O₃ production rate as a function of [NO_x], identifying each chemical regime in the plot. Briefly conclude as to the challenge of predicting the response of O₃ to increasing aircraft NO_x emissions.