

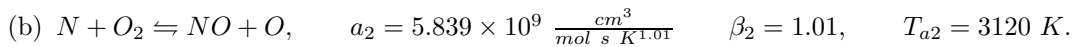
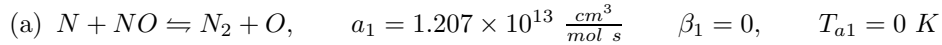
AME 60636

Prof. J. M. Powers

Homework 3

Due: Monday, 11 September 2006

1. Write a description of less than one page of the Zel'dovich mechanism of  $NO_x$  production. Use the L<sup>A</sup>T<sub>E</sub>X text formatter to generate your output. Include appropriate formatted equations and appropriate references. Your text is a starting point.
2. Consider a system which is a part of the Zel'dovich mechanism for formation  $NO$ :



Take the system to be isothermal with  $T = 6000 \text{ K}$  and isobaric with  $P = 10^6 \text{ dyne/cm}^2$ . At  $t = 0 \text{ s}$ , we have  $n_N = 10^{-6} \text{ mol}$ ,  $n_{NO} = 10^{-6} \text{ mol/cm}^3$ ,  $n_{N_2} = 10^{-6} \text{ mol}$ ,  $n_O = 10^{-6} \text{ mol}$ ,  $n_{O_2} = 10^{-6} \text{ mol}$ .

- Write a system of five ordinary differential equations in five unknowns to describe the evolution of each species concentration. Include appropriate initial conditions.
- Find conserved quantities and give the physical significance of each.
- Reduce the system to two ordinary differential equations in two unknowns, where the unknowns are  $\bar{p}_{NO}$  and  $\bar{p}_N$ .
- Find all equilibrium states, and identify which are physical.
- Perform a local linear analysis around each physical equilibrium, and identify the time scales of reaction.
- Write a Fortran code to integrate the full equations from the initial state to the equilibrium state. Include a copy of your code (leaving out the dlsode subroutine) as an appendix to your solution.
- Plot all species concentrations versus  $t$ .
- Plot  $\bar{p}_N$  versus  $\bar{p}_{NO}$ .
- Plot  $P(t)$ .
- Using the thermodynamic tables to estimate the enthalpies at the end states, calculate the total heat transfer in  $kJ$  in the process. Compare these predictions to those in which the gases are estimated to be calorically perfect.