16.50 Spring 2001
Problem Set #5
Assigned: 3/7/01
Due Date: 3/14/01

A Hydrazine thrustor to be used on a satellite uses a catalyst bed to decompose the Hydrazine. Schematically, the process in the catalyst bed is described by

$$N_2H_4 \rightarrow \alpha NH_3 + \beta N_2 + \delta H_2$$

It is adiabatic, and note that this assumes all the N_2H_4 decomposes. The reactants may be assumed to be at standard temperature and pressure.

We will assume that the decomposition goes to chemical equilibrium at a pressure of 20 atm. The equilibrium constant for the Ammonia, $K_{p,\,NH3}$ is defined by

$$\tfrac{1}{2} N_2 + \tfrac{3}{2} H_2 \rightarrow NH_3$$

is given by

$$\log_{10} K_{p,\,NH3} = \frac{2622}{T} - 5.93$$

where T is in degrees K and pressure is in Pascals.

a) First find the composition in the chamber for Chemical Equilibrium?

Note: To keep the calculation simple use constant (room temperature) C_p's. with no vibrational excitation, even though we know this is not quite correct.

b) Now find the effective exhaust velocities in space, assuming the nozzle expands to 0.2 atm in both cases, for:

1) Frozen flow in the nozzle, and
2) Equilibrium flow in the nozzle.

c) Find the required throat area, in m^2, for a thrust of 100 N, assuming frozen flow from the chamber to the throat.