A problem from a previous exam:

This problem concerns a chemical rocket using H\(_2\) as a fuel and F\(_2\) as an oxidizer. The ratio of the propellant molar flow rates, \(\dot{N}_{H_2} / \dot{N}_{F_2} = 1\). The combustion chamber pressure and temperature is 50 atm and 4800K, respectively.

(a) If the combustion products are H, F, and HF, calculate the \(K_p(T)\) for the equilibrium reaction among these species at the combustion chamber conditions, where

\[
\chi_H^* = \chi_F^* = 0.1353 \\
\chi_{HF}^* = 0.7294
\]

(b) The combustion products expand in the exhaust nozzle to a pressure and temperature of 1 atm and 3200K, respectively. Determine \(K_p(T)\) at these exhaust conditions. The bond dissociation energy of HF is 564 kJ/mole.

(c) Using \(K_p(T)\) from part (b), determine the equilibrium mole fractions of H, F, and HF at the exhaust.