

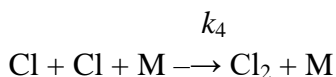
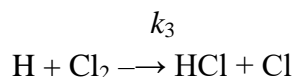
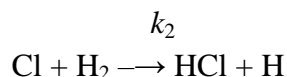
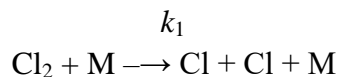
ME301A (First Sem, 2017 – 18)

Assignment 1

Due date: Aug 31 (Thursday)

Submit problem no. 2, 3, 4, 7 only (remaining are for practice)

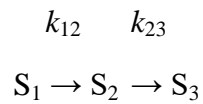
- 1) A mixture of 40% by volume methane, CH_4 , and 60% by volume propane, C_3H_8 , is burned completely with stoichiometric air. Determine the Air/Fuel ratio on a mass and on a mole basis. Determine the lower and upper heating value of the mixture during the stoichiometric combustion
- 2) Consider the (a) constant pressure (b) constant volume, adiabatic combustion of a Methyl alcohol (CH_3OH) with air, at temperature 25°C . Determine the adiabatic flame temperature and plot it for at least 10 values of equivalence ratio ranging from lean to rich mixture. You may write a MATLAB code. Use polynomial expressions for species specific heat.
- 3) Liquid octane (C_8H_{18}) enters the combustion chamber of a gas turbine at 25°C and air enters from the compressor at 250°C . It is determined that 98% of the carbon in the fuel burns to form CO_2 and remaining 2% burns to form CO . What amount of excess air will be required if the temperature of the products is to be limited to 850°C ?
- 4) Calculate the equilibrium composition for the reaction $\text{H}_2 + 1/2\text{O}_2 = \text{H}_2\text{O}$, when the ratio of the number of moles of elemental hydrogen to elemental oxygen is unity. The temperature is 2000K and pressure is 2 atm. Determine the equilibrium composition if O_2 further dissociates in to O atoms, $\text{O}_2 = 2\text{O}$.
- 5) Consider the water-shift reaction $\text{CO}_2 + \text{H}_2 = \text{CO} + \text{H}_2\text{O}$. Assume that the equilibrium constant $k(T)$ is $k(1100\text{K}) = 1$ and $k(2100\text{K}) = 10$. Further assume that the global forward reaction rate coefficient is $K_f = AT^n e^{-\frac{T_A}{T}}$ where $T_A = 15000\text{ K}$, $n=1/2$ and $A=10^{10}\text{ cm}^3\text{ mol}^{-1}\text{ s}^{-1}$. Estimate the global reverse rate coefficient k_r at 1600 K. (The water gas shift reaction is a global description of the reaction sequence $\text{CO}_2 + \text{H} \rightarrow \text{CO} + \text{OH}$, $\text{H}_2 + \text{OH} \rightarrow \text{H}_2\text{O} + \text{H}$.)
- 6) Consider the following elementary reactions of the Hydrogen-Chlorine combustion system:



Derive the following rate expression by assuming quasi-steady state

$$\frac{d[\text{HCL}]}{dt} = 2k_2 \sqrt{\frac{k_1}{k_4}} [\text{Cl}_2]^{0.5} [\text{H}_2]$$

- 7) Assume a simple reaction chain consisting of two elementary steps:



- (a) Derive the rate laws for each species, S_1 , S_2 and S_3 .
- (b) If S_2 is very reactive and has a short chemical time scale ($k_{23} \gg k_{12}$), S_2 is consumed as soon as it is produced. Thus, consumption and production rates of S_2 can be assumed to approximately balance $\frac{d[S_2]}{dt} \approx 0$ and such an assumption is called the quasi-steady state assumption. Simplify the expression obtained in (1) by applying the quasi-steady state assumption.
- (c) Plot species concentrations (you may normalize concentration by $[S_1]_{t=0}$) vs. time.