Chemical Engineering 140 **February 27, 2019**

Midterm Examination #1

(115) 1. Incomplete Combustion of Methane

Methane is now abundant as a clean fuel source in the United States due to the emergence of advanced drilling technologies (i.e., fracking). A methane combustion reactor is fed with methane and air in an air-to-fuel molar ratio of A/F = 2.37. At this ratio, combustion is incomplete and the combustor runs fuel rich. The produced gas contains CO_2 and CO in an equal molar ratio (i.e., the selectivity of the combustion process to CO_2 is 1).

(10) a. What is the limiting reactant for this process?

(15) b. What species are present in the outlet flow stream?

(25) c. Construct a process flow diagram of the combustion reactor, labeling all species present in the inlet and outlet streams. Fill out the diagram with all specified information given in the problem statement.

(20) d. Calculate the percentage deficiency of oxygen (because combustion is incomplete, less oxygen is fed than is required to react completely all methane fuel).

(45). e. Perform species balances to establish mole fractions of each species in the product stream.

(95) 2. Conversion in a Filling Batch Stirred Tank Reactor

A dilute aqueous drug is produced in a BSTR of volume V by first-order irreversible reaction with rate constant k. However, it takes time to fill the initially empty the tank, so the manufacturer produces drug while the tank fills at volumetric flow Q. Reactant concentration in the inlet line is C_{Ao}.

(25) a. Derive an expression for the volume of fluid in the tank.

(45) b. Derive a differential equation for the reactant concentration in the BSTR before the reactor fills. List the initial condition.

(25) c. Integrate your differential equation to obtain $C_A(t)$ before the reactor fills. It is best to recognize that the product C_AV is the moles of A in the reactor and to treat C_AV as the dependent variable