Chemical Reaction Engineering—Homework #0

Due: Online submission on Canvas, **Friday, January 10, 2020 at 11:59pm.**

No late submissions will be accepted.

Problems that require a numeric answer should have 3 significant figures. Units, where required, are shown in blue. Please use these units. Approximate answers are indicated in blue.

This homework is a basic review of chemistry and solving systems of ODE's computationally. These are some of the essentials of this course.

Problem 1: Stoichiometry, Limiting Reagent

Consider the reaction:

$2\ Sb\ (s) + 3\ I_2\ (s) \rightarrow 2\ SbI_3\ (s)$

Determine the limiting reagent and the theoretical yield when:

a. 1.20 mol of Sb and 2.40 mol of I_2 are mixed.

b. 1.20 g of Sb and 2.40 g of I_2 are mixed. What mass of excess reactant is left when the reaction is complete?

Problem 2: Precipitation reactions

An aqueous solution of sodium hydroxide and iron(III) nitrate are mixed and a red precipitate forms in the bottom of the flask. Calculate the mass of the precipitate that is formed when 50.00 mL of 0.200 M NaOH and 30.00 mL of 0.125 M $Fe(NO_3)_3$ are mixed.

Precipitation of $Fe(OH)_3$

Problem 3: Gas phase reactions

A mixture in which the mole ratio of hydrogen to oxygen is 2:1 initially is used to prepare water using the reaction below.

$$2\ H_2\ (g) + O_2\ (g) \rightarrow 2\ H_2O\ (g)$$

The total pressure in the container is 0.950 atm at 25°C before the reaction. What is the final pressure in the container at 125°C after the reaction, assuming an 88.0% yield and no volume change?

Problem 4: Thermochemistry

Given the following system, calculate ΔH for the formation of one mole of dinitrogen pentoxide from its elements in their stable state at 25°C and 1 atm.

$2H_2$ (g) + O_2 (g) → $2H_2O$ (l); ΔH = -571.6 kJ
N_2O_5 (g) + H_2O (l) → $2HNO_3$ (l); ΔH = -73.7 kJ
0.5 N_2 (g) + 1.5 O_2 (g) + 0.5 H_2 (g) → HNO_3 (l); ΔH = -174.1 kJ

Problem 5: Chemical Reaction Equilibrium

For the reaction,

$$N_2O_4\ (g) \rightleftarrows 2\ NO_2\ (g)$$

The equilibrium constant is known to be 11 atm at 373K. Starting with pure N_2O_4 at a pressure of 1.00 atm, what are the equilibrium partial pressures of NO_2 and N_2O_4?

Problem 6: Systems of ordinary differential equations, Plug flow reaction with a pressure drop

Using the system of ODEs below graph X and y on a plot of X vs. W for $0 \le W \le 60$.

$$\frac{dX}{dW} = \frac{k'}{F_{A0}}\left(\frac{1-X}{1+\epsilon X}\right)y$$

$$\frac{dy}{dW} = \frac{-\alpha(1+\epsilon X)}{2y}$$

The following values are known: k′ = 0.0266, F_{A0} = 1.08, α = 0.0166, ϵ = -0.15. Initially, X(0) = 0 and y(0) = 1.