ENGS-37 **Fall 2011**

INTRODUCTION TO ENVIRONMENTAL ENGINEERING

HOMEWORK #1

Assigned: Friday 23 September 2011
Due: 10 a.m., Friday 30 September 2011

1. (10 points) Read the article by the Vermont Department of Health on air quality in offices, posted on the internet at

http://healthvermont.gov/enviro/indoor_air/air_office.aspx

and focus on the 11 recommendations made in the last section "What can be done…".
a. (6 points) Which of these recommendations address pollution prevention and which deal with treatment of existing pollution?
b. (4 points) Which in your opinion are the two most effective strategies to avoid air pollution in offices that are already in existence (as opposed to planning and building new offices)?

2. (5 points) (Mihelcic & Zimmerman, page 49, Problem 2.2, 1st half) A water sample contains 10 mg NO_3^- per liter. What is the concentration (a) in ppm on a mass basis, and (b) in moles/L?

3. (5 points) (Mines & Lackey, page 31, Problem 2.16) Assume the discharge from a wastewater treatment plant has a flow of 30 Mgd (million gallons per day) with a solids concentration of 5 mg/L. Determine the mass flow rate of solids in lb_m/day.

4. (5 points) (Mines & Lackey, page 31, Problem 2.17) Consider a wastewater treatment cell having a length of 100 ft, width of 20 ft, and depth of 20 ft. If the flow into the cell is 50 ft^3/min, calculate the residence time of the treatment cell.

5. (5 points) (Mines & Lackey, page 58, Problem 3.8) Determine the volume in cubic feet occupied by 120 pounds of carbon dioxide at 1.5 atm and 40°C.

6. (10 points) Consider the following reaction representing the combustion of propane:

$$C_3H_8 + O_2 \rightarrow CO_2 + H_2O$$

a. (2 points) Balance the equation.
b. (2 points) How many moles of oxygen are required to burn 1 mole of propane?
c. (3 points) How many grams of oxygen are required to burn 100 g of propane?
d. (3 points) Under standard conditions (temperature of 25^{o}C, pressure of 1 atmosphere, and oxygen concentration equal to 20% on a volume basis), what volume of air is required to burn 100 g of propane?

7. (10 points) (Mihelcic & Zimmerman, page 155, Problem 4.13) A 1.0×10^6 gallon reactor is used in a sewage-treatment plant. The influent concentration is 100 mg/L, the effluent concentration is 25 mg/L, and the flow rate through the reactor is 500 gal/min.

(a) What is the first-order rate constant for decay of BOD in the reactor? Assume that the reactor can be modeled as a CMFR. Report your answer in units of per hour.

(b) Assume that the reactor should be modeled as a PFR with first-order decay, *not* as a CMFR. In that case, what must the first-order decay rate constant be within the PFR reactor?

(c) It has been determined that the outlet concentration is too high, so the residence time in the reactor must be doubled. Assuming all other variables remain constant, what must be the volume of the new CMFR?

8. (10 points) (Based on Mines & Lackey, page 58, Problem 3.10) An incinerator is being designed to burn toluene ($C_6H_5CH_3$, a type of volatile organic compound) from some fume flowing at 1,640 cubic feet per minute under ambient pressure and temperature of 250^{o}F. The toluene concentration in the fume stream is 1,600 ppm on a volume basis, and the fume stream contains no oxygen.

Determine the minimum flow rate of air (in ft^3/min) entering at ambient pressure and at 60^{o}F that needs to be fed to the combustion chamber to ensure complete thermal oxidation of the toluene.

If the allowed speed of incoming air is not to exceed 100 ft/s, determine the minimum cross-sectional area of the intake ducts.