

Homework #2

Released: 10/06/2014 (Mon) - Due: 10/16/2014 (Thu), 5:30 pm (Bldg 35, Room 519)

The homework will NOT be graded, but we will check for MISSING ANSWERS and CHEATING. Note that a cheated homework will get 80% of the lowest score in the class. You can give the answers either in English or Korean.

1. [Mass balance] The SNU River has a flow rate of $3.00 \text{ m}^3/\text{s}$ ¹. A stream named CEE discharges into the SNU River at a flow rate of $0.05 \text{ m}^3/\text{s}$. To study mixing of the stream and the river, a non-reactive compound is to be added to CEE. The detection limit for this compound is 1.0 mg/L . For the compound to be detected after the stream and the river is completely mixed and the system reaches the steady state, what is the minimum amount of the compound (in kg/day) that should be added to the stream? Assume that the compound is not present in the river and the stream prior to the addition.

¹This is a flow rate before the stream discharges to the river.

2. [Reactors] In 1908, H. Chick reported an experiment in which he disinfected anthrax spores with 5% phenol solution. The results of his experiment are shown below. Assuming the experiment was conducted in a completely mixed batch reactor, determine the decay rate constant.

¹anthrax spore: 탄저균 포자

Time (min)	Anthrax spore concentration (numbers/mL)
0	398
30	251
60	158

3. [Reactors] A reactor with a dimension of $4 \text{ m} \times 2.5 \text{ m} \times 50 \text{ m}$ (width $\times$ depth $\times$ length) is receiving a flow rate of $250 \text{ m}^3/\text{hr}$. Assume that the reactor acts as an ideal PFR.

- i) Calculate the retention time.
 - ii) If a terrorist dumped 10 kg of benzene to the influent, how long will it take for the benzene to be detected in the effluent (detection limit = 1 mg/L)? What will be the maximum concentration in the effluent?
4. [Reactors] An ideal CMFR with a reactor volume of 500 m³ is receiving a flow rate of 250 m³/hr.
- i) Calculate the retention time
 - ii) If a terrorist dumped 10 kg of benzene to the influent, how long will it take for the benzene to be detected in the effluent (detection limit = 1 mg/L)? What will be the maximum concentration in the effluent? How long will it take for the benzene to go below the detection limit in the effluent?
5. [Reactors] You are planning to apply chlorine disinfection to kill pathogens in a drinking water treatment plant. The pathogen decay kinetics by chlorine disinfection follows a first-order reaction with a reaction constant of 0.2/min. Your goal is to achieve 99% reduction in the number of pathogens by the disinfection and want to determine whether you have to design a PFR or a CMFR. Assuming the flow rate is 20 m³/min, calculate the volume requirement of the reactor for a PFR and a CMFR.
6. [Ecosystems] Explain how the atmospheric N₂ is converted to a form of nitrogen that is useful for plant growth.
7. [Ecosystems] Draw the typical temperature and dissolved oxygen profile in summer for a lake located in a region of a temperate climate. Explain what happens in late fall when the temperature above the lake goes below 4°C.

8. [Risk] The recommended time weighted average air concentration for occupational exposure to water soluble Cr^{6+} is 0.005 mg/m^3 . This concentration is based on an assumption that the individual is generally healthy and is exposed for 8 hours per day, 5 days per week, 50 weeks per year, over a working lifetime (from age 18 to 65 years). Assuming a body weight of 75 kg and inhalation rate of $15.2 \text{ m}^3/\text{d}$ over the working life, what is the lifetime (75 years) CDI? What is the carcinogenic risk of the individual? You can find the slope factor for the inhalation of Cr^{6+} (Chromium (VI)) in Textbook Table 6-3.
9. [Risk] Characterize the hazard index for a chronic daily exposure by the water pathway (oral) of 0.03 mg/kg-day of toluene, 0.06 mg/kg-day of barium, and 0.3 mg/kg-day of xylenes. You can find the oral reference dose (RfD) for those chemicals in Textbook Table 6-4.