1. (10 points) Consider the following reaction representing the combustion of propane:

\[ \text{C}_3\text{H}_8 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O} \]

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°C, pressure of 1 atm, and oxygen concentration equal to 20% on a volume basis), what minimum volume of air is required to burn 100 g of propane?

2. (5 points) (Mihelcic & Zimmerman, page 49, Problem 2.2, 1st half) A water sample contains 10 mg NO₃⁻ per liter. What is the concentration (a) in ppm on a per mass basis, and (b) in moles/L?

3. (5 points) The waste stream from a food processing facility has a flow of 12 Mgd (million gallons per day) with a solids concentration of 12 mg/L. The filtering treatment applied to this stream removes 95% of the solids, which are subsequently dried. The dried solids are then hauled by truck to a composting facility. If one truck load is 9 short tons (1 short ton = 2,000 pounds), how frequently should a truck come to haul the solids away to composting? Assume continuous operation seven days a week.

4. (10 points) (Mihelcic & Zimmerman, page 155, Problem 4.13) A 1.0 \times 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. (4 points) What is the first-order rate constant for decay of sewage in the reactor? Assume that the reactor can be modeled as a CMFR. Report your answer in per-hour unit.
b. (3 points) 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. (3 points) Because the outlet concentration is too high, it has been determined that the residence time in the reactor must be doubled. Assuming all other variables remain constant, what must be the volume of the new CMFR?

4. (10 points) (From another textbook) A typical motorcycle emits 20 g of carbon monoxide (CO) per mile, and the tailpipe emission diffuses in a 10-m² cross-section behind the cyclist (perpendicular to the direction of travel). What is the maximum number of motorcycles that can be in a group going one behind another along a street before the CO concentration exceeds to air quality standard of 9.0 ppm? (Assume complete mixing in the 10-m² cross-section and that ambient air is at 20°C and 1 atmosphere.)
The extra thinking question
(10 points)

Read the articles reporting on tri-chloro-ethylene (TCE) contamination by the Cold Regions Research & Engineering Laboratory (CRREL), north of campus in Hanover, New Hampshire. The hazardous substance was used in the past as a refrigerant, but leaks contaminated underground water, and there is now evidence that the volatile compound is seeping as a gas above ground level.

1. More Contaminant Found: Low Level of TCE Detected at Dartmouth College Housing, by Sarah Brubeck, Valley News, Saturday, 30 March 30 2013
http://www.vnews.com/home/5365123-95/more-contaminant-found

2. Part One: Intruder at the Border; A Toxin Emerges As Health Threat, But Official Action Comes Slowly, by Sarah Brubeck & Maggie Cassidy, Valley News, Sunday, 30 June 2013
http://www.vnews.com/home/7161937-95/intruder-at-the-border

3. Part Two: TCE Testing Process Took Years; Army Lab’s Neighbors Mixed on Pace of Cleanup Effort, by Sarah Brubeck & Maggie Cassidy, Valley News, Monday, 1 July 2013
http://www.vnews.com/home/7162483-95/tce-testing-process-took-years

(If the links do not lead you to the appropriate pages, cut and past the article titles and dates into your search engine.)

Environmental engineers can perform remediation of a contaminated site, treatment of an effluent, and prevention of future pollution. Explore what these different approaches would mean in this case. Also, argue why multiple approaches should be pursued and which approach should be priority. Finally, describe the risk of doing nothing.

Your answer does not need to be very technical. Two or three paragraphs will suffice.