Midterm 2: Exam Blueprint

CENG 340–Introduction to Environmental Engineering
Instructor: Deborah Sills

November 18, 2013

Exam Format

Exam will include mostly (if not all) problems, but may also include some short answer and multiple choice questions. When solving problems, make sure you write down what you know, and, if you're stuck, describe what you are thinking and how you are approaching the problem.

You should bring a double-side page with equations and unit conversions to use in the exam. You can include words this time, but do not include definitions, descriptions, solved example problems, or diagrams. You will be asked to submit your equation sheet with your exam.

Learning Goals

Environmental Measurements

Relevant sections in Chapter 2 of the textbook: 2.5.1–2.5.3

Topics Covered:

1. Calculate chemical concentrations in units of mass/volume, mole/volume, and eq/volume.
2. Calculate chemical concentration in common constituent units such nitrogen species (e.g. NH_3 in units of "as N"), and alkalinity in units of eq/L, and mass/volume "as $CaCO_3$."

Water Chemistry

Relevant sections of Chapter 3 in the textbook: 3.7 (acid–base and alkalinity), 3.11(kinetics)

Topics Covered:

1. Apply the law of conservation of mass to write balanced chemical equations and to calculate masses of reactants and products.
2. Apply acid-base equilibrium to calculate aqueous concentrations of weak acid and its conjugate base (e.g., HOCl and OCl^- for free chlorine)

3. State, in differential form, a change in concentration with time according to zero- and first-order reaction kinetics.
4. Solve (or integrate) the differential form of zero- and first-order reaction kinetics.
5. Given sufficient data, calculate C, C_0, k, or t for zero- and first-order reactions.

Mass Balance with (or without) reactions

Relevant sections of Chapter 4 in the textbook:pp. 106–127

Topics Covered:

1. Describe the term "mass balance" in words and write the general mass balance equation.
2. Conduct a mass balance on a node where multiple streams meet and mix completely.
3. Conduct a mass balance on a control volume with multiple inputs and outputs, including recycle flows.
4. Prepare a labeled diagram of reactor systems that includes inputs, outputs, control volume, known and unknown variables.
5. Derive equations for batch and CMFR reactors that describe C as f(time), or t as f(C, C_0).
6. Calculate C, t, HRT, V, Q, or k for CMFR, batch, and PFR reactors, given sufficient data.
7. Determine from a problem description, reactor type (batch, PFR, CMFR), and steady-state or non-steady-state conditions. And modify the general mass balance equation accordingly.
8. Compare and explain the efficiency of a PFR and CMFR for zero- and first-order reactions.

Water Treatment

Relevant sections of Chapter 10 in the textbook:pp. 10.1-10.6, 10.7.2 (ignore the part of ex.10.6 that uses Stokes Law), 10.8.2

Topics Covered:

1. Describe the characteristics of water: physical (Table 10.2), chemical (organic and inorganic), and biological (viruses, bacteria, protozoa). Refer to PPT file handed out on Monday, 9/9 (also posted on the schedule page of the course website.
2. Characterize a contaminant as physical, chemical, or biological.
3. Name three pollutants that are regulated by EPA's primary drinking water standards (examples are presented in Table 10.8), and describe their associated health risks.
4. Describe the difference between a MCL and MCLG.
5. Calculate the carbonate, non-carbonate, and total hardness of a water sample, given appropriate chemical concentrations.

6. Define and describe the term "Improved Water Source."

7. Draw block-flow diagrams of water treatment facilities designed to treat surface water (high-turbidity with pathogens) or ground water (high levels of hardness). State the name and purpose of each unit operation.

8. Given the appropriate design basis (including the need for n tanks out of service), determine the volume of coagulation and flocculation tanks and their power requirements.

9. Calculate the amount of coagulant required based on the results of a jar test. And, in the case of alum, calculate the alkalinity requirements for coagulation.

10. Calculate the amount of lime required to remove carbonate hardness due to Ca^{2+}, carbonate hardness due to Mg^{2+}, and non-carbonate hardness due to Mg^{2+}.

11. Evaluate the performance of a clarifier (or sedimentation/settling tank) given an OFR and settling velocities of particles.

12. Given flow rate and clarifier dimensions, calculate HRT and OFR. Alternatively, determine the appropriate clarifier dimensions given flowrate, HRT, OFR, and a number of tanks to be out of service.

13. Given flow rate and rapid-sand-filter dimensions, calculate the HLR. Alternatively, determine the appropriate filter dimensions given HLR, flow rate, and a number of filters to be out of service.

14. State the two primary factors that affect the performance of a disinfection process.

15. With respect to chlorination with "free chlorine", justify that pH influences the effectiveness of disinfection.

16. Define disinfection byproducts (DBPs), describe how they are formed and their impact on human health. Name a DBP.

17. Name three disinfectants and discuss their pros and cons with respect to required dose, residual disinfectant, and disinfection byproducts (DBP).

Biological Oxygen Demand

Relevant sections of Chapter 5 in the textbook: 5.4 through 5.4.4

Topics Covered:

1. Define the following terms: theoretical oxygen demand (ThOD), biochemical oxygen demand (BOD), carbonaceous biological demand (CBOD), ultimate BOD (BOD_u or L_0), L(t), y(t), and nitrogenous biological demand (NBOD).

2. Calculate carbonaceous and nitrogenous ThOD given the chemical formula of a waste.

3. Be able to interpret plots of BOD as L(t) and y(t).

4. Calculate ultimate BOD from results of a BOD test.

5. Describe the laboratory procedures for determining BOD, and state the standard conditions for a BOD test.

6. Calculate the volumes of waste and dilution "water" needed to set up a BOD test, given concentrations of dissolved oxygen and BOD for both solutions.

7. Calculate the effect of temperature on k (BOD decay rate coefficient), L(t), and y(t).

8. Conduct a mass balance on a node to calculate BOD concentrations of mixed streams.

Growth of Microorganisms

Relevant sections of Chapter 5 in the textbook:pp. 164–168, 171–175, Table 5.4

Topics Covered:

1. Describe the four stages of microbial growth.

2. Define and identify the parameters included in the Monod model: μ_{max}, K_s, X, μ, and S.

3. Analyze the Monod model and describe conditions that result in zero- or first-order kinetics.

Wastewater Treatment

Relevant sections of Chapter 11 in the textbook: pp.461–466

Topics Covered:

1. Draw a block-flow diagram of a wastewater treatment facility.

2. Match major constituents in wastewater with the unit process(es) that remove a significant amount of each constituent, based on Table 11.3 on p.466.