Midterm 1: Exam Blueprint

CENG 340–Introduction to Environmental Engineering
Instructor: Deborah Sills

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Exam Format

Exam will include mostly problems, but will 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 single-side page with equations and unit conversions (do not include words) to use in the exam. ("Alk" is the closest thing to a word that should be on the exam.) You will be asked to submit your equation sheet with your exam. I included a list of useful equations and unit conversions at the end of this document.

Learning Goals

State of the Planet–Chapter 1 in the text book

1. Describe three environmental challenges presented in the chapter.
2. Describe how one global environmental challenges may affect the civil and environmental engineering professions.

Environmental Measurements

Relevant sections in Chapter 2 of the textbook: 2.1–2.4, 2.5.1–2.5.3

Topics Covered:

1. Calculate chemical concentrations in units of mass/mass, mass/volume, mole/volume, mole/mole, volume/volume, ppm$_v$, ppm$_m$, and partial pressure.
2. **Demonstrate that you know when to use units of ppm$_m$ (for liquid concentrations), ppm$_v$ (for gas concentrations).**
3. Calculate chemical concentration in common constituent units such nitrogen species (e.g. NO_3^{2-} in units of "as N", greenhouse gases (in units of CO_2 equivalents), and alkalinity in units of eq/L and "as $CaCO_3$."

4. Describe and, given the appropriate data, calculate concentration of the following types of solid particles in water : TS, TSS, TDS, VS, FS, FSS, VSS, FDS, VDS.

Water Quality

Relevant sections of Chapter 10 in the textbook: 10.1-10.3

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. Be able to characterize a contaminant as physical, chemical, or biological.
3. Use Table 10.8 from the text book (would be provided in an exam) to compare a given concentration of a pollutant to the regulated concentration.

Water Chemistry

Relevant sections of Chapter 3 in the textbook:3.1 (approaches in environmental chemistry), 3.3 (stoichiometry), 3.6 (air-water partitioning), 3.7 (acid–base and alkalinity), 3.9 (precipitation–dissolution), pp. 76–79 (sorption), 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. Identify which chemical approach— equilibrium or kinetic— should be applied to a given environmental problem.
3. Apply equilibrium relationships to calculate chemical concentrations of pollutants in air, water, and soil using the following four types of reactions:
   (a) Water–gas partitioning, based on Henry's Law. Be able to use Henry's constant, K_H, in the following units: $\frac{\text{mole}}{\text{L}\times\text{atm}}$, $\frac{\text{L}\times\text{atm}}{\text{mole}}$, $\frac{\frac{\text{mole}}{\text{L}}\,\text{gas}}{\frac{\text{mole}}{\text{L}}\,\text{aq}}$
   (b) Acid-Base
   (c) Precipitation Dissolution
   (d) Solid-Water Partitioning (sorption)
4. State, in differential form, a change in concentration with time according to zero-, first-, and second-order reaction kinetics.
5. Solve (or integrate) the differential form of zero-, first-, and second-order reaction kinetics.
6. Given sufficient data, calculate C, C_0, k, or t for zero-, first-, or second-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. Prepare a labeled diagram of reactor systems that includes inputs, outputs, control volume, known and unknown variables.
3. Derive equations for batch and CMFR reactors that describe C as f(time), or t as f(C, C_0).
4. Calculate C, t, HRT, V, Q, or k for CMFR, batch, and PFR reactors, given sufficient data.
5. Determine from a problem description, reactor type (batch, PFR, CSTR), and steady-state or non-steady-state conditions. And modify the general mass balance equation accordingly.
6. Compare and explain the efficiency of a PFR and CMFR for zero and first order reactions.
7. Sketch concentration vs. time graphs for a conservative tracer in ideal and real CMFR and PFR reactors.

Useful Equations and Unit Conversions:

$$[\mathrm{H}^+][\mathrm{OH}^-] = 10^{-14}$$

$$\mathrm{pH} = -\log[\mathrm{H}^+]$$

$$\mathrm{Alk(eq/L)} = [\mathrm{HCO}_3^-] + 2[\mathrm{CO}_3^{2-}] + [\mathrm{OH}^-] - [\mathrm{H}^+]$$

$$\mathrm{PV} = \mathrm{nRT}$$

$$\mathrm{K} = 273 +^0 \mathrm{C}$$

$$\mathrm{R} = 0.08205\,\frac{\mathrm{L} \times \mathrm{atm}}{\mathrm{mole} \times \mathrm{K}}$$

$$\frac{\mathrm{P_i}}{\mathrm{P_{total}}} = \frac{\mathrm{V_i}}{\mathrm{V_{total}}} = \frac{\mathrm{n_i}}{\mathrm{n_{total}}} = \mathrm{ppm_v} \times 10^6$$

$$1000\,\mathrm{L} = 1\,\mathrm{m}^3$$