CIVE 3331 - ENVIRONMENTAL ENGINEERING
Spring 2003

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Purpose: Exercises related to Lecture # 4. These exercises develop skills in selected environmental chemistry problems. Critical thinking is exercised in determination of analogies between lecture examples and the problems in this exercise set. Direct relationships to various accreditation objectives are highlighted in **Bold** type in the following sections. The exercises start on the next page.

Relevant ABET EC 2000 Criteria: Criterion 3 Program Outcomes and Assessment

(3-a) an ability to **apply knowledge of mathematics, science, and engineering**.
(3-e) an ability to identify, **formulate, and solve engineering problems**.
(3-k) **an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.**

Relevant CEE Educational Objectives:

(3) Emphasize **problem-identification**, **problem-formulation** and communication skills, **problem-solving techniques** and the many facets of engineering design throughout the curriculum.

(5) **Prepare every student to develop the skills for critical thinking and lifelong learning.**

Relevant CEE Program Outcomes:

ii. **Students should acquire the ability to solve practical civil engineering problems by applying the knowledge of mathematics, science**, **engineering**, **modern techniques**, **skills and practical tools** they **gained in their courses.**

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Exercise_004-1

Consider the following reaction representing the combustion of propane:

C_3H_8 + O_2 => CO_2 + H_2O

a) Balance the equation.
b) How many moles of oxygen are required to burn one mole of propain?
c) How many grams of oxygen are required to burn 100g of propane?
d) At STP (standard temperature and pressure) what volume of oxygen would be required to burn 100g propane?
e) If air is 21% oxygen, what volume of air at STP is required?
f) At STP what volume of CO_2 would be produced when 100g of propane is burned?

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Exercise_004-2

An unknown substance is empirically determined to be 40.00 percent carbon by weight, 6.67 percent hydrogen, and 53.33 percent oxygen. Its molecular weight is roughly 55 g/mol. Determine the molecular formula and the correct molecular weight.

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Exercise_004-3

What is the molarity of 10g glucose dissolved into 1 liter of water?

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Exercise_004-4

For the following possible automobile fuels, express their higher heating value (HHV) in Btu/gallon.

a) Methanol (CH_3OH), density 6.7lbs/gallon, H^o = -238.6 kJ/mol
b) Ethanol (C_2H_5OH), density 6.6 lbs/gallon, H^o = -277.6 kJ/mol
c) Propane (C_3H_8), density 4.1 lbs/gallon, H^o = -103.8 kJ/mol

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Exercise_004-5

Find the ThOD for the following solutions:

a) 200 mg/L of acetic acid (CH_3COOH)
b) 30 mg/L ethanol
c) 50 mg/L sucrose ($C_2H_{12}O_6$)

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Exercise_004-6

Water is usually disinfected with chlorine gas, forming hypochlorous acid (HOCl), which partially ionizes into hypochlorite and hydrogen ions:

$HOCl \Leftrightarrow H^+ + OCl^- \quad K_{HOCl} = 2.9 \times 10^{-8}$

The amount of [HOCl], which is the desired disinfectant, depends on the pH. Develop a design curve that relates the fraction of hypochlorous acid in solution to the pH (i.e. $[HOCl]/\{[HOCl] + [OCl^-]\}$. What would be the hypochlorous fraction at pH = 4.0, 6.0, 8.0, and 10.0?

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Exercise_004-7

Hydrogen sulfide (H_2S) is an odorous gas that can be stripped from solution in a process similar to ammonia stripping. The reaction is

$H_2S \Leftrightarrow H^+ + HS^- \qquad K_1=0.86 \times 10^{-7}$

Develop a design curve that relates the fraction of H_2S in solution as a function of pH. What are the fractions at ph = 4, 6, and 8?

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Exercise_004-8

Calculate the equilibrium concentration of dissolved oxygen in 15oC water at 1 atm., and again at an elevation of 2000 meters above sea level.

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Exercise_004-9

Suppose the gas above the soda in a bottle of soft drink is pure CO_2 at a pressure of 2 atm. Calculate the pH of the soft drink.

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Exercise_004-10

It is estimated that the concentration of CO_2 in the atmosphere before the industrial revolution was 275 ppm. If CO_2 accumulation in the atmosphere continues at current rates it may be around 600 ppm by the next century. Calculate the *pH* of rainfall in these two periods (pre-industrialization and next century).

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Exercise_004-11

One strategy for controlling acidification of lakes is to periodically add excess lime ($CaCO_3$) into the lake. Calculate the *pH* of a lake that has enough excess lime so that the lake is saturated with calcium and carbonate ions. This calculation is identical to that one would make to estimate the pH of the oceans, which are saturated with $CaCO_3$.

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