NATIONAL EXAMS

May 2013

11-CS-3, Sustainability, Engineering and the Environment

3 hours duration

NOTES:

1. If a doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. Any non-communicating calculator is permitted. This is an open book exam. Write the name and model designation of the calculator, on the first inside left hand sheet of the exam book.

3. Any four (4) questions constitute an exam paper. Only the first four questions as they appear in your answer book will be marked.

4. All questions are of equal value.

Marking Scheme

1.	25 marks total	(a) 10 marks
		(b) 8 marks
		(c) 1 mark
		(d) 2 marks
		(e) 2 marks
		(f) 2 marks
2.	25 marks total	(5 marks per section)
3.	25 marks total	one question
4.	25 marks total	(a) 4 marks
		(b) 4 marks
		(c) 5 marks
		(d) 12 marks
5.	25 marks total	(a) 4 marks
		(b) 6 marks
		(c) 2 marks
		(d) 3 marks

Question (1) – 25 points

a. Transportation is the source of 60% of human-made NO and NO_2 (= NO_X) emissions to the environment. What are two regional air pollution problems associated with oxides of nitrogen? For each of the two, write a chemical equation to show how NO is involved, and add a sentence or two of explanation. **(10 points)**

b. What can be done to reduce NO from transportation? Specifically describe four solutions. Be sure that your solutions cover the range of degrees of design freedom: optimize the existing system, reengineer the system, and redefine the problem. **(8 points)**

c. List two natural sources of NO. **(1 point)**

d. Explain why NO is a primary pollutant, whereas ground-level ozone is a secondary pollutant. **(2 points)**

e. Explain why ground level ozone is a pollutant, while stratospheric ozone is beneficial. **(2 points)**

f. What is the name of the federal legislation that covers air pollution? Is air pollution a federal or provincial responsibility? **(2 points)**

Question (2) – 25 points

a. One of the 12 Principles of Green Engineering is "Embedded complexity must be viewed as an investment when making design choices on recycle, reuse, or beneficial disposition." Give a specific example of how this principle can be used to prevent pollution. **(5 points)**

b. One of the 12 Principles of Green Engineering is "Targeted durability, not immortality, should be a design goal." Give a specific example of how this principle can be used to prevent pollution. **(5 points)**

c. One of the 12 Principles of Green Engineering is "Multi-component products should strive for material unification to promote disassembly and value retention." Give a specific example of how this principle can be used to prevent pollution. **(5 points)**

d. One of the 12 Principles of Green Engineering is "Designers need to strive to ensure that all material and energy inputs and outputs are as inherently non-hazardous as possible." Explain how this relates to the concept of *Industrial Ecology*. **(5 points)**

e. Assume that you are conducting a life-cycle-assessment on the use of cedar wood shingles or synthetic shingles made of recycled plastic for a rooves. What would be a good functional unit for the LCA? In what stage of the LCA would you expect to find the greatest environmental impact and why? **(5 points)**

Question (3) – 25 points

a. Compare the following methods of generating electricity:

- burning coal
- nuclear fission
- photovoltaic solar cells
- hydroelectric
- wind

Create a table to summarize your analysis. Use the five headings: cost, how long the resource will last (at present rates of consumption), local air pollution, hazardous waste generated, and global warming potential. Use values from the textbook for cost and duration of the resource. For the other four categories, rate the methods as high, medium or low, with an explanation for your rating.

Question (4) – 25 points

a. Turbidity is a parameter used to control processes in drinking water treatment plants. How is turbidity related to microbial water quality? **(4 points)**

b. Describe how waterborne diseases spread in communities lacking proper drinking water treatment and sanitation. **(4 points)**

c. Fecal bacteria in the guts of warm-blooded animals do not grow in the natural environment. When raw sewage is discharged into a lake or river, the bacteria numbers decrease by exponential decay. How many days would it take for a viable bacteria concentration of 10^5 cell/mL to be reduced to 10^2 cell/mL if the decay coefficient is 2.5/day? Show your calculations. **(5 points)**

d. Draw a flow diagram to show the sequence of processes in a typical drinking water treatment plant treating surface water. Label each process and describe which pollutant(s) it removes. **(12 points)**

Question (5) – 25 points

a. What are the four steps in risk assessment? Give a one-sentence description of what occurs in each. **(4 points)**

b. A painter is spray-painting a car using a paint containing toluene. Describe two ways to reduce the hazard of toluene vapour, and two ways to reduce his exposure to gasoline vapour. **(4 points)**

c. How is the risk assessment of exposure to carcinogens different that non-carcinogens? **(2 points)**

d. A 70 kg man drinks 2 L of water each day that contains 0.005 mg/m^3 of arsenic. Calculate his daily dose of arsenic. **(5 points)**

e. Arsenic is a carcinogen. What is the cancer risk for the man exposed as described in part d., if the slope factor for arsenic is 1.5 $(mg/kg\text{-}d)^{-1}$? Is this a safe exposure? **(5 points)**

f. Arsenic also has non-carcinogenic effects. What is the hazard quotient for the man exposed as described in part d., if the reference dose is $3x10^{-4}$ mg/kg-d ? Is this a safe exposure? **(5 points)**