NATIONAL EXAMS

December 2012

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 nitrogen oxide 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. Write a sentence or two of explanation for each to show how these problems are caused by NO. **(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 "Design of processes and systems must include integration of interconnectivity with available energy and materials flows." 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 wood pencils or mechanical pencils for writing. 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 six headings: cost, how long the energy will last (at present rates of consumption), safety, 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 are 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 10^6 cell/mL to be reduced to 10^2 cell/mL if the decay coefficient is 2/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 gasoline attendant is exposed to gasoline vapours repeatedly in his workday. Describe three ways to reduce the hazard of gasoline vapour, and three ways to reduce his exposure to gasoline vapour. **(6 points)**

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

d. A 50 kg women breaths 20 m^3 of air each day that contains 0.002 mg/m^3 of toxalene. Calculate her daily dose of toxaphene. **(3 points)**

e. Assume that toxalene is a carcinogen. What is the cancer risk for the woman exposed as described in part d., if the slope factor for toxalene is 3×10^{-4} (mg/kg-d)$^{-1}$? Is this a safe exposure? **(5 points)**

f. Assume that toxalene is a non-carcinogen. What is the hazard quotient for the woman exposed as described in part d., if the reference dose is 0.010 mg/kg-d ? Is this a safe exposure? **(5 points)**