NATIONAL EXAMS

December 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) 8 marks
		(b) 8 marks
		(c) 4 mark
		(d) 3 marks
		(e) 2 marks
2.	25 marks total	(a) 4 marks
		(b) 4 marks
		(c) 4 mark
		(d) 11 marks
		(e) 2 marks
3.	25 marks total	one question
4.	25 marks total	(a) 12 marks
		(b) 4 marks
		(c) 3 marks
		(d) 6 marks
5.	25 marks total	(a) 4 marks
		(b) 6 marks
		(c) 2 marks
		(d) 3 marks
		(e) 5 marks
		(f) 5 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. **(8 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. Describe the two main ways that humans directly affect the global carbon cycle. State the quantities of CO_2 added to the atmosphere as a result of each of these. **(4 points)**

d. Describe the main mechanism of the global warming theory and the involvement of CO_2. **(3 points)**

e. List two other greenhouse gases and their major anthropogenic sources. **(2 points)**

Question (2) – 25 points

a. One of the 12 Principles of Green Engineering* is *Design for unnecessary capacity or capability should be considered a design flaw. This includes engineering "one size fits all" solutions.* Give a specific example of how this principle can be used to prevent pollution. **(4 points)**

b. One of the 12 Principles of Green Engineering* is *Design of processes and systems must include integration of interconnectivity with available energy and material flows.* Give a specific example of how this principle can be used to prevent pollution. **(4 points)**

c. 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. **(4 points)**

d. Assume that you are conducting a life-cycle-assessment on the use of printed paper books versus electronic readers for a school. **(11 points)**

- **i.** What would be a good functional unit for the LCA?
- **ii.** List the stages of the life-cycle to be considered.
- **iii.** For each stage, decide which of the two alternatives would have the greatest environmental impact and describe why.
- **iv.** In what stage of the LCA would you expect to find the greatest environmental impact for each alternative?

e. Define any two of the following terms: **(2 points)**
- design for disassembly
- industrial ecology
- reverse manufacturing
- pollution prevention
- intrinsic hazard
- intangibles

*Anastas, P. and Zimmerman, J. (2003) Design Through the 12 Principles of Green Engineering. *Env. Sci. Tech.* March 1, p. 94-101.

Question (3) – 25 points

a. Compare the following types of renewable energy technologies:
- solar photovoltaic
- wind turbines
- hydroelectric
- geothermal for building heating
- biofuel (liquid)

Create a table to summarize your analysis. Use the five headings: land requirement, cost, noise, emissions, and safety concerns. Use high/medium/low ratings for land requirement, cost and noise. Provide a few words of explanation for each.

Question (4) – 25 points

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

b. 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 10^7 cell/mL to be reduced to 10 cell/mL if the decay coefficient is 2.5/day? Show your calculations.**(4 points)**

c. Turbidity is a parameter used to control processes in drinking water treatment plants. What does turbidity measure? How is turbidity related to microbial water quality? **(3 points)**

d. Calculate the future water demand, in ML/day, for a town of 5,000 inhabitants at the end of a 20 year design span. The town population is expected to grow exponentially, at a growth rate of 1.5 %/year, whereas the water demand is expected to grow linearly at 0.5 %/year from the current level of 400 L/person/day. **(6 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 the hazard. **(6 points)**

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

d. A 70 kg man breaths 20 m^3 of air each day that contains 40 $\mu g/m^3$ of dichloromethane. Calculate his daily dose of dichloromethane. **(3 points)**

e. Dichloromethane is "likely to be a carcinogen in humans." What is the cancer risk for the man exposed as described in part d. for 350 days/year for 30 years, if the slope factor for dichloromethane is 8.5×10^{-5} $(mg/kg\text{-}d)^{-1}$? Is this a safe exposure? **(5 points)**

f. Dichloromethane also has non-carcinogenic effects (liver damage). What is the hazard quotient for the man exposed as described in part d., if the reference dose is 6.0×10^{-3} mg/kg-d ? Is this a safe exposure? **(5 points)**