NATIONAL EXAMS

May 2014

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. An approved calculator is permitted. This is a closed 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) 5 marks (b) 6 marks (c) 3 mark (d) 3 marks (e) 4 marks (f) 4 marks
2.	25 marks total	(a) 3 marks (b) 3 marks (c) 3 mark (d) 3 marks (e) 9 marks (f) 4 marks
3.	25 marks total	one question
4.	25 marks total	(a) 3 marks (b) 10 marks (c) 4 marks (d) 5 marks (e) 3 marks
5.	25 marks total	(a) 5 marks (b) 8 marks (c) 2 marks (d) 5 marks (e) 5 marks

Question (1) – 25 points

a. What is meant by the term "nitrogen fixation"? Describe two ways that human technologies fix nitrogen and two ways that nitrogen is fixed in nature, listing the main chemical reactants and products in each of these. **(5 points)**

b. 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. **(6 points)**

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

d. Describe the two main ways that humans directly affect the global carbon cycle. Which of these currently results in more CO_2 added to the atmosphere? **(3 points)**

e. List two greenhouse gases other than CO_2, and state their major anthropogenic sources. **(4 points)**

f. Describe the difference between climate change mitigation and climate change adaptation. Give an example of a strategy/technology for each. **(4 points)**

Question (2) – 25 points

a. Define the terms *reuse* and *recycling* and the difference between them. **(3 points)**

b. 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. **(3 points)**

c. 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. **(3 points)**

d. 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. **(3 points)**

e. Assume that you are conducting a life-cycle-assessment on the use of cloth diapers versus disposable diapers for a hospital. **(9 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?

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

e. define any four of the following terms: **(4 points)**
- design for disassembly
- industrial ecology
- reverse manufacturing
- pollution prevention
- intrinsic hazard
- intangibles

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 following five headings: land requirement, cost, noise, emissions, and safety concerns. Use high/medium/low ratings for each cell of the table and provide a few words of explanation for each.

Question (4) – 25 points

a. 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)**

b. 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. **(10 points)**

c. When raw sewage is discharged into a lake or river, the fecal 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 100 cell/mL, if the decay coefficient is 2.4/day? Show your calculations. **(4 points)**

d. Calculate the future water demand, in ML/day, for a town of 6,000 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 380 L/person/day. **(5 points)**

e. Of the three categories of water use by humans: industry, drinking and irrigation, which one results in the greatest worldwide water use? Describe two technologies that would reduce water use. **(3 points)**

Question (5) – 25 points

a. Compare the health risk in living next to a coal-fired power plant versus a nuclear power plant. In each situation, rate (high/medium/low) the relative magnitude of the two risk factors: consequence and likelihood. How is a value for risk evaluated? **(5 points)**

b. Women who work in the textile industry sew clothes at a table, under which is mounted the electric motor that drives their sewing machine. The motor produces electromagnetic radiation, which is normally not harmful. However, if a women sewer becomes pregnant, her developing foetus would be in close proximity to the motor. Negative health effects have been reported when foetuses are exposed to strong electromagnetic radiation. Describe two ways to limit or eliminate the *hazard* in this situation and two ways to reduce the *exposure*. **(8 points)**

c. How is the does-response relationship of exposure to carcinogens different that non-carcinogens? **(2 points)**

d. What is the cancer risk for a woman who drinks 2.0 L/day of water containing 0.005 µg/L (micrograms per litre) of arsenic, 350 days/year for 30 years? The slope factor for arsenic is 1.5 $(mg/kg\text{-}d)^{-1}$? Is this a safe exposure? **(5 points)**

e. Arsenic also has non-carcinogenic effects (nerve damage). What is the hazard quotient for the woman exposed as described in part d., if the reference dose is 3.0×10^{-4} mg/kg-d ? Is this a safe exposure? **(5 points)**