NATIONAL EXAMS DECEMBER 2011

04-Env-A1, Principles of Environmental Engineering

3 hours duration

NOTES:

1. If 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. This is a Closed Book exam with a candidate prepared *8.5in x 11in* double sided Aid-Sheet allowed.

3. Candidates may use one of two calculators, the Casio or Sharp approved models. Write the name and model designation of the calculator, on the first inside left hand sheet, of the exam work book.

4. Any five questions constitute a complete paper. Only the first five answers, to the seven questions, as they appear in your answer book(s) will be marked.

5. Each question is worth a total of 20 marks with the section marks indicated in square brackets [ ] at the end of the question. The complete Marking Scheme is also provided on the final page. A completed exam consists of five (5) answered questions with a possible maximum score of 100 marks.

1. Provide answers to the following questions related to population, economic growth, industrialization, urbanization and energy use as causes of environmental pollution:

   i) Briefly discuss two (2) environmental problems associated with population or economic growth and explain two (2) potential engineering solutions (one for each environmental problem). The engineering solutions may include legislation considerations. **[6]**

   ii) Provincial/territorial air toxics programs are designed to address threats to public health and the environment from toxic air emissions, primarily from industrialization and urbanization. Briefly describe two (2) different types of solutions to resolving the conflicts between adequate employment, associated with industrialization and protecting the environment. **[7]**

   iii) Energy demand is distributed amongst four broad sectors: transportation, residential, commercial, and industrial. In terms of energy production, a shift to clean coal and natural gas utilization has shown an increase. Identify two (2) specific environmental impacts of increased per capita energy utilization. For each impact, provide a well established technology that may be used to minimize the impact and explain the key engineering principle of each technology. **[7]**

2. Provide answers to the following questions related to material and energy balance for engineering systems under steady state and unsteady state conditions.

   i) An automobile driven by an internal combustion engine burns 20 kmol of gasoline consisting of 100% octane (C_8H_{18}) and converts it completely to carbon dioxide and water vapour by a combustion reaction, whose stochiometric equation is:

   $$2C_8H_{18} + 25O_2 \rightarrow 16\ CO_2 + 18H_2O$$

   Assume that all CO_2 and H_2O produced are discharged to the atmosphere and no CO2 enters the combustions chamber. What is the amount of carbon dioxide discharged to the atmosphere from 10 kmol of octane in kg of CO_2? **[7]**

   ii) Consider the carbonate system in a fresh water lake including the air-water-limestone interphase. Briefly describe the response of the lake to a strong alkali spill in the lake and how the carbonate system works to buffer the pH change. In your description, consider using relevant equations and schematics. **[6]**

   iii) Air at 1 atm and 25°C initially fills a bottle of 1 m^3 volume. The bottle is attached to an air line that provides air at 25°C and 50 atm and the bottle is "charged" to a pressure of 50 atm. There is heat transfer from the bottle, so that the air within is held at 25°C throughout the process. Provide a schematic of the system, identify an appropriate control volume and determine the heat transfer for your control volume during this process? Note that a clear explanation of how to solve this problem, without a numerical solution, is considered equivalent to numerical solution and would receive full marks. Remember to identify any assumptions made. **[7]**

3. Provide answers to the following questions related to the application of technical and non-technical environmental principles of solid waste management, environmental impact assessment and environmental ethics:

   i) Briefly describe three (3) solid waste management (SWM) practices normally adopted in industrialised countries as part of a SWM hierarchy. In your description, explain one (1) important environmental ethical consideration necessary to promote the success of the SWM strategy. **[6]**

   ii) An environmental impact assessment (EIA) is important to identify the critical environmental issues during the construction of a new landfill site to serve a regional municipality. Briefly describe three (3) steps you would take as an engineer having been asked to conduct an EIA. In your description, identify a situation where environmental ethics would play an important role during the EIA. **[8]**

   iii) Give a short example to describe how technical and non-technical environmental principles may complement each other to reduce the environmental impacts of solid waste in an urban community. **[6]**

4. Provide an answer to the following questions related to air toxics, sustainable development, life cycle analysis, principles of environmental quality objectives, standards and guidelines:

   Compare and contrast the following terms and/or process descriptions. Note that an example may be used to clarify the similarities and differences:

   i) Air toxic pollutants and ambient concentrations **[5]**

   ii) Application of sustainable development and life cycle analysis principles **[5]**

   iii) Drinking water quality objectives and water treatment plants design standards **[5]**

   iv) Material standards and material production process design guidelines **[5]**

5. Provide answers to the following questions related to disinfection reaction kinetics, environmental ecology and water or wastewater treatment principles:

   i) Briefly explain how the Chick's and Watson Law expressions may be used to determine the level and effectiveness of a disinfectant used in drinking water or wastewater treatment applications. [7]

   ii) A basic phenomenon of environmental ecology is the conservation or cycling of nitrogen through plants, organisms and environmental systems. Briefly describe the main components of the Nitrogen Cycle and their role in sustaining life. [6]

   iii) Consider a typical water treatment plant or wastewater treatment plant and briefly explain the key function associated with the following: (1) sedimentation, (2) disinfection and (3) filtration. In your explanation, you may use diagrams, equations or narrative. [7]

6. Provide answers to the following questions related to thermal pollution, noise pollution, greenhouse gas effects and acid precipitation:

   i) Briefly describe two (2) potential adverse impacts and two (2) corresponding remedial solutions to alleviate the thermal impacts of cooling water to a cold water fishery. **[5]**

   ii) Compare two (2) noise reduction strategies useful to ensure the necessary decibel reductions within a typical residential neighbourhood from a train route within 100 m from the nearest residence. **[5]**

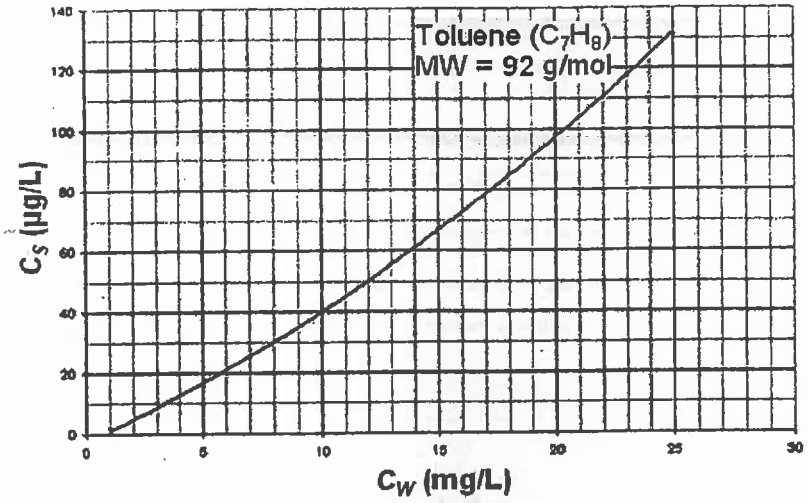
   iii) Briefly describe how global warming may be impacted by the reduction in the emission of greenhouse gasses. Identify two (2) greenhouse gasses and provide two (2) engineering measures (one for each greenhouse gas) that may be used to reduce these emissions giving an advantage and a disadvantage of each engineering measure. **[5]**

   iv) Briefly explain the main cause(s) of acid rain and provide two (2) engineering solutions to reduce the production of acid precipitation from the burning of fossil fuels. In your explanation, give the main challenge associated with the implementation of the engineering solutions. **[5]**

7. Provide answers to the following questions related to contaminant partitioning in water with solids, chemistry of species in equilibrium and reactor material balances:

i) The mobility and fate of Toluene (C_7H_8) in the soil-water (S-W) environment is directly related to its equilibrium partitioning coefficient (K_D) and this can be defined by the equation below. From the plot of the equilibrium partitioning of Toluene in a soil-water mixture and equation provided below, estimate the K_D and n value. **[7]**

$$K_D = \frac{C_S}{C_W^{1/n}}$$



ii) Steady-state equilibrium exists between ammonia and ammonium in the effluent of a primary sewage treatment plant at 20°C and a pH of 8. Given the total ammonia-nitrogen (TAN) concentration is 20 mg/L, calculate the percentage of ammonia-nitrogen (NH_3-N) and ammonium-nitrogen (NH_4^+-N) present in the effluent. Assume that the equilibrium ionization constant is 2×10^{-5} at 20 °C. **[7]**

iii) The water contaminant hydrogen sulphide (H_2S) undergoes first-order decay with rate constant k. Calculate the mean residence time (as a function of k) in a completely mixed flow reactor (CMFR) to achieve a 99.9% removal (i.e., $C_{out}/C_{in} = 0.001$, where C_{out} is the steady-state outlet concentration for a constant inlet concentration C_{in}). **[6]**

Marking Scheme

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December, 2011

1. (i) 6 (ii) 7 (iii) 7 marks; 20 marks total
2. (i) 7 (ii) 6 (iii) 7 marks; 20 marks total
3. (i) 6 (ii) 8 (iii) 6 marks; 20 marks total
4. (i) 5 (ii) 5 (iii) 5 (iv) 5 marks; 20 marks total
5. (i) 7 (ii) 6 (iii) 7 marks; 20 marks total
6. (i) 5 (ii) 5 (iii) 5 (iv) 5 marks; 20 marks total
7. (i) 7 (ii) 7 (iii) 6 marks; 20 marks total