NATIONAL EXAMS DECEMBER 2009

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 This is a Closed Book Exam with a candidate prepared 8 ½ *in* x 11 *in* double sided Aid-Sheet allowed.

3. **Any Casio or Sharp model calculator is permitted into the exam room.**

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

5. Each question is equally weighted at twenty (20) marks with the mark indicated in square brackets [ ] beside 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 and energy use, as causes of urban environmental pollution.* Briefly explain the terms below, identify and discuss one direct connection to the causes of environmental pollution identified above (*in italicised font).* For each pollution term give one (1) possible non-technical solution. Use a matrix to answer each part:

   i) Thermal water pollution [6]

   ii) Particulate (PM_{10}) emissions [7]

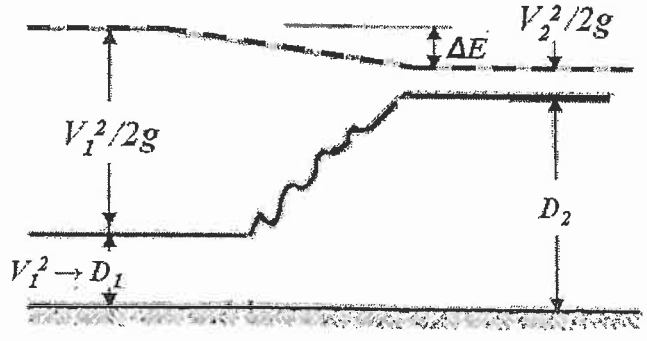
   iii) Black or grey-out phenomena [7]

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

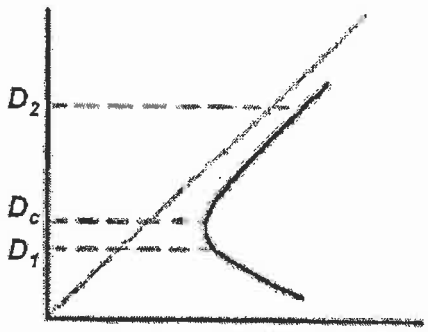
   i) The total alkalinity of a wastewater sample is 200 mg/L as $CaCO_3$. If the temperature and pH of the sample are 10 °C and 10, respectively, calculate the carbonate, bicarbonate and hydroxide alkalinities in mg/L as $CaCO_3$. Assume that the dissociation constant K_a = 5 x 10^{-11} mole/L at 10 °C and use the following atomic masses: Ca = 40; C = 12; O = 16. [8]

   ii) Consider that radon (Rn) decay is a first order phenomena in groundwater with k=0.18 d^{-1}. Assuming that we wish to deliver 1 m^3/d of water to a household with the Rn at 5% of its initial concentration. How long would we have to hold the water in storage to ensure this level of reduction? [5]

   iii) The analysis of a *hydraulic jump* (unsteady state phenomena) requires the energy balance for analysis. Using the figure below provide an explanation of this phenomena using the energy equation or a valid engineering explanation. [7]



Hydraulic Jump Profile



Depth vs Energy Profile

3. Provide answers to the following questions related to *physical and transport properties of homogeneous and heterogeneous mixtures*:

   i) Provide three (3) similarities and three (3) differences between how homogenous and heterogeneous mixtures of contaminants would behave in the case of a liquid waste spill from a transport truck into a flowing stream. **[5]**

   ii) Consider a completely stirred tank reactor (CSTR) and a plug flow reactor (PFR) each of equal volume V (m^3) and having an influent wastewater flowrate of Q (m^3/d). The wastewater containing toluene ($C_6H_5CH_3$) enters both reactors at an influent concentration C_o. Within each reactor the toluene undergoes first-order decay with a rake constant k. In which reactor in the effluent concentration C_e, the least and by how much? Show your analysis. **[5]**

   iii) A tracer test study is commonly used to investigate the transport properties of a reactor. Provide three (3) key properties of a mixture or compound that would make it a good tracer and briefly explain how you would interpret the results of a tracer test to determine if a reactor is a CSTR or a PFR. **[5]**

   iv) Contaminant X is part of a homogenous mixture and is to be treated by a chemical reaction in a PFR. If the reaction proceeds by first-order rate R=k[X], what must the hydraulic detention time T, be to achieve a 90% removal. Briefly explain qualitatively how T might change if X was part of a heterogeneous mixture. Give any assumptions the are necessary to your answer. **[5]**

4. Provide answers to the following questions related to *contaminant partitioning and transport in air, water and solids*. Including *characteristics of particles, chemistry of solutions and gases, material balances, reaction kinetics, microbiology and ecology, as related to the natural environment*:

   i) Toluene ($C_6H_5CH_3$) is a gasoline additive and in low concentration ends up in sanitary sewers as part of the wastewater. Using the physical-chemical properties given below predict the partitioning into the air (stripping), water (dissolved) or solids (sorbed) as it is treated in a wastewater treatment plant. **[10]**
      - Henry's Law constant, H =0.007 atm·m^3/mol;
      - Vapour pressure, P=22 mm Hg;
      - Log octanol-water partition coefficient, $logK_{ow}$=2.7;
      - Water solubility, S_w=0.5 g/L; and
      - Viscosity, v= 0.6 cP.

   ii) Briefly explain how contaminants associated with two (2) *different* particle sizes may affect their fate in the natural environment. Consider colloidal (< 1 μm) versus non-colloidal particle sizes (10 μm). Create a table showing the expected physical, chemical and biological reactions in solution or in the atmosphere. **[10]**

5. Provide answers to the following questions related to *application of environmental principles (technical and non-technical) pertaining to water resource management, water and wastewater treatment, air pollution control, solid waste management, environmental impact assessment and environmental ethics.*

   i) Explain how environmental effluent quality objectives for wastewater treatment plants *or* ambient air quality standards for air pollution control equipment design are useful non-technical tools used by regulators to control environmental pollution. Note to select *only one* case.**[6]**

   ii) Briefly describe three (3) important strategies for solid waste management for an urban centre like Vancouver from 2009 to 2030. In your description use a matrix to highlight how your strategies will help you achieve your objectives and what targets will determine how the objectives have been achieved.**[7]**

   iii) Describe three (3) key principles associated with environmental impact assessment used to establish a municipal solid waste landfill site. Also explain one (1) issue where environmental ethics will play an important part in locating the landfill site. **[7]**

6. Provide answers to the following questions related to *thermal pollution, noise pollution, greenhouse effects, acid precipitation, ozone depletion, air toxics and ground-level ozone and fine particulates (photochemical smog):*

   Briefly explain the terms below, identify and discuss one direct connection to the causes of environmental pollution and for each pollution term give one (1) possible engineering solution:

   i) Noise pollution **[5]**

   ii) Acid rain **[5]**

   iii) Atmospheric ozone depletion **[5]**

   iv) Photochemical smog **[5]**

7. Provide answers to the following questions related to *sustainable development, life cycle analysis and principles of environmental quality objectives, standards and guidelines:*

   i) Use a matrix/table to compare and contrast three (3) common issues related to sustainable development and life cycle analysis. **[10]**

   ii) Use a matrix/table to compare and contrast three (3) common issues related to the use of environmental quality objectives and standards in controlling environmental pollution from a industrial park located near a residential area in a city.**[10]**

MARKING SCHEME

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DECEMBER 2009

1. (i) 6 (ii) 7 (iii) 7 marks; 20 marks total

2. (i) 8 (ii) 5 (iii) 7 marks; 20 marks total

3. (i) 5 (ii) 5 (iii) 5 (iv) 5 marks; 20 marks total

4. (i) 10 (ii) 10 marks; 20 marks total

5. (i) 6 (ii) 7 (iii) 7 marks; 20 marks total

6. (i) 5 (ii) 5 (iii) 5 (iv) 5 marks; 20 marks total

7. (i) 10 (ii) 10 marks; 20 marks total