NATIONAL EXAMS DECEMBER 2018

16-Civ-A3 Elementary 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 $8\frac{1}{2}''$ x $11''$ 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 (5) questions constitute a complete paper. Only the first five (5) answers as they appear in your work book(s), will be marked.

5. Each question is worth a total of 20 marks with the section marks indicated in brackets ( ) at the left margin 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.

Problem 1

Provide answers to the following questions as related to environmental engineering *material balances*, *reaction kinetics* and *microbiology and ecology*:

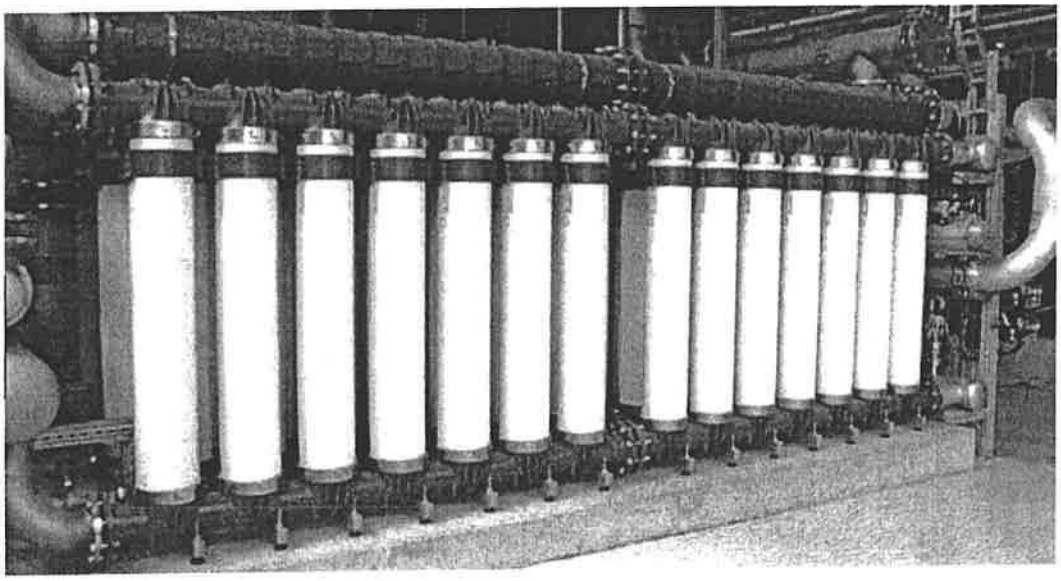
(6) (i) Use mass and energy balances to estimate the lead (Pb) emission in kg/yr from a 2000 MW coal-fired power plant. Assume that the higher heating value of coal (HHV) is 30 x 10^6 J/kg; the concentration of Pb in coal is 5 μg/g and the overall efficiency of the power plant is 50%.

(6) (ii) Consider the fundamental gas phase reaction and the corresponding rate law below:

$$2A + B \Longrightarrow C$$
$$-r_A = k_A C_A^2 C_B$$

Assuming that the reaction is carried out at constant T (400 K) and P (10 atm) with k_A = 100 dm^6/mol^2, determine the completely stirred tank reactor (CSTR) volume that is necessary to achieve a 90% conversion when the feed is 40% mole A and 60% mole B.

(8) (iii) During testing of a new type of membrane filter for the treatment of drinking water, bacteriophage concentrations of 10^6 mL^{-1} and 10 mL^{-1} were measured in the raw surface water and treated water, respectively. Calculate the following: (1) the percent reduction, (2) the corresponding log reduction values and (3) briefly discuss the advantages and disadvantages of using a membrane technology to provide disinfection compared to the current use of chlorine in drinking water treatment plants.



Problem 2

Provide answers to the following questions related to the application of enviornmental principles pertaining to *environmental impact assessment*, *sustainable development* and *environmental ethics*:

(6) (i) The growth of biofuel production from crops has been reported to have a direct impact on the land and the environment. Briefly explain how an environmental impact assessment may be applied to reduce the environmental damage and reduce the life cycle costs associated with the operation and maintenance of a large biodiesel plant (e.g., 200 ML per year) using plants such as sugar cane, maize or soybeen as feed stocks.

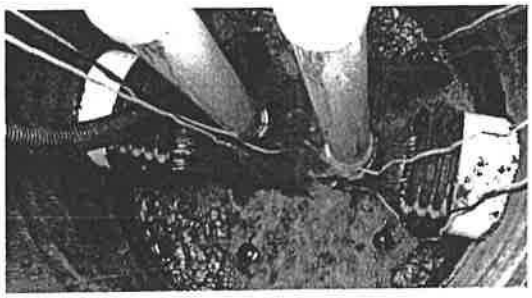
(6) (ii) The following three (3) projects have been selected by Sustainable Development Technology Canada for funding: (1) Developing and marketing natural gas technology for internal combustion engines, (2) Salmon-recirculation aquaculture project to improve yield and reduce waste and (3) Solar power conversion technology. Consider *one (1)* of these projects reaching full commercialization and discuss three (3) key strategies in achieving two (2) important sustainable development goals. Use table(s) to organize your answer.

(8) (iii) An engineer on contract by a construction firm is supervising the commissioning of a new sewage pumping station that is overbudget and past the estimated opening date. The engineer notices what appears to be incorrect flow capacity testing of the main pump. Inadequate system flow capacity may affect the ability of the system to perform adequately during peak flow conditions resulting in sewage overflow to the environment or sewage backups into basements. Briefly explain the actions that should be taken by the engineer, considering the following canons of professional duty:

(a) Act for each employer or client as faithful agents or trustees;

(b) Issue public statements only in an objective and truthful manner; and

(c) Hold paramount the safety, health, and welfare of the public.



Problem 3

Provide answers to the following questions related to *particle characteristics*, *gaseous emissions* and *chemistry of solutions* as it pertains to environmental engineering:

(8) (i) The removal of particles from drinking water is critical for effective treatment. Briefly explain the combined role of coagulation, flocculation and filtration in the effective removal of colloidal and suspended particles in the source surface waters. As part of your explanation, provide a simplified labelled schematic of a typical engineering process that combines the use of the above treatment units.

(5) (ii) Briefly explain two (2) environmental or health and safety impacts and two (2) engineering control methods of gaseous emissions originating in wastewater collection systems that typically migrate to sewage pumping stations. Consider such gasses as hydrogen sulfide (H_2S), methane (CH_4) and other sulfur based volatile malodorous compounds.

(7) (iii) The average analysis results of Ca, Mg and Cu of groundwater near a limestone quarry is given below. Calculate the hardness of the groundwater in mg/L as $CaCO_3$, assuming that the atomic weights are: Ca = 40; Mg = 24; Cu = 64; H=1; C=12 and O=16 and indicate how you would classify this water (i.e., soft, moderately hard or hard):

Ca^{2+} = 40 mg/L
Mg^{2+} = 20 mg/L
Cu^{2+} = 40 mg/L

Problem 4

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

Briefly explain two (2) major environmental impacts and two (2) corresponding potential environmental engineering solutions to reduce impacts from air emissions and increase in water quantity needs associated with the following growth areas (**use a 2 x 3 table as provided below**). Assume that strict environmental requirements are to be met following further growth and industrialization:

(6) (i) Increase in energy use;

(7) (ii) Industrial expansion; and

(7) (iii) Urbanization expansion.

2-Impacts & 2-Solutions	Energy Use	Industrial Expansion	Urbanization Expansion
Air Emissions			
Water Quantity			

Problem 5

Provide answers to the following questions related to the application of environmental principles (technical and non-technical) to *water* and *wastewater treatment*:

(10) (i) Typical source waters contain contaminants including dissolved organics, colloidal particulates, dissolved inorganics, pathogenic microorganisms and floatables. Provide a water treatment plant process configuration to remove these water contaminants. Show the configuration in a clearly labelled schematic and breifly explain the engineering principles at work in each treatment unit necessary to achieve potable water.

(10) (ii) Provide a labelled schematic which includes three (3) main treatment processees of an advanced secondary wastewater treatment plant designed to reduce both nitrogen and phosphorus. In addition, briefly discuss the application of two (2) non-technical principles to ensure that effluent regulatory compliance is maintained over the life of the facility.

Problem 6

Provide answers to the following questions associated with *air pollution control* and *solid waste management* considering both technical and non-technical environmental principles:

(i) Briefly describe, using engineering principles, how each of the following three (3) systems work to control the emission of the specific air pollutants given below (e.g., equipment – contaminant):

(3) (a) Settling chambers – particulates

(3) (b) Packed tower – SO_2

(4) (c) Combustion – NO_x

(ii) Briefly provide strategies, using both technical and non-technical environmental principles, to deal with the following issues related to solid waste management:

(3) (a) Solid waste generation reduction and separation at the source

(3) (b) Efficient transportation routes and need for transfer stations

(4) (c) Estimate of the volume of waste to be generated over the life of a landfill site

Problem 7

Provide answers to the following questions related to *water resources management*, considering both technical and non-technical environmental principles:

(10) (i) Identify and discuss the application of three (3) water resources management strategies, either technical or non-technical, to provide both the short term and the long term protection of the source water in a large aquifer, located near a mining operation. The aquifer is the main source for a drinking water supply serving the local municipality.

(10) (ii) To address the multi-faceted nature of water management, many countries are now introducing an integrated approach to water resources management at the *watershed level*. Assuming that you are the watershed level water resource manager, discuss three (3) key resources management strategies you would apply, using both technical and non-technical environmental principles, to ensure a long term protection and stainability of a large freshwater lake (the main final receiver within your watershed). The lake is both the main drinking water source and used for recreation by a large population from a local municipality.

Marking Scheme
16-CIV-A3 Elementary Environmental Engineering
December 2018

1. (i) 6, (ii) 6, (iii) 8 marks, 20 marks total

2. (i) 6, (ii) 6, (iii) 8 marks, 20 marks total

3. (i) 8, (ii) 5, (iii) 7 marks, 20 marks total

4. (i) 6, (ii) 7, (iii) 7 marks, 20 marks total

5. (i) 10, (ii) 10 marks, 20 marks total

6. (i) (a) 3, (b) 3, (c) 4, (ii) (a) 3, (b) 3, (c) 4 marks, 20 marks total

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