NATIONAL EXAMS MAY 2017

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) Under ambient environmental conditions the rate of iron (Fe^{2+}) oxidation to form a precipitate out of solution is second order with the rate constant $r = -k \cdot C^2$ and $k = 5000$ M/s. If these conditions apply, what mean residence time (t in min) is necessary in a completely stirred tank reactor (CSTR) at steady state to lower the Fe^{2+} concentration from 10 μM to 5 μM? If the flow rate is 1 m^3/s, what reactor size is required? Recall that:

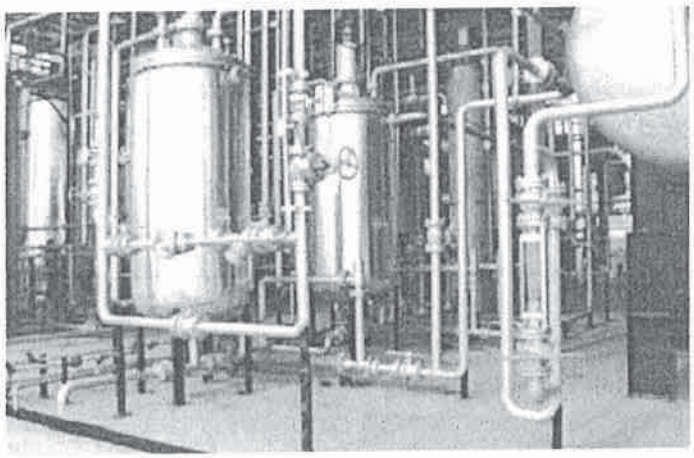
$$\int_{C_o}^{C} \frac{dC}{C^2} = -k \int_{0}^{t} dt \qquad \text{resulting in} \qquad \frac{1}{C_o} - \frac{1}{C} = -kt$$

(6) (ii) Consider the reaction of cumene hydroperoxide (CHP) to phenol and acetone:

$$(C_6H_5)C(CH_3)_2OOH \Longrightarrow (C_6H_5)OH + (CH_3)_2CO$$
$$CHP \Longrightarrow Phenol + Acetone$$

Assuming that the reaction is pseudo-first order with rate constant $r = k \cdot C_{CHP}$, find the reactor volume (V in m^3) to achieve a 90% conversion of CHP at steady state. Assume that the flowrate into the reactor is Q = 30 m^3/hr and k= 4 hr^{-1}.

(8) (iii) Briefly explain how a disinfectant like ultraviolet light or chlorine (**select only one**) works to inactivate microbial pathogens commonly present in source waters. In your explanation, discuss how dose (D) and reaction time (t) affect the effectiveness of the inactivation of microbial pathogens.



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*.

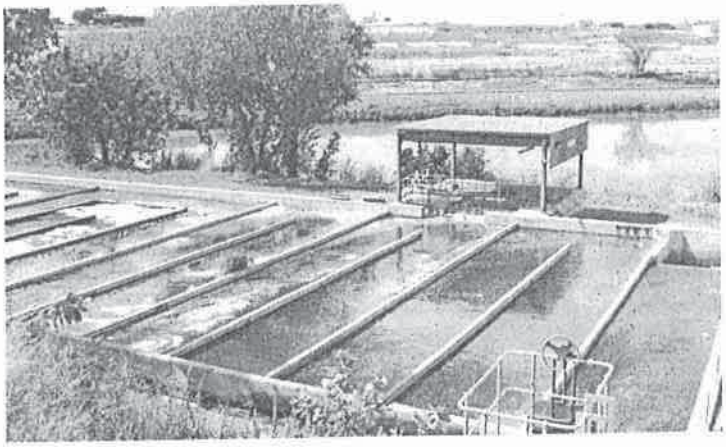
(5) (i) Briefly explain how an environmental impact assessment may be applied to reduce the environmental damage and loss of natural resources from the creation of a dam resulting in loss of valuable land located in northern Ontario.

(5) (ii) Briefly discuss the key principle of sustainable development and to what degree the use of solar power may achieve the principle of sustainability.

(10) (iii) A chemical engineer on contract by the provincial regulator is supervising the commissioning of a new continuous discharge wastewater treatment plant disinfection system that is overbudget and past the estimated opening date. The chemical engineer notices what appears to her to be grab sampling during the low flow diurnal period where the disinfection concentraiton is highest and contact time is the longest and may be over representative of the overall effectiveness of the disinfection system. A very low *E. coli* is required in the summer months due to a busy beach area downstream of the treatment plant effluent discharge point. Briefly explain the actions that should be taken by the chemical engineer, considering the following two (2) ethical principles:

(a) Engineers shall hold paramount the health, safety and welfare of the public in the practice of their profession; and

(c) Engineers shall appropriately report any public works, engineering decisions, or practices that endanger the health, safety and welfare of the public. When, in an engineer's judgment, a significant risk to the public remains unresolved, that engineer may ethically make the concerns known publicly.



Problem 3

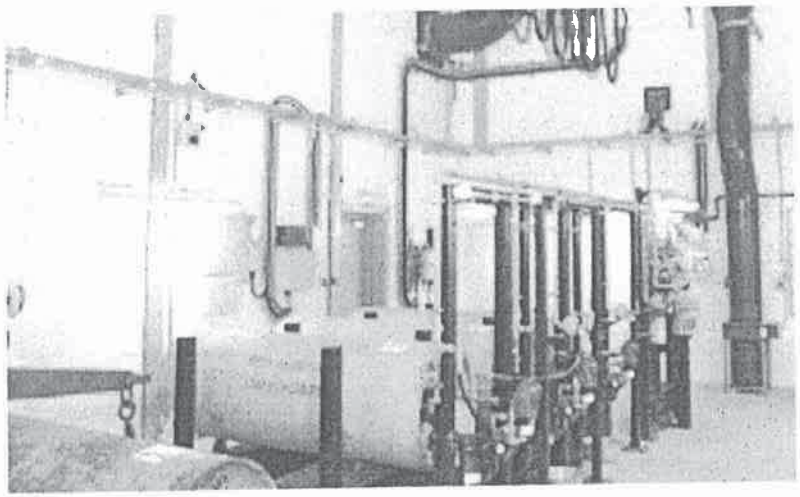
Provide answers to the following questions related to *particle characteristics*, *chemistry of solutions* and *gaseous emissions* as it pertains to environmental engineering:

(8) (i) It becomes obvious that the removal of particles from surface water or wastewater is crucial for effective treatment. Briefly explain the combined role of coagulation-flocculation and filtration in the effective removal of particles. As part of your explanation, provide a labelled schematic of a typical engineering process that combines the use of a coagulation-flocculation and filtration system for either a water or wastewater system (**select only one**).

(7) (ii) The average analysis in terms of Ca^{2+}, Mg^{2+} and Cu^{2+} results of Lake Huron waters near a copper mine is given below. Calculate the hardness of the lake water 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+}	=	100 mg/L
Mg^{2+}	=	500 mg/L
Cu^{2+}	=	80 mg/L

(5) (iii) Briefly explain the use of chlorine gas [Cl_2 (g)] or ozone [O_3 (g)] (**select only one**) as they are applied for the purpose of disinfection of drinking water and any special precautions that need to be taken in their use.



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, water demands and increase in wastewater treatment demands associated with the following growth areas (**use a 3 x 3 table as provided below**). Assume that strict environmental requirements are to be met following further growth and industrialization:

(7) (i) Population growth;

(7) (ii) Industrial expansion; and

(6) (iii) Energy use increases.

2-Impacts & 2-Solutions	Population Growth	Industrial Expansion	Energy Use Increases
Air Emissions			
Water Demand			
Wastewater Treatment			

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) A municipality projects that its population over the next 25-years will double and you as the lead process engineer in the firm have been tasked with developing strategies to increase the existing water treatment capacity of the municipal water filtration plant to meet the needs over the next 25-years. Present two (2) technical and one (1) non-technical engineering low cost strategies to ensure the municipal water treatment needs are met.

(10) (ii) Provide a labelled schematic which includes three (3) main treatment processes of a conventional activated sludge sewage treatment plant. In addition, briefly discuss two (2) non-technical principles to ensure that the sewage treatment plant is well maintained and operated for the expected 30-year 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:

(10) (i) Briefly describe two (2) different types of air pollution controls [one (1) technical and one (1) non-technical] that can be used to reduce the emission of air toxics (e.g., chlorinated hydrocarbons, PM_{10}) from industrial fixed sources. For each type of control, briefly provide one (1) advantage and one (1) limitation of the control and an example of where the control is most appropriate. Use a table to organize your answer.

(10) (ii) The existing landfill site for the city's solid waste will reach capacity in ten (10) years at the current rate of solid waste production. You have been hired to recommend an engineering plan for the next 20 years by the city to assist in managing their solid waste. Identify and briefly discuss two (2) technical and one (1) non-technical strategy that you would recommend in your solid waste management plan. In addition, briefly explain how you would implement each strategy to minimize the overall cost of the plan. Use a table to organize your answer.

Problem 7

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

(8) (i) A large open subsurface water aquifer used as a drinking water supply for a large town is vulnerable to surface water infiltration from surface runoff and air pollution associated with a large smelting operation. Discuss two (2) water resource management strategies to protect both the short term and the long term viability of this valuable water resource.

(6) (ii) Briefly explain two (2) water resource management strategies to ensure the sustainability and effectiveness of the water distribution infrastructure system within a large municipality like Vancouver, British Columbia, over the full 50-year expected life of the system.

(6) (iii) Briefly explain two (2) water resource management strategies to ensure the sustainability and effectiveness of the stormwater collection infrastructure system within a large municipality like Edmonton, Alberta, over a 50-year expected life of the system.

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

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

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

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

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

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

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