NATIONAL EXAMS DECEMBER 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) Use mass and energy balances to estimate the arsenic (As) emission in kg/yr from a 1200 MW coal-fired power plant. Assume that the higher heating value of coal (HHV) is 29 x 10^6 J/kg; the concentration of As in coal is 0.1 μg/g and the overall efficiency of the power plant is 40%.

(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 (500 K) and P (15 atm) with k_A = 10 dm^6/mol^2, determine the completely stirred tank reactor (CSTR) volume that is necessary to achieve a 95% conversion when the feed is 50% mole A and 50% mole B.

(8) (iii) Consider Figure A (below) and briefly explain how the form of chlorine changes its effectiveness and explain which form of chlorine is most effective at disinfecting E. coli. Consider Figure B (below) and explain how the type of microorganism affects the $\mathbf{C}\cdot t_c$ requirement and which microorganism is most resistant to chlorine (HOCl) disinfection.

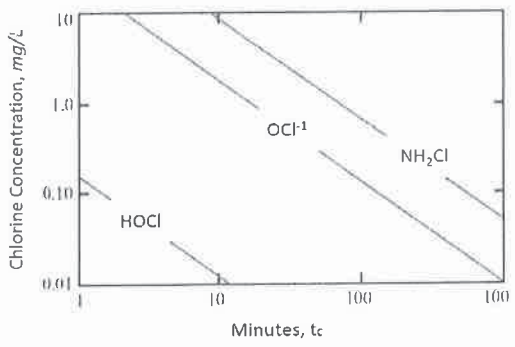


Figure A. Concentration (C) versus contact time (t_c) for 99% kill of E. coli by various forms of chlorine.

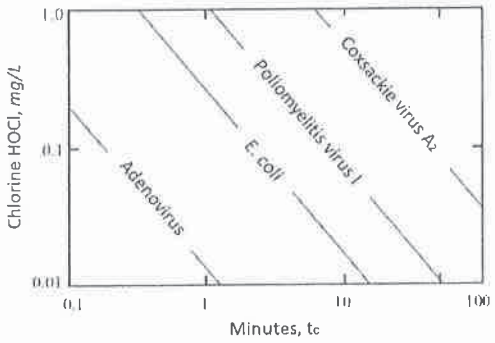


Figure B. Concentration (C) of HOCl versus contact time for (t_c) 99% kill of E. coli and three enteric viruses.

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 reduce the life cycle costs associated withe the creation, operation and maintenance of a gold mine operation located in northern British Columbia within a salmon spawning watershed region.

(5) (ii) Consider energy production using both renewable and non-renewable sources to discuss three (3) key strategies in achieving two (2) important sustainable development goals. Use table(s) to organize your answer.

(10) (iii) An engineer on contract by the construction firm is supervising the commissioning of a new water distribution system that is overbudget and past the estimated opening date. The engineer notices what appears to be incorrect pressure loss testing of the main water trunk. Inadequate system pressure may effect the ability of the system to perform adequately during emergency fire conditions. The correct testing may reveal insufficient system pressure that could jeopordise the safety of home owners in the area. 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) Hold paramount the safety, health, and welfare of the public; and

(c) Issue public statements only in an objective and truthful manner.

Problem 3

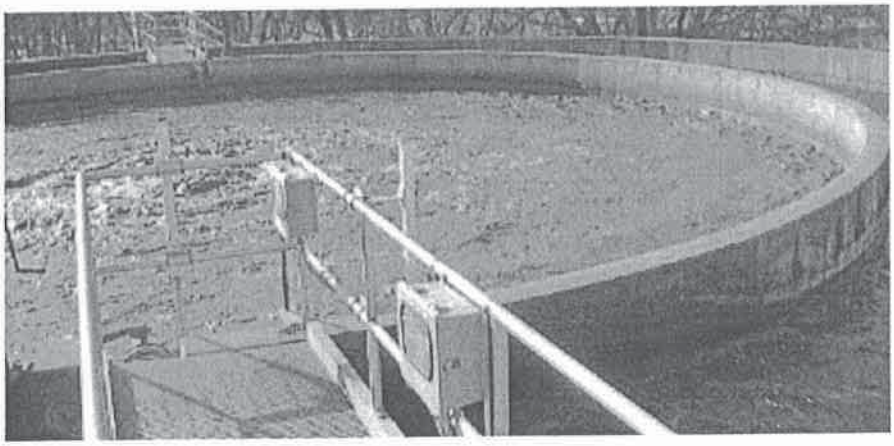
Provide answers to the following questions related to *particle characteristics*, *chemistry of solutions* and *gaseous emissions* as it pertains to environmental engineering:

(8) (i) The removal of particles from wastewater is critical for effective treatment. Briefly explain the combined role of primary and secondary clarification (sedimentation) in the effective removal of settleable and suspended particles. As part of your explanation, provide a simplified labelled schematic of a typical engineering process that combines the use of primary and secondary clarification for a wastewater treatment system.

(7) (ii) The average analysis in terms of Ca, Mg and Cu results of ground water near a gold 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+}	=	50 mg/L
Mg^{2+}	=	60 mg/L
Cu^{2+}	=	30 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 wastewater final effluent and two (2) important precautions that need to be taken in terms of potential environmental impacts.



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 wastewater treatment demands 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) Population growth;

(7) (ii) Industrial expansion; and

(7) (iii) Urbanization expansion.

2-Impacts & 2-Solutions	Population Growth	Industrial Expansion	Urbanization Expansion
Air Emissions			
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 will double over the next 25-years. However the water supply is limited so that at the current water demand it can only supply half the projected future population. You as the lead process engineer in the firm have been tasked with developing strategies to upgrade the existing water treatment and distribution system so that the future population needs can be met with the current water supply. Through the application of environmental principles, propose two (2) technical and two (2) non-technical strategies to ensure that the existing water supply will be adequate over the next 25-years while at the same time living standards will not be compromised.

(10) (ii) Provide a labelled schematic which includes three (3) main treatment processees of a tertiary wastewater treatment plant designed to reduce both nitrogen and phosphorus. In addition, briefly discuss two (2) non-technical principles to ensure that effluent 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:

(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 PM_{10} and nitrogen oxides from mobile sources. For each type of control, briefly provide one (1) advantage and one (1) limitation of the control. Use a table to organize your answer.

(10) (ii) The existing landfill site for the city's solid waste will reach capacity in 10-years at the current rate of solid waste generation. You have been hired by the city to develop an engineering plan for the next 20-years to assist in managing their solid waste within the existing landfill site constraints. Identify and briefly discuss two (2) technical and two (2) non-technical strategies you would recommend in your solid waste management plan to ensure a 50% reduction of the material destined for disposal over the next 20-years.

Problem 7

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

(8) (i) Identify and discuss the application of three (3) water resource management strategies, either technical or non-technical, to protect both the short term and the long term designated uses of a large fresh water lake, located near a large municipality. The main uses include recreation (i.e., fishing, swimming, boating), a source of drinking water supply and a habitat for aquatic life.

(6) (ii) Briefly explain two (2) water resource management strategies, one (1) technical and one (1) non-technical to ensure the protection of source waters impacted by both combined sewer overflows from the collection system and overflows and bypasses from treatment plants. In this case the source water refers to surface water where the intake for the local water treatment plant is located.

(6) (iii) In certain areas of southwestern Ontario water shortages are common during the summer months due to drought conditions and heavy tobacco farm usage from rivers with inadequate flows to support the designated usages. Provide two (2) water resource management strategies, one (1) technical and one (1) non-technical that incorporate "water reuse" of highly treated wastewater as a means to address summer water shortages. Also provide one (1) potential problem with "water reuse" on farms.

Marking Scheme
16-CIV-A3 Elementary Environmental Engineering
December 2017

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) 6, (ii) 7, (iii) 7 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