# NATIONAL EXAMS DECEMBER 2016

## 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 $8\frac{1}{2}''$ 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 related to *contaminant partitioning*, *microbiology* and *mass and energy balance* as related to environmental engineering:

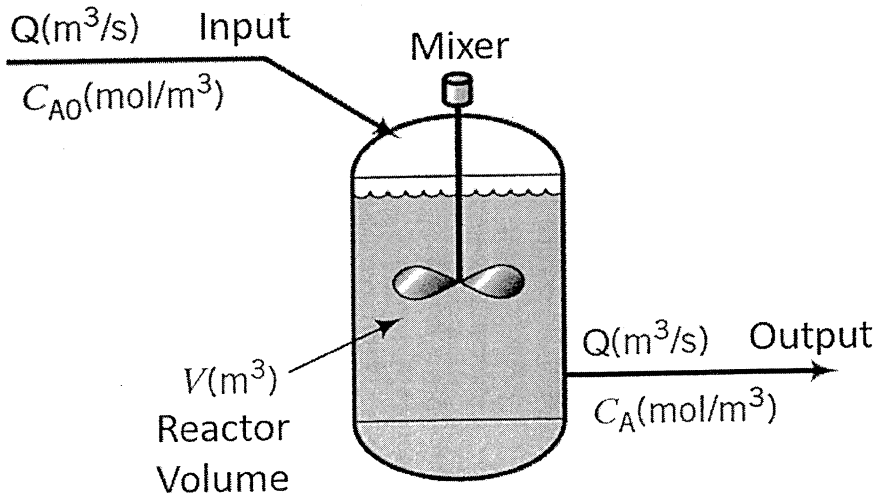
(6) (i) The partitioning of contaminants between the aqueous and gaseous phases, for dilute solutions, is governed by Henry's Law and the volatility of the contaminant given by it's partial pressure. Briefly state and explain the use of Henry's Law to predict the fate of volatile contaminants between the aqueous and gaseous phases under equilibrium conditions.

(7) (ii) Give an example of an indicator microorganism and provide four (4) important characteristics that are critical to be used as an indicator microorganism for regulatory assessment of the effectiveness of the treatment of surface water for the production of drinking water.

(7) (iii) A liquid-phase chemical reaction A $\longrightarrow$ B takes place in a completely stirred tank reactor (see figure below). The concentration of the feed is $C_{A0}$ (mol/$m^3$) and that in the tank output is $C_A$ (mol/$m^3$). The feed and outlet concentrations of $A$ are constant over time. The volume of the tank contents is $V$ ($m^3$) and the volumetric flow rate of the inlet and outlet streams is $Q$ ($m^3$/s). The rate $r_A$ (mol/s) at which $A$ is consumed by the reaction in the tank is given by the expression:

$$r_A = kVC_A$$

where $k$ is constant. Write a mass balance equation for $C_A$ and predict the concentration of $A$ in the output of the reactor when $k = 0$ and when k $\longrightarrow \infty$.



## Problem 2

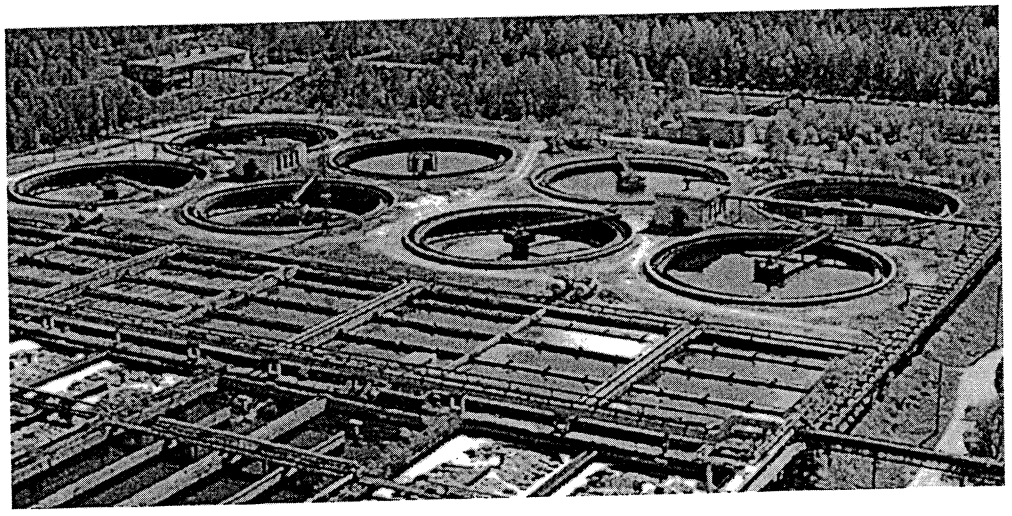
Provide answers to the following questions related to *environmental ethics* and *water and wastewater treatment*:

(10) (i) An engineer was in charge of modelling a sewer system and to review observations taken by survey crews. One day the engineer was shown a photo taken by the survey crew of a company actively dumping industrial waste chemicals (paint) into a sewer. What should the engineer have done? Briefly explain the actions that should be taken by the 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.

(10) (ii) Briefly identify and discuss three (3) key operational principles for maintaining a water or wastewater treatment facility (**select only one**) to perform effectively to meet or exceed design standards. In your discussion you may consider both technical and non-technial environmental principles.



## Problem 3

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

Briefly explain two (2) major environmental impacts and two (2) corresponding potential environmental engineering solutions to reduce impacts of air emissions, water demands and wastewater treatment 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 increase;

(7) (ii) Wastewater generation increase; and

(6) (iii) Industrial intensification.

| 2-Impacts & 2-Solutions | Population Increase | Wastewater Generation | Industrial Intensification |
|---|---|---|---|
| Air Emissions | | | |
| Water Demand | | | |
| Wastewater Treatment | | | |

## Problem 4

Provide answers to the following questions related to *environmental impact assessment*, *sustainable development* and *life cycle analysis*:

(10) (i) Explain how an environmental impact assessment (EIA) may be applied to reduce the pollution in the development of an automobile parts manufacturing plant. Use a table to identify three (3) key EIA steps to assist with reducing waste associated with the manufacturing processes.

(10) (ii) Briefly discuss the key principle of life cycle analysis (LCA) and how one may use LCA to ensure sustainable development in the agricultural or food production sector.

## Problem 5

Provide answers to the following questions associated with *air pollution control of air toxics*, *solid waste management* and *environmental quality objectives, standards and guidelines*:

(8) (i) Briefly describe two (2) different methods that can be used to control air toxics (e.g., VOCs, $PM_{2.5}$) from industrial fixed sources. For each method, briefly provide one (1) advantage and one (1) limitation of the method and an example of where the method is most appropriate. Use a table to organize your answer.

(6) (ii) The existing landfill site for the city's solid waste will reach capacity in five (5) years at the current rate of solid waste generation. You have been hired to recommend an engineering plan for the next 25 years by the city to assist in managing their solid waste issues. Identify and briefly discuss three (3) strategies that you would recommend in your solid waste management plan to ensure the longevity of the landfill site.

(6) (iii) Environmental controls are typically managed by the use of environmental guidelines or standards. Briefly explain two (2) key differences between environmental guidelines and standards. As part of your explanation, indicate when each type of environmental control is better at mitigating environmental hazards.

## Problem 6

Provide answers to the following questions related to *water resource management*, *greenhouse effect*, *noise pollution* and *technical and non-technical environmental principles*:

(5) (i) A large groundwater reservoir used as a drinking water supply for a city is vulnerable to saltation due to ocean water encroachment. Discuss two (2) water resource management strategies to protect the long term viability of the groundwater aquifer as a fresh water resource.

(5) (ii) Briefly explain one (1) main man made cause for the greenhouse effect and two (2) technical solutions to help reduce associated environmental impacts.

(5) (iii) Briefly explain two (2) engineering methods to reduce noise pollution from a stone crushing operation located within 1 km from a residential community and briefly explain the preferred method.

(5) (iv) Compare and contrast the application of a technical and non-technical environmental principle in the reduction of air emissions from a large fleet of diesel trucks operating on a common stretch of highway located adjacent to a retirement community.

## Problem 7

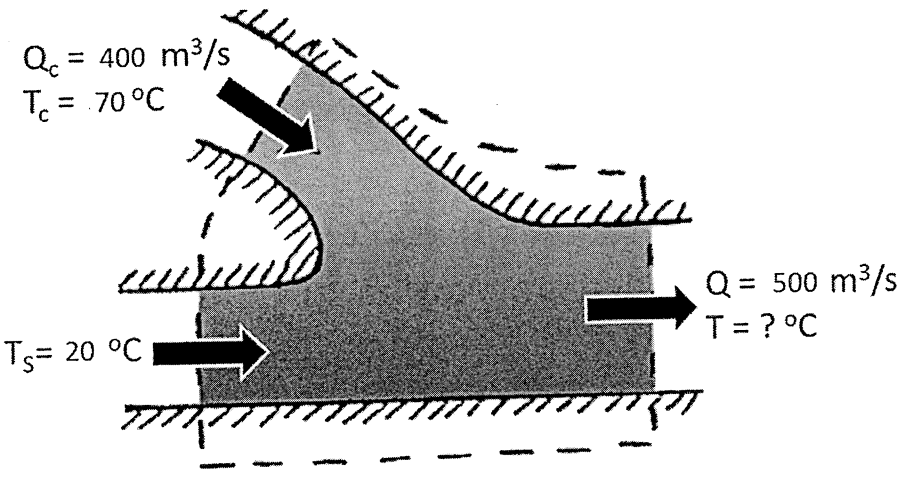
Provide answers to the following questions related to *particle characteristics*, *chemistry of solutions* and *thermal pollution*:

(8) (i) Coagulation and flocculation are important elements of the removal of colloidal particulates found in untreated water. Briefly define and then explain how coagulation and flocculation work to assist with the water or wastewater treatment process.

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

$Ca^{2+}$ = 100 mg/L
$Mg^{2+}$ = 80 mg/L
$Cu^{2+}$ = 50 mg/L

(5) (iii) Calculate the temperature of the downstream river (T) in degree Celsius ($^oC$) (see diagram below) and assume that this elevated temperature will impact a downstream cold water fishery. Give two (2) possible engineering solutions to further reduce the downstream water temperature or reduce the upstream temperature assumed to be discharged at 70 $^oC$ from a cooling tower.



# Marking Scheme
# 04-Env-A1 Principles of Environmental Engineering
# December 2016

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

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

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

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

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

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

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