# NATIONAL EXAMS MAY 2010

## 04-Chem-B2, 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 *enginering aspects of air and water pollution abatement and effluent treatment.*

(8) (i) Briefly describe two (2) engineered air pollution control methods that can be used to reduce fine particulate matter ($PM_{10}$ or $PM_{2.5}$) coming from an industrial manufacturing industry. For each control method, briefly provide two (2) advantages and two (2) limitations and give an example of where it would be most appropriate to be used.

(8) (ii) Suspended solids and associated contaminants discharged in water pollution control plant effluents are a major environmental concern. Briefly explain one treatment process used to reduce suspended solids in final effluents. In your explanation provide two (2) key design parameters, two (2) operational issues and two (2) maintenance approaches to prevent failure of the treatment process.

(4) (iii) Briefly explain two key design parameters in the proper design of a disinfection process commonly used to reduce pathogens from sewage treatment plant final effluents or in drinking water treatment plants.

## Problem 2

Provide answers to the following questions related to *control methods for particulates, gases and vapours.*

Compare the following control devices for the control of particulate, gaseous or vapourous air pollutants emitted to the atmosphere: In your **comparison**, briefly describe the process principle for each device, provide two (2) advantages, two (2) limitations and a specific process where each device can be appropriately applied. A table or matrix is recommended to organize your answer.

(10) (i) Electrostatic precipitator and Scrubber; and

(10) (ii) Cyclone and Cartridge filters.

## Problem 3

Provide answers to the following questions related to *characterization of water contaminants and their measurement*, *biochemical oxygen demand* and *sedimentation*.

(7) (i) The primary objective of drinking water treatment is to provide an engineered system that reliably and consistently eliminates water contaminants measurements of the treated water are necessary to ensure the public a safe potable water supply. Give two (2) examples of typical contaminants in ground or surface source waters that are targeted and eliminated by engineered systems and two (2) source water measurements used to help optimize drinking water treatment systems. In your examples, provide brief explanations as to why these contaminants and measurements are selected.

(ii) A BOD test is conducted at standard temperature conditions, using 50 $mL$ of primary effluent mixed with 250 $mL$ of water. The initial DO in the mix is 10 $mg/L$. After 5 days, the DO drops to 3 $mg/L$ and after 20 days the DO has stabilized at 1 mg/L. Assume that nitrification has been inhibited so that the only BOD being measured is carbonaceous.

(3) (a) Calculate the 5-day carbonaceous BOD of the secondary effluent in $mg/L$;

(3) (b) Estimate the ultimate carbonaceous BOD in $mg/L$; and

(1) (c) What is the remaining BOD after 5 days in $mg/L$.

(6) (iii) Explain how coagulation-flocculation pretreatment assists in improving engineered sedimentation systems (primary or secondary) and how it is used in water or wastewater treatment. In your example, provide a brief explanation of the design basis and two (2) issues related to operation and maintenance of the coagulation-flocculation process.

## Problem 4

Provide answers to the following questions related to *pH control*, *ion exchange*, *reverse osmosis* and the *activated sludge process*.

(i) Provide an example of the use and the underlying design principle of each process used in drinking water treatment applications:

(3) (a) pH control;

(4) (b) ion exchange; and

(3) (c) reverse osmosis.

(ii) Briefly explain the purpose of each of the following components associated with a typical conventional activated sludge treatment plant:

(3) (a) Return of activated sludge from the secondary clarifier to the aeration tank;

(4) (b) Waste activated sludge that is removed from the system; and

(3) (c) Aeration with dissolved oxygen concentrations maintained between 1 to 2 $mg/L$.

## Problem 5

Provide answers to the following questions related to *contaminant soil remediation* and *measurement techniques* as applied to contaminant soil remediation.

(6) (i) Briefly define bioremediation, phytoremediation and bioaugmentation. Give an example where each method is the most appropriate for soil contaminant remediation.

(8) (ii) An important decision with respect to remediation is the closure criteria. Identify two (2) measurement criteria and associated measurement techniques that may be used by engineering consultants to identify that the cleanup is complete. In your answer you should also consider possible groundwater contamination issues.

(6) (iii) Briefly explain how phased sampling would work to improve or optimize the bioremediation process for a large site with contaminated soils.

# Problem 6

Provide answers to the following questions related to *sources and dispersion of atmospheric pollutants*.

A large steel manufacturing plant located in northern Ontario releases sulfur dioxide ($SO_2$) during the smelting and refining operation. The $SO_2$ is released from a 30 $m$ stack at a rate of 10 $g/min$. The average wind speed is 15 $m/s$, with strong solar radiation.

(10) (i) What is the distance downwind of the plume centerline emission point at which the predicted sulfur dioxide ($SO_2$) ground-level concentration falls to about 50 $\mu g/m^3$;

(5) (ii) Briefly provide two (2) possible measures (excluding control devices) that can be used to reduce the ground level $SO_2$ concentration indicating an advantage and a disadvantage of each measure; and

(5) (iii) What is the minimum control device efficiency required, if the maximum background $SO_2$ concentration is 20 $\mu g/m^3$ and the 24-hour ambient air quality criteria is 40 $\mu g/m^3$.

Assume an estimate of the dispersion parameters is provided by the following equations:

$$\sigma_y = a \cdot x^{b-c \cdot ln(x)}$$

$$\sigma_z = d \cdot x^{e-f \cdot ln(x)}$$

The variables to calculate the appropriate dispersion parameters are taken from the appropriate stability class given in the table below:

| Stability Class | a | b | c | d | e | f |
|---|---|---|---|---|---|---|
| A | 200 | 1.0 | -0.008 | 200 | 2.5 | 0.2 |
| B | 150 | 1.0 | -0.006 | 110 | 1.0 | 0.01 |
| C | 100 | 1.0 | -0.005 | 60 | 1.0 | 0.0 |
| D | 60 | 1.0 | -0.005 | 30 | 0.75 | -0.03 |
| E | 50 | 1.0 | -0.005 | 20 | 0.70 | -0.05 |

# Problem 7

Provide answers to the following questions related to *photochemical reactions, noxious pollutants and odour control.*

Photochemical smog has been identified as a primary cause of urban air pollution resulting in respiratory problems among the general population and thousands of asthma attacks among the more susceptible in our cities.

(6) (i) Briefly explain how photochemical smog is produced and give three (3) possible ways to prevent the formation of photochemical smog. For each preventative measure, provide an advantage and a disadvantage.

(6) (ii) A strong association has been revealed between noxious air pollutants and the occurrence of cardiovascular disease. Some of these pollutants are associated with $PM_{2.5}$. Briefly describe a regulatory and a technology measure to reduce the exposure of people to $PM_{2.5}$. Briefly explain which method is more attractive to industry and why.

(8) (iii) Activated carbon systems are commonly used for the control of odours from organic gases and vapour emissions. Briefly explain how you would design, operate and maintain an activated carbon odour control system for a sewage pumping station or an industrial facility. In your explanation, consider the percent odour removal provided by your design.

# Marking Scheme

1. (i) 8 (ii) 8 (iii) 4 marks, 20 marks total

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

3. (i) 7.(ii) (a) 3, (b) 3, (c) 1 (iii) 6 marks, 20 marks total

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

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

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

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