NATIONAL EXAMS MAY 2011

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 VOCs emissions 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 the most appropriate to be used.

(8) (ii) Dissolved solids and associated contaminants discharged via water pollution control plant effluents are a major environmental concern. Briefly explain one treatment process used to reduce dissolved 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 (2) key design parameters in the proper design of a primary settling basin commonly used to reduce settleable solids from raw sewage, having gone through preliminary treatment.

Problem 2

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, provide an example of its use and give two (2) important engineering design principles to ensure appropriate soil remediation.

(8) (ii) An important decision with respect to remediation is whether to remove contaminated soil or conduct in-situ remediation. Explain three (3) criteria or methods of analysis to determine which is the more environmentally appropriate solution. In your answer, you should also consider extraneous impacts of plume migration from the site.

(iii) Briefly explain by providing the key steps or principles involved in the following processes used in soil remediation steps.

(3) (a) Soil separation method; and

(3) (b) Contaminant removal or neutralization method.

Problem 3

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 case where each device can be appropriately applied. A table or matrix is recommended to organize your answer.

(10) (i) Settling chamber and Cyclone; and

(10) (ii) Filter and Electrostatic precipitator.

Problem 4

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 and produce potable treated water that is safe to drink. Give two (2) examples of typical inorganic contaminants in surface source waters that are targeted and eliminated by engineered systems and two (2) drinking water treatment system measurements used to measure the effectiveness of the treatment system.

(ii) A CBOD test is conducted at standard temperature conditions, using 100 mL of secondary effluent mixed with 200 mL of water. The initial DO in the mix is 8 mg/L. After 5 days, the DO drops to 2 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 CBOD.

(3) (a) Calculate the 5-day CBOD of the secondary effluent in mg/L; and

(3) (b) Estimate the ultimate CBOD in mg/L.

(7) (iii) Explain two (2) operational controls and two (2) key design principles to ensure that the sedimentation unit treatment process, used in water or wastewater treatment, is effective at reducing solids.

Problem 5

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

(i) Provide one (1) example of the use, one (1) underlying design principle and one (1) maintenance/opearional issue for each unit process (below) used in drinking water and/or wastewater treatment application:

(3) (a) pH control;

(4) (b) ion exchange; and

(3) (c) reverse osmosis.

(ii) Briefly explain the purpose and/or importance of the following associated with a typical conventional activated sludge (CAS) treatment plant:

(3) (a) Maintaing a minimum solids reterntion time (SRT*min*);

(4) (b) The use of return activated sludge (RAS) pumping from the secondary clarifier to the aeration tank; and

(3) (c) Maintaining aerobic conditions during peak loading events.

Problem 6

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 formed and give three (3) possible ways to prevent the formation of photochemical smog in a heavily industrialized city. Consider both regulatory and source control strategies.

(7) (ii) A strong association exists between cardiovascular disease and air emissions of noxious pollutants associated with particulate of PM <10 μm in size. Briefly describe one (1) regulatory and one (1) technology measure to reduce the exposure of people to PM <10 μm in size. In your explanation, provide one (1) advantage and one (1) limitation associated with each measure.

(7) (iii) Give three (3) underlying engineering principles in the design of odour control equipment through the use of an example.

Problem 7

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

A large nickel producing plant located in northern Ontario releases sulphur dioxide (SO_2) during the smelting and refining operation. The SO_2 is released from a 50 m stack at a rate of 30 g/min. The environmental conditions include a an average wind speed of 20 m/s and strong solar radiation conditions.

(10) (i) What is the distance downwind of the plume centerline emission point at which the predicted sulphur dioxide (SO_2) ground-level concentration falls to about 30 $\mu g/m^3$?

(5) (ii) Briefly provide two (2) possible measures 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 needs to be 10 $\mu g/m^3$ and the 7-day ambient air quality criteria is set at 30 $\mu g/m^3$.

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	220	1.0	-0.007	210	2.3	0.3
B	160	1.0	-0.005	10	1.2	0.02
C	110	1.0	-0.004	70	1.2	0.00
D	70	1.0	-0.004	40	0.80	-0.04
E	60	1.0	-0.004	30	0.60	-0.06

Marking Scheme

1. (i) 8 (ii) 8 (iii) 4 marks, 20 marks total
2. (i) 6 (ii) 8 (iii) (a) 3, (b) 3 marks, 20 marks total
3. (i) 10 (ii) 10 marks, 20 marks total
4. (i) 7 (ii) (a) 3, (b) 3, (iii) 7 marks, 20 marks total
5. (i) (a) 3, (b) 4, (c) 3 (ii) (a) 3, (b) 4, (c) 3 marks, 20 marks total
6. (i) 6 (ii) 7 (iii) 7 marks, 20 marks total
7. (i) 10 (ii) 5 (iii) 5 marks, 20 marks total