NATIONAL EXAMS DECEMBER 2009

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.*

(10) (i) Briefly describe two (2) engineered air pollution control methods that can be used to reduce PM_{10} particulates emissions. 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.

(10) (ii) Bacterial and pathogen content from water pollution control plant effluent discharges is a major environmental concern particularly if beaches are located downstream of the effluent discharges. Briefly explain how disinfection can be used as an effective effluent treatment method. In your explanation provide two (2) key design parameters, two (2) operational issues and two (2) maintenance approaches to prevent failure of the disinfection system.

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 particulates and other 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 industrial process where each device can be appropriately applied. A table or matrix is recommended to organize your answer.

(10) (i) Cyclone and Scrubber; and

(10) (ii) Electrostatic precipitator and Baghouse filter.

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 and provides key measurements of the treated water that ensure the public a safe potable water supply. Give two (2) examples of water contaminants that are targeted and eliminated by engineered systems and two (2) finished drinking water measurements used to ensure safe drinking water. 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, but only using 100 mL of primary effluent mixed with 200 mL of water. The initial DO in the mix is 8 mg/L. After 5 days, the DO is 2 mg/L and after 20 days the DO has stabilized at 0.5 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 primary effluent in mg/L;

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

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

(6) (iii) Provide an example of an engineered sedimentation system (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.

Problem 4

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

(i) Explain the following and the reason that they are used in drinking water treatment applications:

(3) (a) pH control;

(4) (b) ion exchange; and

(3) (c) reverse osmosis.

(ii) A conventional activated sludge plant is to treat $100,000\ m^3/d$ of municipal sewage. You have been asked to assist the senior process design engineer by determining the following:

(3) (a) The required aeration tank volume V in m^3 and the aeration tank hydraulic retention time ϕ in hours;

(4) (b) the quantity of sludge to be wasted daily Q_w in Kg/d; and

(3) (c) the sludge recycle ratio, Q_r/Q_o.

Use the following process information:

- Influent BOD_5 and $TSS = 250\ mg/L$;
- effluent BOD_5 and $TSS = 25\ mg/L$;
- yield coefficient, $Y = 0.5$;
- decay rate, $k_d = 0.04 \cdot d^{-1}$;
- average MLSS in the aeration tank, $X = 3,000\ mg/L$;
- waste MLSS from the clarifier, $X_w = 8,000\ mg/L$; and
- mean cell residence time, $\phi_c = 20\ days$;

Problem 5

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

A large steel manufacturing plant located in Quebec releases sulfur dioxide (SO_2) during the smelting and refining operation. The SO_2 is released from a 40 m stack at a rate of 8 g/min. The average wind speed is 10 m/s, with moderate 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 100 $\mu g/m^3$;

(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 25 $\mu g/m^3$ and the 24-hour ambient air quality criteria is 50 $\mu g/m^3$.

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 moderated unstable 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 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.

(7) (i) Provide three (3) primary ingredients necessary in the formation of photochemical smog and three (3) secondary pollutants produced with an brief explanation of the interactions;

(6) (ii) Briefly explain how ozone (O_3) is produced from NO_x and other hydrocarbon emissions giving the general chemical equations; and

(7) (iii) Utilize the *photo-stationary-state relation* (given below) to explain the typical phenomena of low ozone levels occurring during the night and early morning, rising to a high peak by mid afternoon and declining rapidly to near zero as the sun sets.

$$Y_{O_3} = \frac{k_1 Y_{NO_2}}{k_3 Y_{NO}}$$

Problem 7

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

(7) (i) Provide an example and explain two (2) appropriate technologies commonly used in soil remediation when soil contamination from volatile organic solvents have impacted groundwater resources;

(6) (ii) Briefly describe a bioremediation technology, its general process and give an example of its application; and

(7) (iii) 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 regulators to identify closure or that the cleanup is complete.

Marking Scheme

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

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

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

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

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