NATIONAL EXAMS DECEMBER 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 abatement measures to control or reduce VOC emissions from industrial sources. For each control method, briefly provide two (2) advantages and two (2) limitations and give an example of where each abatement measure would be most appropriate to be used.

(6) (ii) Give an example of how water pollution abatement legislation is used by regulators to effectively prevent pollution of surface or ground water. In your answer, provide the name of an existing provincial/territorial or federal legislation and briefly explain two important parts of the legislation that make it an effective abatement tool.

(6) (iii) Suspended solids content in treated sewage effluents is a major environmental concern particularly because of associated contaminants. Briefly explain how coagulation and flocculation with sedimentation can be used as an effective effluent treatment method for the removal of suspended solids. In your explanation, provide two (2) key design parameters, two (2) operational issues and two (2) maintenance approaches to prevent failure of the treatment system.

Problem 2

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

Compare and/or contrast the following control devices for the control pollutants indicated. In your answer, briefly describe the key process principle for each device, provide one (1) advantage and one (1) limitation of the control equipment. A table or matrix is recommended to organize your answer.

(7) (i) Wet scrubbers and Dry scrubbers for acid gas or SO_2 emission control;

(7) (ii) Thermal oxidizers and Catalytic oxidizers for VOC abatement; and

(6) (iii) NO_x scrubbers and and low NO_x burners for NO_x emission control.

Problem 3

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

(i) For each of the following contaminants, provide one (1) important engineering strategy and one (1) control method used in drinking water treatment.

(3) (a) Pathogens;

(3) (b) Lead; and

(3) (c) Particulates.

(ii) A BOD test is conducted at standard temperature conditions, but only using 200 mL of secondary effluent mixed with 100 mL of water. The initial DO in the mix is 6 mg/L. After 5 days, the DO is 1 mg/L and after 20 days the DO has stabilized at 0.5 mg/L. Assume that nitrification has been inhibited and the only BOD being measured is carbonaceous.

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

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

(5) (iii) Provide two (2) reasons why sedimentation is applied following the aeration treatment tank in a conventional activated sludge sewage treatment plant.

Problem 4

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

(i) Give one (1) short example of how each of the following treatment methods are used in drinking water treatment applications. The example should explain the reason and effect of its use on the treated water.

(4) (a) pH control

(4) (b) ion exchange

(4) (c) reverse osmosis

(ii) A conventional activated sludge plant is to treat 200,000 m^3/d of municipal sewage. You have been asked to assist the senior process design engineer by determining the following:

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

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

Use the following process information:

- Influent BOD_5 and $TSS = 200\ mg/L$;
- effluent BOD_5 and $TSS = 20\ mg/L$;
- yield coefficient, $Y = 0.4$;
- decay rate, $k_d = 0.03 \cdot d^{-1}$;
- average MLSS in the aeration tank, $X = 3,500\ mg/L$;
- waste MLSS from the clarifier, $X_w = 10,000\ mg/L$; and
- mean cell residence time, $\phi_c = 25\ days$;

Problem 5

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

A large steel manufacturing plant located in the Northwest Territories 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 20 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 80 $\mu g/m^3$?

(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.

(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 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.

(5) (i) Provide two (2) primary ingredients necessary in the formation of photochemical smog and two (2) secondary pollutants produced with a brief explanation of the interactions;

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

(5) (iii) Give one (1) example of an odour control system and provide two (2) fundamental engineering principles that make the control system effective at reducing odours; and

(5) (iv) Utilize the *photo-stationary-state relationship* (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.

(5) (i) Provide an example and one (1) appropriate technology that may be used in soil remediation when soil contamination from pesticides or herbicides have impacted groundwater resources used as a drinking water source;

(5) (ii) Briefly describe a bioremediation technology, two (2) key engineering processes and give an example of its application;

(5) (iii) An important decision with respect to remediation is the closure criteria. Provide one (1) measurement criteria and associated measurement technique that may be used by regulators to identify that the cleanup is complete; and

(5) (iv) Briefly explain the importance of human health or ecological risk assessment for a contaminated site that has been slated for remediation.

Marking Scheme

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

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

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

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

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

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

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