NATIONAL EXAMS DECEMBER 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 *engineering 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 *VOC* 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) Eutrophication of lakes has been attributed to effluents from sewage treatment plants. Briefly explain two (2) primary causes of eutrophication and one (1) effective treatment method for each cause. In your explanation of the treatment method, provide two (2) key design parameters, two (2) operational issues and two (2) maintenance issues to ensure the effectiveness of the treatment system.

Problem 2

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

Select one (1) technology from each of the following categories and compare the control devices for the control of particulates and *VOCs* 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 used. A table or matrix is recommended to organize your answer.

(10) (i) Combustion and Particulate based Technology; and

(10) (ii) Scrubber and Filter based technology.

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 uses key measurements of the treated water that ensure the public a safe potable water supply. Give two (2) examples of water contaminants that are required to be eliminated by engineered systems and two (2) treated water measurement methods that may be used to ensure the water is free from contamination. Briefly discuss how you would ensure that the measurement methods provide a consistent and reliable measure of good treated water quality.

(ii) A BOD test is conducted at standard temperature conditions, but only using 150 mL of secondary effluent mixed with 150 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 0.3 mg/L. Assume that nitrification has been inhibited so that the only $CBOD_5$ (5-day carbonaceous biochemical demand) is being measured.

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

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

(2) (c) What is the remaining CBOD 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, briefly explain the use of two (2) important design parameters for the design and operation of the sedimentation system.

Problem 4

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

(i) Give an example of how each technology may be used in water or wastewater treatment:

(3) (a) pH control;

(4) (b) ion exchange; and

(3) (c) reverse osmosis.

(ii) A conventional activated sludge plant is to treat $500,000\ m^3/d$ 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 $TSS = 200\ mg/L$;
- effluent BOD_5 and $TSS = 20\ mg/L$;
- yield coefficient, $Y = 0.4$;
- decay rate, $k_d = 0.05 \cdot d^{-1}$;
- average MLSS in the aeration tank, $X = 4,000\ mg/L$;
- 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 coal fired power plant producing 100 GW of power releases sulfur dioxide (SO_2) during its operation. The SO_2 is released from a 50 m stack at a rate of 10 g/min. The average wind speed is 15 m/s, with moderate solar radiation.

(10) (i) What is the distance downwind of the plume centerline emission point at which the predicted 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 10 $\mu g/m^3$.

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 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	175	1.0	-0.006	200	2.4	0.3
B	125	1.0	-0.005	110	1.0	0.02
C	110	1.0	-0.004	60	1.0	0.0
D	50	1.0	-0.004	30	0.8	-0.04
E	40	1.0	-0.004	20	0.6	-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) Briefly explain the role of solar radiation, hydrocarbon free radicals and reactive hydrocarbons in the formation of smog;

(6) (ii) Identify a noxious pollutant from an industrial or municipal treatment process and briefly describe an engineering process or processes to identify, control and prevent the release of this noxious pollutant to the natural environment; and

(7) (iii) Identify an engineered biological method of odour control and briefly explain its design principle and operational requirements.

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 semi-volatile organic compounds (SVOCs) which have impacted a surface water resource (e.g. lake used as a drinking water source);

(6) (ii) Briefly explain two (2) main differences and two (2) primary similarities between the application of bioremediation versus physical-chemical based remediation technologies; and

(7) (iii) Identify one (1) measurement technique used in contaminant soil remediation operations and briefly explain the importance of monitoring or measurement techniques. In your explanation, consider the sensitivity, reliability, accuracy of the instruments used along with the proper use of the final resulting measurements.

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