NATIONAL EXAMS DECEMBER 2019

16-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 *control methods for particulates, gases and vapours.*

For the three (3) technology types (below), describe how each may be used to control the contaminant types identified. In your explanation, briefly describe the main technology principle, provide two (2) advantages, two (2) limitations and one (1) specific application where each technology may be used. A table or matrix is recommended to organize your answer.

(7) (i) Catalytic reactors for gases (e.g., hazardous volatile organics)

(6) (ii) Biofilters for vapour emissions (e.g., VOCs)

(7) (iii) Cyclones for particulates (e.g., PM_{50})

Problem 2

Provide answers to the following questions related to *engineering aspects of air and water pollution abatement and effluent treatment.*

(6) (i) Calculate the concentration in $\mu g/m^3$ of nitrogen dioxide (NO_2) in the air at 1.0 ppm at STP and state any assumptions in your calculation. Briefly explain how NO_2 air monitoring would be done to ensure the pollution source(s) are adequately abated to meet established air quality standards.

(7) (ii) Give an example of a *regulatory* water pollution abatement approach and compare to using *best available technology economically achievable* to provide a similar environmental abatement. The comparison should include three (3) key differences.

(7) (iii) Eutrophication in rivers and lakes has been attributed to high phosphorus loadings from effluent discharges from sewage treatment plants. Briefly explain one (1) effective treatment method that would reduce total phosphorus loadings to the receiver. In your explanation of the treatment process briefly explain two (2) important engineering design components to ensure good phosphorous removal.

Problem 3

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

(6) (i) Provide an example and explain one (1) appropriate technology that may be used in soil remediation of a site that has soil contamination from petroleum products.

(6) (ii) Describe and give one (1) example of an in situ remediation technique for removing biodegradable soil contaminants.

(8) (iii) Discuss three (3) important elements of good measurement techniques for air or drinking water quality. Consider how good measurements are essential for regulatory compliance designed to protect human health.

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 of each technology applied to water or wastewater treatment and briefly explain one (1) process design parameter:

(3) (a) pH control

(4) (b) ion exchange

(3) (c) reverse osmosis

(ii) An activated sludge plant is to treat $200,000\ m^3/d$ of municipal wastewater. You have been asked to assist the senior process design engineer by calculating 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 $TSS = 10\ mg/L$;
- yield coefficient, $Y = 0.4$;
- decay rate, $k_d = 0.05 \cdot d^{-1}$;
- average MLSS in the aeration tank, $X = 5,000\ mg/L$;
- waste MLSS from the clarifier, $X_w = 12,000\ mg/L$; and
- mean cell residence time, $\phi_c = 8\ days$;

Problem 5

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

(6) (i) Briefly explain how smog is produced by considering the physical atmospheric conditions and the associated chemical reactions.

(7) (ii) Air pollution is defined as the presence of noxious pollutants in the air at levels that cause a health hazard. Briefly identify three (3) noxious pollutants from fixed sources and explain an engineering solution for each pollutant to reduce their concentration levels.

(7) (iii) Identify an effective odour control technology and briefly explain three (3) design principles to ensure effective and efficient removal of water-soluble solvents with an example.

Problem 6

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

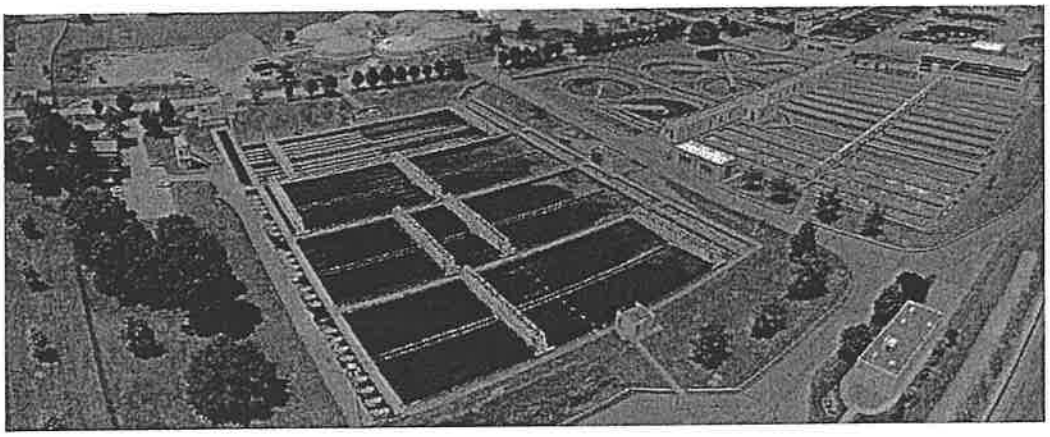
(8) (i) A drinking water treatment plant uses groundwater under the influence of surface water infiltration in a heavily farmed community. Give one (1) chemical and one (1) microbiological contaminant that typically needs to be treated for from groundwater supplies. Provide one (1) treatment method for each contaminant type that may be used to ensure the water is potable. Briefly discuss how you would use measurement methods to ensure that contaminants are sufficiently reduced below any aesthetic (e.g., odour) or health effect (e.g., illlness).

(ii) A BOD test is conducted at standard temperature conditions using 250 mL of secondary effluent mixed with 250 mL of water. The initial DO in the mix is 10 mg/L. After 5 days, the DO is 3 mg/L and after 20 days the DO has stabilized at 0.5 mg/L. Assume that nitrification has been inhibited so that only $CBOD_5$ (5-day carbonaceous biochemical oxygen demand) is being measured.

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

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

(6) (iii) Give three (3) important design parameters for a primary sedimentation system (e.g., a primary clarifier in a wastewater treatment plant), briefly explain how the three (3) parameters influence the performance of the system and give typical design values (with dimensions for each parameter) used in any wastewater treatment application.



Problem 7

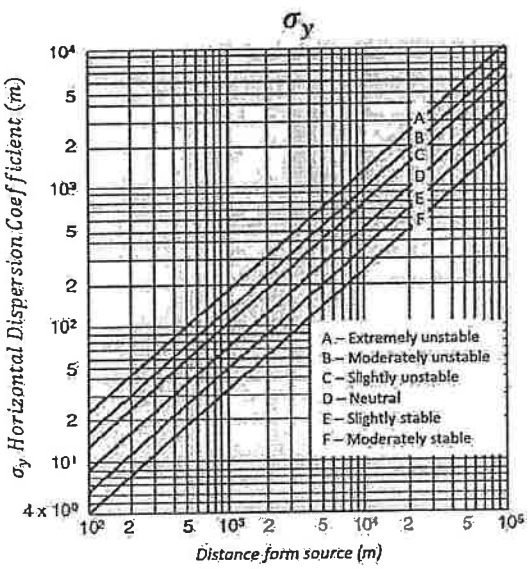
Provide answers to the following questions related to *sources and dispersion of atmospheric pollutants*.

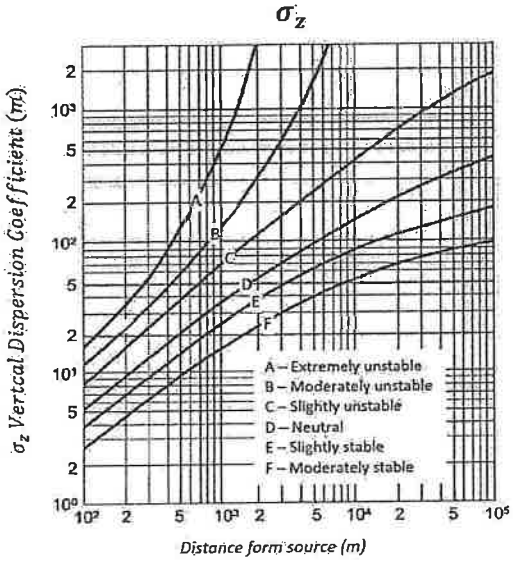
An industrial boiler is burning 10 tons of 3.0% heavy oil/hr with an NO_2 emission rate of 100 g/s. The following exist: the stack height, H = 50 m, the wind speed, $u = 4$ m/s at 10 m elevation. It is one hour before sunrise and the sky is thinly overcast with large cloud cover.

(10) (i) Find the downwind centerline ground level NO_2 concentration at a distance x = 1000 m from the stack. State any assumptions made clearly.

(10) (ii) Provide three (3) possible engineering measures that may be used to reduce the ground level NO_2 concentration and compare each method in terms of the overall carbon footprint.

Assume an estimate of the dispersion parameters is provided by the following figures and stability classes in the following table:





	Day			Night	
	Incoming Solar Radiation			Thinly Overcast	
Wind Speed, 10 m (m/sec)	Strong	Moderate	Slight	>4/8 Cloud	<3/8 Cloud
<2	A	A–B	B	E	F
2–3	A–B	B	C	D	E
3–5	B	B–C	C	D	D
>6	C	D	D	D	D

Marking Scheme

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