NATIONAL EXAMS DECEMBER 2018

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.

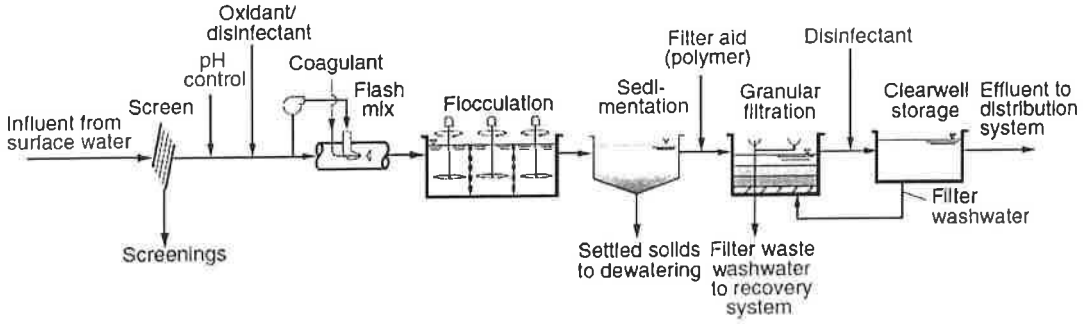
Problem 1

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

(7) (i) Some elements of an integrated air pollution abatement program include: (1) Monitoring of point and non-point source air pollution, (2) Using emissions models, (3) Assessing impacts on health and environment and (4) Adopting best management practices. Briefly explain how *any two (2)* elements of the integrated program work to effectively reduce the emissions of air toxins.

(6) (ii) Briefly describe an advanced wastewater treatment method to remove nutrients from the final effluent. As part of your description, explain *one (1)* key treatment processes for nitrogen reduction and and *one (1)* for phosphorous reduction.

(7) (iii) A typical treatment train for a surface water treatment plant is shown in the figure below. Select *any two (2)* major components or processes and for each one briefly explain the primary engineering principles involved and its main purpose in the overall treatment.



Problem 2

Provide answers to the following questions related to *control methods for particulates, gases and vapours*. Identify three (3) differnt contaminant removal technologies [*one (1)* for each type of contaminant given below] and for each technology provide: (a) one (1) key design parameter that affects the performance; (b) one (1) important operational issue to ensure a high performance efficiency and (c) one (1) maintenance issue.

(6) (i) Particulates (e.g., PM_{10} from quarry operation)

(7) (ii) Gases (e.g., VOCs from spray paint booth); and

(7) (iii) Vapours (e.g., odorous emissions from rendering plant)

Problem 3

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

(6) (i) Describe an engineering method and three (3) key engineering steps in the in-situ remediation of soil contaminated with *any one (1)* of the following: petroleum hydrocarbons, pesticides or lead and other heavy metals.

(6) (ii) Traditionally, there are three main soil remediation technologies: (1) soil washing, (2) bio-remediation and (3) thermal desorption. Briefly describe two (2) key engineering principles or quantitative strategies associated with each technology.

(8) (iii) Identify and briefly describe the key engineering principle associated with a measurement technique used to monitor: (1) gaseous pollutants in the ambient air and (2) pathogens in treated water. As part of your description, briefly explain how calibration is performed to improve the precision of the instrument used in each case. State clearly any assumptions made in your answer.

Problem 4

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

(8) (i) Water quality can be measured by various characteristics needed for proper design of treatment systems including (a) turbidity, (b) dissolved oxygen and (c) nutrients. Briefly explain how each contaminant may be characterized and how it can be measured or indirectly quantified using reliable techniques.

(ii) A BOD_5 test is conducted at standard temperature conditions 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 1.0 mg/L and after 20 days the DO has stabilized at 0.03 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) Briefly explain three (3) main design principles to ensure the efficient performance of an aeration system used in the activated sludge wastewater treatment process.

Problem 5

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

(i) Briefly explain the main function and an operational issue associated with each technology given below in the production of drinking water from surface water that has significant colloidal and suspended solids, a low pH and high conductivity:

(3) (a) floatation;

(4) (b) pH control; and

(3) (c) ion exchange.

(ii) A conventional activated sludge plant is used to treat 200,000 m^3/d of municipal wastewater. You have been asked to prepare the preliminary process design 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 = 240 mg/L;
- effluent BOD_5 and TSS = 25 mg/L;
- yield coefficient, Y = 0.4;
- decay rate, k_d = 0.05 d^{-1};
- average MLSS in the aeration tank, X = 6,000 mg/L;
- waste MLSS from the clarifier, X_w = 9,000 mg/L; and
- mean cell residence time, ϕ_c = 12 days;

Problem 6

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

A large natural gas fired power plant producing 3000 GW of power releases nitrogen dioxide (NO_2) during its operation. The NO_2 is released from a 40 m stack at a rate of 20 g/min. The average wind speed is 11–15 m/s with clear sky conditions.

(10) (i) Provide three (3) possible engineering approaches or technologies that may be used to reduce the ground level NO_2 concentration and briefly provide one (1) benefit and one (1) disadvantage associated with each engineering approach or technology.

(10) (ii) What is the distance downwind of the plume centerline emission point at which the predicted NO_2 ground-level concentration falls to less than 4 $\mu g/m^3$;

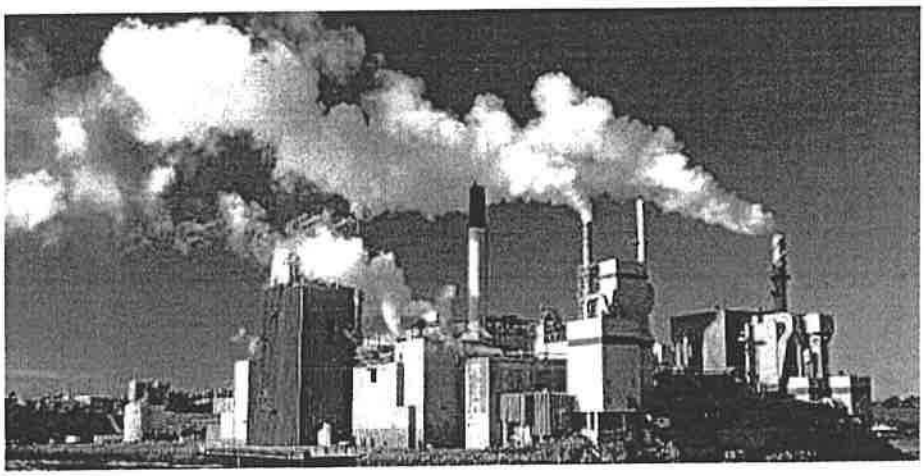
Assume an estimate of the dispersion parameters is provided by the following equations:

$$\sigma_y = a \cdot x^{b-c \cdot ln(x)}$$

$$\sigma_z = d \cdot x^{e-f \cdot ln(x)}$$

The variables to calculate the moderated unstable dispersion parameters are to be taken from the appropriate stability class given in the table below:

Stability Class	a	b	c	d	e	f
A	80	1.0	-0.004	150	2.0	0.5
B	70	0.9	-0.005	130	1.4	0.04
C	90	1.1	-0.004	100	1.1	0.04
D	30	0.8	-0.005	80	1.3	-0.06
E	40	1.2	-0.006	50	0.6	-0.07



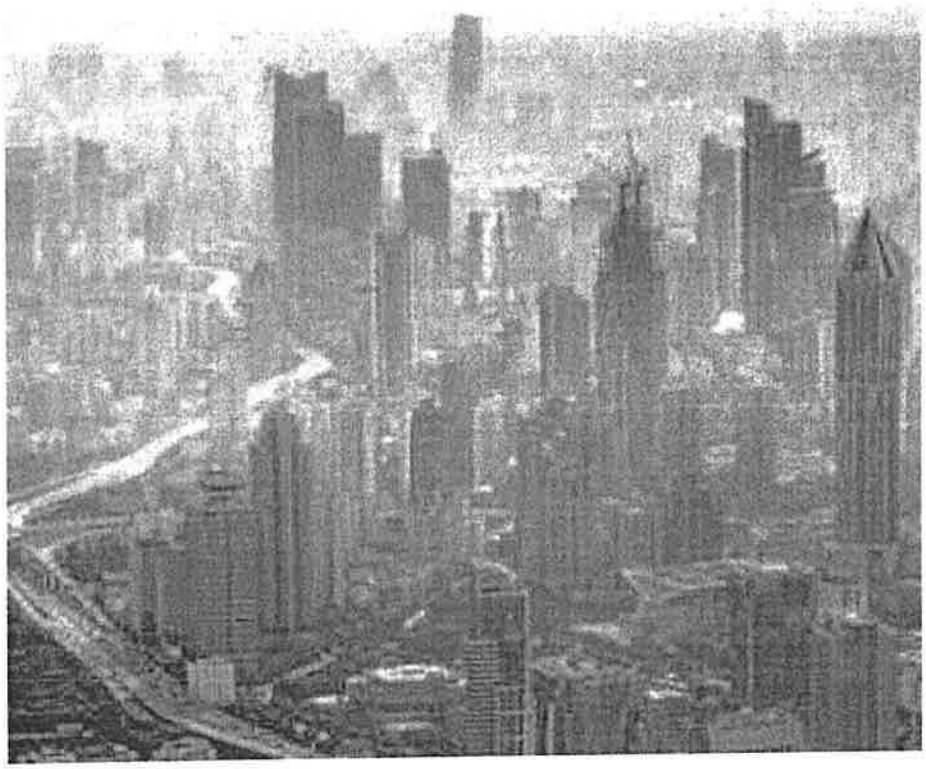
Problem 7

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

Photochemical smog has been identified as one of the primary causes of urban air pollution resulting in respiratory problems among the general population and other health effects among the more susceptible in our cities.

(10) (i) Briefly explain three (3) main causes of smog and three (3) possible hard or soft engineering control methods to reduce smog production or its environmental adverse effects. For each proposed control method, provide one (1) advantage and one (1) disadvantage or challenge associated with implementing the control method.

(10) (ii) Identify three (3) key causes of odorous emissions from the pretreatment area of a sewage treatment plant (e.g., screening room) or a furniture paint operation (e.g., paint and lamination furniture system). For the facility selected (**only one**), provide two (2) different control technologies that may reduce odorous emissions effectively at over 99%. Briefly explain what operation and maintenance issues need to be addressed to ensure consistent operation of the emission controls.



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) 8 (ii) (a) 3, (b) 3 (iii) 6 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) 10 (ii) 10 marks, 20 marks total

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