NATIONAL EXAMS DECEMBER 2016

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 $8\frac{1}{2}'' \times 11''$ 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. A completed exam consists of five (5) answered questions with a possible maximum score of 100 marks.

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

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

    3. (i) 10 (ii) 10 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

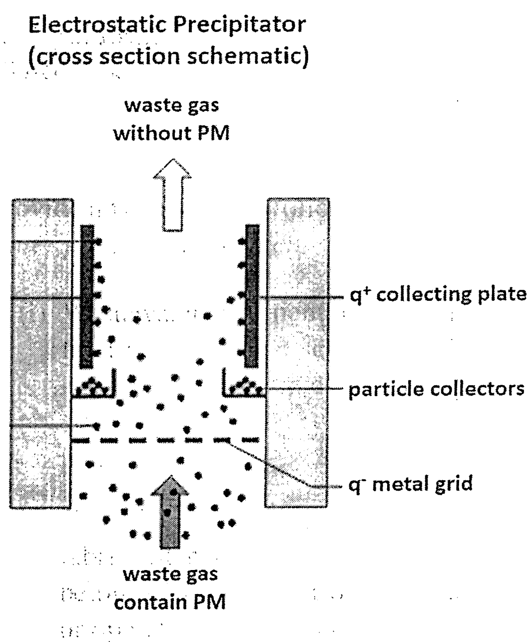
    7. (i) 10 (ii) 10 marks, 20 marks total

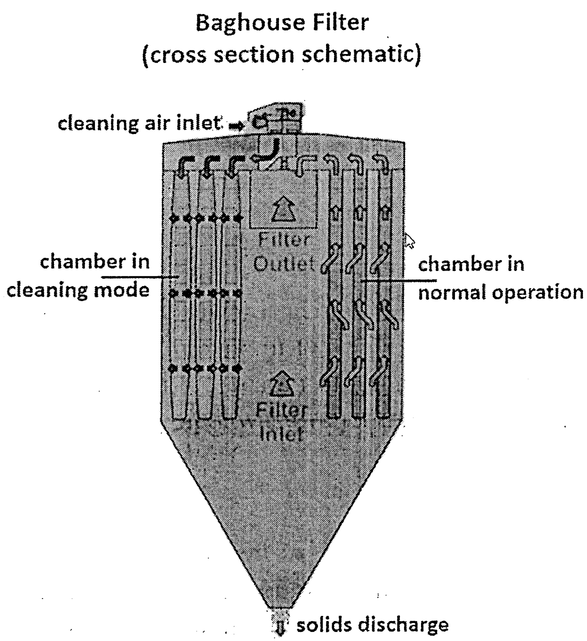
Problem 1

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

(10) (i) Wastewater treatment involves a series of sequential steps towards achieving treated final effluent for discharge to the natural waters. Briefly explain two (2) primary engineering principles or design parameters involved in the design of (a) aeration system, (b) secondary clarifier and (c) disinfection, in a typical wastewater treatment plant.

(10) (ii) Consider an electrostatic precipitator for the reduction of fine aerosol VOCs and a fabric filter to control the emission of small PM (dust) as shown in the schematics below. For each control equipment, explain three (3) important engineering design or operational considerations to ensure proper pollutant abatement.





Problem 2

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

For the three (3) technology types below, explain their typical application ranges by providing the following information related to each technology: (a) the minimum particle size or range, (b) the typical efficiency range on a % mass basis, (c) 1-advantage and (d) 1- challenge in using this technology.

(7) (i) Wet scrubber

(7) (ii) Cyclone collector

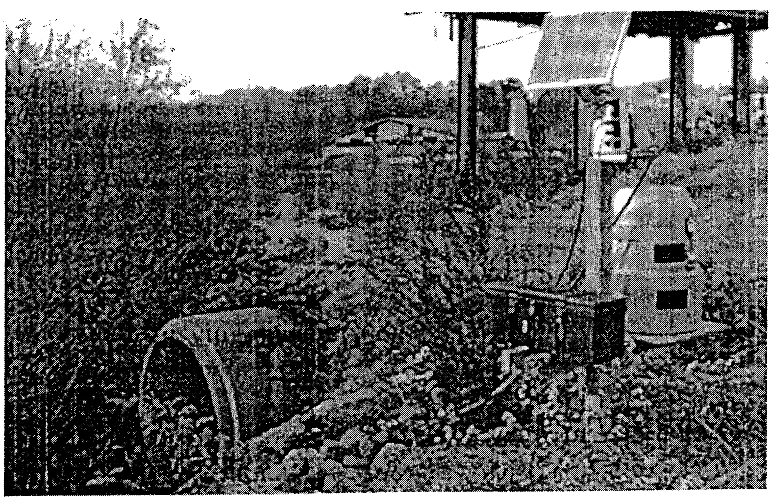
(6) (iii) Thermal oxidizer

Problem 3

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

(10) (i) Describe an engineering method and three (3) key engineering steps in the in-situ remediation of soil contaminated with toxic organic waste.

(10) (ii) Define and discuss how measurement (a) variability and (b) instrument sensitivity, related to wastewater effluent quality, may impact regulatory compliance and how these two factors need to be carefully considered when designing a compliance sampling plan.



Problem 4

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

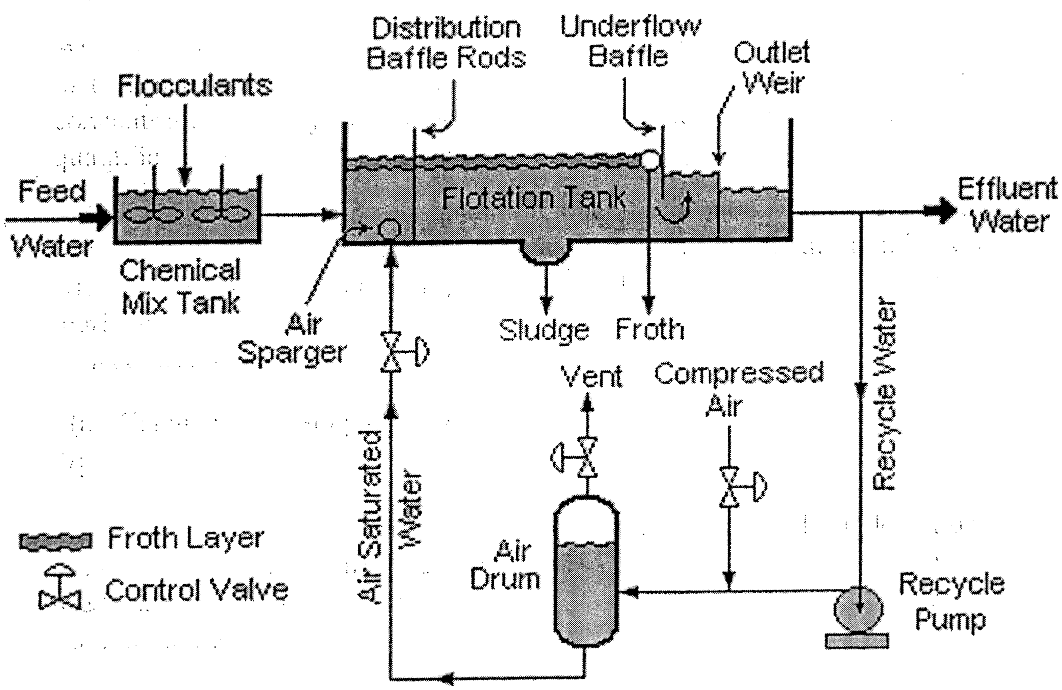
(8) (i) Water quality can be measured by various characteristics needed for proper design of treatment systems including (a) alkalinity, (b) dissolved oxygen and (c) metals concentration. Briefly explain how each characteristic can be measured or indirectly quantified by measuring other related parameters.

(ii) A BOD_5 test is conducted at standard temperature conditions using 350 mL of tertiary effluent mixed with 150 mL of water. The initial DO in the mix is 5 mg/L. After 5 days, the DO is 0.3 mg/L and after 20 days the DO has stabilized at 0.05 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 tertiary effluent in mg/L; and

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

(6) (iii) With reference to the diagram below of a typical dissolved air floatation (DAF) system, briefly explain how the system works from an engineering perspective when used for sludge thickening or removal of oil from wastewater. Equations may be used in your answer.



Problem 5

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

(i) Provide a short example of how each technology may be applied in the production of drinking water from a surface water or the treatment of wastewater:

(3) (a) pH control;

(4) (b) ion exchange; and

(3) (c) reverse osmosis.

(ii) An extended aeration 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:

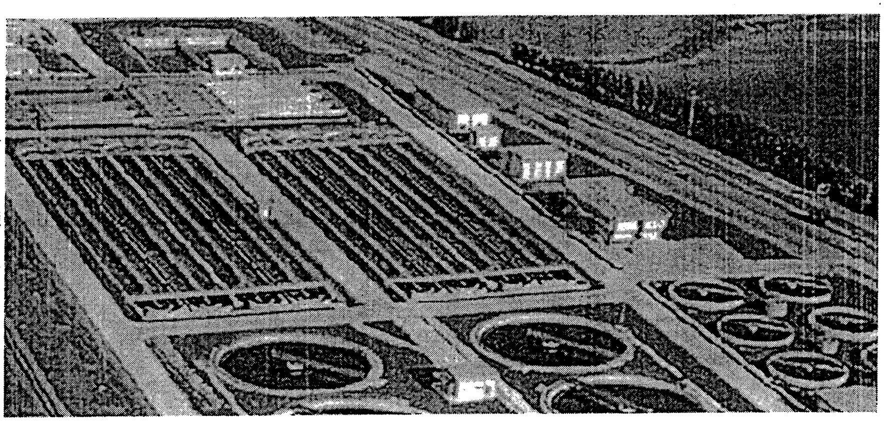
(3) (a) The required aeration tank volume V in m^3 and the aeration tank hydraulic retention time (ϕ) in hours;

(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 = 400 mg/L;
- effluent BOD_5 and TSS = 30 mg/L;
- yield coefficient, $Y = 0.4$;
- decay rate, $k_d = 0.05\ d^{-1}$;
- 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, $\phi_c = 30$ days;



Problem 6

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

A large gas fired power plant producing 3000 GW of power releases sulfur dioxide (SO_2) during its operation. The SO_2 is released from a 60 m stack at a rate of 20 g/min. The average wind speed is 2–3 m/s with clear sky conditions.

(10) (i) What is the distance downwind of the plume centerline emission point at which the predicted SO_2 ground-level concentration falls to less than 3 $\mu g/m^3$;

(10) (ii) Provide three (3) possible engineering measures that may be used to reduce the ground-level SO_2 concentration and prioritize each method in sequence of least to most costly. Consider the life cycle cost by assuming a 20-year equipment life of each engineering solution. Use a table to organize your answer.

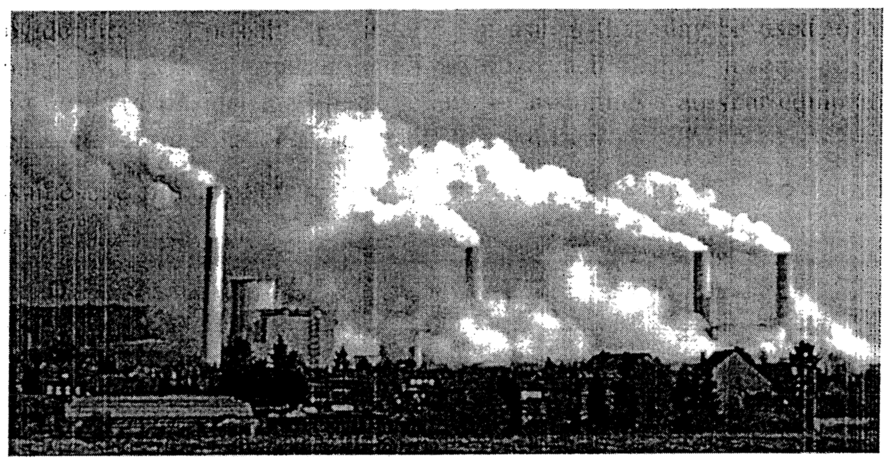
Assume an estimate of the dispersion parameters is provided by the following equations:

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

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

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	100	1.1	-0.005	160	2.1	0.6
B	95	1.0	-0.006	140	1.3	0.05
C	110	1.2	-0.003	90	1.0	0.03
D	50	0.9	-0.004	70	1.2	-0.05
E	40	1.1	-0.005	40	0.5	-0.05



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 cause 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 photochemical reactions or conditions that determine the production of smog and three (3) possible hard or soft engineering control methods.

(10) (ii) Identify three (3) key substances or causes of odorous emissions from an industrial operation of your choice and three (3) different methods or control technologies to reduce odorous emissions. Also, briefly explain two (2) important operational and maintenance requirements to ensure the long term performance of the methods or control technologies proposed at reducing odorous emissions.