NATIONAL EXAMS DECEMBER 2015

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.

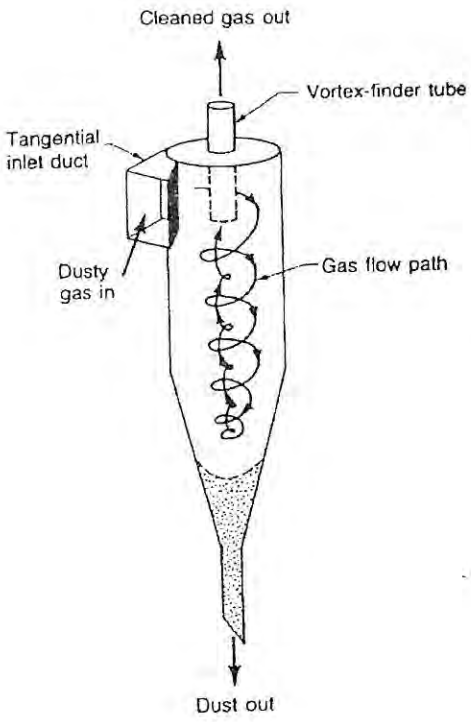
5. Each question is worth a total of 20 marks with the section marks indicated in brackets ( ) at the left margin of the question. The complete Marking Scheme is also provided on the final page. A completed exam consists of five (5) answered questions with a possible maximum score of 100 marks.

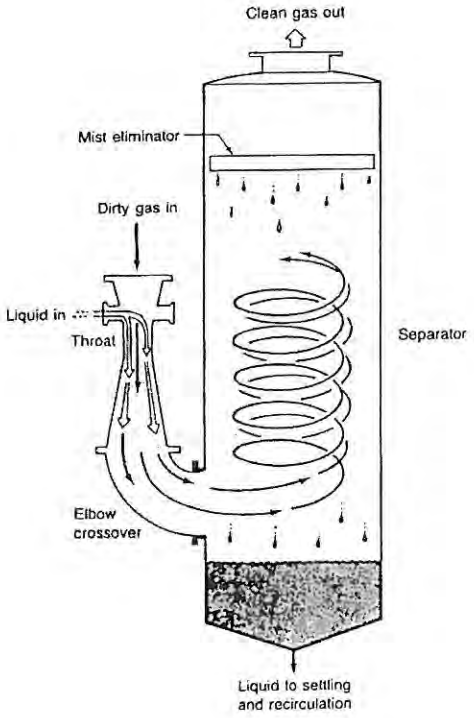
Problem 1

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

(10) (ii) Wastewater treatment involves a series of sequential steps towards achieving treated final effluent for dischrge to the natural waters. Briefly explain the primary engineering principle involved in the design of (a) sedimentation, (b) aeration and (c) final effluent disinfection, in a typical wastewater treatment plant.

(10) (i) Consider a cyclone for the reduction of large particulate matter (PM) and a scrubber to control the emission of corrosive gasess as shown in the schematics below. For each control equipment, explain two (2) important engineering design 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 range 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) Gravimetric settlers

(7) (ii) Electrostatic precipitators

(6) (iii) Fabric filters

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 steps in the remediation of soil contaminated with PCBs.

(10) (ii) Define and discuss how (a) reliability and (b) reproducibility is maintained in measurement techniques as applied to air quality parameters.

Problem 4

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

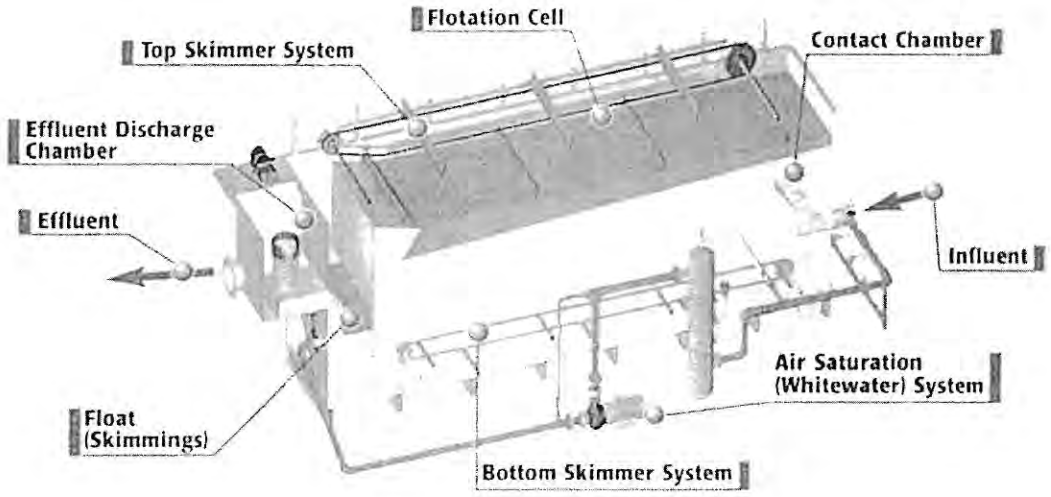
(8) (i) Water quality can be measured by various characteristics including (a) turbidity, (b) conductivity and (c) pH. Briefly explain how each parameter can be measured and its fundamental significance.

(ii) A BOD_5 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 6 mg/L. After 5 days, the DO is 0.4 mg/L and after 20 days the DO has stabilized at 0.1 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) With reference to the diagram below of a typical dissolved air floatation (DAF) system, briefly explain how the system works from an engineering perspective. 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) Briefly explain how each technology works in a water or wastewater treatment application:

(3) (a) pH control;

(4) (b) ion exchange; and

(3) (c) reverse osmosis.

(ii) A conventional activated sludge plant is to treat 100,000 m^3/d of municipal wastewater. You have been asked to assist the senior process design engineer by calculating the following:

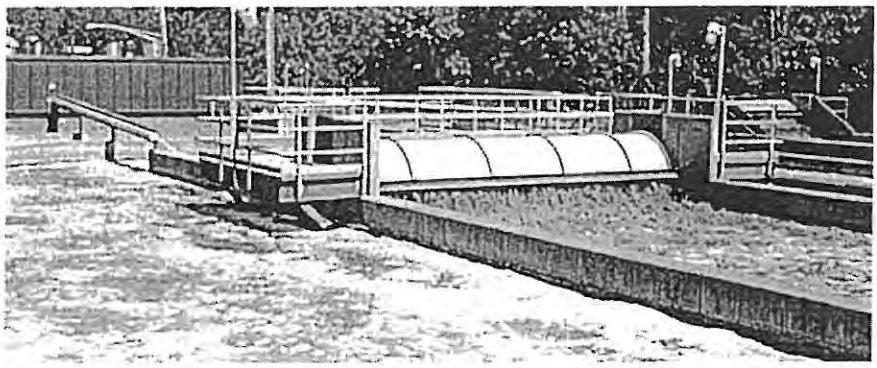
(3) (a) The required aeration tank volume V in m^3 and the aeration tank hydraulic retention time (ϕ) in hours;

(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 = 300 mg/L;
- effluent BOD_5 and TSS = 10 mg/L;
- yield coefficient, $Y = 0.5$;
- decay rate, $k_d = 0.04\ d^{-1}$;
- average MLSS in the aeration tank, X = 3,000 mg/L;
- waste MLSS from the clarifier, X_w = 9,000 mg/L; and
- mean cell residence time, ϕ_c = 25 days;



Problem 6

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

A large coal fired power plant producing 2000 GW of power releases sulfur dioxide (SO_2) during its operation. The SO_2 is released from an 80 m stack at a rate of 25 g/min. The average wind speed in the range of 4–6 m/s with overcast 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 5 $\mu g/m^3$;

(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 operation and maintenance requirements.

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	120	1.2	-0.004	170	2.2	0.7
B	90	0.9	-0.005	130	1.2	0.04
C	100	1.1	-0.004	80	1.1	0.02
D	45	0.8	-0.005	60	1.1	-0.06
E	35	1.0	-0.004	30	0.6	-0.04

Problem 7

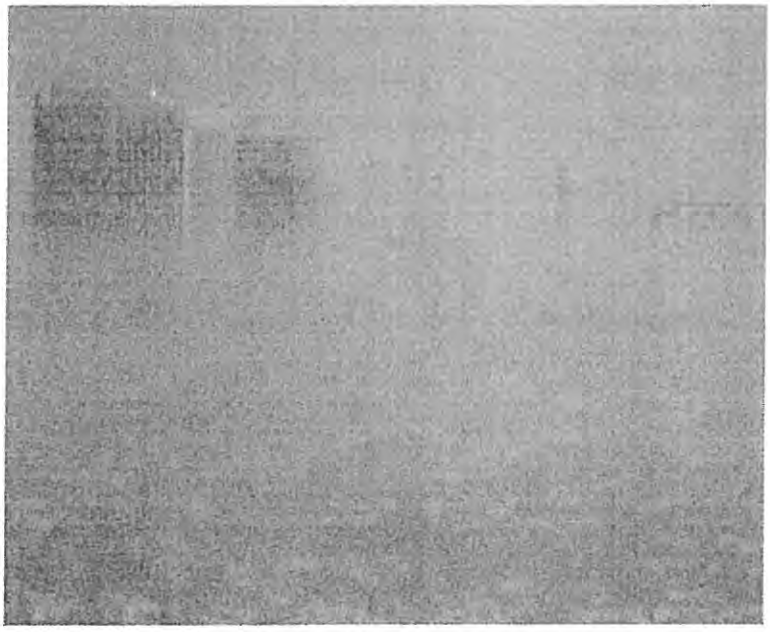
Provide answers to the following questions related to *photochemical reactions, noxious pollutants and odour control.*

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

(6) (i) Briefly explain three (3) main photochemical reactions that determine the production of smog.

(7) (ii) Briefly describe one effective engineering control method to deal with benzene emissions from mobile or stationary sources.

(7) (iii) Identify a biologically based odour control technology to control odorous emissions from a rendering plant and briefly explain two (2) important operational and maintenance requirements to ensure the long term performance of the technology at reducing odorous emissions.



Marking Scheme

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) 6 (ii) 7 (iii) 7 marks, 20 marks total