NATIONAL EXAMS MAY 2013

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 *characterization of water contaminants and their measurement*, *biochemical oxygen demand* and *flotation*.

(8) (i) A wastewater treatment plant is required to reduce total phosphorous (TP) to prevent downstream eutrophication. Provide two (2) treatment methods (one physical and one biological) that may be used to reduce effluent levels of TP to less than 1 mg/L on a monthly average basis. Briefly discuss two (2) advantages and two (2) disadvantages for each treatment method.

(6) (ii) A BOD test is conducted at standard temperature conditions using 100 mL of tertiary effluent mixed with 200 mL of water. The initial DO in the mixture is 6 mg/L. After 5 days, the DO is 2 mg/L and after 20 days the DO has stabilized at 0.2 mg/L. Assume that nitrification has been inhibited so that only $CBOD_5$ (5-day carbonaceous biochemical oxygen demand) is being measured.

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

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

(6) (iii) Briefly explain the steps necessary to design: (1) dissolved air floatation (DAF) system to thicken 10 ML/d of waste activated sludge from 0.5% to 2% total solids <u>or</u> (2) a DAF for any other application in treating 10 ML/d of municipal or industrial wastewater or solid residuals. Answer part (1) or (2) **<u>not both</u>**.

Problem 2

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

(10) (i) Provide an example and explain two (2) appropriate technologies that may be used in soil remediation when soil contamination from heavy hydrocarbons has impacted a surface water body used for recreation and fishing;

(10) (ii) Define and discuss the importance of replication (R), method detection limit (MDL) and measurement frequency (v) in pollutants quantification for compliance purposes of effluents of permitted facilities discharging to the natural environment.

Problem 3

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

(8) (i) Briefly describe two (2) engineered air pollution control methods that can be used to reduce particulate (e.g., PM10, PM2.5, aerosols) emissions. For each control method, briefly provide the main engineering design principle and give an example where it would be the most appropriate to be used.

(8) (ii) Acute effects associated with ammonia discharges from sewage treatment plants have caused fish kills. Briefly explain two (2) primary causes of acutely toxic effluents 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 long term effectiveness of the treatment system.

(4) (iii) Provide two (2) benefits and two (2) costs associated with the implementation of buffer strips on crop lands to try and alleviate nutrients from reaching water courses. The use of buffer strips is often cited as a good water pollution abatement measure.

Problem 4

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

For the three (3) technology types given 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 industrial process where each technology may used. A table or matrix is recommended to organize your answer.

(7) (i) fabric filters based technology for particulates

(7) (ii) absorption based technology for gases

(6) (iii) catalytic reactors for odorous vapours

Problem 5

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

A large power plant producing 300 GW of power releases sulfur dioxide (SO_2) during its operation. The SO_2 is released from a 40 m stack at a rate of 30 g/min. The average wind speed is 10 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 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 compare each method in terms of their environmental impact and recommend the preferred option.

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	140	1.0	-0.004	300	2.0	0.4
B	100	1.0	-0.004	210	1.0	0.03
C	110	1.0	-0.005	75	1.2	0.03
D	50	1.0	-0.006	55	1.0	-0.05
E	40	1.0	-0.002	25	0.5	-0.06

Problem 6

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 two (2) general engineering approaches that can be used to minimize the formation of smog in populated municipal areas;

(7) (ii) Briefly describe the design of an engineering process to reduce the release of chlorinated hydrocarbons or similar noxious pollutants by 99.5% from an industrial emitter. Identify all the assumptions you need to make to arrive at your answer; and

(7) (iii) Identify an effective physical-chemical process based engineered odour control technology and briefly explain its design principle, operational and maintenance requirements.

Problem 7

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

(10) (i) Explain three (3) key design principles in the application of each technology in water or wastewater treatment:

(a) pH control;

(b) ion exchange or reverse osmosis.

(10) (ii) A conventional activated sludge plant is to treat $100,000\ m^3/d$ of combined residential wastewater and stormwater (its a combined sewershed). You have been asked to assist the senior process design engineer by calculating the following:

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

(b) the quantity of sludge to be wasted daily (Q_w) in kg/d; and

(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 $TSS = 25\ mg/L$;
- yield coefficient, $Y = 0.7$;
- 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, $X_w = 10,000\ mg/L$; and
- mean cell residence time, $\phi_c = 25\ days$;

Marking Scheme

1. (i) 8 (ii) 6 (iii) 6 marks, 20 marks total
2. (i) 10 (ii) 10 marks, 20 marks total
3. (i) 8 (ii) 8 (iii) 4 marks, 20 marks total
4. (i) 7 (ii) 7 (iii) 6 marks, 20 marks total
5. (i) 10 (ii) 10 marks, 20 marks total
6. (i) 6 (ii) 7 (iii) 7 marks, 20 marks total
7. (i) 10 (ii) 10 marks, 20 marks total