NATIONAL EXAMS MAY 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) (i) A wastewater treatment plant is discharging to the subsurface and is required to reduce total nitrogen (TN) to prevent groundwater contamination used as a drinking water source. Describe a treatment system that may be used to reduce effluent levels of TN to less than 10 mg/L on a monthly average basis. As part of your answer, provide a labelled schematic, a brief description of each treatment component and the key design principle involved in each treatment component.

(10) (ii) Briefly describe engineered air pollution control methods that can be used to reduce VOCs (e.g., benzene, methylene chloride, hexane) emissions, particulates (e.g., PM10, aerosols) and air toxics (e.g., CO, NOx, SOx). Describe one (1) method for each contaminant type. For each method, briefly provide the main engineering design principle and an important operation and maintenance issue you need to consider when operating the system. You may use a matrix to organize your answer.

Problem 2

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 industrial process where each technology may used. A table or matrix is recommended to organize your answer.

(7) (i) Oxidation based technology for toxic gases

(7) (ii) Condensation based technology for odorous vapours

(6) (iii) Adsorption based technology for aerosols

Problem 3

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

(8) (i) A drinking water treatment plant is designed to remove settleable particulates, dissolved solids and microbial contaminants. Describe three (3) different engineered treatment components, typical of a water treatment plant, used to remove each of the contaminants mentioned. In your description, provide the key design principle involved.

(ii) A BOD test is conducted at standard temperature conditions using 300 mL of secondary effluent mixed with 200 mL of water. The initial DO in the mix is 7 mg/L. After 5 days, the DO is 1.5 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.

(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) Provide a clear explanation of how a dissolved air floatation system works to remove suspended matter such as oils or solids. Provide a labeled schematic and equations to explain the key engineering principles involved.

Problem 4

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

(i) Provide one (1) key design principle and one (1) important and specific operation and maintenance parameter that needs to be addressed for the successful consistent application each technology in water or wastewater treatment:

(3) (a) pH control;

(4) (b) ion exchange; and

(3) (c) reverse osmosis.

(ii) A conventional activated sludge plant is to treat 500,000 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 = 200 mg/L;
- effluent BOD_5 and TSS = 2 mg/L;
- yield coefficient, $Y = 0.7$;
- decay rate, $k_d = 0.04\ d^{-1}$;
- average MLSS in the aeration tank, $X = 4{,}000$ mg/L;
- waste MLSS from the clarifier, $X_w = 12{,}000$ mg/L; and
- mean cell residence time, $\phi_c = 20$ days;

Problem 5

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

A large natural gas power plant generating 5000 GW of power releases sulfur dioxide (SO_2) during its operation. The SO_2 is released from a 100 m stack at a rate of 20 g/min. The average wind speed is 15 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 less than 4 $\mu g/m^3$;

(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 expected long term performance and operation and maintenance needs.

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	110	1.2	-0.005	160	1.9	0.6
B	100	1.0	-0.006	100	1.0	0.05
C	110	1.0	-0.004	80	1.0	0.05
D	60	1.2	-0.005	70	0.9	-0.07
E	50	1.0	-0.005	40	0.7	-0.07

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 in our cities.

(6) (i) Briefly explain under what atmospheric conditions smog forms and the key chemical reactions that cause smog formation;

(7) (ii) Briefly describe the design of an engineering process to reduce the release of halogenated hydrocarbons by 99.9%. Identify any assumptions made; and

(7) (iii) Identify one (1) effective odour control technology to control odorous emissions caused by volatile sulfur compounds emitted from an industrial facility and briefly explain two (2) important design principles used in the application of the technology.

Problem 7

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

(10) (i) Provide the key steps in contaminant soil remediation using an example of a site that has been contaminated from heavy metals (e.g., Hg, Pb) and now has to be remediated for the establishment of a park. Assume that the soils are to be treated and replaced back to the source.

(10) (ii) Define and discuss the importance of sample size (n), sensitivity (S) and reliability (R) in environmental measurement techniques as applied to the measurement of ambient air quality parameters or water quality measurements.

Marking Scheme

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