NATIONAL EXAMS MAY 2012

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) Briefly describe two (2) engineered air pollution control methods that can be used to reduce Particulate (e.g., PM_{10}) emissions. For each control method, briefly provide two (2) advantages and two (2) limitations and give an example of where it would be most appropriate to be used.

(10) (ii) Limiting dissolved oxygen (DO) conditions in rivers has been attributed to effluents from sewage treatment plants. Briefly explain two (2) primary causes of limiting DO 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 effectiveness of the treatment system.

Problem 2

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

For the four (4) technology types, 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.

(5) (i) Absorption based technology for gases

(5) (ii) Particle control technology for particulates

(5) (iii) Combustion based technology for vapours

(5) (iv) Biological based technology for odorous vapours

Problem 3

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

(7) (i) A drinking water treatment plant is to operate reliably and consistently to ensure the public a safe potable water supply. Give one (1) organic or one(1) biological contaminant that typically need to be removed from surface water supplies. Provide two (2) treated water measurement methods (one for each contaminant type) that may be used to ensure the water is free from the organic and biological contaminant identified. Briefly discuss how you would ensure that the measurement methods can be relied on to guarantee that the contaminants are sufficiently reduced.

(ii) A BOD test is conducted at standard temperature conditions, but only using 100 mL of tertiary effluent mixed with 200 mL of water. The initial DO in the mix is 8 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.

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

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

(1) (c) What is the remaining CBOD after 5 days in mg/L.

(6) (iii) Provide an example of an engineered flotation system and how it is used in water or wastewater treatment. In your example, briefly explain the use of two (2) important design parameters for the design and operation of the flotation system.

Problem 4

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

(i) Give an example of the purpose of each technology in water or wastewater treatment:

(3) (a) pH control;

(4) (b) ion exchange; and

(3) (c) reverse osmosis.

(ii) A extended aeration activated sludge plant is to treat $100,000\ m^3/d$ of combined residential and industrial 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 $TSS = 25\ mg/L$;
- yield coefficient, $Y = 0.5$;
- decay rate, $k_d = 0.06 \cdot d^{-1}$;
- average MLSS in the aeration tank, $X = 5,000\ mg/L$;
- waste MLSS from the clarifier, $X_w = 12,000\ mg/L$; and
- mean cell residence time, $\phi_c = 30\ days$;

Problem 5

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

A large natural gas power plant producing 200 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 15 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 35 $\mu g/m^3$;

(5) (ii) Briefly provide two (2) possible engineering measures that may be used to reduce the ground level SO_2 concentration indicating an advantage and a disadvantage of each measure; and

(5) (iii) What is the minimum control device efficiency required, if the maximum background SO_2 concentration is 20 $\mu g/m^3$ and the 24-hour ambient air quality criteria is 5 $\mu g/m^3$.

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 taken from the appropriate stability class given in the table below:

Stability Class	a	b	c	d	e	f
A	170	1.0	-0.005	220	2.5	0.4
B	120	1.0	-0.004	100	1.2	0.03
C	115	1.0	-0.003	70	1.1	0.01
D	40	1.0	-0.002	40	0.9	-0.03
E	30	1.0	-0.002	10	0.7	-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 causea of urban air pollution resulting in respiratory problems among the general population and thousands of asthma attacks among the more susceptible in our cities.

(7) (i) Briefly explain the formation of smog;

(6) (ii) Briefly describe an engineering process or processes to control or prevent the release of chlorinated hydrocarbons or similar toxins to the natural environment from an industrial process; and

(7) (iii) Identify an engineered odour control technology and briefly explain its design principle and operational requirements.

Problem 7

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

(7) (i) Provide an example and explain two (2) appropriate technologies commonly used in soil remediation when soil contamination from heavy hydrocarbons has impacted a groundwater aquifer used as a drinking water source;

(6) (ii) Briefly explain three (3) main differences between the application of bioremediation and physical-chemical based remediation technologies; and

(7) (iii) Discuss the importance of sensitivity, reliability and accuracy in measurement techniques. In your discussion, use a realistic environmental engineering example.

Marking Scheme

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

2. (i) 5 (ii) 5 (iii) 5 (iv) 5 marks, 20 marks total

3. (i) 7 (ii) (a) 3, (b) 3, (c) 1 (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) 5 (iii) 5 marks, 20 marks total

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

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