NATIONAL EXAMS MAY 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. 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 ($PM_{2.5}$ and PM_{10}) emissions from an industrial source. Select one control method for $PM_{2.5}$ and a different control method for PM_{10}. For each control method: (a) briefly provide two (2) main engineering design principles and (b) two (2) operational considerations to ensure efficient performance of the control methods. Use a table to organize your answer.

(10) (ii) Ammonia (NH_3) has been identified as a primary effluent toxin to fish. To achieve a level below a toxic concentration in the receiving lake waters, the final total ammonia-nitrogen (TAN) effluent limit has been set to < 5 mg/L by the Ontario Ministry of the Environment. Assume that the municipal raw wastewater concentration level of TAN is 25 mg/L briefly describe three (3) possible treatment methods to achieve this final concentration level. As part of your answer provide three (3) labelled block diagrams showing the treatment train for each case.

Problem 2

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

Describe one (1) technology and how each may be used to control the contaminant types identified below. In your explanation, briefly describe the main design principle for each technology; two (2) operational considerations and two (2) limitations in the application of the technology. You may select a particular example(s) and also use a table to organize your answer.

(7) (i) Particulates

(7) (ii) Toxic gases

(6) (iii) Odorous vapours

Problem 3

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

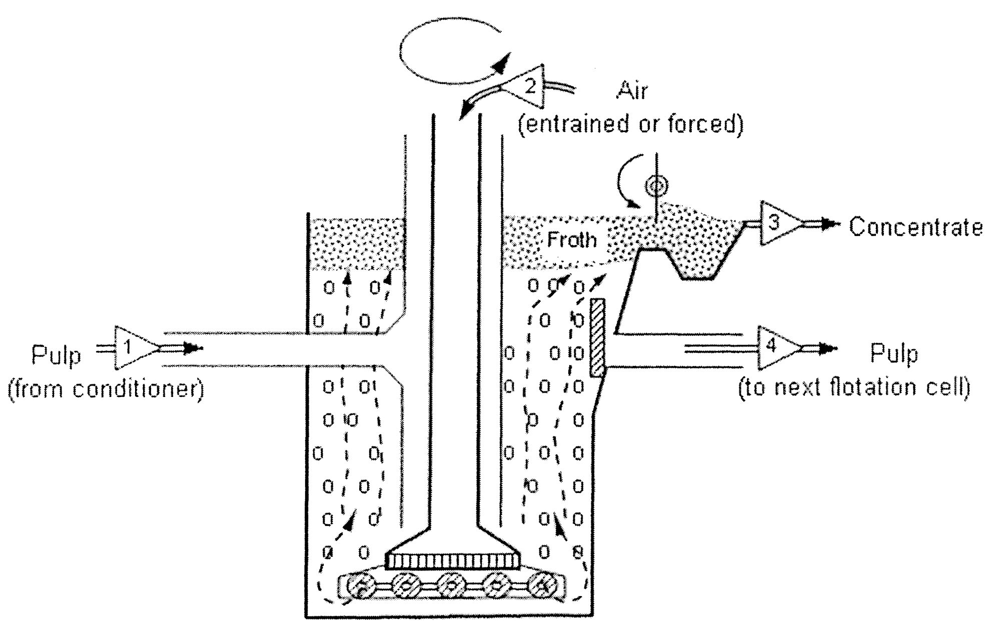
(8) (i) A drinking water treatment plant uses surface water as its source of raw water for drinking water. Give one (1) inorganic and one (1) microbiological contaminant that typically needs to be treated from surface water supplies. Provide two (2) raw water measurement methods (one for each contaminant type) that may be used to determine the degree of treatment necessary prior to entering the distribution system. Briefly discuss how you would ensure that the measurement methods are accurate and precise.

(ii) A BOD test is conducted at standard temperature conditions using 150 mL of primary effluent mixed with 100 mL of water. The initial DO in the mix is 7 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 primary effluent in mg/L; and

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

(6) (iii) With reference to the section view of a floatation treatment system below, briefly describe three (3) important design steps in the engineering design of the process in a drinking water or wastewater treatment application (select only **one (1)** treatment system).



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, one (1) important operational issue and one (1) critical maintenance condition that need to be addressed for the consistent application of each technology in a drinking water or wastewater treatment applicaiton:

(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:

(2) (a) The required aeration tank volume V in m^3;

(2) (b) the aeration tank hydraulic retention time (ϕ) in hours;

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

(3) (d) the sludge recycle ratio (Q_r/Q_o).

Use the following process information:

- Influent BOD_5 and TSS = 250 mg/L;
- effluent BOD_5 and TSS = 5 mg/L;
- yield coefficient, $Y = 0.6$;
- decay rate, $k_d = 0.03\ d^{-1}$;
- 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, ϕ_c = 15 days;

Problem 5

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

A large natural gas fired power plant producing 6000 GW of power releases sulfur dioxide (SO_2) during its operation. The SO_2 is released from a 120 m stack at a rate of 20 g/min. The average wind speed is 5 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 2 $\mu g/m^3$;

(10) (ii) Provide three (3) possible engineering measures that may be used to reduce the ground level SO_2 concentration and compare each measure in terms of its long-term environmental impacts and recommend the preferred measure.

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	1.0	-0.005	160	1.7	0.6
B	115	1.2	-0.006	100	1.0	0.05
C	120	1.0	-0.006	70	1.0	0.05
D	60	1.2	-0.004	60	0.9	-0.05
E	50	1.1	-0.005	40	0.7	-0.05

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 cause 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% from an industrial process. Justify any assumptions made; and

(7) (iii) Describe one (1) effective odour control technology to control odorous emissions from the screening or pre-treatment area of a sewage treatment plant. As part of your description, briefly explain the main design principle along with the most important operational and maintenance requirement.

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 by heavy metals (e.g., Cd, As, Pb) and is to be remediated to a useful condition for a residential development. Assume that the soils are to be treated and replaced back to the source.

(10) (ii) Define and discuss the importance of sensitivity (S), reliability (R) and accuracy (A) in measurement techniques as applied to instrumentation used to measure the final effluent quality of a secondary municipal wastewater treatment plant or treated drinking water quality.

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) 2 (b) 2 (c) 3 (d) 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