NATIONAL EXAMS MAY 2018

16-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.

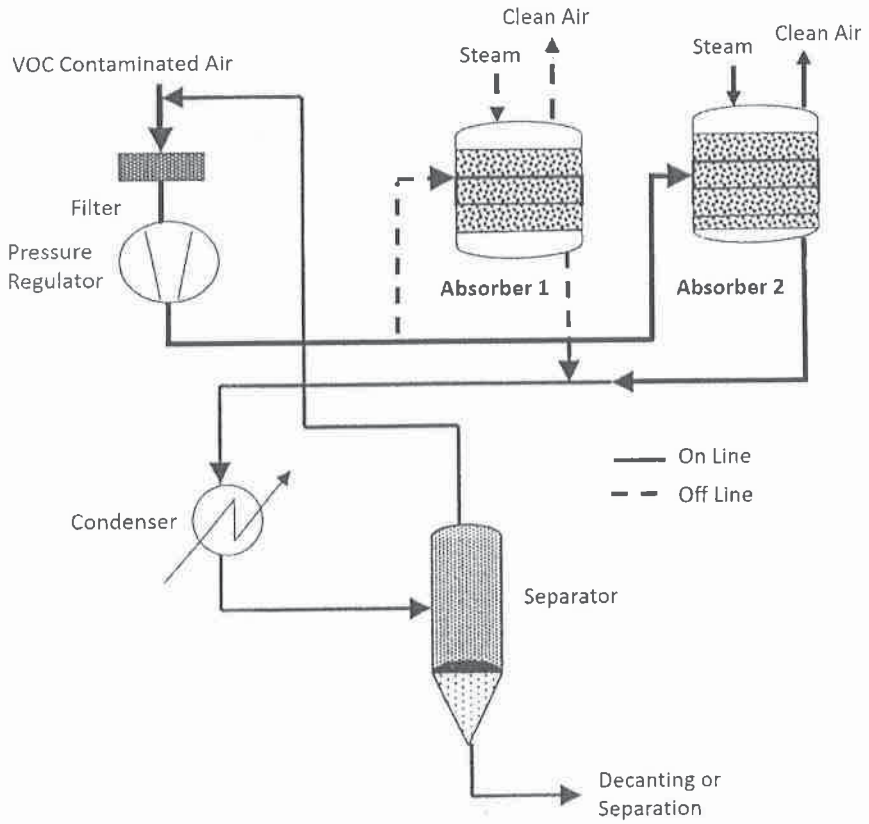
Problem 1

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

(8) (i) Water treatment involves a series of sequential steps towards achieving treated or potable water for distribution to consumers. Briefly explain two (2) primary engineering principles involved in the design of (a) a coagulation-flocculation system; (b) a sand filter and (c) a disinfection system, in a typical water treatment plant.

(4) (ii) Tertiary wastewater treatment is becoming increasingly important as regulators demand higher quality effluent with reduced environmental impacts. Briefly provide an example of a tertiary wastewater treatment component and how it would improve the final effluent quality.

(8) (iii) Consider the adsorber (e.g. activated carbon) process design schematic below for VOC reduction and condensation. Briefly explain three (3) important engineering design principles or operational considerations to ensure the proper pollutant abatement of the VOC contaminated air.



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 the key design basis to ensure their efficient reduction of either particulates, gases or vapours. The following information should be provided in your explanation: (a) one (1) key design parameter that affects the performance; (b) the typical efficiency range on a % mass basis, and (c) one (1) important maintenance issue to ensure a consistently high performance efficiency. *Note that a table to organize your answer is recommended.*

(7) (i) Electrostatic Precipitator

(7) (ii) Wet Scrubber

(6) (iii) Fabric Filter ("Baghouse")

Problem 3

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

(8) (i) Describe an engineering method and three (3) key engineering steps in the in-situ remediation of soil contaminated with heavy metals (e.g., mercury).

(4) (ii) Briefly describe two (2) important differences (advantages or disadvantages) in using physical-chemical soil remediation techniques versus a biologically based remediation approach in cleaning up oil contaminanted soil.

(8) (iii) A properly planned field environmental sampling program should take into account the potential for various sources of error and uncertainty associated with measurement techniques. Identify three (3) potential sources of error and briefly explain three (3) potential remedies to address the associated errors. In answering this question, consider an air or a water contaminant and that the sampling is to determine if there are significant seasonal differences in concentration.

Problem 4

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

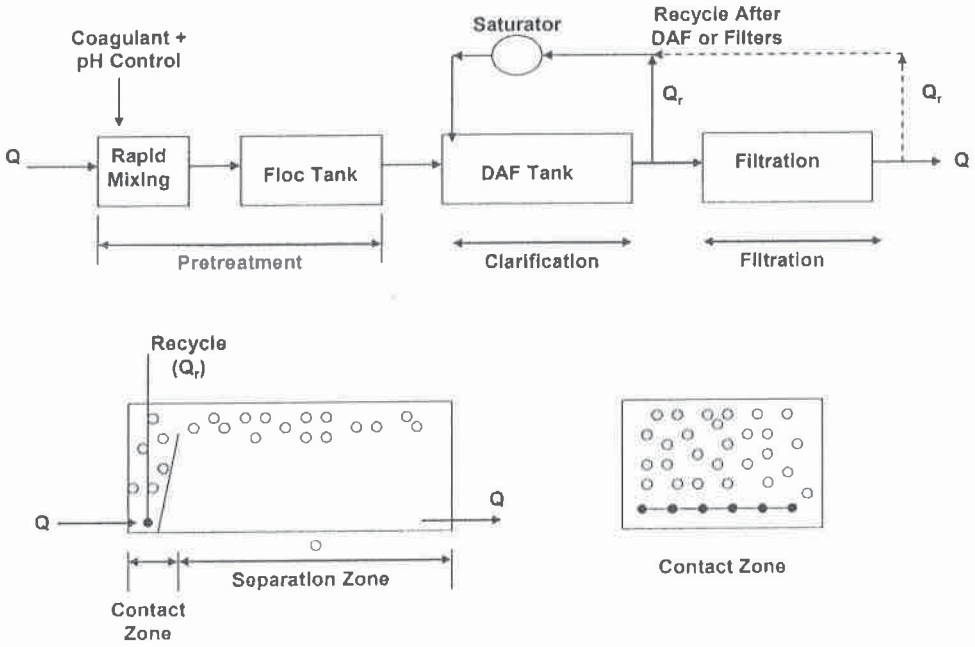
(8) (i) Water quality can be measured by various characteristics needed for proper design of treatment systems including (a) pH, (b) conductivity and (c) toxicity. Briefly explain how each characteristic can be measured or indirectly quantified using reliable techniques.

(ii) A BOD_5 test is conducted at standard temperature conditions using 300 mL of tertiary effluent mixed with 200 mL of water. The initial DO in the mix is 7 mg/L. After 5 days, the DO is 2.0 mg/L and after 20 days the DO has stabilized at 0.05 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; and

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

(6) (iii) With reference to the process schematic below of a dissolved air floatation (DAF) water treatment system, briefly explain three (3) main functions of the DAF unit in overall treatment process. Note that the bottom two (2) figures are the cross sections from the side and front view of the DAF reactor.



Problem 5

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

(i) Briefly explain the main function and an operational issues associated with each technology as applied in the production of drinking water from a ground aquifer that has a low pH or the treatment of wastewater with a high pH. Select **only one example** to work with:

(3) (a) pH control;

(4) (b) ion exchange; and

(3) (c) reverse osmosis.

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

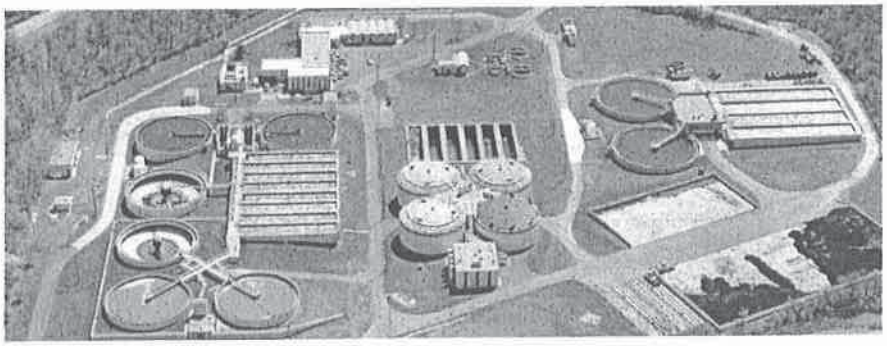
(3) (a) The required aeration tank volume V in m^3 and the aeration tank hydraulic retention time (ϕ) in hours;

(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 = 40 mg/L;
- yield coefficient, $Y = 0.5$;
- decay rate, $k_d = 0.04\ d^{-1}$;
- average MLSS in the aeration tank, X = 5,000 mg/L;
- waste MLSS from the clarifier, X_w = 8,000 mg/L; and
- mean cell residence time, ϕ_c = 8 days;



Problem 6

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

A large coal fired power plant producing 4000 GW of power releases sulfur dioxide (SO_2) during its operation. The NO_x is released from a 50 m stack at a rate of 25 g/min. The average wind speed is 5–10 m/s with overcast sky 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 10 $\mu g/m^3$;

(10) (ii) Provide three (3) possible engineering measures that may be used to reduce the ground level NO_x concentration and prioritize each method in sequence of least to most costly by assuming a 25-year life cycle cost and considering an annual maintenance program. Use a table to organize your answer.

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	90	1.0	-0.004	150	2.0	0.5
B	80	0.9	-0.005	130	1.4	0.04
C	100	1.1	-0.004	100	1.1	0.04
D	40	0.8	-0.005	80	1.3	-0.06
E	35	1.2	-0.006	50	0.6	-0.07

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 other health effects among the more susceptible in our cities.

(10) (i) Briefly explain three (3) main causes of smog and three (3) possible hard or soft engineering control methods to reduce smog production or its environmental adverse effects.

(10) (ii) Identify three (3) key causes of odorous emissions from a an animal rendering plant (e.g., chicken slaughter house) or a car paint spray booth operation (e.g., automotive painting facility). For the facility selected (**only one**), provide two (2) different control technologies that may reduce odorous emissions effectively at over 99%. Briefly explain how you can ensure a consistently high performance efficiency in odour reduction.

Marking Scheme

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