NATIONAL EXAMS DECEMBER 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 *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 emissions from industrial sources. For each control method: (a) briefly provide two (2) main engineering design principle and (b) two (2) operation or maintenance considerations during the life of the control system.

(10) (ii) Nutrients such as nitrogen (N) in the form of ammonia (NH_3) and phosphorous (P) have been attributed to toxicity and eutrophication issues of fresh water lakes, respectively. The main source of these pollutants has been identified as an upstream primary municipal wastewater treatment plant. Explain the use of two (2) different treatment methods to upgrade the wastewater treatment plant and reduce NH_3 and P to sufficiently low levels that toxicity and eutrophication are significantly reduced. Select one (1) different treatment technology or system to address each pollutant.

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) Membrane based technology for particulates

(7) (iii) Condensation based technology for gases

(6) (iv) Adsorption 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.*

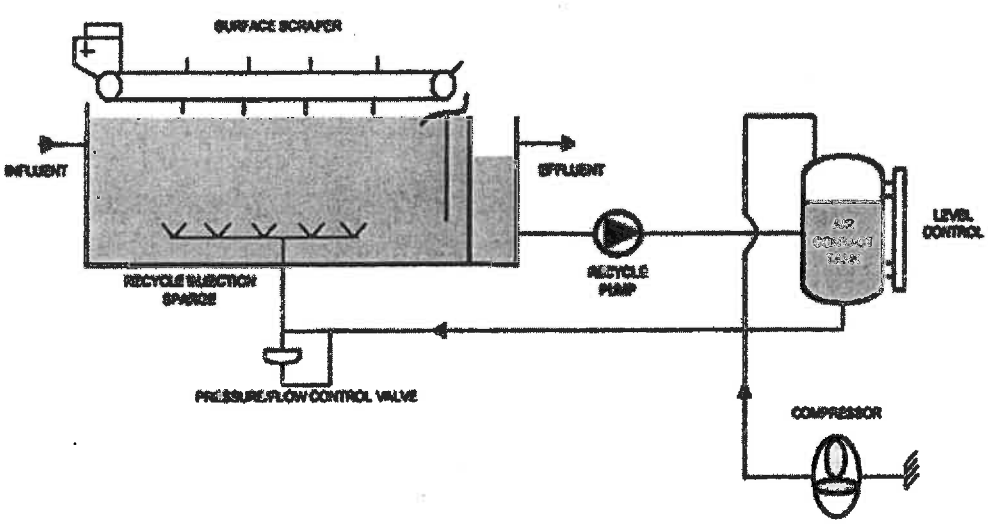
(8) (i) A drinking water treatment plant uses a surface water from a polluted river as their only source of raw water for local municipality. Give one (1) inorganic and one(1) microbiological contaminant that typically needs to be treated for from surface water supplies. Provide two (2) raw water measurement methods (one for each contaminant type) that may be used to determine the degree of pre-treatment necessary prior to filtration. Briefly discuss how you would ensure that the measurement methods can be relied on to guarantee that the contaminants are sufficiently reduced after filtration or after the disinfection step.

(ii) A BOD test is conducted at standard temperature conditions using 300 mL of primary effluent mixed with 200 mL of water. The initial DO in the mix is 5 mg/L. After 5 days, the DO is 0.5 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 primary effluent in mg/L; and

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

(6) (iii) With reference to the diagram below, briefly describe three (3) important design steps in the engineering design of a dissolved air floatation (DAF) system to thicken sludge or deal with floatables.



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) short example of the application of 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 200,000 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 = 250 mg/L;
- effluent BOD_5 and TSS = 5 mg/L;
- yield coefficient, $Y = 0.8$;
- decay rate, $k_d = 0.05$ d^{-1};
- average MLSS in the aeration tank, $X = 3{,}000$ mg/L;
- waste MLSS from the clarifier, $X_w = 10{,}000$ mg/L; and
- mean cell residence time, $\phi_c = 15$ 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 1000 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 20 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 method in terms of their long-term environmental impacts and recommend the preferred solution.

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	-0.005	180	2.0	0.6
B	100	1.0	-0.004	120	1.0	0.05
C	110	1.0	-0.003	70	1.0	0.03
D	40	1.0	-0.004	50	1.0	-0.05
E	30	1.0	-0.005	20	0.5	-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 among the general population and thousands of asthma attacks among the more susceptible in our cities.

(6) (i) Briefly explain the formation of smog in terms of the physical atmospheric conditions and chemical reactions necessary;

(7) (ii) Briefly describe the design of engineering process to reduce the release of chlorinated hydrocarbons or similar noxious pollutants by 99.99%. Identify all the assumptions you need to make to arrive at your answer; and

(7) (iii) Identify one (1) effective odour control technology to control sulfur odorous emissions from an industrial facility and briefly explain its design principle, operational and maintenance requirements.

Problem 7

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 one (1) appropriate technology that may be used in soil remediation when: (a) soil has been contaminated from a large toxic metals spill (e.g., cadmium and mercury) and (b) soil has been contaminant from heavy crude oils. Assume that the soils are to be treated and replaced back from 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 ambient air quality parameters.

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