# NATIONAL EXAMS MAY 2014

## 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 noxious gas emissions from commercial or industrial sources. For each control method: (a) briefly provide two (2) main engineering design principles and (b) two (2) operation or maintenance considerations to ensure continued efficient performance of the control methods throughout the life of the system.

(10) (ii) Nutrients such as nitrogen (N) and phosphorus (P) have been identified as sources of pollution that require abatement and also potential resources in sewage treatment plant effluents. For each nutrient, briefly provide the following:

(a) Two (2) potential impacts to the environment;

(b) Two (2) treatment methods to reduce the concentrations in the final effluents; and

(c) One (1) potential way to recover these nutrients for beneficial reuse.

## Problem 2

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

Identify one (1) technology and explain how each may be used to control the contaminant types identified below. 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 be used. A table or matrix is recommended 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 measurement, biochemical oxygen demand* and *floatation.*

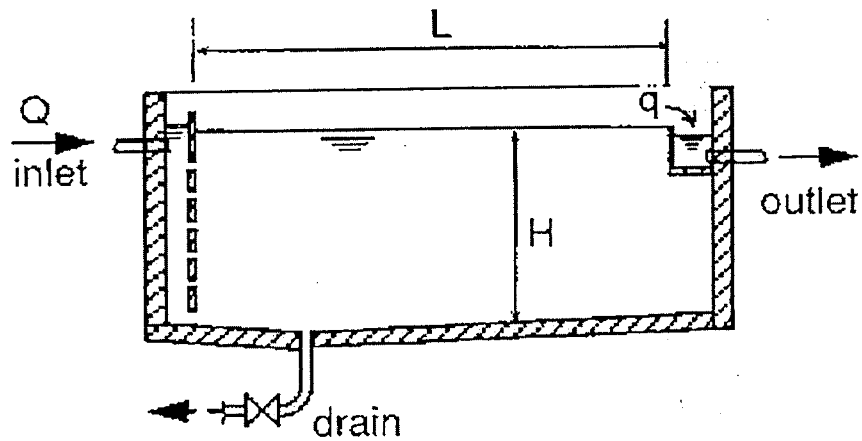
(8) (i) A drinking water treatment plant uses groundwater from a polluted aquifer as its only source of raw water for drinking water. Give one (1) inorganic and one (1) microbiological contaminant that typically needs to be treated from groundwater supplies. Provide two (2) raw water measurement methods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

(ii) A BOD test is conducted at standard temperature conditions using 400 $mL$ of secondary effluent mixed with 100 $mL$ of water. The initial DO in the mix is 6 $mg/L$. After 5 days, the DO is 1 $mg/L$ and after 20 days the DO has stabilized at 0.1 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) With reference to the section view of a sedimentation tank below, briefly describe three (3) important design steps in the engineering design of a sedimentation process in a water or wastewater treatment system [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 and one (1) important and specific operation and maintenance parameter that need to be addressed for the successful and consistent 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 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 ($\phi$) 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 coal fired power plant producing 5000 GW of power releases sulfur dioxide ($SO_2$) during its operation. The $SO_2$ is released from a 150 m stack at a rate of 30 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 less than 5 $\mu g/m^3$;

(10) (ii) Provide three (3) possible engineering measures that may be used to reduce the ground-level $SO_2$ concentration and compare them 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 | 120 | 1.1 | -0.004 | 170 | 1.8 | 0.5 |
| B | 110 | 1.1 | -0.005 | 110 | 1.1 | 0.04 |
| C | 100 | 1.1 | -0.005 | 60 | 0.9 | 0.04 |
| D | 50 | 1.1 | -0.003 | 60 | 0.8 | -0.06 |
| E | 40 | 1.1 | -0.006 | 30 | 0.6 | -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 causes of urban air pollution resulting in respiratory problems in our cities.

(6) (i) Briefly define what smog is, 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 99.99%. Identify any assumptions made; and

(7) (iii) Identify one (1) effective odor control technology to control odorous emissions caused by methane or mercaptans (SH group bonded to C; very odorous organic compounds) 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 the key steps in contaminant soil remediation using an example of a site that has been contaminated from light crude oils and now has to be remediated to a useful condition for 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 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