# NATIONAL EXAMS DECEMBER 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.*

(5) (i) Calculate the concentration in $\mu g/m^3$ for ozone in the air at 0.15 ppm at STP and state any assumptions in your calculation. Briefly explain how air monitoring or sampling would be done to ensure the pollution source(s) are adequately abated to meet established air quality standards.

(5) (ii) The 24-hour national air quality standard for sulfur dioxide is 350 $\mu g/m^3$; however the source performance standard is 90 g/$10^6$ kJ. Briefly explain how each standard is used and how they are related to each other.

(10) (iii) Eutrophication in rivers and lakes has been attributed to high phosphorous (P) in effluents from sewage treatment plants. Briefly explain an effective treatment method that would reduce the P-loading to the receiver. In your explanation of the treatment method, provide a labelled schematic showing the key treatment processes and explain one (1) important design or operating parameter for each treatment unit.

## Problem 2

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

For the following three (3) technology and contaminant types, describe how each technology may be used to control the contaminant type identified. In your explanation, briefly describe the main technology principle, provide two (2) advantages, two (2) limitations and one (1) specific application where each technology may used. A table or matrix is recommended to organize your answer.

(7) (i) Fabric filters for particulates

(7) (ii) Thermal oxidizers for vapours

(6) (iii) Adsorption towers for gases

# Problem 3

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

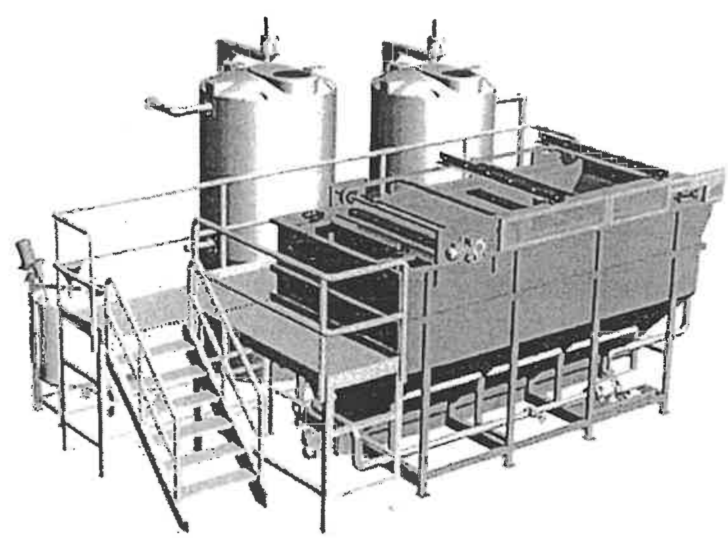
(8) (i) A drinking water treatment plant uses surface water from a river where the water intake is downstream of a heavily farmed community. Give one (1) inorganic and one (1) microbiological contaminant that typically needs to be treated for from surface water supplies. Provide two (2) treated water measurement methods (one for each contaminant type) that may be used to ensure the water is free from the inorganic and microbiological contaminant identified. Briefly discuss how you would ensure that the measurement methods used will provide a guarantee that contaminants are sufficiently reduced.

(ii) A BOD test is conducted at standard temperature conditions using 300 $mL$ of tertiary effluent mixed with 150 $mL$ 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 $mg/L$; and

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

(6) (iii) Give three (3) important design parameters for a dissolved air floatation (DAF) system. Briefly explain how the three (3) parameters influence the performance of the DAF system and give typical design values (with dimensions for each parameter) used in wastewater treatment applications. A typical DAF unit is shown below.



## Problem 4

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

(i) Explain two (2) key design principles in the applicationof 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 ($\phi$) 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 $TSS = 250\ mg/L$;
- effluent $BOD_5$ and $TSS = 10\ mg/L$;
- yield coefficient, $Y = 0.5$;
- decay rate, $k_d = 0.05 \cdot d^{-1}$ ;
- average MLSS in the aeration tank, $X = 3,000\ mg/L$;
- waste MLSS from the clarifier, $X_w = 9,000\ mg/L$; 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 300 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 20 $g/min$. The average wind speed is 12 $m/s$, with strong 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 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 the overall carbon footprint.

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 | 1.1 | -0.005 | 180 | 2.2 | 0.5 |
| B | 100 | 1.1 | -0.005 | 120 | 1.0 | 0.04 |
| C | 110 | 1.0 | -0.005 | 60 | 1.2 | 0.02 |
| D | 40 | 1.0 | -0.004 | 50 | 0.9 | -0.04 |
| E | 40 | 1.0 | -0.004 | 20 | 0.7 | -0.07 |

## 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 in our cities resulting in respiratory problems among the general population and thousands of asthma attacks among the more susceptible.

(6) (i) Briefly explain how sunlight drives the formation of smog. Consider the physical atmospheric conditions and chemical reactions;

(7) (ii) Briefly describe the design of an engineering process to reduce the release of chlorinated hydrocarbons or similar noxious pollutants by 99.5%. Identify all the assumptions you need to make to arrive at your answer; and

(7) (iii) Identify an effective physical-chemical based engineered odour control technology and briefly explain its design principle and 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.

(5) (i) Provide an example and explain one (1) appropriate technology that may be used in soil remediation when soil contamination from heavy hydrocarbons has impacted a shallow groundwater aquifer used as a drinking water source;

(5) (ii) Give an example of the application of a bioremediation technology. As part of your example provide a labelled schematic showing the conceptual process; and

(10) (iii) Define and discuss the importance of sensitivity (S), reliability (R) and accuracy (A) in measurement techniques as applied to air or water quality parameters (select only one application).

# Marking Scheme

1. (i) 5, (ii) 5 (iii) 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) 5 (ii) 5 (iii) 10 marks, 20 marks total