

NATIONAL EXAMS December 2010

04-Env-B9, Environmental Chemistry/Microbiology

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 assumption made.
2. This is a **CLOSED BOOK EXAM**.
A Sharp or Casio model approved calculator is permitted.
3. The exam has **two (2)** sections: **CHEMISTRY** and **MICROBIOLOGY**. The chemistry portion of the exam has **seven (7)** questions and the microbiology section has **eight (8)** questions. The **fifteen (15)** questions constitute a complete exam paper.
4. Each question is of the value indicated. There are **50** marks for the **chemistry** portion and **50** marks for the **microbiology** portion of this exam. The total examination mark is **100**.
5. Clarity and organization of the answers are important.

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SECTION 1: CHEMISTRY (7 questions, 50 marks)

10 1. DEFINE:

- 1.1 Langelier Index
- 1.2 Solubility Product
- 1.3 Boyle's Law
- 1.4 pH
- 1.5 Thermal stratification
- 1.6 Fick's Law
- 1.7 Mole
- 1.8 First order reaction
- 1.9 Normality
- 1.10 Equivalent Weight

5 2. A 1.67×10^{-3} M glucose solution ($C_6H_{12}O_6$) is completely oxidized to CO_2 and H_2O . Calculate the amount of oxygen required to complete the reaction. C = 12; H = 1; O = 16.

5 3. A groundwater sample contains 100 mg/L of Ca^{2+} and 10 mg/l of Mg^{2+} . Express its hardness in units of meq/L and mg/L as $CaCO_3$. Ca = 40; Mg = 24; C = 12; O = 16

4. A hazardous waste treatment facility annually receives inorganic wastes consisting of:

- solids for direct burial (90,000 t), density 1.5 t/m^3
- sludges to be dewatered (10,000 t), density 1.0 t/m^3 and
- liquids for pH adjustment (10,000 t), density 1.0 t/m^3

Incoming organics include:

- oily wastes (10,000 t), density 1.0 t/m^3
- solvents and other rich organics (42,000 t) from which about 5% recovery is achieved, density 1.0 t/m^3 and
- organic sludges (10,000 t), density 1.0 t/m^3 .

Past records have indicated that an average of 35 kg of hazardous waste per capita per year (wet basis) are generated.

3 4.1 estimate the population served by this facility

7 4.2 determine the volume to be landfilled and the length of time until the landfill which has a capacity of 1.4 million m^3 is filled.

State any assumptions made.

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5. Green Lake, with a surface area of $80 \times 10^6 \text{ m}^2$ is fed by a tributary having an average flow of $15.0 \text{ m}^3/\text{s}$ with an average total phosphorus concentration of 0.010 mg/L . A treated effluent from a wastewater treatment plant adds $0.20 \text{ m}^3/\text{s}$ of flow with a total phosphorus concentration of 5.0 mg/L . Tests have shown that the average phosphorus settling rate in Green Lake is 10 m/year .

The steady-state concentration of total phosphorus is expressed as:

$$P = S / (Q + v_s A)$$

P = the concentration of phosphorus

S = the rate of addition of phosphorus from all sources

Q = stream flow rate

v_s = the phosphorus settling rate

A = surface area of the lake

- 5 5.1 Estimate the average total phosphorus concentration.
- 5 5.2 What rate of phosphorus removal at the wastewater treatment plant would be required to keep the concentration of phosphorus in the lake at an acceptable level of 0.010 mg/L ?
- 4 6. Name 4 alternative disinfection technologies.
- 6 7. Name the factors influencing the action of disinfectants.

50

SECTION 2: MICROBIOLOGY (8 questions, 50 marks)

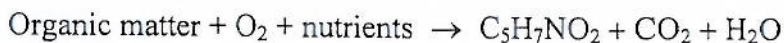
- 10 **1. DEFINE:**
- 1.1 *Brownian Movement*
 - 1.2 *chromophores*
 - 1.3 *glycogen*
 - 1.4 *fungi*
 - 1.5 *Vegetative mycelium*
 - 1.6 *hypha*
 - 1.7 *apoenzyme*
 - 1.8 *metallic activator*
 - 1.9 *ATP*
 - 1.10 *MPN*

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- 4 2. TRUE or FALSE
- 2.1 Fungi are anaerobic organisms.
 - 2.2 Algae are heterotrophic organisms.
 - 2.3 Aerobic bacteria can metabolize organic matter at a faster rate than anaerobic bacteria
 - 2.4 Prokaryotic cells contain a nucleus enclosed within a well defined nuclear membrane.
- 5 3. Name 5 common diseases which have been found to be spread through the air.
- 5 4. Sketch and label a complete process flow diagram for a typical municipal wastewater treatment plant providing primary and secondary treatment using the activated sludge process.
- 3 5. Sketch and label the rate of growth for mesophilic bacteria with increasing temperature.
- 5 6. Bacterial cells are often represented by the empirical formula $C_5H_7NO_2$. Determine the potential carbonaceous BOD_u of 1 g of cells.
- 3 7. Name 3 diseases which are transmitted by water.
8. An aerobic, complete-mix biological treatment process without recycle receives wastewater with a biodegradable soluble COD of 500 g/m^3 . The flowrate is $10,000 \text{ m}^3/\text{d}$ and the reactor effluent soluble COD and VSS concentrations are 50 and 200 g/m^3 , respectively.
- 5 8.1 Calculate the observed yield in $\text{g VSS/g COD removed}$?
10 8.2 Calculate the amount of oxygen used in $\text{kgO}_2/\text{kg COD removed}$ and in kg/d ?

Assume the following general reaction is applicable:



100 TOTAL EXAMINATION MARK