NATIONAL EXAMINATIONS December 2011

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 Casio or Sharp approved calculator is permitted.

3. The exam has two sections: ***CHEMISTRY*** and ***MICROBIOLOGY***. The chemistry portion of the exam has ***ten*** (10) questions and the microbiology section has ***eleven*** (11) questions. The ***Twenty-one*** (21) 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 (10 questions, 50 marks)

5 1. You have measured the process effluent from an industry and found that during the production day the pH values were: 5, 7 and 9. What does that mean to you and what is the average pH?

2 2. What is a buffer?

3 3. State Boyle's law.

5 4. You have determined that the composition of digester gas from the anaerobic digestion of wastewater sludge is: 68% CH_4, 30% CO_2 and 2% H_2S. If 1000 kg of the gas mixture is stored in a gas a tank at a pressure of 300 kPa, calculate the partial pressure of each component present. C =12, H =1, O =16 S = 32

5 5. An industry discharges its liquid waste into a river which has a minimum flow-rate of 10 m/s. The major pollutant in the waste is a non-reactive organic material called X at a concentration of 3,000 mg/L. The waste stream has a flow rate of 0.1 m/s. Under minimum flow-rate conditions the upstream concentration of the non-reactive material X is 20 mg/L. The Provincial regulatory agency has set a maximum limit of 100 mg X/L in the river. Assume that complete mixing occurs in the river. Will the industry be able to discharge the waste without treatment?

5 6. A reaction has the stoichiometric equation $A \Rightarrow C + D$. What is the order of reaction?

6.1 If it is known that the reaction is elementary and irreversible, what is the order of reaction with respect to A?

5 7. Calculate the number of kg chlorine needed per day and the capacity of the contact tank in a water treatment plant supplying a city of 100,000 people. The chlorine demand is 1 mg/L. Existing regulations require a minimum contact time of 30 minutes . Make any other assumptions you feel are necessary.

5 8. Determine the COD of $C_5H_7NO_2$, state any assumptions.
C = 12, H = 1, N = 14, O = 16

10 9. Name and briefly state the role of 5 chemical unit processes used in water/wastewater treatment engineering.

5 10. Why and how is UV technology used in water and wastewater treatment?

50 sub-total

SECTION 2: MICROBIOLOGY (11 questions, 50 marks)

5 1. Define RNA and DNA and state their function.

5 2. Using a sketch show the steps of binary fission of bacterial cells.

3 3. Name 3 pathogenic microorganisms.

3 4. Identify 3water borne diseases.

6 5. What is sludge bulking? What causes it? How could you combat it?

3 6. Name 3 airborne respiratory diseases.

5 7. A conventional activated sludge plant treats 100,000 m^3/d of municipal wastewater with SS and BOD of 225 mg/L and 200 mg/L, respectively. If the MLSS concentration in the 24,000 m^3.capacity aeration tanks is 1,800 mg/L, is the plant overloaded? If so, how might the situation be rectified?

3 8. What is endogenous metabolism?

5 9. Define and state the role of the F/M ratio in the design of suspended growth systems.

2 10. What role does microbiology play in refuse management?

10 11. You have been commissioned to investigate how much useable energy could be generated from a chicken farm of 200,000 birds. During your literature search you come up with the following information:

A hen produces an average of 0.00019 m^3/d of manure with an average COD (C_i) of 150,000 g/m^3. An average sludge growth rate (r_g) is 600 g/m^3 at an HRT of 12 days. The fraction of COD removed is 79 %. 0.37 m^3 of methane are produced per kg of COD destroyed.

Conversion factors:

85,750 kJ / kW; at 20 deg C and 1 atm pressure, methane has a heat value (H) of 36,500 kJ/m^3

$$M_{CH4} = CH_{4\ produced}/kg\ COD_{\ destroyed}\ (COD_{\ fraction\ rem.} \times Q \times C_i - 1.42\ r_g\ V) / 1000$$

50 sub-total

100 TOTAL