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.
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% CH₄, 30% CO₂ and 2% H₂S. If 1000 kg of the gas mixture is stored in a gas 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 \( C_5H_2NO_2 \), 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 3 waterborne 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 m³/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 m³ 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 m³/d of manure with an average COD (Cᵣ) of 150,000 g/m³. An average sludge growth rate (rₑ) is 600 g/m³ at an HRT of 12 days. The fraction of COD removed is 79%. 0.37 m³ 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/m³

\[ M_{CH₄} = \frac{CH₄ \text{ produced/Kg COD destroyed} \times (COD \text{ fraction rem.} \times Q \times Cᵣ - 1.42 \times rₑ \times V)}{1000} \]

50 sub-total

100 TOTAL