NATIONAL EXAMS May 2011

04-Env-B9, Environmental Chemistry and 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. One aid sheet 8.54" x 11" (both sides) and a Casio or Sharp approved calculator is permitted.

3. The exam (4 pages) has two sections: ***CHEMISTRY*** and ***MICROBIOLOGY***. The chemistry portion of the exam has ***FIVE*** (5) questions and the microbiology section has ***NINE*** (9) questions. The Fourteen (14) 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 (5 questions, 50 marks)

10 **1. DEFINE:**

1.1 Normality
1.2 Mole fraction
1.3 Solubility product
1.4 Environmental contaminant
1.5 Stoichiometry
1.6 Molality
1.7 Temporary hardness
1.8 Molarity
1.9 equivalent weight
1.10 first order reaction

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

10 **3.** As the pollution control process engineer for the city of Humbug you are required that your existing wastewater treatment facility remove phosphorus to meet the Provincial Phosphorus effluent criterion of 0.5 mg TP /L. Your wastewater treatment facility has been rated at an average flow rate of 10,000 m^3/d. Data analyses of plant influent data over the last three years show that the average influent Total Phosphorus concentration is 8.0 mg/L. You have also determined in your laboratory that 1.5 mole of Al will be required per mole of P.

3.1 Determine the amount of liquid alum required to precipitate the phosphorus.
3.2 Determine the required storage capacity if a 30 day supply is to be stored at the treatment facility.

The following data are for the liquid alum supply:

1. formula for liquid alum $Al_2(SO_4)_3 \cdot 18H_2O$, alum strength = 48 %
2. density of liquid alum solution = 1,280 kg/m^3

10 **4.** A treated effluent is to be used for golf course irrigation. The effluent has a concentration of 5 mg/L (as Cl_2). You are looking at strategies to lower this to 0.5 mg/L (as Cl_2). Among many options you still have to examine using activated carbon and sulfur dioxide. The flow rate is 1,900 m^3/d.

4.1 Determine the amount of activated carbon required for de-chlorination.
4.2 Determine the concentration of sulfur dioxide required for de-chlorination.

$$C + 2Cl_2 + 2\,H_2O \text{ ---- } 4HCl + CO_2$$
$$SO_2 + HOCl + H_2O \text{ ---- } Cl^- + SO_4^{2-} + 3H^+$$
$$Cl_2 + H_2O \leftrightarrow HOCl + 3H^+ + Cl^-$$

mw Cl = 35.5; mw C = 12; mw S = 32

SECTION 1: CHEMISTRY (5 questions, 50 marks)

10 **5.** You have accepted a promotion to the position of chief process engineer at the city of Inconsequence. The waste treatment facility consists of primary treatment only. You know from your experience that adding chemicals will enhance TSS removal. Assume that 60 percent of the TSS is removed in the primary settling tanks without the addition of chemicals, and that the addition of ferric chloride results in an increased removal of TSS to 85 percent.

5.1 Estimate the **mass** and **volume** of sludge produced from the untreated wastewater **without** and **with** the use of ferric chloride for the enhanced removal of TSS.

5.2 You know that you will also have to add lime to supplement the natural alkalinity in the wastewater. Estimate the amount of lime required for the specified ferric chloride dose.

Also assume that the following data and reactions apply:

1. wastewater flow rate, m^3/d 20,000
2. wastewater TSS, mg/L 220
3. wastewater alkalinity as $CaCO_3$, mg/L 136
4. ferric chloride ($FeCl_3$) added, kg/1,000 m^3 40
5. raw sludge properties:
   specific gravity 1.03; moisture content 94%
6. chemical sludge properties:
   specific gravity 1.05; moisture content 92.5%

Prepare a summary table of sludge ***masses*** and ***volumes*** **without** and **with** chemical precipitation.

$$2FeCl_3 + 3Ca(HCO_3)_2 \leftrightarrow 2Fe(OH)_3 + 3CaCl_2 + 6CO_2$$
(soluble) (soluble) (insoluble) (soluble) (soluble)

$$2FeCl_3 + 3Ca(HCO)_2 \leftrightarrow 2Fe(OH)_3 + 3CaCl_2$$
(soluble) (slightly soluble) (insoluble) (soluble)

mw = 162 $FeCl_3$; mw = 100 (as $CaHCO_3$); mw = 107 $Fe(OH)_3$

50 *sub-total*

SECTION 2: MICROBIOLOGY (9) questions, 50 marks)

10 **1. DEFINE:**

1.1 sanitary microbiology
1.2 binary fission
1.3 enzyme
1.4 pathgogenicity
1.5 SRT
1.6 facultative bacteria
1.7 indicator organism
1.8 exotoxin
1.9 chemoautotrophs
1.10 polyribosomes

4 **2.** Sketch and identify the phases of the growth pattern based on mass of microorganisms for viable microorganisms.

5 **3.** Describe how a BOD test is carried out.

5 **4.** Name 5 reasons why environmental engineers should have a basic knowledge of microbiology.

4 **5.** Explain and illustrate the role of microorganisms in the nitrification process.

6 **6.** Your are the citys' engineer responsible for water. You are notified that a water sample taken from the distribution system indicated the presence of e.coli. Outline in point form a course of action that you would take to address this situation?

3 **7.** Identify 3 causes of sludge bulking?

3 **8.** Use a sketch to illustrate the effect of nitrification on the BOD test?

10 **9.** An anaerobic reactor, operated at 35°C, processes an industrial wastewater process effluent with a flow of 3,000m^3/d and a bsCOD concentration of 5,000 g/m^3. At 95% bsCOD removal and a net biomass synthesis yield of 0.04 VSS/ g COD used, what is the amount of methane produced in m^3/d?

PV = nRT

R = 0.082057 atm.L/mole.K

Assume that the CH_4 equivalent of COD converted under anaerobic conditions is 0.40 L CH_4/g COD.

50 *sub-total*

100 *TOTAL MARK*