

NATIONAL EXAMS December 2009

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 model is permitted plus one aid sheet written on both sides.
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 **TEN (10)** questions. The **Seventeen (17)** 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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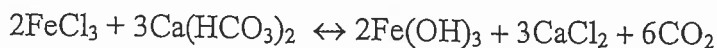
SECTION 1: CHEMISTRY (7 questions, 50 marks)

10 1. DEFINE:

- 1.1 saturated solution
- 1.2 normality
- 1.3 equivalent weight
- 1.4 Henry's Law
- 1.5 molecular weight
- 1.6 NTU
- 1.7 solute
- 1.8 alkalinity
- 1.9 buffer
- 1.10 electrolyte

- 10 2. Estimate the mass and volume of sludge produced from untreated wastewater without and with the use of ferric chloride for the enhanced removal of TSS. Also estimate the amount of lime required to completely neutralize the addition of the specified ferric chloride dose. Assume that 60 percent of the TSS is removed in the primary settling tank without the addition of chemicals, and that the addition of ferric chloride results in an increased removal of TSS to 85 percent. Also assume that the following data apply:

1. wastewater flow rate, m ³ /d	1,000
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



question 2 continued on page 3 of 4

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question 2. continued

suggested answer format

TREATMENT	SLUDGE	
	Mass, kg/d	Volume, m ³ /d
without chemical precipitation		
with chemical precipitation		

- 8 3. Name and briefly identify and state the role of 5 Chemical Unit Processes used in water/wastewater treatment engineering.
- 10 4. The existing 12,000 m³/d wastewater treatment facility now is required to discharge an effluent with a TP concentration of 1.0 mg/L. The 50 percentile influent TP is 8.0 mg/L. You determined that chemical precipitation using alum is the most cost effective phosphorous removal solution.
The theoretical phosphate precipitation with alum is:



Based on your laboratory testing 1.5 mole of Al will be required per mole of P. The molecular weight of Al and P are 27 and 31. The following data are for the liquid alum supply:

- formula for liquid alum $Al_2(SO_4)_3 \cdot 18 H_2O$
- molecular weight of alum = 666.5
- Alum strength = 48 %
- density of liquid alum solution = 1.2 kg/L
atomic weight of Al = 27
atomic weight of P = 31

4.1 Determine the amount of liquid alum required per day.

4.2 Determine the required alum storage capacity if a 30-day supply is to be stored at the treatment plant site

- 3 5. Determine the suspended solids and the percent volatile matter in a solids sample based on the following data:
- sample size = 25 mL
tare mass of filter = 1.5325 g
tare mass of filter plus retained solids = 1.5415 g
tare mass of filter plus retained ash = 1.5378 g

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- 5 6. Name the factors influencing the action of disinfectants.
- 4 7. Determine the COD of $C_5H_7NO_2$

50

end of Section 1 - Chemistry

SECTION 2: MICROBIOLOGY (10 questions, 50 marks)

- 10 **1. DEFINE:**
- 1.1 what is the role of DNA
 - 1.2 what are autotrophs
 - 1.3 the role of enzymes
 - 1.4 F/M Ratio
 - 1.5 MPN
 - 1.6 what is a virus
 - 1.7 what do we mean by synthesis
 - 1.8 what is binary fission
 - 1.9 OUR
 - 1.10 metabolism
- 4 2. Sketch and identify: the growth phases based on mass of organisms.
- 2 3. Sketch and label: the rate of growth for mesophilic bacteria with increasing temperature.
- 2 4. Sketch and label: all components of a typical bacterial cell.
- 4 5. Explain the difference between sterilization and disinfection.
- 3 6. Name 3 diseases which are transmitted by water.
- 4 7. Describe and compare the nutritional requirements of autotrophic and heterotrophic bacteria.
- 3 8. How is the F/M ratio used in wastewater engineering?

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- 5 9. Bacterial cells are often represented by the empirical formula $C_5H_7NO_2$. Determine the potential carbonaceous BOD_u of 1 g of cells.
10. An aerobic, complete-mix biological treatment process without recycle receives wastewater with a biodegradable soluble COD of 700 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 10.1 What is the observed yield in $\text{g VSS/g COD removed}$?
- 8 10.2 What is the amount of oxygen used in $\text{kg O}_2/\text{kg COD removed}$ and in kg/d ?

Assume the following general reaction is applicable:



50

100 TOTAL EXAMINATION MARK