UNIVERSITY OF MINES AND TECHNOLOGY, TARKWA

SECOND SEMESTER EXAMINATIONS, MAY, 2018

COURSE NO: ES 472
COURSE NAME: **WATER AND WASTEWATER TREATMENT**
CLASS: ES III TIME: 3 HOURS

Name**:** _____Index Number: _____

SECTION A

ANSWER ALL QUESTIONS (20 marks)

1. Which of the following is a disadvantage of anaerobic sludge digestion?

   a) Energy intensive
   b) Does not produce energy
   c) Highly sensitive to pH fluctuations
   d) Destroys Pathogenic Organisms

2. What are the four major cations in water?

   a) Ca, Mg, Pb, K
   b) Mg, K, Na, Fe
   c) Mg, Ca, K, Na
   d) Mg, Mn, K, Ca

3. Which of these zones is completely illuminated by light?

   a) Euphotic zone
   b) Dysphotic zone
   c) Benthic zone
   d) Profundal zone

4. In water treatment procedures, the purpose of coagulation and flocculation is to_____.

   a) Disinfect the water supply
   b) Remove microorganisms, organic matter, and suspended fine particles
   c) Soften the water by removing calcium and magnesium
   d) Remove taste and odor problems

5. Which of the following is true of indicator organisms, or microbes that can serve as an index of possible water contamination by pathogens?

   a) It should be harmless to humans
   b) It should survive longer than the hardiest enteric pathogens

c) The assay procedure for the indicator should have great specificity

d) All of the above

6. Which of the following is a common index organism of water contamination?

a) Coliforms
c) Cyanobacteria
b) Rhizobia
d) Staphylococci

7. In the water purification process, chlorination may create disinfection by-products (DBPs) that may be _____.

a) Allergens
c) Carcinogens
b) Neurotoxins
d) All of the above

8. Which major step in wastewater treatment prepares the wastewater for treatment by physically removing the majority of solid material?

a) Primary treatment
c) Tertiary treatment
b) Secondary treatment
d) All of the above

9. Which major step in wastewater treatment promotes the biological transformation of dissolved organic matter into microbial biomass and carbon dioxide?

a) Primary treatment
c) Tertiary treatment
b) Secondary treatment
d) All of the above

10. Where is methane produced during the wastewater treatment process?

a) Anaerobic digestion
c) Trickling filters
b) Activated sludge system
d) All of the above

11. What is the concentration of NH3 (in mg/L) of household bleach that contains 3.00 percent by weight of NH3? Assume the density of water = 1,000 kg/m3.

a) 25,000 mg/L
c) 40,000 mg/L
b) 30,000 mg/L
d) 31,000 mg/L

12. If 15 mg/ L of HOCl is added to portable water for disinfection and the final measured pH is 7.0, what percent of the HOCl is not dissociated? Assume the temperature is $25^{O}C$.

a) 77.4%
c) 77.6%
b) 77.5%
d) 77.7%

13. How many mg/L of PO_4^{3-} would be in solution at equilibrium with AlPO4 (s)? Given $pK_s = 20$.

a) 6.5 x 10-6
c) 9.5 x 10-6
b) 8.5 x 10-6
d) 4.5 x 10-6

14. Find the weight sodium bicarbonate, NaHCO3, necessary to make a 1 M solution.

a) 84,000 mg/L
b) 90,000 mg/L
c) 85,000 mg/L
d) 94,000 mg/L

15. Which of the following is true of anaerobic digestion in the wastewater treatment process?

a) Microbes consume large amounts of organic matter because methanogenesis is energetically very inefficient
b) Methane can be produced as a by-product of the process
c) Dried sludge can be sold as garden fertilizer
d) All of the above

16. Point source discharges are _____.

a) Discharges that show up in the system and at the plant from an unidentified or explained source.
b) Discharges that come from pipes or ditches that are monitored controlled and inspected.
c) Discharges that have Intermittent, dispersed flows having little or no control.
d) Discharges that contribute greatly to the BOD and COD and typically come from dairies and farm related activities.
e) None of the above

17. Non-Point Source Discharges are _____.

a) Discharges that have intermittent, dispersed flows having little or no control.
b) Discharges that come from pipes or ditches that are monitored controlled and inspected.
c) Discharges that come from municipalities, or industry.
d) Discharges that are high in BOD & typically come from food establishments.
e) None of the above

18. Besides disinfection, chlorine has other uses at the wastewater treatment plant such as _____

a) Reduces BOD, Odor, Algae growth, Helps with grease
b) Reduces COD, Aids in Algae growth, & the need for other chemicals
c) Good antiseptic scrub for floors in the office & lab
d) Operators can take it home for household use

19. Which of the following treatment devices is commonly used to separate and remove large solids form raw wastewater?

a) A Grit Chamber
b) A Comminutor
c) A Mechanically raked bar screen
d) A Primary Clarifier

20. A comminutor would be _____.

a) A mechanical device that screens & cuts large solids in small particles
b) A electrical device that channels inflow from on trough to another
c) A hydraulic driven device that is used to recycle sludge
d) A mechanical device that is used when bypassing secondary treatment

SECTION B

ANSWER QUESTION ONE AND ANY OTHER TWO QUESTIONS

Question 1

a) Distinguish between sewer, sewage and sewerage. **(3 marks)**

b) The groundwater from the fictitious Apex Aquifer contains 2.3×10^{-5} M CO_2. It is being pumped at a rate of 200 L·s−1 to serve the residents of the town of Tarkwa. The pH of the water is 7.6 and the water analysis is presented in the Table below.

Ion	mg/L as Ion	Molecular weight (g/mol)	Weight Equivalents (Eq · mol−1)	Concentration (Eq · L−1)	Concentration (mg·L−1 as CaCO3)
Ca^{2+}	150.3	40.08	2	7.5	375
Fe^{3+}	1.19	55.85	3	0.064	3.2
Mg^{2+}	14.6	24.31	2	1.20	60
Na^{+}	100	22.99	1	4.35	217.5
Cl^{-}	201.4	35.45	1	5.68	284.0
HCO_3^{-}	450.3	61.02	1	7.38	369.0

i. Determine the mass (in kilograms) of hydrated lime that must be added each day to neutralize the carbon dioxide present in the water. **(2 marks)**

ii. Determine the mass (in kilograms) of hydrated lime that must be added each day to precipitate the carbonate hardness due to calcium and magnesium. **(2 marks)**

iii. Determine the mass (in kilograms) of hydrated lime and of soda ash that must be added each day to precipitate the noncarbonate hardness due to calcium and magnesium. **(2 marks)**

iv. Determine the total mass of hydrated lime and of soda ash that must be added each day. **(2 marks)**

c) Define the following terms:

i. Oxygen Demand (OD) **(1 mark)**

ii. Biological Oxygen Demand (BOD) **(1 mark)**

iii. Chemical Oxygen Demand (COD) **(1 mark)**

iv. Theoretical Oxygen Demand (ThOD) **(1 mark)**

d) If the 5 day BOD at 37°C is 200 mg/L and if the rate of deoxygenation is 0.17/day, what is the ultimate BOD and BOD remaining after 5 days? **(7 marks)**

e) The table below shows the constituents of the water which is to be treated for domestic supply at the Bonsa treatment plant. Provide the appropriate unit process that could be employed to remove each constituent. **(5 marks)**

Constituent	**Unit Process**
Turbidity and particles	
Major dissolved inorganics	
Minor dissolved inorganics	
Pathogens	
Major dissolved organics	

f) List three processes that are responsible for transporting pollutants from land to ground waters. **(3 marks)**

Question 2

a) A home water softener has 0.1 m^3 of ion-exchange resin with an exchange capacity of 57 Kg/m^3. The occupant uses 2,000 L of water per day. If the water contains 280.0 mg/L of hardness as $CaCO_3$ and it is desired to soften it to 85 mg/L as $CaCO_3$, how much should be bypassed? What is the time between regeneration cycles? **(5 marks)**

b) Distinguish between the following:

i. pollutants and contaminants **(2 marks)**
ii. infiltration and percolation **(2 marks)**
iii. evaporation and transpiration **(2 marks)**
iv. influent and effluent **(2 marks)**

c) What is turbidity? How does it affect fishes in aquatic systems? **(3 marks)**

d) i) Define the term dewatering as applied to sludge treatment. List two means by which dewatering may be achieved. **(3 marks)**

ii) Differentiate between unit operations and unit processes in wastewater treatment **(2 marks)**

e) List four qualities of a good filter. **(4 marks)**

Question 3

a) i) Differentiate between coagulation and flocculation. **(2 marks)**

ii) Explain the physics of coagulation using the four mechanisms of coagulation. **(8 marks)**

b) What are indicator organisms? List three qualities of indicator organisms. **(4 marks)**

c) Water samples are usually acidified for metal analysis. Among HNO_3, H_2SO_4 and HCl, which of them would you recommend for the acidification of the samples as an environmentalist? Justify your answer. **(3 marks)**

d) Discuss the importance of cohesion and adhesion properties of water **(2 marks)**

e) A sample of water contains 100.0 mg/L CO_3^{2-} and 75.0 mg/L HCO_3^- at a pH of 10. Calculate the alkalinity exactly at 25°C. Approximate the alkalinity by ignoring [OH-] and [H+] and estimate the Error in percentage. **(6 marks)**

Question 4

a) Distinguish between colloidal, suspended and dissolved particles based on their size. State two ways by which each can be removed. **(4 marks)**

b) i) Define adsorption and list three factors that affect adsorption. **(4 marks)**

ii) Distinguish between adsorbent and adsorbate. **(1 mark)**

c) Write an account of the effects of organic waste on streams. **(4 marks)**

d) With the aid of a diagram, briefly explain the various stages of wastewater treatment. **(8 marks)**

e) i) Define the water cycle and give its importance in nature. **(2 marks)**

ii) Based on the thermal properties of water, discuss why shoreline areas have more constant temperatures than inland areas. **(2 marks)**

Question 5

a) i) With the aid of a diagram, describe the nitrogen cycle. **(5 marks)**

ii) What is eutrophication? How does it affect aquatic system? **(3 marks)**

b) List and define the two main categories of biological wastewater treatment process. **(4 marks)**

c) Define contact angle and state what would happen to the wettability of a surface with the following contact angles?

i. $Ø = 0^o$

ii. $Ø < 90^o$

iii. $Ø > 180^o$ **(3.5 marks)**

d) Draw and label the structure of a surfactant. Briefly explain how a surfactant would work to remove an oil stain from a fabric. **(4.5 marks)**

e) Explain the effect of various chemical additions to the carbonate buffer system. Your explanation should include the effect on the displacement of the reaction (left or right), effect on CO_2 (into or out of solution) and effect on pH (increase, decrease or no change).

(5 marks)

Examiner: Assoc Prof Samuel Ndur