UNIVERSITY OF ESWATINI
Faculty of Health Sciences
Department of Environmental Health Science

B.Sc. DEGREE IN: ENVIRONMENTAL MANAGEMENT & OCCUPATIONAL SAFETY AND HEALTH
- ENVIRONMENTAL MANAGEMENT AND WATER RESOURCES

MAIN EXAMINATION PAPER 2021

TITLE OF PAPER	:	WASTEWATER MANAGEMENT
COURSE CODE	:	EHS 434
DURATION	:	2 HOURS
MARKS	:	100
INSTRUCTIONS	:	READ THE QUESTIONS & INSTRUCTIONS CAREFULLY
	:	ANSWER **ANY FOUR** QUESTIONS
	:	EACH QUESTION **CARRIES 25** MARKS.
	:	WRITE NEATLY & CLEARLY
	:	NO PAPER SHOULD BE BROUGHT INTO THE EXAMINATION ROOM.
	:	BEGIN EACH QUESTION ON A SEPARATE SHEET OF PAPER.

DO NOT OPEN THIS QUESTION PAPER UNTIL PERMISSION IS GRANTED BY THE INVIGILATOR.

QUESTION ONE (Each question below carries 5 marks)

1A. State whether each of the following process is a) chemo heterotroph b) chemo autotroph c) photo heterotroph or d) phototroph

i. The carbonaceous oxidation activated sludge process (1 mark)
ii. The nitrification activated sludge process (1 mark)
iii. Denitrification (1 mark)
iv. Algal ponds (1 mark)
v. Iron bacteria (1 mark)

1B. State whether each of the following reactions are homogenous or heterogeneous reactions. Give reasons for your choice (1 mark each)

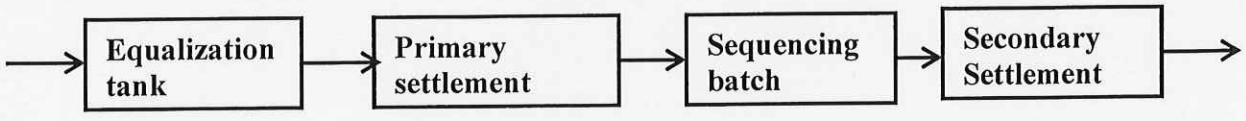
i. Fluidized bed reactor
ii. Packed bed reactor
iii. Ammonia stripping
iv. Chemical precipitation
v. Ion exchange

1C. Develop expression for the rate of substrate utilization for the following conditions:

i. When there is excess substrate available (2 & ½ marks)
ii. When the substrate available is limited ((2 & ½ marks)

1D. An industry produces wastewater from 6AM to 6 PM for 12 hours at a uniform rate of 10 m^3/hr. If the flow out of the equalization tank is to be uniform over a 24 hour period, determine the volume of the equalization tank. Show your answer both graphically (sketch) and numerically (calculation).

1E. A wastewater system designer came with a layout of wastewater treatment process design for a particular wastewater. Comment on this layout and suggest any correction/improvement.



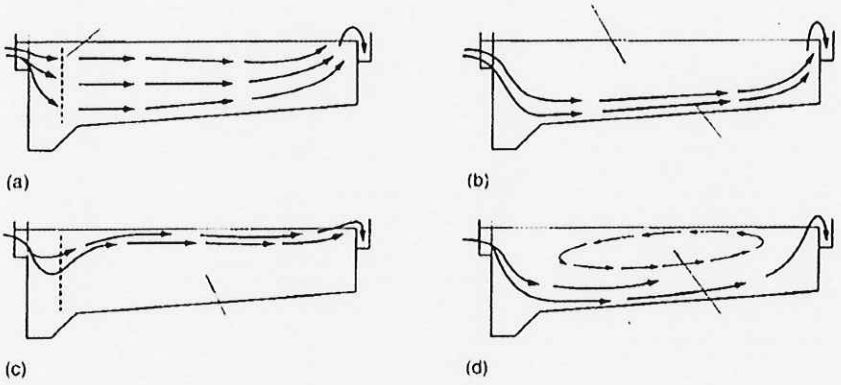
QUESTION TWO (Each question below carries 5 marks)

2A. List three techniques applicable to each of the following sludge processing activities.

i. Sludge thickening (2 marks)
ii. Sludge stabilization (2 marks)
iii. Sludge dewatering (1 mark)

2B. What is the importance of grit chambers in wastewater treatment?

2C. The figures a,b,c and d below show flow pattern and extent of short circuiting in primary settlement tanks. Identify the possible causes (or lack of) of short circuiting in each case .



2D. Describe the following types of settlement of solids in wastewater treatment processes and indicate where they may occur in wastewater treatment processes.

i. Discrete particle settling ...(2 marks)
ii. Flocculent settling ...(1 mark)
iii. Hindered (zone) settling... (1 mark)
iv. Compression settling .... (1 mark)

2E. Differentiate between the following oil suspensions in wastewater.

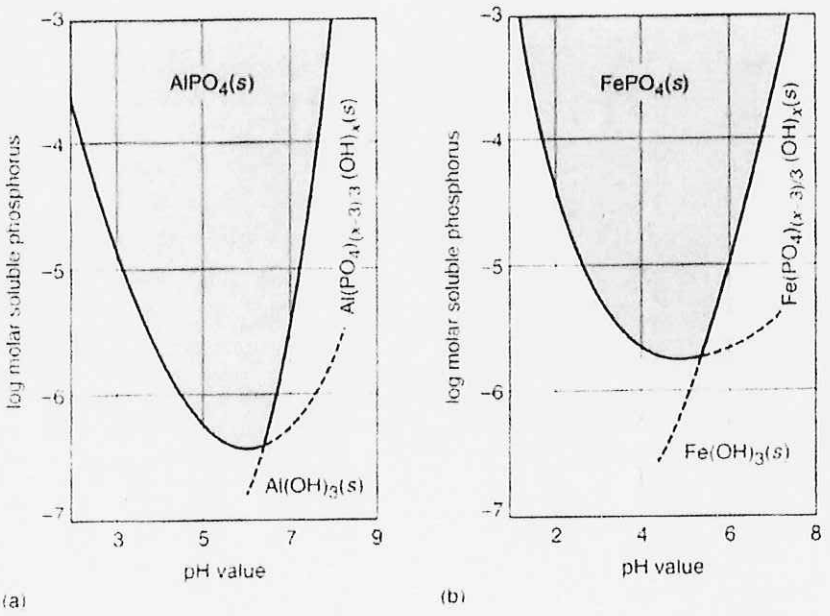
i) Free oil (2 marks)
ii) Physical emulsion (1 mark)
iii) Chemical emulsion (1 mark)
iv) Dissolved oil (1 mark)

QUESTION THREE (Each question below carries 5 marks)

3A. Define the following terms used in relation to chemical unit processes: (1 mark each)

i. Extinction coefficient
ii. Gas stripping
iii. Advanced oxidation
iv. Photolysis
v. Reverse osmosis

3B. According to the solubility diagram shown below if initially 100 mg/L of phosphorous was present in a given wastewater, determine the amount remaining in wastewater after sufficient addition of aluminum sulphate at a pH of seven. Also evaluate the percentage removal of phosphorus as a result.



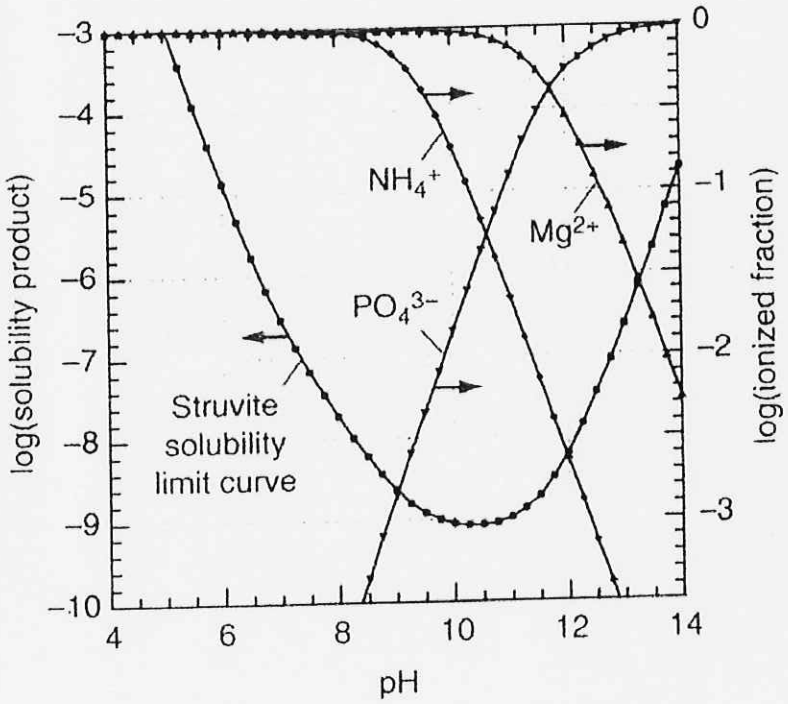
3C. Compare the potentials of the following oxidation processes for treating wastewater

i. Ozone/UV (2 marks)
ii. UV/Hydrogen peroxide (2 marks)
iii. Ozone/Hydrogen peroxide (1 mark)

3D. Given the following compounds involved in the complete oxidation of ammonia by chlorine. Arrange them in chemical equation (reactants and products) and balance the chemical reaction equation).

$HOCl$, H^+, HCl, NH_4^+, N_2, H_2O

3E. From the struvite solubility diagram shown in the figure below, state the inhibiting factor against precipitation of phosphorous i) at low pH and ii) at high pH



QUESTION FOUR (Each question below carries 5 marks)

4A. A wastewater effluent from a sugar processing industry has a theoretical COD of 3000 mg/L. using the chemical reactions provided below answer the following questions:

i. What is the mass of glucose present ($C_6 H_{12} O_6$) in the waste in mg/L

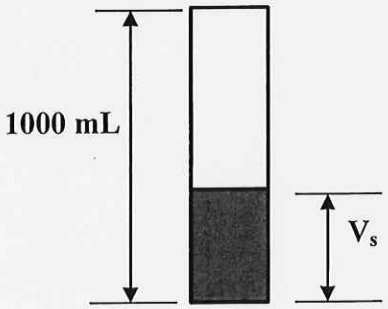
ii. What is the mass of sludge produced (MLVSS) in mg/L

$$3C_6H_{12}O_6 + 8O_2 + 2NH_3 \rightarrow 2C_5H_7NO_2 + 8CO_2 + 14H_2O$$

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$$

$$C_5H_7NO_2 + 5O_2 \rightarrow 5CO_2 + NH_3 + 2H_2O$$

4B. A sludge settleability test indicated that the sludge volume index was 100 ml/mg. The initial MLSS concentration of the sludge before settlement was 3000 mg/L. Estimate the return sludge concentration in mg/L. Assume that all the solids occupy the settled position and that no solid is left in the supernatant water after settlement.



4C. The expression for the solids retention time of an activated sludge process is given by the formula below.

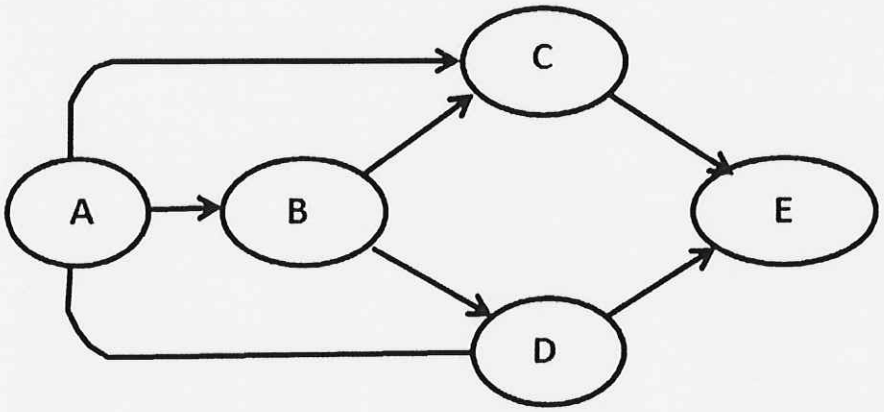
$$SRT = \frac{VX}{(Q_W X_R + Q_e X_e)}$$

Calculate the solids retention time of an activated sludge process. The waste water inflow rate to the activated sludge tank is 5 million liters per day. One percent of the inflow wastewater exits through the sludge wasting line and the remaining 99% of the inflow wastewater passes as treated effluent wastewater. The return sludge concentration is 10,000 mg/L and the MLSS concentration in the reactor is 5000 mg/L. The effluent solids concentration 50 mg/L. The hydraulic retention time in the activated sludge reactor is 2 hours.

4D. For the anaerobic process diagram shown in the figure below:

i. List the substances that are involved in each of the process stages labeled A, B, C, D and E

ii. Name the processes (step) taking place in the following steps: A-B, B-C, B-D, C-E, D-E.



4E. Draw a diagram of the UASB reactor with sludge recycle and indicate its advantage.

QUESTION FIVE (Each question below carries 5 marks)

5A. It is suspected that a ground water supply may have been contaminated by industrial wastewater containing arsenic.

i. Estimate the incremental risk of Arsenic toxicity for an adult associated with drinking 2L per day of ground water containing 0.2 mg/L arsenic. Arsenic has a potency factor of $1.5(mg/Kg.day)^{-1}$ for oral route exposure.

ii. To limit arsenic exposure to acceptable risk of 1 in 1,000,000, determine the concentration of arsenic that can be allowed in the extracted groundwater.

5B. Describe the sources of odours in wastewater treatment plants and the mechanism that can be placed to minimize odours.

5C. Describe with the help of a diagram the following processes of denitrification in activated sludge:

i. The pre-anoxic process (3 marks)
ii. Post-anoxic process (2 marks)

5D. Discuss the causes and remedies to the following problems that may occur in the operation of trickling filters:

i. High suspended solids in the filter effluent (1 mark)
ii. ponding (1 mark)
iii. odour (1 mark)
iv. flies (1 mark)
v. Hogh BOD (1 mark)

5E. Compare the performance of aerobic and anaerobic treatment processes in terms of:

i. Sludge production (2 marks)
ii. Nutrient requirements (2 marks)
iii. The biological kinetics (rate of conversion of organic matter into biomass). (1 mark)