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

BACHELOR OF SCIENCE IN ENVIRONMENTAL MANAGEMENT AND WATER RESOURCES

MAIN EXAMINATION PAPER 2016

TITLE OF PAPER	:	WATER TREATMENT
COURSE CODE	:	EHM 423
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(5 Marks each)

1A. If the average intensity of the UV radiation to which a sample was exposed is 10 mW/cm^2, determine the UV intensity measured at the water surface in a petri dish. The depth of water in the petri dish is 15 mm. Assume the absorptivity k (at λ = 254 nm) is equal to 1.15 cm^{-1}.

1B. Determine the alkalinity (both in milli equivalents per liter as well as mg/L as $CaCO_3$) of water sample that has the following characteristics:

Parameter	pH	$CO_3^{=}$	HCO_3^-	H_2CO_3
Concentration	8.9	65 mg/L	120 mg/l	5 mg/l

1C. Discuss the factors that influence film diffusion in ion exchange resins and the instances under which film diffusion can become a controlling factor.

1D. For ion exchange resins and with the help of a sketch, define the following capacities:

i)Breakthrough capacity ii) Operating capacity iii) Ultimate capacity

1E. Figures Q1-A and B show the exchange isotherms of ion B originally present in solution compared to that of ion A originally present on the resin. Compare the two figures in terms of the strength of adsorption of ion B onto the ion exchange resin vis-à-vis that of ion A.

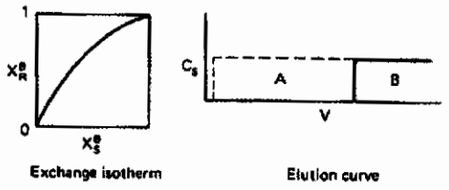

Figure Q1-A

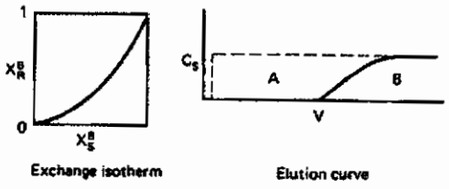

Figure Q1-B

QUESTION TWO

2A. State the three distinct steps (process) that must take place for adsorbate material to get adsorbed onto activated carbon. State which of these steps process are the rate determining steps for i) granular activated carbon and ii) batch process using powdered activated carbon. .....[6 marks]

2B. A given activated carbon produced was found to possess a pH of 8.5. Discuss the potential of this activated carbon for the removal of organic matter in which:

i. The pH of the water is low.....[3 marks]

ii. The pH of the water is high. .....[3 marks]

2C. A batch adsorption study of a given polluted water gave the data shown in the table below. If the raw water COD was 250 mg/L and the treated water COD should be restricted to 4.70 mg/L or less, determine:

i. The total water volume that can be treated before breakthrough if the total weight of activated carbon provided is 100 kg and the rate of flow is 200 lit/day. .....[7 marks]

ii. Determine the length of time that this 100 kg activated carbon serves before it is taken out of operation because of breakthrough.

.....[6 marks]

Flask No.	*Wt. of Carbon (mg) (m)*	*Volume in Flask (mℓ)*	*Final COD (mg/ℓ) (C)*	*Wt. of Adsorbate Adsorbed (mg)*	$\frac{x}{m}$ *(mg/mg)*
1	804	200	4.70	49.06	0.061
2	668	200	7.0	48.6	0.073
3	512	200	9.31	48.1	0.094
4	393	200	16.6	46.7	0.118
5	313	200	32.5	43.5	0.139
6	238	200	62.8	37.4	0.157
7	0	200	250	0	0

QUESTION THREE

3A. For each of the experimental cases described in Table Q3-1 below, Calculate the apparent odour synergism between two compounds A and B. .....[10 marks]

	Compound A	Compound B	Olfactile added total	Olfactle found in mixture
Olfactile added				
Case I	0.3	0.5	0.8	1.0
Case II	0.5	0.3	0.8	0.8
Case III	0.8	0.75	1.55	1.0

3B. Determine the Threshold odour number (TON) and the Odour Intensity Index (OII) for a sample water when the number of 25:175 dilutions made was 3 times after which a 70 mL of the diluted sample was transferred to the 200 mL flask to achieve the just detectable odour. .....[10 marks]

3C. Looking at the solubility diagrams of iron shown in Figure Q3-1 below, discuss the influence the presence of significant amount of alkalinity on the solubility of iron and the implication on water treatment for the removal of iron .....[5 Marks]

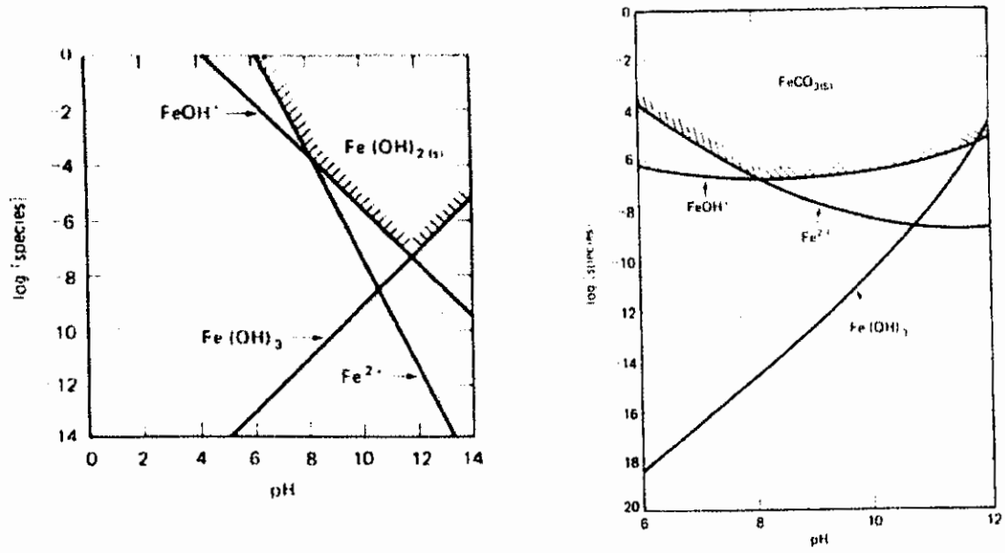

Figure Q3-1: Solubility of iron diagram for OH^- controlled and carbonate controlled precipitation of iron

QUESTION FOUR(**25 Marks)**

The table below shows the results of water quality analysis of a sample of raw water intended for potable water treatment. Determine:

i. The bicarbonate and permanent hardness in mg/L of $CaCO_3$ ..... [13 Marks]

ii. The lime and soda ash required to soften this water. .....[12 Marks]

Parameter	TDS	Ca	Mg	Na	K	HCO_3	SO_4	Cl	$H_2CO_3^*$	pH
Unit	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	pH units
Concentration	300	65	20	15	5	200	120	25	20	7.2

QUESTION FIVE(5 marks each)

5A. Compare the operating characteristics of membrane filters and granular filters in terms of:

i. Filtration rate
ii. Operating pressure
iii. Filter cycle duration
iv. Filtration mechanism

5B. Compare the advantages and disadvantages of:

i. Inside-out membrane operation and
ii. Outside-in membrane operations

5C. Explain why cross flow filtration mode may not be useful for water treatment applications compared to the dead end mode.

5D. According to the information provided on the percent rejection for MF and UF membranes in Figure Q5-1 shown below, determine the retention ratings of i) MF membrane ii) UF membrane.

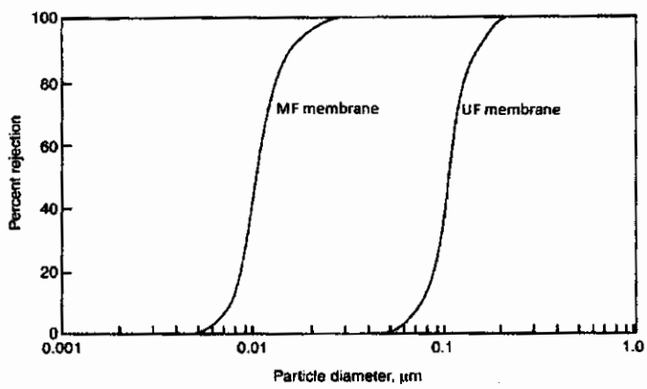

Figure Q5-1: Percent rejection of MF and UF membranes

5E. List the pretreatment and post treatment requirements of reverse osmosis plants.