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

B.Sc. Degree in Environmental Health Science

MAIN EXAMINATION PAPER DECEMBER 2015

TITLE OF PAPER	:	WATER TREATMENT
COURSE CODE	:	EHM423
DURATION	:	2 HOURS
MARKS	:	100
INSTRUCTIONS	:	THERE ARE FIVE QUESTIONS IN THIS EXAM
	:	ANSWER ANY FOUR OUT OF THE FIVE QUESTIONS
	:	EACH QUESTION CARRIES A MAXIMUM MARK OF 25%

Question One (5 marks each))

1A. List five objectives of chemical methods of water treatment

1B. Describe with the help of a chemical equation a possible chemical method for the removal of ammonia.

1C. State whether each of these reactions are homogenous or heterogeneous

i. Stripping of ammonia from water using air
ii. Removal of water hardness by softening
iii. Removal of water hardness by ion exchange
iv. Removal of organic matter by activated carbon adsorption

1D. The variation of the rate of reaction for a certain reaction is shown below:

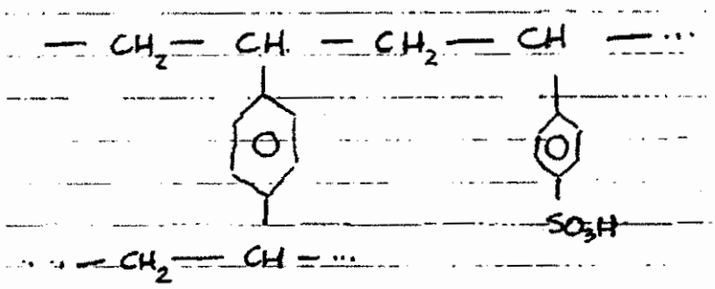
$$r = \frac{kC}{K+C}$$

i) What is the maximum rate of reaction?
ii) For what value of the concentration C does the maximum rate of reaction occur
iii) What will be the order of reaction when the concentration C is very large?
iv) What will be the order of reaction when the concentration C is small?

1E. If the average intensity of the UV radiation to which a sample was exposed is 20 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 10 mm. Assume the absorptivity k (at λ = 254 nm) is equal to 1.3 cm^{-1}.

Question Two (5 marks each)

2A. The diagram shown below is a chemical structure of ion exchanger material. Which of the following statements is/are true



a. The exchanger material is anion exchanger
b. The sulfonic group is the ion exchanger
c. The exchanger is strong acid exchanger
d. The exchanger is regenerated with sodium chloride

2B. For the ions listed below, choose the correct order of preference of a cation exchanger

a. $Ca^{2+} > Ba^{2+} > Pb^{2+} > Cd^{2+}$
b. $Cs^{+} > H^{+} > NH_4^{+} > K^{+}$
c. $Cu^{2+} > Co^{2+} > Zn^{2+} > Ag^{2+}$
d. $SO_4^{2-} > I^{-} > NO_3^{-} > Br^{-}$

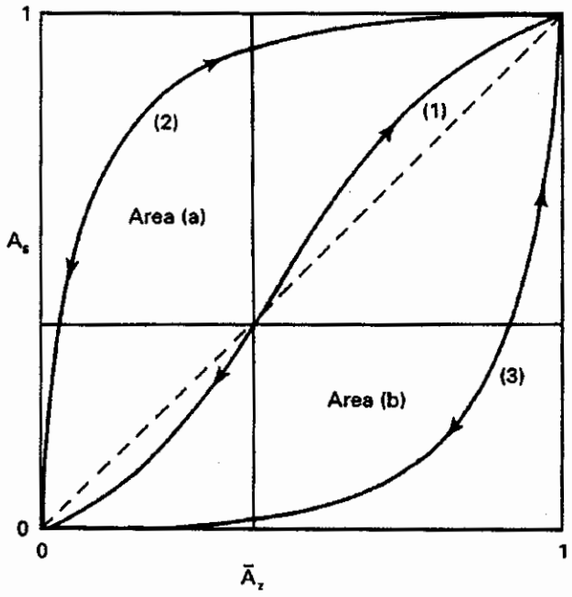
2C. Which of the following statements is/are true about ion exchange process for water treatment

a. Ion exchange is an adsorption process
b. Ion exchange is an absorption process
c. Ion exchange is more favoured for the removal of inorganic compounds rather than organic compounds.
d. Strong cation exchangers have sharp break-through curve

2D. Which of the following statements is/are false about the structure of ion exchange resins:

a. Spherically shaped resins beads are preferable for uniformity and to avoid compaction of the resin.
b. Ion exchange resins with high degree of cross linking are stronger
c. The pH of the water has little effect on the efficiency of adsorption of ions.
d. The selectivity of cation exchanger is more at higher pH due to greater mobility of the cations by combining with hydroxyl ions.

2E. The diagram below shows the selectivity if ion 'a ' over ion 'b ' for three different ion exchangers, namely, 1, 2 and 3 as shown in the figure. Note that the A_s (y-axis) represent the fraction of the ions of a in solution and that of the x-axis (i.e., $\tilde{A}$) represents the fraction of ions a that are taken up by the resin. Which of the following statement (s) are false?



a. Resin (1) has equal almost equal selectivity for both ions a and b.
b. Resin 2 is more selective of ion b than ion a
c. Resin (3) is more selective of ion (a) than ion (b)
d. None of the above

QUESTION THREE (5 marks each)

3A. What are the advantages of the columnar fixed or fluidized bed activated carbon systems compared to the slurry systems?

3B. If you are required to sequence sand filter with activated carbon in series, which filter would you place first? Give reasons for your answer.

3C. Describe the three important phases of the production of activated carbon.

3D. Describe the tests required to characterize each of the following characteristics of a given activated carbon.

i. Measurement of the percentage of micro pores present
ii. Measurement of the volume of transitional and macro pores
iii. Measurement of the ability of carbon to withstand handling and slurry transfer.

3E. How do you characterize the amenability to adsorption on activated carbon of the following compounds?

i) Alcohols ii) amines iii) aromatics

QUESTION FOUR (5 marks each)

A water with ionic characteristics shown below is to be softened to the minimum possible hardness by the excess lime soda ash process. Assume that 0.6 me/L of calcium carbonate and 0.2 me/L of magnesium hydroxide will be in the effluent of the second stage before recarbonation. Assume also that 0.2 meq/L of magnesium hydroxide and 0.3 meq/L of the 0.6 calcium carbonate will be converted to bicarbonate by second stage recarbonation to reach water stability. (Note that you do not need atomic weights as concentrations are given meq/L).

4A. Draw the ion bar diagram of the raw water

4B. Determine the lime and soda ash requirement for the first stage

4C. Determine the carbon dioxide requirement of the first stage recarbonation

4D. Determine the carbon dioxide requirement of the second stage recarbonation

4E. Determine the final sodium concentration in me/L

Compound	Concentration (meq/L)	Compound (meq/L)	Concentration (meq/L)
Carbon dioxide	1	Bicarbonate	7.35
Calcium	5.1	Sulfate	3.75
Magnesium	4.5		
Sodium	1.5		

QUESTION FIVE (5 marks each)

5A. Differentiate between retention rating and pore size of membrane filters

5B. In terms of hydrophobicity what characteristics of membranes are desirable to avoid fouling of membranes?

5C. Compare the roles of adsorption and straining in membrane filtration.

5D. Compare the rejection rates of membrane filters and ultra-filters against:

i. Giardia lamia cysts
ii. Bacteria
iii. Viruses

5E. Discuss the merits and demerits of applying chlorine to control bio-fouling in membrane filters.