



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

BACHELOR OF SCIENCE IN ENVIRONMENTAL
MANAGEMENT AND WATER RESOURCES

RE-SIT EXAMINATION PAPER JANUARY 2019

TITLE OF PAPER : WATER TREATMENT

COURSE CODE : EHS 429

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.** List five objectives of chemical methods of water treatment
- 1B.** Describe with the help of a chemical method a possible chemical method for the removal of ammonia.
- 1C.** State whether each of these reactions are homogenous or heterogeneous
- Stripping of ammonia from water using air
 - Removal of water hardness by softening
 - Removal of water hardness by ion exchange
 - Removal of organic matter by activated carbon adsorption

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

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

- What is the maximum rate of reaction?
 - For what value of the concentration C does the maximum rate of reaction occur
 - What will be the order of reaction when the concentration C is very large?
 - 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/cm², 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 $\lambda = 254$ nm) is equal to 1.3 cm⁻¹.

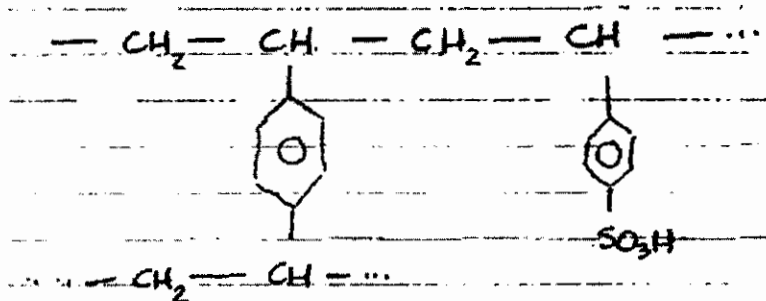
QUESTION TWO (25 marks and marks are indicated for each question)

- 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 300 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 80 kg and the rate of flow is 150 lit/day.[7 marks]
 - ii. Determine the length of time that this 80 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 (5 marks each)

3A. The diagram shown below is a chemical structure of ion exchanger material. Which of the following statements is/are true



- The exchanger material is anion exchanger
- The sulfonic group is the ion exchanger
- The exchanger is strong acid exchanger
- The exchanger is regenerated with sodium chloride

3B. For the ions listed below, choose the correct order of preference of a cation exchanger

- $\text{Ca}^{2+} > \text{Ba}^{2+} > \text{Pb}^{2+} > \text{Cd}^{2+}$
- $\text{Cs}^+ > \text{H}^+ > \text{NH}_4^+ > \text{K}^+$
- $\text{Cu}^{2+} > \text{Co}^{2+} > \text{Zn}^{2+} > \text{Ag}^{2+}$
- $\text{SO}_4^{2-} > \text{I}^- > \text{NO}_3^- > \text{Br}^-$

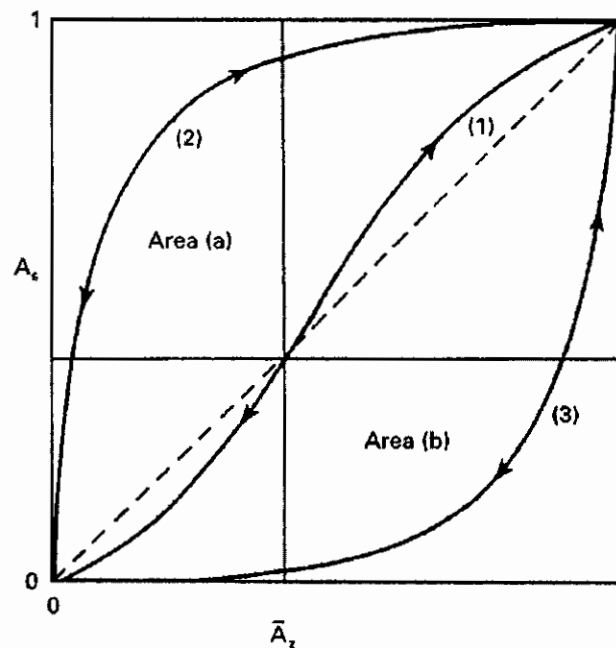
3C. Which of the following statements is/are true about ion exchange process for water treatment

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

3D. Which of the following statements is/are false about the structure of ion exchange resins:

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

3E. The diagram below shows the selectivity of 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., \bar{A}_z) represents the fraction of ions a that are taken up by the resin. Which of the following statement (s) are false?



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

QUESTION FOUR (25 Marks and marks are indicated for each question)

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.

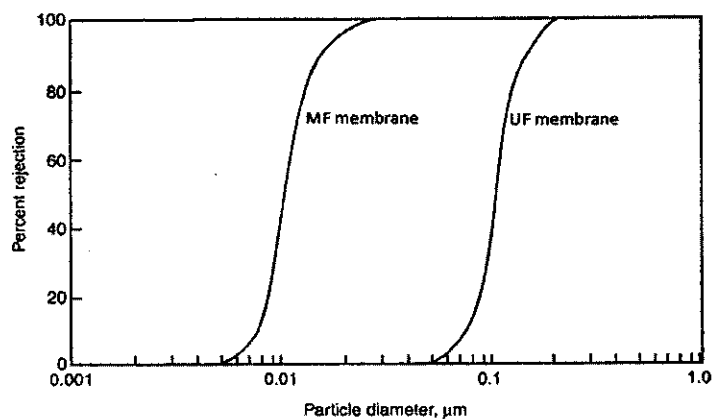


Figure Q5-1: Percent rejection of MF and UF membranes

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