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

BSc Environmental Health

MAIN EXAMINATION PAPER DECEMBER 2012

TITLE OF PAPER : WATER TREATMENT I

COURSE CODE : EHS:584

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 OF 25 MARKS

: NO PAPER SHOULD BE BROUGHT INTO OR OUT OF THE EXAMINATION ROOM

Question One (25 Marks)

A. Draw a diagram of water treatment processes arranging the unit processes listed below in the proper sequence.

Flash mixing – pre-ozonation- settling – flocculation-chlorination- micro straining – Activated carbon adsorption – post ozonation – filtration. .....[5 Marks]

B. Describe the conditions leading to the presence of greater concentration of dissolved iron and manganese, carbon dioxide, and lack of oxygen in ground water.

.....[5 Marks]

C. Differentiate between aesthetic objectives (AO) and operational guidelines (OG) of water quality standards. Give examples of parameters that fall under each of the above objectives. .....[5Marks].

D. State the principal biological treatment objectives of water intended for drinking purposes.

.....[5 Marks]

E. Describe with the help of a sketch and chemical equations how iron bacteria may thrive in a distribution systems. Explain the factors that contribute to increased concentration of iron bacteria in water. .....[5 Marks].

Question Two (25 Marks)

A) For the stability diagram of iron pipe shown in Fig Q2A below, indicate on the diagram the areas of: corrosion, passivation and immunity. Also state how passivation and immunity may be achieved for iron pipe. (Note: indicate the areas on this diagram and return this diagram with your answer sheet).

.....[8 Marks]

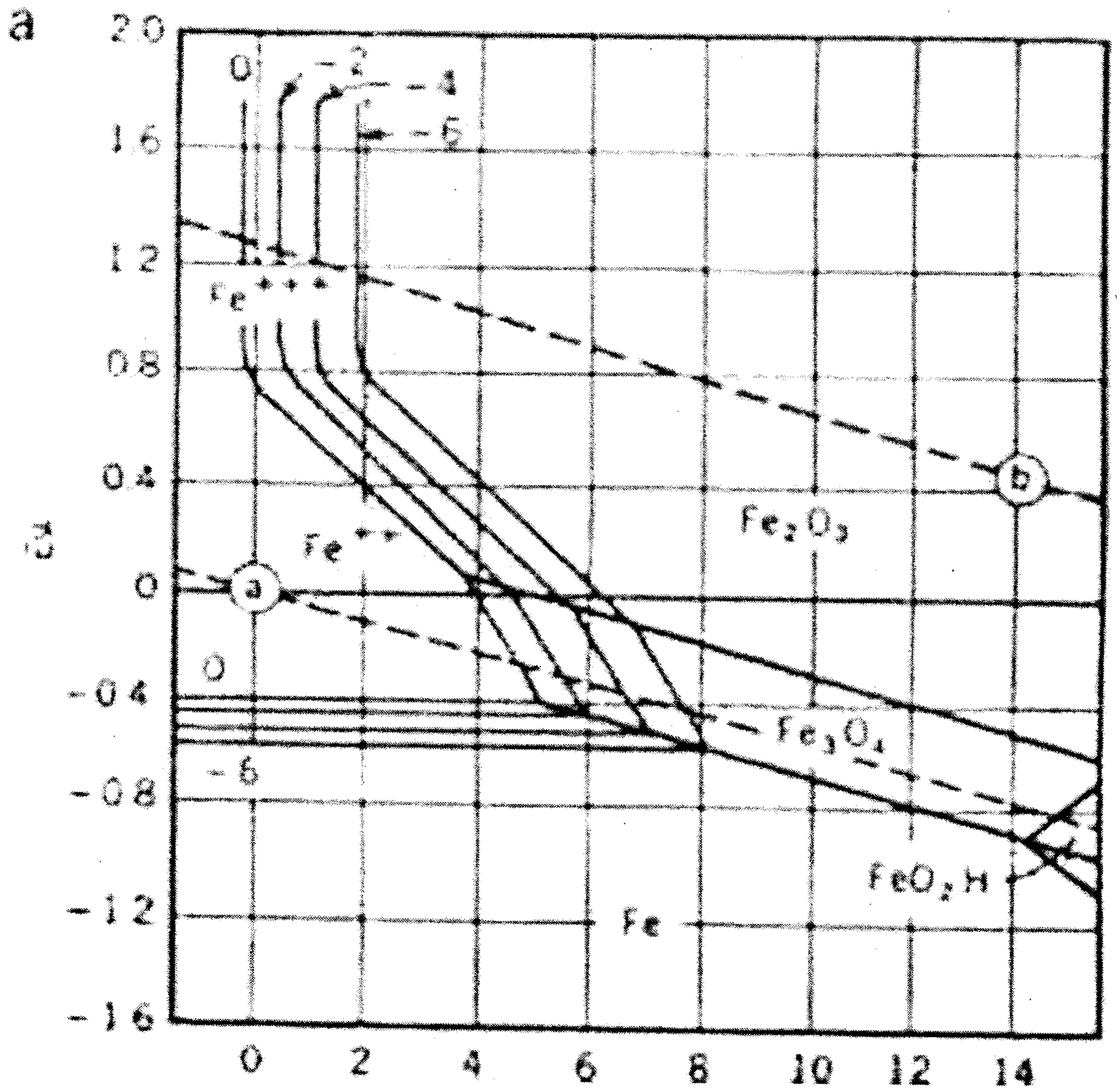


Figure Q2A

B. Analysis of water gave an alkalinity of 200 mg/L, Calcium of 100 mg/L (both expressed as $CaCO_3$) and a pH of 7.3. Compute the Langelier Index and the Ryzner Stability Index. Comment on these values and the stability of the water. Assume a water temperature of 5^0C and an ionic strength of 0.012M. Use the formulae and tables provided below.

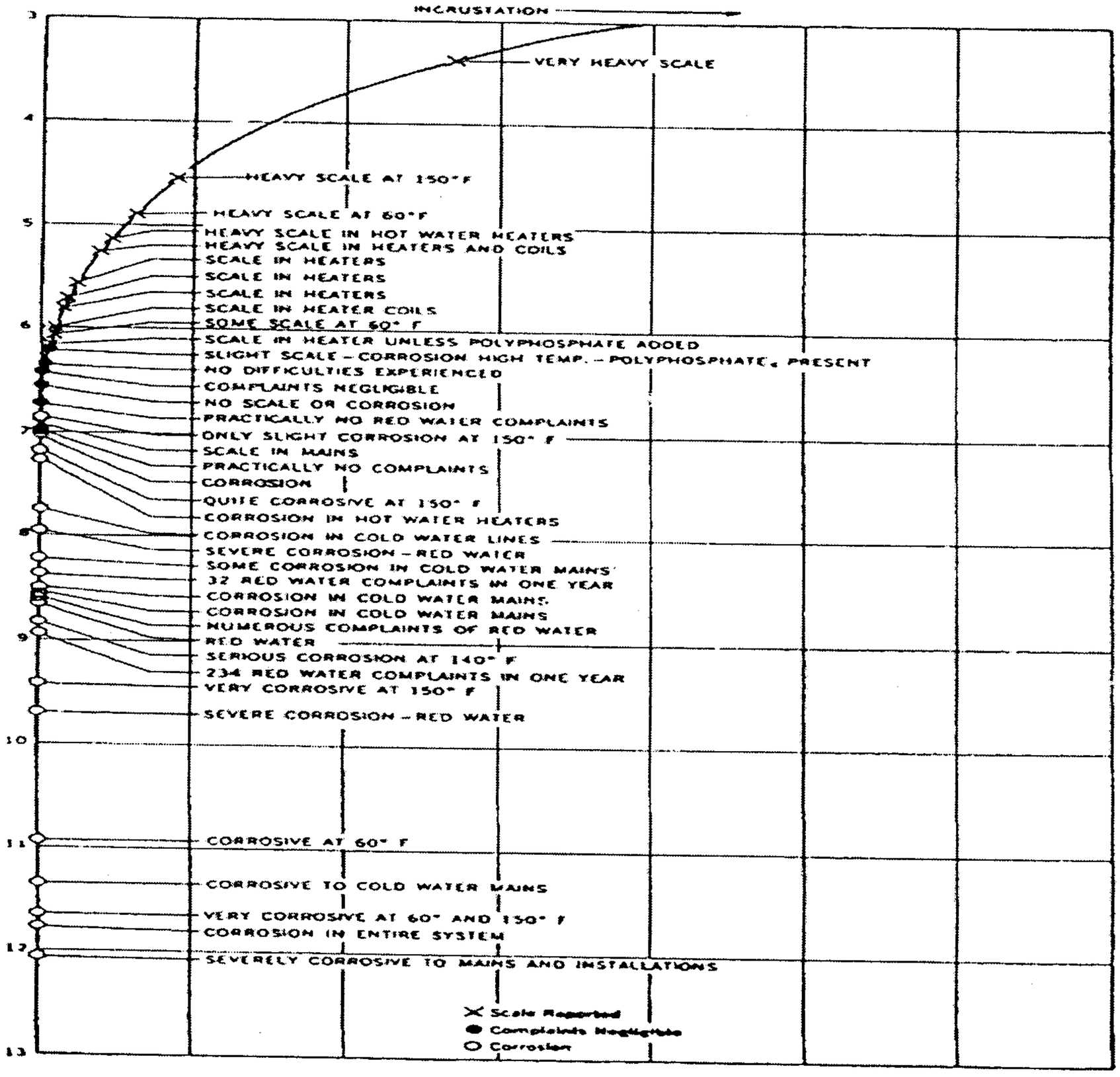
.....[8 Marks]

$$log_{10}(\gamma_m) = -0.5102 * z^2 * \left(\frac{\sqrt{I}}{1 + \sqrt{I}} - 0.3\,I\right)$$

$$\underline{pHs} = pK_2 + pCa^{2-} - \underline{Pk_s} - Log(2[\underline{Alk}]) - Log(\gamma_m)$$

Table VIII. Values of pK_2' and pK_s' at 25°C for Various Ionic Strengths and of the Difference ($pK_2' - pK_s'$) for Various Temperatures[a]

Ionic Strength	Total Dissolved Solids	25°C			$pK_2' - pK_s'$[b]							
		pK_2'	pK_s'	$pK_2' - pK_s'$	0°C	10°C	20°C	50°C	60°C	70°C	80°C	90°C
0.0000	0	10.26	8.32	1.94	2.20	2.09	1.99	1.73	1.65	1.58	1.51	1.44
0.0005	20	10.26	8.23	2.03	2.29	2.18	2.08	1.82	1.74	1.67	1.60	1.53
0.001	40	10.26	8.19	2.07	2.33	2.22	2.12	1.86	1.78	1.71	1.64	1.57
0.002	80	10.25	8.14	2.11	2.37	2.26	2.16	1.90	1.82	1.75	1.68	1.61
0.003	120	10.25	8.10	2.15	2.41	2.30	2.20	1.94	1.86	1.79	1.72	1.65
0.004	160	10.24	8.07	2.17	2.43	2.32	2.22	1.96	1.88	1.81	1.74	1.67
0.005	200	10.24	8.04	2.20	2.46	2.35	2.25	1.99	1.91	1.84	1.77	1.70
0.006	240	10.24	8.01	2.23	2.49	2.38	2.28	2.03	1.94	1.87	1.80	1.73
0.007	280	10.23	7.98	2.25	2.51	2.40	2.30	2.05	1.96	1.89	1.82	1.75
0.008	320	10.23	7.96	2.27	2.53	2.42	2.32	2.07	1.98	1.91	1.84	1.77
0.009	360	10.22	7.94	2.28	2.54	2.43	2.33	2.08	1.99	1.92	1.85	1.78
0.010	400	10.22	7.92	2.30	2.56	2.45	2.35	2.10	2.01	1.94	1.87	1.80
0.011	440	10.22	7.90	2.32	2.58	2.47	2.37	2.12	2.03	1.96	1.89	1.82
0.012	480	10.21	7.88	2.33	2.59	2.49	2.39	2.13	2.04	1.97	1.90	1.83
0.013	520	10.21	7.86	2.35	2.61	2.50	2.40	2.15	2.06	1.99	1.92	1.85
0.014	560	10.20	7.85	2.36	2.62	2.51	2.41	2.16	2.07	2.00	1.93	1.86
0.015	600	10.20	7.83	2.37	2.63	2.52	2.42	2.17	2.08	2.01	1.94	1.87
0.016	640	10.20	7.81	2.39	2.65	2.54	2.44	2.19	2.10	2.03	1.96	1.89
0.017	680	10.19	7.80	2.40	2.66	2.55	2.45	2.20	2.11	2.04	1.97	1.90
0.018	720	10.19	7.78	2.41	2.67	2.56	2.46	2.21	2.12	2.05	1.98	1.91
0.019	760	10.18	7.77	2.41	2.67	2.57	2.47	2.21	2.12	2.05	1.98	1.91
0.020	800	10.18	7.76	2.42	2.68	2.58	2.48	2.22	2.13	2.06	1.99	1.92



C) Determine the acidity and alkalinity (both in mill 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 (mg/L)	8.9	30	180	10

.....[9 marks]

Question Three (25 Marks)

A. Determine the type of pretreatment required prior to slow sand filtration for each of the following raw water quality:

i. The raw water turbidity less than 1.0NTU and E.coli count is zero.

ii. The raw water turbidity <10 NTU and E.coli count is less than 10 cfu /100 mL.

iii. The raw water turbidity is between 20 and 100 NTU.

iv. The raw water turbidity is greater than 1000 NTU.

.....[5 Marks]

B. Describe the advantages of pretreatment prior to rapid sand filtration.

.....[5 Marks]

C. Describe the functions of the following structures provided within sedimentation tanks:

i. Inlet weirs .....[2 Marks]

ii. Inlet baffles .....[1 Mark]

iii. Outlet weirs .....[2 Marks]

D. Sketch an outline of tilted tube settlers and state the advantage of providing tilted tube settlers over horizontal flow sedimentation tanks.

.....[5 Marks]

E. Describe the advantages and disadvantages of:

i) horizontal flow roughing filtration

ii) vertical flow roughing filtration.

.....[5 Marks]

Question Four (25 Marks)

A. Define the following terms i) suspension ii) colloid iii) floc iv) coagulation v) flocculation. .....[5 Marks]

B. Order the cations, aluminum, sodium and calcium in terms of their coagulation potential from the highest to the lowest. Indicate also the ratio of their respective power of coagulation. .....[5 Marks]

C. Looking at the coagulation chemical reaction below state whether i) the pH after coagulation decreases or increases ii) the alkalinity after coagulation increases or decreases.

$$Al_2(SO_4)_3 \cdot 18H_2O + 3Ca(HCO_3)_2 = 2Al(OH)_{3(s)} + 3CaSO_4 + 6CO_{2(g)} + 18H_2O$$

.....[5 Marks]

D. How do you differentiate the mechanism of stabilization of i) hydrophilic (lyophilic) and ii) hydrophobic (lyophobic) colloids?

.....[5 Marks]

E. The zone of counter ion attraction is described by two layers. Name these two layers and describe their formation and characteristics.

.....[5 Marks]

Question Five (25 Marks)

A. Differentiate between i) discrete particle settlement and ii) flocculant settlement in terms of particle diameter and density.

.....[5 Marks]

B. Derive the formula used to express the overflow rate of sedimentation tanks.

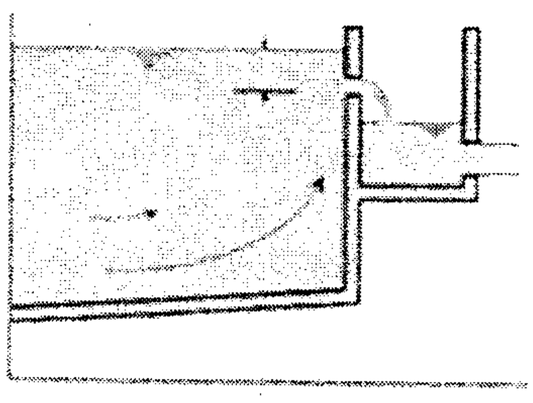
.....[5 Marks]

C. Given below is the formula for scouring velocity of settled solids in sedimentation tanks. State what each symbol used in the formula represents and explain how they affect scouring of settled solids.

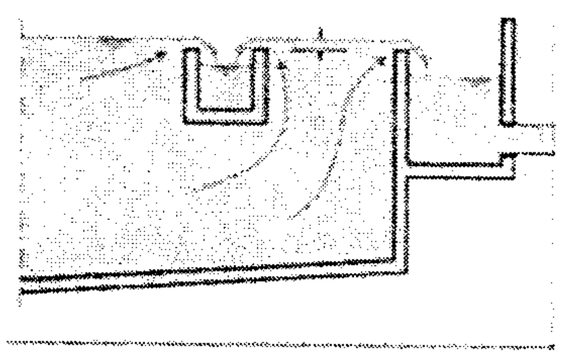
$$V_c = \sqrt{\frac{8\beta}{f} g D (S-1)}$$

.....[5 Marks]

D. Given the outlet arrangement diagrams below, describe the advantages offered by the outlet arrangement shown by outlet A and outlet B



Outlet A



Outlet B

.....[5 Marks]

E. Describe the change in the rate of removal of particles for a given constant flow rate in each of the following cases:

i. The depth of the tank is doubled while the other dimensions of the tank (width and length) remain unchanged.

ii. The length of the tank is doubled while the other dimensions of the tank remain constant.

.....[5 Marks]