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

BSc Environmental Health

MAIN EXAMINATION PAPER DECEMBER 2013

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

<u>Question One</u> (25 Marks)

Referring to the pE – pH diagram of iron shown in Figure Q1 below, answer the following questions.

1A. Sketch on the figure, the areas of corrosion, immunity and passivation. ……..[12 Marks]

1B. Discuss the corrosion protection measures available for iron and state the advantages and disadvantages of each option………………………….. …...................[13 Marks]

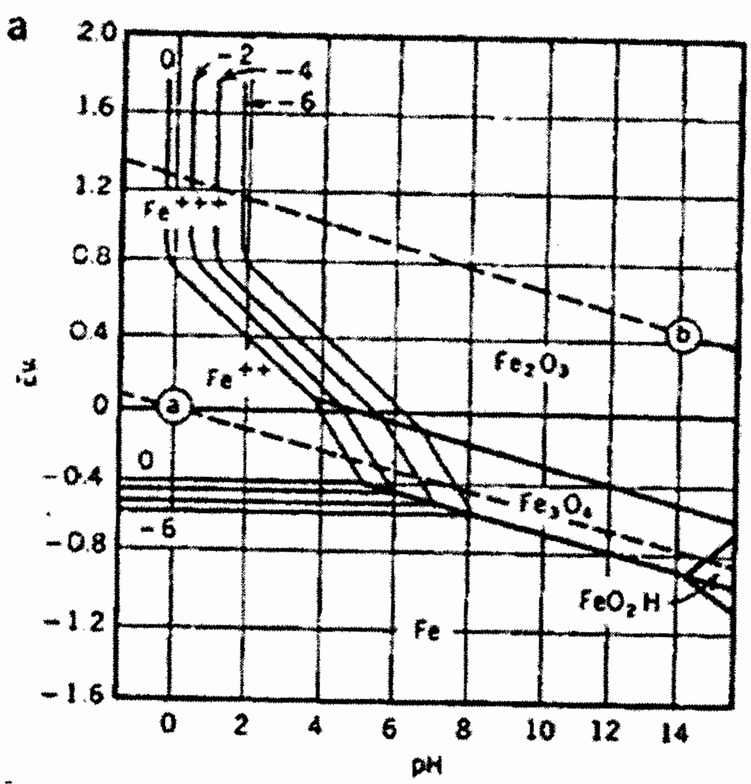


Fig Q1

Question Two (25 Marks)

2A. Analysis of water gave an alkalinity of 350 mg/L, Calcium of 150 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.

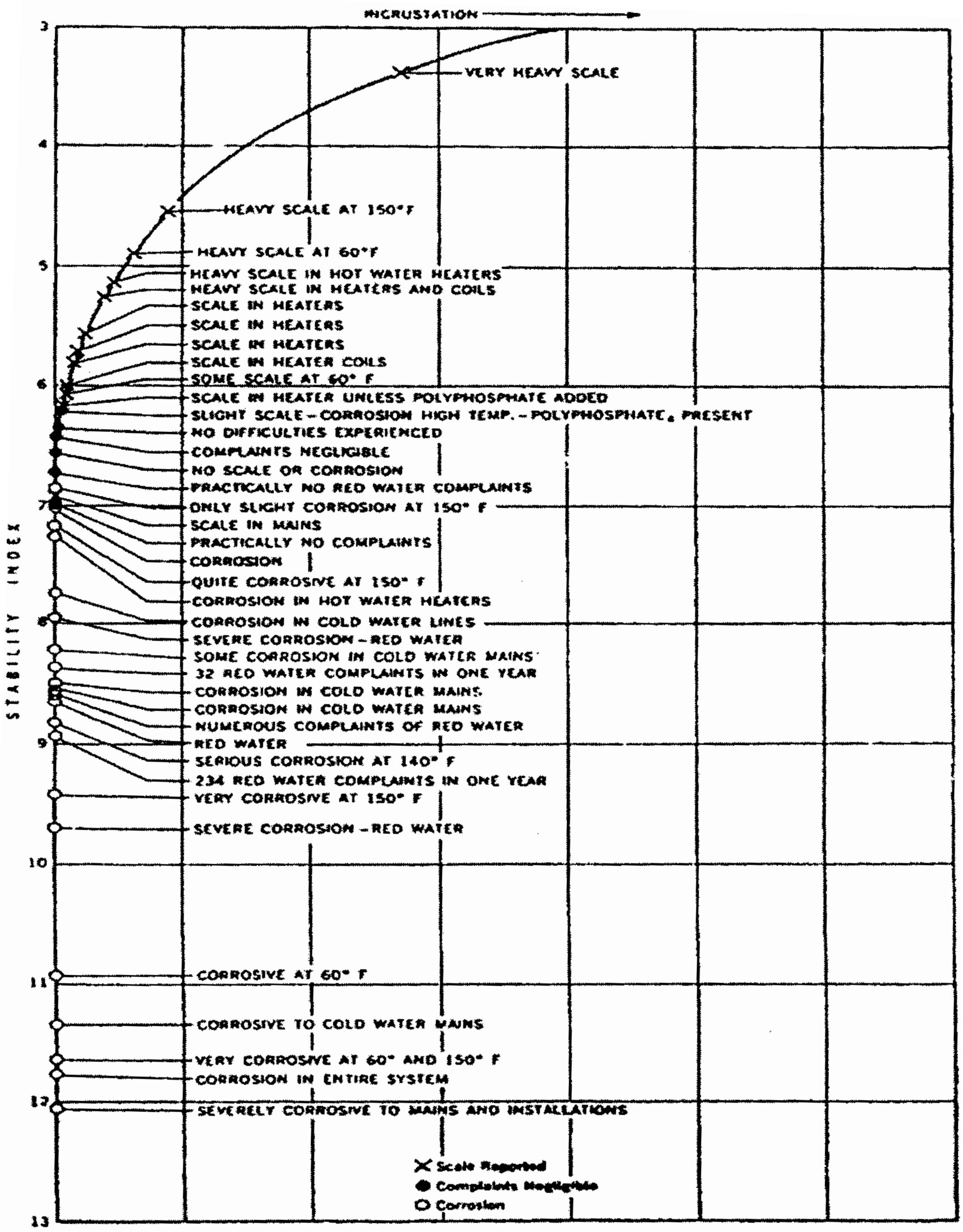
……………………..[13 Marks]

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

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

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'	25°C pK_s'	25°C $pK_2' - pK_s'$	$pK_2' - pK_s'$ [b] 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


INCRUSTATION
VERY HEAVY SCALE
HEAVY SCALE AT 150°F
HEAVY SCALE AT 60°F
HEAVY SCALE IN HOT WATER HEATERS
HEAVY SCALE IN HEATERS AND COILS
SCALE IN HEATERS
SCALE IN HEATERS
SCALE IN HEATERS
SCALE IN HEATER COILS
SOME SCALE AT 60° F
SCALE IN HEATER UNLESS POLYPHOSPHATE ADDED
SLIGHT SCALE – CORROSION HIGH TEMP. – POLYPHOSPHATE PRESENT
NO DIFFICULTIES EXPERIENCED
COMPLAINTS NEGLIGIBLE
NO SCALE OR CORROSION
PRACTICALLY NO RED WATER COMPLAINTS
ONLY SLIGHT CORROSION AT 150° F
SCALE IN MAINS
PRACTICALLY NO COMPLAINTS
CORROSION
QUITE CORROSIVE AT 150° F
CORROSION IN HOT WATER HEATERS
CORROSION IN COLD WATER LINES
SEVERE CORROSION – RED WATER
SOME CORROSION IN COLD WATER MAINS
32 RED WATER COMPLAINTS IN ONE YEAR
CORROSION IN COLD WATER MAINS
CORROSION IN COLD WATER MAINS
NUMEROUS COMPLAINTS OF RED WATER
RED WATER
SERIOUS CORROSION AT 140° F
234 RED WATER COMPLAINTS IN ONE YEAR
VERY CORROSIVE AT 150° F
SEVERE CORROSION – RED WATER
CORROSIVE AT 60° F
CORROSIVE TO COLD WATER MAINS
VERY CORROSIVE AT 60° AND 150° F
CORROSION IN ENTIRE SYSTEM
SEVERELY CORROSIVE TO MAINS AND INSTALLATIONS
STABILITY INDEX
3
4
5
6
7
8
9
10
11
12
13
Scale Reported
Complaints Negligible
Corrosion

2B. Determine the acidity and 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 (mg/L)	8.9	30	180	10

....[12 marks]

<u>Question Three</u> (25 Marks)

3A. Define a false bottom and its function. State the requirement of providing false bottom for:

i) horizontal flow roughing filter ....[1.5 Marks]

ii) vertical flow roughing filter..[1.5 Marks]

3B. Explain the dominant mechanism for solids removal in roughing filtration.

....................................[4 Marks]

3C. Compare the extent of occurrence of short circuiting in plain sedimentation tanks with that of roughing filters. ....[4 Marks]

3D. Compare the impact of sudden change in flow rate on the performance of horizontal flow roughing filters with that of vertical flow roughing filters. ....[3 Marks]

3E. Describe the design variables that affect the efficiency of removal of solids in roughing filtration. ....[4 Marks]

3F. Explain the mechanism by which flow disturbance caused by the outflow of water in plain sedimentation tanks can be minimized. ....[3 Marks]

3G. Explain how the depth of water in sedimentation tanks affects the efficiency of solids removal. ....[4 Marks]

Question Four (25 Marks)

4A. State the dominant mechanisms for the formation of hydrophilic colloids in water...[3 Marks]

4B. Compare the performances of aluminum sulphate and ferric chloride as coagulants for the removal of colloidal solids from water. ....[4 Marks]

4C. Describe the mechanisms by which hydrophobic colloids may be stabilized in water. ....[3 Marks]

4D. Describe the four major mechanisms of destabilization of colloids in water ....[4 Marks]

4E. Compare the advantages and disadvantages of i) hydraulic rapid mixing and ii) mechanical rapid mixing. ....[4 Marks]

4F. Differentiate between i) perikinetic flocculation and ii) orthokinetic flocculation. In each case explain the dominant mechanism responsible for the formation of flocs

....[4 Marks]

4G. State the formula used for calculation of velocity gradient and indicate how the velocity gradient may be varied to achieve a desired rate of flocculation.

...................................[3 Marks]

Question Five (25 Marks)

5A. Show that for a given flow rate Q, the minimum settlement velocity of a particle removed in a sedimentation tank of surface area A is given by:

$$V = \frac{Q}{A}$$

....[10 Marks]

5B. For a flow in a sedimentation tank, assume that the water temperature is 10^0c and the depth of the settling tank is 3.0 m. Calculate the theoretical settling velocity (in m/sec), surface loading rate and detention time required for the removal silt particles with a relative density of 2.65 and diameter 0.001 cm. Take kinematic viscosity (ν) of water at 10 ^{0}C as $1.306*10^{-6}$ m^2/sec and density of water (ρ_w) = 999.1 kg/m^3.

....[15 Marks]

$$R_N = \frac{\phi V_s d_s}{\upsilon}$$

$$For\ R_N < 0.5, \qquad C_D = \frac{24}{R_N}$$

$$V_s = \frac{gd^2(\rho_s - \rho_w)}{(18\,\nu)\,\rho}$$

$$Otherwise, \qquad C_D = \frac{24}{R_N} + \frac{3}{\sqrt{R_N}} + 0.34$$

$$V_s = \sqrt{\frac{4g(sg-1)d}{3C_d}}$$