UNIVERSITY OF JOHANNESBURG

PROGRAM	:	BACCALAUREUS TECHNOLOGIAE: *ENGINEERING : CIVIL*
SUBJECT	:	**WATER TREATMENT TECHNOLOGY IV**
CODE	:	**WTT 411**
ASSESSMENT	:	WINTER EXAMINATION (SUPPLEMENTARY PAPER)
DATE		16 JULY 2014
DURATION	:	(SESSION 2) 11:30 - 14:30
WEIGHT	:	40:60
TOTAL MARKS	:	90

ASSESSOR	:	G.K. NKHONJERA
MODERATOR	:	PROF. F.M. ILUNGA
NUMBER OF PAGES:		PAGES: 8 including the cover page and Annexures.

INSTRUCTIONS :

1. This is a closed-book type of Exam.
2. This paper contains 6 questions: ANSWER **ALL** QUESTIONS
3. Make sure that you understand what the question requires before attempting it.
4. Any additional material is to be placed in the answer book and must indicate clearly the question number, your name, and Student number.
5. Where necessary, answers without calculations will not be considered.

ANSWER **ALL** QUESTIONS

QUESTION 1 [15]

1.1 Briefly, explain why light in the ultraviolet range of wavelengths is effective in disinfection while light in other wavelengths is not. (2)

1.2 With respect to chlorination process in water treatment, distinguish between the following terms:

a) Hypochlorous acid and Hydrochloric acid. (2)
b) Chlorine demand and Chlorine residual. (2)

1.3 Explain the phenomenon of the break-point chlorination with the help of a chlorine dosage vs chlorine residual chlorine curve. (9)

QUESTION 2 [15]

2.1 With respect to a conventional water treatment works, describe the role of the following unit processes.

a) Rapid mixing. (2)
b) Screening process. (2)

2.2 Evaluate the ability of a horizontal flow rectangular pre-settling tank to remove discrete sand particles having a diameter of 0.21 mm. The particle and water densities are taken as 1.85 g/cm^3 and 1000 kg/m^3 respectively. Make the following assumptions where necessary:
Sticky material dimensionless value, $\beta = 0.03$.
Darchy-Weisbatch factor, $f = 0.020$.
Water temperature, $T = 12^{o}C$. (11)

QUESTION 3 [20]

3.1 Explain why it is important to provide for "filter-to-waste" or "filter-to-recycle" in the filter design. (4)

3.2 With a well labeled illustration, briefly, describe the principles of operation of a Rapid Sand filter in a conventional water treatment works. (6)

3.3 A new design flow rate of 1.0 m^3/s is being proposed for a water treatment plant. A deep bed monomedia filter with a design loading of 600 $m^3/d.m^2$ of filter is to be used. If each filter box is limited to 50 m^2 of surface area, how many filter boxes will this treatment plant require? Also check the design loading when you decide to use two more filters. (10)

QUESTION 4 [20]

4.1 A water treatment plant has a total number of 4 media filter boxes. Each filter is 10m x 15m in size. The filters are loaded at a filtration rate of 480 m/d when in operation. With proper operational practice, determine the maximum flow rate through the filters in m^3/s. (8)

4.2 A sedimentation basin is to be built to treat an average flow rate of 5.5 ML/d of water at a temperature of 20°C. The dimension of this basin is 30 m long, 5 m wide and 3.0 m deep (effective water depth). The water entering the clarifier contains a substantial amount of clay agglomerates with specific gravity of 1.15 and diameter of 0.05 mm. Assuming water enters the settling zone of the basin uniformly, determine the percentage of these particles that will be removed from the basin. (12)

QUESTION 5 [20]

Determine the dimensions of a horizontal flow rectangular sedimentation basin given that the maximum day design flow rate is 25000 m^3/d. Assume the following design information:

Overflow rate, V_o = 45 $m^3/d.m^2$.
Water temperature, T = 12°C.
Number of tanks = 4.
Length-to-width ratio, (L:W) = 6 : 1.
Side water depth (SWD) = 2.5 m.
Also, check for the L:D ratio, velocity, Reynolds Number and Froude Numbers.

GOOD LUCK TO YOU ALL !!!!

APPENDIX A

FORMULAS

1	Velocity Gradient, G $$G = \sqrt{\frac{P}{\mu \forall}}$$	Hydraulic Radius, R_h, $$R_h = \frac{A_w}{P_w}$$
2	Froude Number, Fr, $$F_r = \frac{V_h^2}{gR_h}$$	Weir loading, WL $$WL = \frac{Q}{Length}$$
3	Reynolds Number, N_R, $$N_R = \frac{V_h R_h}{v}$$	Percentage removal, P, $$P = \frac{V_s}{V_o} \times 100\%$$
4	Stoke's Law formula $$V_s = \frac{g(\rho_s - \rho)d^2}{18\mu}$$	$$A = \frac{Q}{n V_a}$$ $$V_{sc} = \sqrt{\frac{8\beta(\rho_s - \rho)gd}{1000 f}}$$

Where:

- N_R = Reynolds number, dimensionless
- Fr = Froude Number, dimensionless
- V_h = Average horizontal fluid velocity in tank, m/s
- R_h = Hydraulic radius, m
- A_w = Wetted cross sectional area, m^2
- P_w = Wetted perimeter, m
- v = Kinematic viscosity, m^2/s ; $v = \mu/\rho$
- μ = Dynamic viscosity, Pa · s
- ρ = Density of fluid, kg/m^3
- ρ_s = Density of the particle, kg/m^3
- d = Size of the particle (m)

- V_s = Settling velocity (m/s)
- V_o = Overflow rate (m/s or $m^3/s.m^2$)
- P = Power of mixing (W)
- G = Velocity gradient (s^{-1})
- $\forall$ = Volume of the tank (m^3)
- V_a = Filtration rate
- A = Area of filter bed (m^2)
- V_{sc} = Scour velocity (m/s)

APPENDIX B

TYPICAL DESIGN CRITERIA FOR HORIZONTAL-FLOW RECTANGULAR SEDIMENTATION BASINS

(M.L. DAVIS, 2010)

PARAMETER	TYPICAL RANGE OF VALUE	COMMENT
INLET ZONE		
Distance to diffuser wall	2 m	
Diffuser hole diameter	0.10–0.20 m	
SETTLING ZONE		
Overflow rate	$40–70\ m^3/d \cdot m^2$	
Side water depth (SWD)	3–5 m	
Length	30 m	Wind constraint
	60 m	Chain-and-flight
	≥80–90 m	Traveling bridge
Width	0.3 m increments	Chain-and-flight
	6 m maximum per train	Chain-and-flight
	24 m maximum = 3 trains per drive	Chain-and-flight
	30 m maximum	Traveling bridge
L:W	4:1 to 6:1	≥6:1 preferred
L:D	15:1	Minimum
Velocity	0.005–0.018 m/s	Horizontal, mean
Reynolds number	< 20 000	
Froude number	$> 10^{-5}$	
OUTLET ZONE		
Launder length	1/3–1/2 length of basin	Evenly spaced
Launder weir loading	$140–320\ m^3/d \cdot m$	See Table 10-3
SLUDGE ZONE		
Depth	0.6–1 m	Equipment dependent
Slope	1:600	Mechanical cleaning
Sludge collector speed	0.3–0.9 m/min	

APPENDIX C

PHYSICAL PROPERTIES OF AIR, WATER, AND SELECTED CHEMICALS

Temperature (°C)	Density, ρ (kg/m³)	Specific weight, γ (kN/m³)	Dynamic viscosity, μ (mPa · s)*	Kinematic viscosity, ν (μm²/s)*
0	999.842	9.805	1.787	1.787
3.98	1,000.000	9.807	1.567	1.567
5	999.967	9.807	1.519	1.519
10	999.703	9.804	1.307	1.307
12	999.5	9.802	1.235	1.236
15	999.103	9.798	1.139	1.14
17	998.778	9.795	1.081	1.082
18	998.599	9.793	1.053	1.054
19	998.408	9.791	1.027	1.029
20	998.207	9.789	1.002	1.004
21	997.996	9.787	0.998	1
22	997.774	9.785	0.955	0.957
23	997.542	9.783	0.932	0.934
24	997.3	9.781	0.911	0.913
25	997.048	9.778	0.89	0.893
26	996.787	9.775	0.87	0.873
27	996.516	9.773	0.851	0.854
28	996.236	9.77	0.833	0.836
29	995.948	9.767	0.815	0.818
30	995.65	9.764	0.798	0.801
35	994.035	9.749	0.719	0.723
40	992.219	9.731	0.653	0.658
45	990.216	9.711	0.596	0.602
50	988.039	9.69	0.547	0.554
60	983.202	9.642	0.466	0.474
70	977.773	9.589	0.404	0.413
80	971.801	9.53	0.355	0.365
90	965.323	9.467	0.315	0.326
100	958.366	9.399	0.282	0.294

***Pa · s = (mPa · s) × 10^{-3}**
***m²/s = (μm²/s) × 10^{-6}**