Second Semester Examination
2020/2021 Academic Session

July/August 2021

EAP215 – Water Supply and Treatment Engineering

Duration : 2 hours

Please check that this examination paper consists of **SEVEN (7)** pages of printed material before you begin the examination.

Instructions: This paper contains **FOUR (4)** questions. Answer **ALL** questions.

All questions **MUST BE** answered on a new page.

1. (a). The capability of a water sample to neutralize acids or hydrogen ions is measured by its alkalinity. It is measured by titrating a water sample with a standard acid solution, most commonly H_2SO_4. In terms of water quality, there are two forms of alkalinity. By giving appropriate examples, explain the differences between the two forms of alkalinity.

[6 marks]

(b). **Table 1** shows the concentration of the selected compound from a sample of river water.

Table 1: River water characteristic

Ca^{2+} = 16 mg/L	HCO_3^- = 54 mg/L
Mg^{2+} = 8 mg/L	SO_4^{2-} = 5 mg/L
Na^+ = 10 mg/L	Cl^- = 20 mg/L
K^+ = 15 mg/L	CO_3^{2-} = 22 mg/L
	NO_3^- = 4 mg/L

Based on the given data in **Table 1**, determine the total, carbonate, and non-carbonate hardness in mg/L as $CaCO_3$. Justify the answer for the carbonate and non-carbonate harness.

[14 marks]

(c). After identifying sources of water to be used for water supply, it is important to study the factors that may influence the selection of water resources. Discuss briefly the influencing factors in the selection of water sources.

[5 marks]

2. (a). Explain one of the main mechanisms in coagulation-flocculation process for portable drinking water treatment.

[4 marks]

(b) Treatment of 40,000 m^3/day of water requires 20 mg/L of alum as a coagulant. The natural alkalinity of the water is equivalent to 5.5 mg/L of $CaCO_3$. Determine the required quantities of quicklime (containing 85% CaO) and alum in kg/day.

(Note: [Ca^{2+}] = 40.1 g/mol, [C] = 12 g/mol, [O] =16 g/mol)

[6 marks]

(c). Head loss through an upflow and downflow baffles of a flocculation tank is 0.48 m when the output is 30 MLD at a temperature of 27°C **(Please refer Appendix 2)**. At this flowrate, the detention time in the flocculation chamber is 32 minutes. Calculate the velocity gradient and Camp number when the flowrate is changed to 15 MLD at a temperature of 27°C.

[6 marks]

(d). For mechanical flocculation process, three flocculation tanks are required to be constructed in series. The design velocity gradient for the first, second and third tanks are 80 s^{-1}, 60 s^{-1}, 30 s^{-1}, respectively. The flowrate for each tank is 2.5 MGD and water temperature is 25°C. Detention time in each tank is 2.0 minutes. From the data given, determine the dimensions of each flocculation tank.

[9 marks]

3. (a). Horizontal roughing filters (HRF) using limestone media have been promoted and constructed by Universiti Sains Malaysia (USM) for the benefit of bottom billion communities at Kg Orang Asli, Kg Langkor, Sg Siput (U) and at a remote Malay village Kg Sg Air Jernih, Ijok, Selama, Perak. The filters were developed through laboratory findings by the researchers from the School of Civil Engineering and put into practice for the benefit of the community.

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i) Sketch a diagram of a typical HRF. Describe the advantages and disadvantages of HRF for community water supply in terms of removal of turbidity and coliform organisms.

[7 marks]

ii) Discuss the sustainability of the HRF system in terms of maintenance, community empowerment and ownership.

[6 marks]

(b). A horizontal sedimentation tank has a capacity of 3.8 MLD, a detention time of 3.1 hours, and a surface loading of 1.5 m/hour. The tank is designed with length to breadth ratio of 4:1. Determine the dimensions of the tank and the length of the outlet weir.

[8 marks]

(c). A sodium silicofluoride solution is prepared by dissolving 6.5 kg of 97.5% commercial powder in 86 kg water. Determine the feeding rate of the solution into a water being treated to increase the fluoride ion content of 0.92 mg/L. Give your answer in gram of solution applied per cubic meter of the treated water.

[4 marks]

4. (a). Water pipeline system is classified according to their layout. With the help of sketches, explain **THREE (3)** types of water pipeline system.

[6 marks]

(c). **Figure 1** shows a water reticulation system. Estimate the flow rate in each pipeline using Hardy-Cross Method and Hazen-William formula **up to two iterations**. Adopt Hazen-William coefficient, C, as 100. Use initial flowrate of 70 litres per second (L/s) from point A to B. The lengths and diameters for pipes AB, BC, CD, and AD are as follows:

[19 marks]

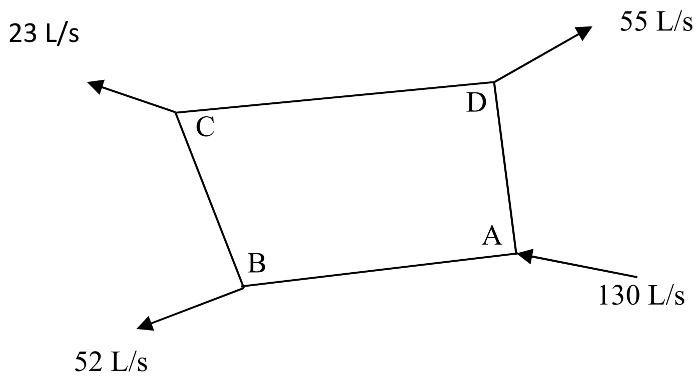

Figure 1: Reticulation system

Pipe AB: length= 900 m and diameter = 250 mm

Pipe BC: length = 650 m and diameter = 200 mm

Pipe CD: length = 1000 m and diameter = 200 mm

Pipe AD: length = 550 m and diameter = 250 mm

This formula might help in your calculation:

$$H_L = \frac{12.25 \times 10^9}{D^{4.87}} L \left[\frac{Q}{C}\right]^{1.85}$$

…6/-

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APPENDIX 1

Equations related to water supply:

$$P_n = P_i + nI$$

$$P_n = P_i\left(1+\frac{i}{100}\right)^n$$

$$P_n = P_i + n(I+m)$$

$$P_n = P_i\left(1+\frac{(1-k}{100}\right)^n$$

$$G = \left(\frac{P}{\mu\forall}\right)^{1/2}$$

$$P = \frac{1}{2}C_d\rho A \vee^3$$

$$P = \rho Qgh$$

$$h_L = KQ^2$$

$$\frac{d_1}{d_2} = \frac{1}{2}\left[\left(1-8F^2\right)^{1/2} - 1\right]$$

$$F = \frac{V_1}{(gd_1)^{1/2}}$$

$$\mathrm{Re} = \frac{\rho vd}{\mu}$$

$$\Delta H = [(v_1^2 + 5v_2^2 + 4v_3^2)/2g] + \text{normal channel friction}$$

$$h = \frac{nv_1^2 + (n-1)v_2^2}{2g}$$

$$v_s = \frac{gd^2(\rho_s - \rho_w)}{18\mu}$$

$$t = \frac{2\pi H}{Q}\int_{R1}^{R2} rdr = \frac{\pi\left(R_2^2 - R_1^2\right)H}{Q}$$

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

$$D = V_s t$$

$$L = \frac{0.2Q}{HV_s}$$

$$H = \frac{1128\times10^9}{d^{4.87}}\left[\frac{Q}{100}\right]^{1.85}$$

$$\Delta = -\frac{\Sigma H}{N\sum\frac{H}{Q_a}}$$

Appendix 2

TABLE A-9

Properties of saturated water

Temp. T, °C	Saturation Pressure P_{sat}, kPa	Density ρ, kg/m³ Liquid	Vapor	Enthalpy of Vaporization h_{fg}, kJ/kg	Specific Heat c_p, J/kg·K Liquid	Vapor	Thermal Conductivity k, W/m·K Liquid	Vapor	Dynamic Viscosity μ, kg/m·s Liquid	Vapor	Prandtl Number Pr Liquid	Vapor	Volume Expansion Coefficient β, 1/K Liquid
0.01	0.6113	999.8	0.0048	2501	4217	1854	0.561	0.0171	1.792×10^{-3}	0.922×10^{-5}	13.5	1.00	-0.068×10^{-3}
5	0.8721	999.9	0.0068	2490	4205	1857	0.571	0.0173	1.519×10^{-3}	0.934×10^{-5}	11.2	1.00	0.015×10^{-3}
10	1.2276	999.7	0.0094	2478	4194	1862	0.580	0.0176	1.307×10^{-3}	0.946×10^{-5}	9.45	1.00	0.733×10^{-3}
15	1.7051	999.1	0.0128	2466	4185	1863	0.589	0.0179	1.138×10^{-3}	0.959×10^{-5}	8.09	1.00	0.138×10^{-3}
20	2.339	998.0	0.0173	2454	4182	1867	0.598	0.0182	1.002×10^{-3}	0.973×10^{-5}	7.01	1.00	0.195×10^{-3}
25	3.169	997.0	0.0231	2442	4180	1870	0.607	0.0186	0.891×10^{-3}	0.987×10^{-5}	6.14	1.00	0.247×10^{-3}
30	4.246	996.0	0.0304	2431	4178	1875	0.615	0.0189	0.798×10^{-3}	1.001×10^{-5}	5.42	1.00	0.294×10^{-3}
35	5.628	994.0	0.0397	2419	4178	1880	0.623	0.0192	0.720×10^{-3}	1.016×10^{-5}	4.83	1.00	0.337×10^{-3}
40	7.384	992.1	0.0512	2407	4179	1885	0.631	0.0196	0.653×10^{-3}	1.031×10^{-5}	4.32	1.00	0.377×10^{-3}
45	9.593	990.1	0.0655	2395	4180	1892	0.637	0.0200	0.596×10^{-3}	1.046×10^{-5}	3.91	1.00	0.415×10^{-3}
50	12.35	988.1	0.0831	2383	4181	1900	0.644	0.0204	0.547×10^{-3}	1.062×10^{-5}	3.55	1.00	0.451×10^{-3}
55	15.76	985.2	0.1045	2371	4183	1908	0.649	0.0208	0.504×10^{-3}	1.077×10^{-5}	3.25	1.00	0.484×10^{-3}
60	19.94	983.3	0.1304	2359	4185	1916	0.654	0.0212	0.467×10^{-3}	1.093×10^{-5}	2.99	1.00	0.517×10^{-3}
65	25.03	980.4	0.1614	2346	4187	1926	0.659	0.0216	0.433×10^{-3}	1.110×10^{-5}	2.75	1.00	0.548×10^{-3}
70	31.19	977.5	0.1983	2334	4190	1936	0.663	0.0221	0.404×10^{-3}	1.126×10^{-5}	2.55	1.00	0.578×10^{-3}
75	38.58	974.7	0.2421	2321	4193	1948	0.667	0.0225	0.378×10^{-3}	1.142×10^{-5}	2.38	1.00	0.607×10^{-3}
80	47.39	971.8	0.2935	2309	4197	1962	0.670	0.0230	0.355×10^{-3}	1.159×10^{-5}	2.22	1.00	0.653×10^{-3}
85	57.83	968.1	0.3536	2296	4201	1977	0.673	0.0235	0.333×10^{-3}	1.176×10^{-5}	2.08	1.00	0.670×10^{-3}
90	70.14	965.3	0.4235	2283	4206	1993	0.675	0.0240	0.315×10^{-3}	1.193×10^{-5}	1.96	1.00	0.702×10^{-3}
95	84.55	961.5	0.5045	2270	4212	2010	0.677	0.0246	0.297×10^{-3}	1.210×10^{-5}	1.85	1.00	0.716×10^{-3}
100	101.33	957.9	0.5978	2257	4217	2029	0.679	0.0251	0.282×10^{-3}	1.227×10^{-5}	1.75	1.00	0.750×10^{-3}
110	143.27	950.6	0.8263	2230	4229	2071	0.682	0.0262	0.255×10^{-3}	1.261×10^{-5}	1.58	1.00	0.798×10^{-3}
120	198.53	943.4	1.121	2203	4244	2120	0.683	0.0275	0.232×10^{-3}	1.296×10^{-5}	1.44	1.00	0.858×10^{-3}
130	270.1	934.6	1.496	2174	4263	2177	0.684	0.0288	0.213×10^{-3}	1.330×10^{-5}	1.33	1.01	0.913×10^{-3}
140	361.3	921.7	1.965	2145	4286	2244	0.683	0.0301	0.197×10^{-3}	1.365×10^{-5}	1.24	1.02	0.970×10^{-3}
150	475.8	916.6	2.546	2114	4311	2314	0.682	0.0316	0.183×10^{-3}	1.399×10^{-5}	1.16	1.02	1.025×10^{-3}
160	617.8	907.4	3.256	2083	4340	2420	0.680	0.0331	0.170×10^{-3}	1.434×10^{-5}	1.09	1.05	1.145×10^{-3}
170	791.7	897.7	4.119	2050	4370	2490	0.677	0.0347	0.160×10^{-3}	1.468×10^{-5}	1.03	1.05	1.178×10^{-3}
180	1,002.1	887.3	5.153	2015	4410	2590	0.673	0.0364	0.150×10^{-3}	1.502×10^{-5}	0.983	1.07	1.210×10^{-3}
190	1,254.4	876.4	6.388	1979	4460	2710	0.669	0.0382	0.142×10^{-3}	1.537×10^{-5}	0.947	1.09	1.280×10^{-3}
200	1,553.8	864.3	7.852	1941	4500	2840	0.663	0.0401	0.134×10^{-3}	1.571×10^{-5}	0.910	1.11	1.350×10^{-3}
220	2,318	840.3	11.60	1859	4610	3110	0.650	0.0442	0.122×10^{-3}	1.641×10^{-5}	0.865	1.15	1.520×10^{-3}
240	3,344	813.7	16.73	1767	4760	3520	0.632	0.0487	0.111×10^{-3}	1.712×10^{-5}	0.836	1.24	1.720×10^{-3}
260	4,688	783.7	23.69	1663	4970	4070	0.609	0.0540	0.102×10^{-3}	1.788×10^{-5}	0.832	1.35	2.000×10^{-3}
280	6,412	750.8	33.15	1544	5280	4835	0.581	0.0605	0.094×10^{-3}	1.870×10^{-5}	0.854	1.49	2.380×10^{-3}
300	8,581	713.8	46.15	1405	5750	5980	0.548	0.0695	0.086×10^{-3}	1.965×10^{-5}	0.902	1.69	2.950×10^{-3}
320	11,274	667.1	64.57	1239	6540	7900	0.509	0.0836	0.078×10^{-3}	2.084×10^{-5}	1.00	1.97	
340	14,586	610.5	92.62	1028	8240	11,870	0.469	0.110	0.070×10^{-3}	2.255×10^{-5}	1.23	2.43	
360	18,651	528.3	144.0	720	14,690	25,800	0.427	0.178	0.060×10^{-3}	2.571×10^{-5}	2.06	3.73	
374.14	22,090	317.0	317.0	0	—	—	—	—	0.043×10^{-3}	4.313×10^{-5}			