First Semester Examination
Academic Session 2021/2022

February/March 2022

EAP581 – Water Supply Engineering

Duration : 2 hours

Please ensure that this examination paper contains **EIGHT (8)** printed pages before you begin the examination.

Instructions: This paper contains **FIVE (5)** questions. Answer **FOUR** questions.

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

(1). (a). A moderate-scale residential area consists of 60 unit double storey terrace houses, 40 unit double storey semi detached houses and 20 unit single storey bungalow houses with ordinary construction and the floor area of 2480, 2912 and 3500 square feet, respectively. With the aid of following information, estimate the fire demand and the total flow required in one day.

Table 1: Estimated Water Demand Rate for Planning of External Water Reticulation System

Type of Premises/Buildings	Average Daily Water Demand (Litres)
Low cost terrace house / low cost flat	1100 / unit
Single storey terrace house / low cost house (less than RM25,000) / low medium & medium cost flats	1300 / unit
Double storey terrace house / high cost flat / apartment / town house	1500 / unit
Semi detached house / cluster	2000 / unit
Bungalow/ condominium	2000 / unit

Uniform Technical Guidelines, Suruhanjaya Perkhidmatan Air Negara (SPAN)

Table 2: Residential flow duration

Required fire flow (litre/minute)	Duration (hour)
< 3780 (<1000gpm)	4
3780 – 4725 (1000 – 1250 gpm)	5
4725 – 5670 (1250 – 1500 gpm)	6
5670 – 6615 (1500 – 1750 gpm)	7
6615 – 7560 (1750 – 2000 gpm)	8
7560 – 8505 (2000 – 2250 gpm)	9
> 8505 (>2250 gpm)	10

[8 marks]

(b). River water sample was tested on the ionic composition. **Figure 1** shows an ion balance chart for all the ionic composition in the river water.

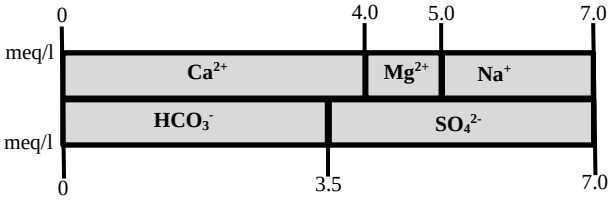


Figure 1: Ion balance bar chart of a river water sample

Calculate the total, carbonate and non-carbonate hardness concentation in mg/l as $CaCO_3$.

[9 marks]

(c). Non-revenue water has become one of the major issues in sustainability water management. Based on your understanding, explain the incidence of non- revenue water in Malaysia and **THREE (3)** suitable measures to overcome it.

[8 marks]

(2). A column analysis of a flocculating suspension is shown below. The initial solids concentration is 200 mg/L. The resulting matrix is given in **Table 3**.

Table 3: Concentrated solids measured (mg/L) for a flocculent settlement column test.

Depth (m)	**Time of sampling (minutes)**					
	30	**60**	**90**	**120**	**150**	**180**
0.5	135	85	53	40	31	25
1	181	123	92	64	54	45
1.5	202	149	120	95	71	55
2	215	167	133	111	92	67
2.5	218	177	143	121	105	83
3	227	189	157	134	115	97

(a). Calculate the removal fraction at each depth and time.

[10 marks]

(b). Based on the isoremoval flocculent sedimentation diagram given in **Appendix 2**, calculate the overall removal efficiency of a settling basin which is 3 meters deep with a detention time of 1 hour and 45 minutes.

[10 marks]

(c). Sedimentation is applied in several sections of a water treatment plant including prior to filtration and after coagulation. Based on Newton's law, explain **TWO (2)** approaches to troubleshoot any challenges that may hinder optimum settling rate.

[5 marks]

(3). (a). The action of metallic coagulants during coagulation involves the dissolution of the coagulant salt added. Explain the complete hydrolysis equation of an aluminium sulfate coagulant added in the water suspension. Describe the species of the aluminium sulfate compound that will precede in the coagulation process.

[10 marks]

(b). Describe using a schematic diagram of a general model how the colloidal particles interact between one another in the coagulation reactor. Highlight and elaborate **THREE (3)** key points.

[11 marks]

(c). Explain **TWO (2)** mechanisms of the filtration processes using different materials. Use examples to provide your explanation.

[4 marks]

(4). (a). **Figure 2** shows a 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. The lengths and diameters for pipes AB, BC, CD, and AD are as follows:

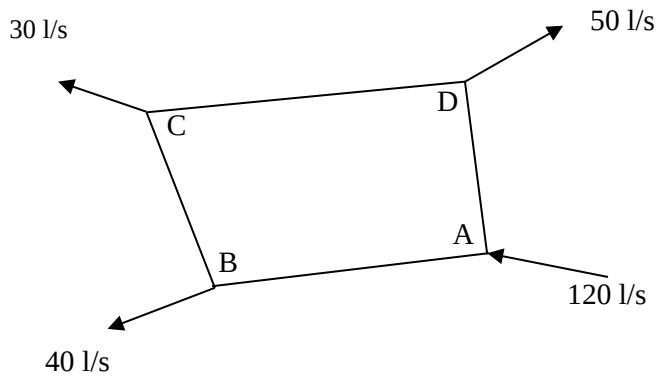


Figure 2: Water reticulation system

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

Pipe BC: length = 750 m and diameter = 200 mm

Pipe CD: length = 950 m and diameter = 250 mm

Pipe AD: length = 750 m and diameter = 200 mm

[15 marks]

(b). A pond is used to treat an industrial wastewater before the liquid is discharged into a river. The inflow to the pond has a flow rate of 3500 m^3/day and a BOD concentration of 70 mg/L. The volume of the pond is 20,000 m^3. The purpose of the pond is to allow time for the decay of BOD to occur before discharge into the environment. BOD decays in the pond with a first-order rate constant equal to 0.27 day^{-1}. With the help of sketches, determine the BOD concentration at the outflow of the pond, in units of mg/L. Conclude if the BOD of the effluent from the pond satisfies either Class A or B for the Industrial Effluent (Fifth Schedule EQR 2009).

[10 marks]

(5). (a). Dissolved air flotation is one of the advanced water treatment processes. Discuss important mechanisms for bubble-floc attachment in the process.

[6 marks]

(b). A groundwater borehole at USM engineering campus contains 3000 mg/L of TDS. The flow is 0.32 m^3/s. The design TDS concentration of the product water is below 400 mg/L. The net pressure is 40 atm. The membrane manufacturer provides that the membrane has a water flux rate coefficient of 2.2 x 10^{-6} s/m and a solute mass transfer rate of 1.5 x 10^{-6} m/s. Calculate the membrane area required for the RO system.

[12 marks]

(c). A water treatment at Nibong Tebal receiving a raw water contains a concentration of 0.5 µg/m^3 atrazine from Kerian River. In order to comply with the drinking water quality guideline, the treatment plant should reduce the concentration of Atrazine to 0.1 µg/L. If the dosing of powdered activated carbon have been applied before the coagulation, calculate the minimal dose of PAC in mg/m^3.

[7 marks]

APPENDIX 1

P = 180t-0.1

Max daily demand = 180% of annual average

Max weekly demand = 148% of annual average

Max monthly demand = 128% of annual average

Max hourly demand (Peak hour rate) = 150% of max daily demand

F = 18C(A)0.5

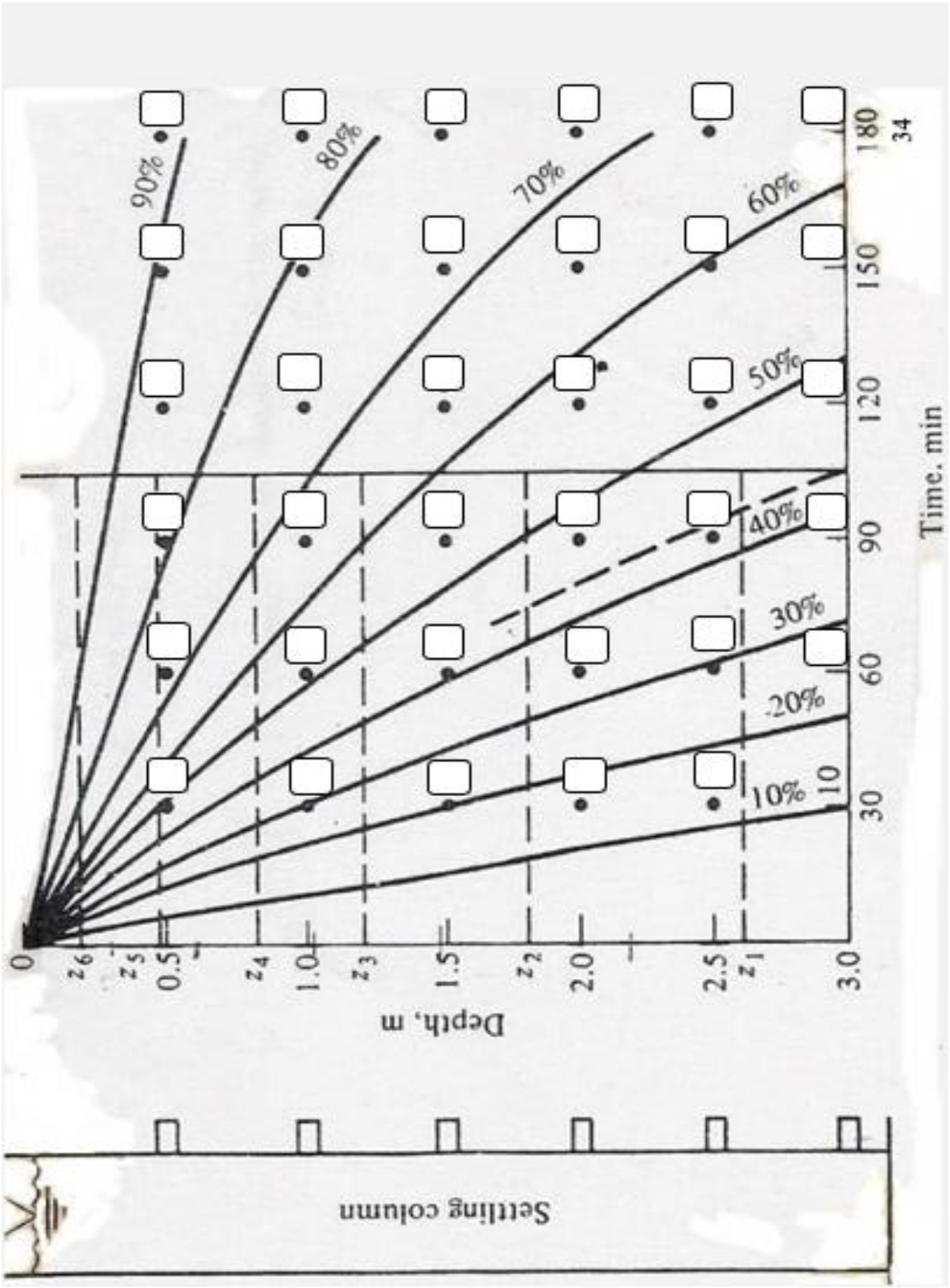
C = 1.5 for wood construction

= 1.0 for ordinary construction

= 0.8 for non-combustible contruction

= 0.6 for fire resistive contruction

APPENDIX 2



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