M.E. (Water Resources & Hydraulic Engineering) Examination, 2024

(1st Semester)

WATER WORKS ENGINEERING

(Paper - V)

Time : Three Hours   Full Marks : 100

Answer any ***four*** questions.

1. (a) The water with following chemical constituents is to be softened using quantities of following Lime Soda Ash Process. Compute the quantities Chemicals required (lime as CaO and soda ash as of Na_2CO_3) to treat 250 m^3/hr. water flow assuming practical units of removal for $CaCO_3$ to be 30 mg/L and for Mg $(OH)_2$ as 10 mg/L. Also prepare a meq/L bar graph of raw and finished water with hypothetical consideration.

CO_2 = 9.9 mg/L; Ca^{+2} = 100 mg/L; Mg^{2+}= 8.9 mg/L; Na^+ = 11.5 mg/L; Alkalinity = 175 mg/L; SO_4^{-2} = 107 mg/L, Cl^- = 17.8 mg/L

(b) Design a secondary Circular sedimentation tank to remove alum with following data,

Average flow= 250 m^3/hr., water lost in desludging = 2%.

Minimum size of alum floc to be removed= 0.8 mm; specific gravity of alum=1.002; Expected removal efficiency of alum = 80%, Assumed Performance of settling = very good (n=1/8); Kinematic viscosity of water at 20^0C= $1.01\text{x}10^{-6}$ m^2/s

Also check whether Stoke's law is applicable.   15+10

2. (a) Water is passed through a filter bed at 5000 lts/h/m^2. The bed is 0.75 m deep and is composed of non-uniform sand (sp. Gravity 2.65) stratified so that the smallest particles are on top and the largest on bottom. The porosity and shape factors are 0.42 and 0.87 throughout the depth of the bed. The size distribution of the granules is given in the table below. Determine the head loss for clear water through the bed.

U.S. Sieve no		Particle size range mm		Average size d_{ij}, mm	Mass fraction in size range X_{ij}
Passing	Retained	Passing	Retained		
	14		1.41	1.41	0.01
14	20	1.41	0.84	1.13	0.11
20	25	0.84	0.71	0.78	0.20
25	30	0.71	0.60	0.66	0.32
30	35	0.60	0.50	0.55	0.21
35	40	0.50	0.42	0.46	0.13
40		0.42		0.42	0.02

Dynamic Viscosity = 1.002 x 10^{-3} kg/m-sec

(b) A small water treatment unit is to be constructed for supplying water in a village having present population of 9000. Draw a suitable scheme for village water supply. Water quality analysis report (Surface Water is as follows) pH: 7.6; Suspended Solids: 220 mg/L;TH: 140 mg/L (as $CaCO_3$); Chloride as Cl: 70 mg/L; Fecal Coliform : 1800 MPN per 100 ml. Assume any other data during design if necessary.

E values for HRF

Gravel size	Filtration rate (lts/hr/m^2)	Filter length (m)			
		1	2	3	4
5mm	750	28.3	8.0	2.3	0.6
	1000	39.9	15.9	6.4	2.5
10 mm	750	50.7	27.7	13.0	6.7
	1000	61.7	38.1	23.5	14.5
15 mm	750	62.4	39.0	24.3	15.2
	1000	72.1	51.9	37.4	27.0
20 mm	750	69.6	48.5	33.7	23.5
	1000	78.1	61.0	47.6	37.2

3. (a) Explain briefly the physical and chemical forces which govern coagulation and flocculation.

(b) A water treatment plant is being designed to process 70000 m^3/day of water. Jar testing and pilot plant analysis indicate that an alarm dosage of 60 mg/l with flocculation at a G*t value of 5.5 x10^4 produces optimal results at the expected water temperature of 18°C. Determine:

(i) The monthly alum requirement

(ii) The flocculation basin dimension if three cross flow horizontal paddles are to be used. The flocculator should be a maximum 12 m wide and 5 m deep in order to connect appropriately with settling basin

(iii) The power requirement

(iv) Size and number of paddles configuration

(v) Draw sketch of flocculator and paddles.

Given: At 18°C, μ=1.053 x10^{-3} NS/m^2 ; At 18°C density of water = 998.7 kg/m^3

C_D=1.9 (Assume any other data if required)

5+20=25

4.(a) Briefly discuss the theory of flocculation. On What factors flocculation depends?

(b) Briefly discuss design criteria and guidelines for rapid mixing unit.

(c) A rapid mixing unit is to be designed for dosing alum for water treatment. The following data may be used for calculation.

Design flow to be treated = 6.5 MLD, Detention time = 40 sec, Ratio of tank height to diameter = 2: 1, Ratio of impeller diameter to tank diameter = 0.3: 1, Rotational speed of impeller = 130 rpm, velocity gradient = 500/sec, viscosity of water =1.0087x10^{-3} N-s/m^2

Calculate the following:

(i) Dimension of rapid mixing tank

(ii) Power requirement

(iii) Dimension of mixing system

6+6+13=25

5. (a) How is the staging height of an overheard reservoir selected for a water supply distribution network?

(b) Calculate the Langelier Index and Ryznar Index of a water sample whose temperature is 20^0C, pH is 8.2, TDS is 270 mg/l, calcium ion concentration is 60 m/l as Ca^{2+}, total alkalinity (bicarbonate only) is 80 mg/l as $CaCO_3$. Suggest a chemical name for stability adjustment, if any. Then determine the amount of daily chemical dosing to maintain the Ryznar Index. Assume any other data, if required.

(c)The hourly time-plant output-pump flow data for a distribution system are given here. The water is pumped into an elevated storage reservoir at a variable rate as given below.

Time	Plant output (10^3 m^3/h)	High Service pumping flow (10^3 m^3/h)	Time	Plant output (10^3 m^3/h)	High Service pumping flow (10^3 m^3/h)
1 am	4.75	2.84	1 pm	4.75	5.7
2	4.75	2.84	2	4.75	5.7
3	4.75	2.84	3	4.75	5.7
4	4.75	2.84	4	4.75	5.7
5	4.75	2.84	5	4.75	5.7
6	4.75	2.84	6	4.75	5.7
7	4.75	5.7	7	4.75	5.7
8	4.75	5.7	8	4.75	5.7
9	4.75	5.7	9	4.75	5.7
10	4.75	5.7	10	4.75	5.7
11	4.75	5.7	11	4.75	2.84
12 noon	4.75	5.7	12 mn	4.74	2.83

Determine the water demand for chemical dilution and feed water, clearwell volume for pump operation water demand, for in-plant domestic water demand, for filter backwash water demand, balancing of plant output and high service pumping rate. Finally, estimate the dimensions of the clearwell by using the mass diagram method.

2+7+16 = 25

Table Values of $pK_2 - pK_s$ with Respect to Temperature and Total Dissolved Solids (TDS)

TDS, mg/L	$pK_2 - pK_s$ 0°C	10°C	20°C	30°C	40°C	50°C	80°C
	2.45	2.23	2.02	1.86	1.68	1.52	1.08
40	2.58	2.36	2.15	1.99	1.81	1.65	1.21
80	2.62	2.40	2.19	2.03	1.85	1.69	1.25
120	2.66	2.44	2.23	2.07	1.89	1.73	1.29
160	2.68	2.46	2.25	2.09	1.91	1.75	1.31
200	2.71	2.49	2.28	2.12	1.94	1.78	1.34
240	2.74	2.52	2.31	2.15	1.97	1.81	1.37
280	2.76	2.54	2.33	2.17	1.99	1.83	1.39
320	2.78	2.56	2.35	2.19	2.01	1.85	1.41

6. (a) A municipal water supply has total dissolved solids (TDS) concentration of 1000 mg/L. Develop the design and size various component of a reverse osmosis system to produce finish water having a TDS concentration of less than 300 mg/L. The Plant Capacity is 19000 m^3/d. Use the following data.

Plant Information

Plant Design Capacity	19000 m^3/d
Feed Water temperature	27° C
TDS raw water	1000 mg/L
TDS finish water	300 mg/L

Manufacturer information

Recovery factor, R	75 %
Salt rejection factor, S	95%
Design pressure	4140 kN/m^2
Flux rate	0.82 m^3/m^2d

(b) Briefly describe the ion-exchange process with process flow diagram.

20+5=25