M.E. (Water Resources & Hydraulic Engineering) Examination, 2025

(1st Semester)

WATER WORKS ENGINEERING

(Paper - Program Core 2)

Time : Three Hours Full Marks : 100

Answer any ***four*** questions.

1. (a) Design a mechanical rapid mixing unit with following data for the treatment plant – design flow 250 m^3/h, detention time 30 sec, ratio of tank height to tank diameter = 1.5:1, ratio of impeller diameter to tank diameter = 0.4:1. Rotational speed of impeller 120 rpm, velocity gradient 600 sec^{-1}. Assume temp 20^0C and any suitable data as per the guideline.

   (b) Discus briefly the concept of colloidal stability, electric double layer, and zeta potential in connection with the coagulation process in water treatment.

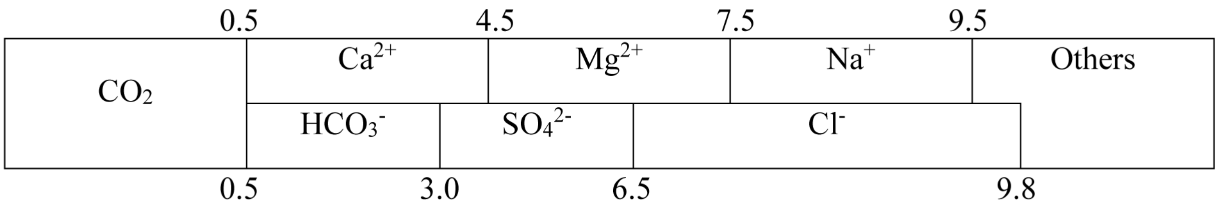
   15+10=25

2. (a) A water treatment plant is being designed for 60,000 m^3/day of water. Jar testing and pilot plant analysis indicate that an alum dosage of 40 mg/l with flocculation at a G*t of 4.5 * 10^4 produces optimal results at the expected water temperature of 15°C. Determine (i) monthly alum requirement (ii) flocculation basin dimension if 3 cross flow horizontal pedals are to be used, and (iii) flocculator should be of maximum 12 m wide and 5 m deep to connect the settling basin (iv) power requirement (v) pedal configuration. Take μ = 1.139 * 10^{-3} N-s/m^2 at 15°C. Assume any other data if required as per CPHEEO Manual.

   (b) A water treatment plant is to be designed with vertical blades. Water enters through a central influent pipe and is fed into the flocculation zone through pores. The effluent from flocculation zone passes below the partition wall dividing the flocculator portion and the clarifier portion. The clarifier effluent is collected by a peripheral effluent launder. The components of the clariflocculator are to be designed, including the influent pipe, the flocculator, the clarifier, and the effluent launder. Consider desired average outflow = 250 m^3/h, water lost in de-sludging = 2%, detention time = 20 minutes, G value = 40 s^{-1}. Design a circular clariflocculator. Assume any other data if required as per CPHEEO Manual.

   10+15=25

3. (a) A water treatment plant processes 24,500 m^3/day of water.



   (i) Determine the quantities of chemical (kg/day) required to soften this water to the minimum possible hardness by two stage lime soda ash softening.

   (ii) Draw a bar diagram for the finished water.

(iii)Calculate the dry mass of the solids in the sludge.

(b) A water treatment plant is to be installed for a Peri-Urban area. The present population is 25000, and per capita water supply is 70 L/day. Consider additional water requirement, including unaccounted water as 85% with 16 hours running. The raw water quality is as follows:

pH: 7.4, Suspended Solids: 190 mg/L, Total Hardness: 120 mg/L, Chloride: 30 mg/L

Total Coliform: 3600/ 100 ml, Fecal Coliform :1800/ 100 ml.

Design the water treatment Plant (HRF-SSF).

E-Values of HRF

Gravel Size (mm	Filtration Rate (m/hr)	Efficiency (%)			
		Filter length (m)	1 m	2 m	3 m
20 mm	0.5		56.9	32.4	18.4
	0.75		69.6	48.5	33.7
	1.0		78.1	61.0	47.6
15 mm	0.5		48.4	23.5	11.4
	0.75		62.4	39.0	24.3
	1.0		72.1	51.9	37.4
10 mm	0.5		35.6	12.7	4.5
	0.75		50.7	27.7	13.0
	1.0		61.7	38.1	23.5
5 mm	0.5		15.2	2.3	0.4
	0.75		28.3	8.0	2.3
	1.0		39.9	15.9	6.4

7+18=25

4. (a) Water is passed through a rapid sand filter bed at 6500 lt/hr/m^2. The bed slope is 0.85 m deep and is composed of non-uniform sand (sp. gr. 2.65) stratified so that the smallest particles are on top and the largest on the bottom. The porosity and shape factors are 0.45 and 0.86 throughout the depth of the bed. The size distribution of the granules is given in the table below. Determine the head loss for water flow through the bed.

Sieve analysis

U S Sieve No				Average Size (mm)	Mass fraction in size range
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

(b) Differentiate between slow sand filter and rapid sand filter. Also, state the specification of both the filters.

15+10=25

5. a) What do you mean by water stability? Differentiate between corrosive water and scaling water.

b) A marble test is conducted on a water sample. The beginning alkalinity is 90 mg/l as $CaCO_3$. The ending alkalinity is 120 mg/l as $CaCO_3$. Is the water scaling or corrosive? Discuss any optional treatment needs.

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

d) Why is it necessary to determine the disinfection contact period in estimating the storage of a clearwell?

e) The hourly time-demand data for a distribution system are given here. The water is pumped into an elevated storage reservoir at a constant rate of 1069.32 m^3/h. Determine the reservoir capacity by using the deficiency method.

Time	Demand (LPM)	Time	Demand (LPM)
1 am	7220	1 pm	24586
2	7125	2	24548
3	6992	3	24472
4	6821	4	24776
5	6978	5	25498
6	7296	6	27037
7	12236	7	34238
8	19000	8	33060
9	21090	9	20216
10	22876	10	8436
11	23636	11	8018
12 noon	24016	12 midnight	7600

4+5+2+2+12 = 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) Define the term non-conventional water treatment process.

   b) Briefly describe the ion exchange process along with a process flow diagram.

   c) 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^2.d

2+6+17=25