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B.Sc. Engg. (CEE)/ 4th Sem. 08 May, 2023 (Group B)

# ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
## ORGANISATION OF ISLAMIC COPERATION (OIC)
## DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

**Semester Final Examination** **Summer Semester: 2021-2022**
**Course No.: CEE 4431** **Full Marks: 150**
**Course Title: Water Supply Engineering** **Time: 3.0 hours**

There are 7 (Seven) questions. **Questions 1, 6 and 7 are compulsory**. Answer any **3 questions from Q2, 3, 4 and 5.** The related CO-PO and marks are shown in the right. Programmable calculators are not allowed. Do not write on this question paper. The symbols have their usual meaning.

1(a) Per Capita water consumption is very important in designing a water supply system. How can you calculate the per capita water demand of a community? How to calculate the peak water demand of a community? CO1, PO1: (04)

(b) List the impurities that should be removed from raw water in order to make water safe for drinking and suitable for domestic uses? What are the treatment methods that could be used for removing those impurities from the water? CO1, PO1: (05)

(c) A ground water sample has the following chemical analysis at $20^{O}C$. CO1, PO1: (06)

| Cations | Conc. (mg/L) | Anions | Conc. (mg/L) |
|---|---|---|---|
| $Ca^{+2}$ | 180 | $HCO_3^-$ | 300 |
| $Mg^{+2}$ | 65 | $CO_3^{-2}$ | 40 |
| $Na^+$ | 60 | $SO_4^{-2}$ | 60 |
| $K^+$ | 20 | $Cl^-$ | 348 |
| $Fe^{+2}$ | 0.5 | $NO_3^-$ | 35 |

(i) Calculate the total hardness, non-carbonate hardness and alkalinity of the water in mg/L as $CaCO_3$.

(ii) This water needs to be treated by Caustic Soda for hardness removal. Calculate the amount of Caustic Soda required for hardness removal.

2(a) What are the basic differences of shallow, intermediate and deep tubewell? Water from PSF and RWH may contain pathogenic microorganisms. What disinfection strategies can be adopted for the disinfection of water from (i) PSF and (ii) RWH? CO2, PO2: (06)

(b) (i) An engineer has proposed to add coagulants to improve the Type I solids removal in the sedimentation process and thereby increase the overall solids removal. Will this increase the removal of Type I solids in sedimentation process and why? CO2, PO2: (06)

(ii) The performance of a circular basin is higher than a horizontal flow rectangular basin. Explain the reasons with settling diagram.

(c) State the guidelines for the design of slow sand and rapid sand filtration units. Mentions the operation and maintenance problems of rapid sand filter. Why slow sand filter is not used in water treatment plants in Bangladesh? CO2, PO2: (07)

(d) In a rural area, the water from shallow TW contains excessive amount of both Fe and Mn. It is required to remove both Fe and Mn in a single treatment plant. Draw the process flow diagram for the simultaneous removal of Fe and Mn from the water. State the purpose of each step of your process flow diagram. CO2, PO2: (06)

3(a) What are the causes of alkalinity in water? Explain the type of hardness present in water under the following conditions:

i. When alkalinity = hardness
ii. When alkalinity > hardness and pH < 8.3
iii. When alkalinity < hardness

(b) What are effect of water pH and coagulant dosage on the Coagulation and Flocculation processes? Using the appropriate chemical reaction, calculate how much alkalinity will be consumed by the addition of 1.0 mg/L of $FeCl_3$ in coagulation process. CO2, PO2: (06)

(c) Differentiate between primary disinfection and secondary disinfection? Under what conditions, the secondary disinfection is essential and what is the usual practice of secondary disinfection and why? CO2, PO2: (05)

(d) Which type of tubewell will you suggest for the following cases of ground water table: CO2, PO2: (03)

(i) 1.0 m below the ground surface
(ii) 5.5 m below the ground surface
(iii) 10.0 m below the ground surface.

(e) What are the mechanisms to be followed for the removal of colloidal particles from water? CO2, PO2: (06)

A clarifier with an area of 150 $m^2$ treats a flow of 3000 $m^3$/day. The water entering the clarifier contains a substantial number of clay particles with a specific gravity of 1.05 and a diameter of 0.05 mm. What percentage of these particles will be removed in the clarifier? ($\rho$ = 0.99823 and $\mu$ = 1.0087 centipoise at $20^0$C)?

4(a) What are the health risks associated with dug well water, if the water is not chlorinated and the water is chlorinated? CO2, PO2: (06)

What is the allowable limit of THMs in drinking water? State the strategies that can be followed in controlling THMs formation in the treated water.

(b) Calculate the volume of chlorine contact basin and the quantity of chlorine needed in kg/day. The average design flow is 0.2 $m^3$/sec, the contact time is 15 minutes, total chlorine demand is 6.0 mg/L and the chlorine residual maintained is 1.5 mg/L. CO2, PO2: (06)

(c) Based on a hydraulic analysis, it was found that the travel time for water to be carried to the most distant customer is 20 hours in Gazipur city area. A laboratory study of the decay of chlorine in the filtered water yielded the results shown below. What **dose of chlorine** is required to maintain a residual of 0.55 mg/L of chlorine at the most distant customer's tap? The decay of chlorine in water can be expressed as' CO2, PO2: (07)

$$C_t = C_0 e^{-kt}$$

| Time (hr) | Chlorine residual, mg/L |
|---|---|
| 0 | 1.1 |
| 1 | 1.02 |
| 3 | 0.90 |
| 6 | 0.76 |

(d) (i) Why aeration is more commonly used in groundwater than surface water? CO2, PO2: (06)
(ii) Why lime-soda softening process cannot produce water completely free of hardness?
(iii) In chlorination, it is desirable to maintain a lower pH-explain why?

5(a) What are the desirable properties of pressure pipe? A water transmission line is placed in the middle of Mirpur road. List the external loads that should be considered in designing a pipe section for this transmission line. State the recommended procedure for testing of a newly constructed pipeline. CO2, PO2: (06)

(b) A baffled flocculation basin is divided into 16 channels by 15 around-the-end baffles. The velocities at the channels and at the slots are 0.65 and 2.2 ft/sec, respectively. The flow rate is 15.5 $ft^3$/sec. Find (i) the total head loss neglecting channel friction; (ii) the power dissipated, (iii) the mean velocity gradient at $60^0$F; the basin size is 16 x 15 x 80 $ft^3$ and (iv) average loading rate. Assuming $\mu = 2.359 \times 10^{-5}$ lb.sec/$ft^2$ at $60^0$ F. CO2, PO2: (07)

(c) What are the objectives of undertaking Water Safety Plan (WSP)? List the major activities involved in a WSP. Describe different categories of likelihood and impact of determining risk scores. CO2, PO2: (06)

(d) Drinking water is supplied to a Pourashava from ground water extracted via DTWs and through a piped distribution with good quality control measures in place. The ground water contains high concentrations of both Iron (10.0 mg/L) and Arsenic (1.0 mg/L). There is risk of ingress of contamination when there is low/no pressure in the system. Ignoring any control measures, calculate "raw risk" score and category for these three hazardous events: (i) high Fe conc. in ground water, (ii) high As conc. in ground water; and (iii) ingress of contaminants to the distribution system. CO2, PO2: (06)

Recalculate the risk score and risk category of the water supply system as mentioned above considering control measures as follows: an arsenic-iron removal plant (AIRP) for removal of arsenic and iron (for this example, assume that the IRP operates effectively, and brings down arsenic and iron concentration below the respective national drinking water standards of 0.05 mg/L and 1.0 mg/L, respectively.

6(a) A water has the following ionic constituents in mequiv/L: CO3, PO3: (14)

$Ca^{+2} = 4.7$ $HCO_3^- = 2.5$

$Mg_{+2} = 1.0$ $SO_4^{-2} = 2.9$

$Na^+ = 2.2$ $Cl^- = 2.5$

$CO_2 = 0.6$

Design of an ion exchange system (volume of the resin and tank configuration) used to treat this raw water to allow continuous operation if the regeneration time is 2 hours.

The resin has an exchange capacity of 95 kg/$m^3$ when operated at a flow rate of 0.35 $m^3/m^2$.min. Calculate also NaCl requirement for regenerating of ion-exchange system, if regeneration is accomplished using 140 kg of sodium chloride per cubic meter of resin in 10% solution.

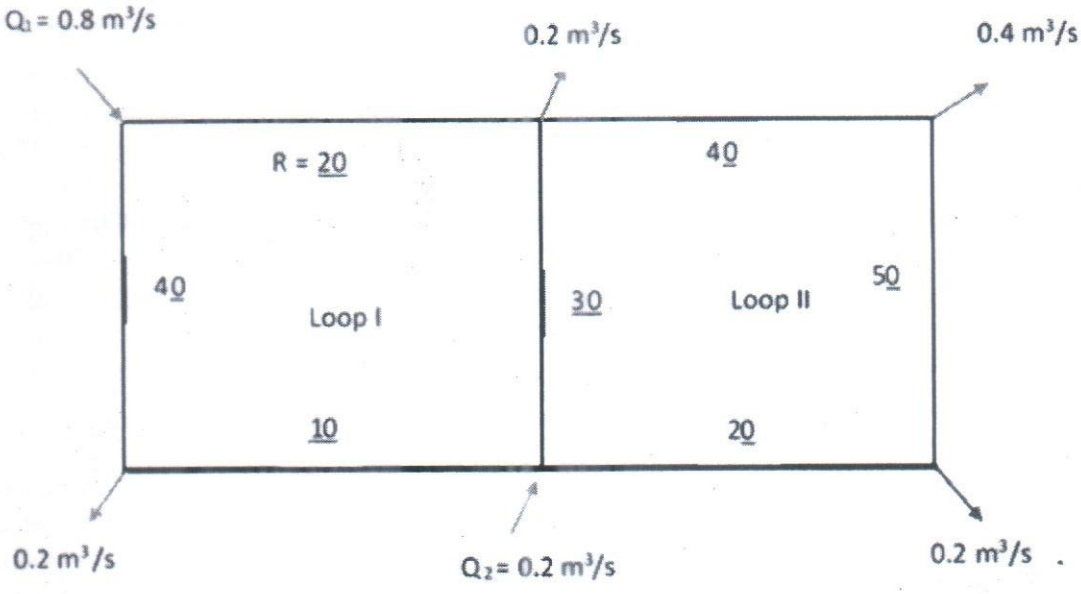
(b) The results of sieve analysis test carried out on a 508 gm sand sample collected from an aquifer proposed for installing a tubewell is given below. CO3, PO3: (15)

| Sieve size (mm) | >2.54 | 1.80 | 0.98 | 0.30 | 0.25 | 0.21 | 0.16 | 0.12 | <0.12 |
|---|---|---|---|---|---|---|---|---|---|
| Wt. of material retained (gm) | 0 | 12 | 18 | 32 | 302 | 28 | 54 | 38 | 24 |

Design the gravel pack and the slot size of the strainer to be used for the tubewell. The diameter of the well strainer is 100 mm and the opening of the strainer is 20% of the total surface area of the strainer, calculate the yield of this tubewell per meter length, assume entrance velocity = 0.02 m/sec.

(c) An engineer suggests the following design parameters for a city's proposed rapid sand filter: flow rate = 0.6 $m^3$/sec and loading rate to filter = 125.0 $m^3/m^2$-day. How much surface area is required for the filter? Select the number of equally sized rectangular filters with a width-to-length ratio of 1.0 to 2.5 and a maximum surface area of each filter tank being limited to 75 $m^2$. CO3, PO3: (06)

7(a) For the network as shown below, the head loss is given by $h = RQ^{1.85}$. The water supply and demand at each nodal point are also shown. Using the Hardy Gross method, design the network (diameter of each pipe). Assume a reasonable velocity of water in each pipe. Use at least 02 iterations. CO3, PO3: (15)




(b) Calculate the minimum capacity of the storage tank required for a family of 10 persons to be supplied with 12 lpcd of rainwater. The yearly rainfall intensity is 2400 mm and the rainfall distribution is such that at least 40% of the rainwater must be stored for uninterrupted water supply throughout the year. Also calculate the minimum catchment area required, if the runoff coefficient is 0.80. CO3, PO3: (05)

(c) A city must treat about 15,000 $m^3$/day of water. Flocculating particles are produced by coagulation, and a column analysis indicates that an overflow rate of 20 m/d will produce satisfactory removal at a depth of 2.5 m. Determine the size of the required settling tank (type II). CO3, PO3: (05)