Part A: Answer any eight of the following questions briefly to the point

Total marks 8 x 4 = 32

1. Explain with sketch the term break point chlorination and its application in the estimate of chlorine dosage

2. What are the differences between a slow and a rapid sand filter w.r.t performance, treatment methods, operation and sand characteristics?

3. Compare the contact times for Chlorination required in Delhi during summer with an average temperature of 35°C and winter with a temperature of 5°C for a 99.9%

4. Estimate the total quantity of water that must be processed and the quantity and quality of waste streams from a RO facility required to produce 4000 cum/d of water for industrial cooling operations. Assume both recovery (water) and rejection rates (solute) are equal to 90% and the concentration of feed water is 400g/m³

5. What are the three methods used for desalination of water? What are the pretreatment and post treatment required for the desalination unit using membranes?

6. Write the mass balance expression relating adsorption capacity and the concentration of adsorbate. What are the two isotherms used to describe the performance of an adsorbent?

7. Estimate the volume of the activated carbon adsorption column needed for removing phenol from water at a flow rate of 1000L/min and a detention time of 10 minutes. Given Initial Concentration 1.00mg/l, Final concentration 0.005mg/l, GAC density = 450 g/l. What is the life of the carbon column?

8. Define a) BOD b) COD c) Septic tank d) Constructed wetland

9. Discuss the removal mechanisms in Waste stabilization pond and an aerated lagoon using sketches and highlight the difference between the two.

10. Differentiate between the following in one or two sentence along with sketches
    a. Adsorption and Absorption
    b. Electrodialysis and Reverse osmosis
Part B:

1. A hydrostatic head of 2 m is maintained above a 0.6 m deep of filter sand. The sand is uniformly sized with diameter 0.4 mm, specific gravity 2.65, and shape factor 0.85 and porosity 0.4. Determine the flow rate through the bed if the head measured at the bottom of the filter bed is 1 m. If the filter bed is to be expanded to 1.6 times its original depth during backwash. Determine the required backwash velocity (m/h).

2. Estimate the Chlorine dosage required for a 99.9 percent kill for a contact time of 40 minutes, at a temperature of 20°C and pH of 8.5. Experiments were conducted to arrive at the expression for the disinfection rate constant, K.

<table>
<thead>
<tr>
<th>S No</th>
<th>Concentration mg/l</th>
<th>Time min</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.05</td>
<td>18</td>
</tr>
<tr>
<td>2</td>
<td>0.07</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>0.14</td>
<td>4.7</td>
</tr>
</tbody>
</table>

Try to fit the data to the Chick Watson model. \( K = k' C^n \). You should get \( k' = 10.48 \) and \( n = 1.2 \). Results of Chlorine demand test on raw water are given below:

<table>
<thead>
<tr>
<th>Sample No</th>
<th>Chlorine dosage mg/l</th>
<th>Residual chlorine after 10 min contact (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.2</td>
<td>0.19</td>
</tr>
<tr>
<td>2</td>
<td>0.4</td>
<td>0.36</td>
</tr>
<tr>
<td>3</td>
<td>0.6</td>
<td>0.50</td>
</tr>
<tr>
<td>4</td>
<td>0.8</td>
<td>0.48</td>
</tr>
<tr>
<td>5</td>
<td>1.0</td>
<td>0.2</td>
</tr>
<tr>
<td>6</td>
<td>1.2</td>
<td>0.4</td>
</tr>
<tr>
<td>7</td>
<td>1.4</td>
<td>0.6</td>
</tr>
<tr>
<td>8</td>
<td>1.6</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Sketch a ‘chlorine demand curve’. What is the break point dosage and what is the actual chlorine dosage if residual requirement is 0.4 mg/l?
Design Criteria for water treatment units

1. Rapid mixer: Range of $G = 700$ to $1000 \text{s}^{-1}$ \hspace{1cm} (Use 1000\textsuperscript{°})
2. Flocculation basin $Gt = 10^4 - 10^5$ \hspace{1cm} (Use 105)
3. Surface loading rate: 12-18m\textsuperscript{3}/day/m\textsuperscript{2} \hspace{1cm} (Use 15 m\textsuperscript{3}/d/m\textsuperscript{2})
   - Depth discrete: 2.5 to 3m
   - Horizontal flow velocity, $v_h \leq 36 \text{ m/hr}$ (Heavy discrete)
   - Weir overflow rate, $v_w \leq 14 \text{ m}^3/\text{hr/m length}$ (Heavy discrete)
4. Slow sand filters rate $= 100$ to $200 \text{ l/h/m}^2$
   - Rapid sand filters rate $= 3000$ to $6000 \text{ l/h/m}^2$ (Use 5000 l/h/m\textsuperscript{2})
   - Pressure sand filters rate $= 6000$ to $15,000 \text{ l/h/m}^2$

Constants:
- $\mu_w = \text{Viscosity of water} = 1.139 \times 10^{-3} \text{Ns/m}^2$
- $\rho_w = \text{Density of water @25C} = 981 \text{ kg/m}^3$
- $R = \text{Universal Gas Constant} = 8.3144 \text{ J/mole.K}$
- $E = \text{Activation Energy for Cl}_2 @ \text{pH 7} = 34,340 \text{ J/mole}$

Formulae:
1. $G = (P/V\mu)^{1/2}$
2. $P = \frac{C_{10}A_{p}\rho_{w}v_{p}^{3}}{2}$
3. $h_f = \frac{\int\frac{L(1-e)v_{j}^{2}}{e^{3}gd_{p}}}{R_{z}}$
4. $f' = \frac{150(1-e)}{R_{z}} + 1.75$
5. $L_{\mu} = \frac{L(1-e)}{(1-e_{\mu})}$
6. $e_{b} = \left(\frac{v_{l}}{v_{l}}\right)^{5.22}$
7. $q_{e} = k_{j}C_{e}^{1/n}$
8. $q_{e} = \frac{abC_{e}}{(1+bC_{e})}$
9. $V_{j} = \frac{(\rho_{r} - \rho_{p})a^{2}}{18\mu}$
10. $F_{w} = k_{w}(\Delta P_{a} - \Delta \Pi)$
11. $F_{r} = k_{r}C_{r} = \frac{Q_{p}C_{p}}{A}$
12. $\ln\frac{t_{2}}{t_{1}} = \frac{E(T_{2} - T_{1})}{RT_{1}T_{2}}$