**MODULE 1**

**SOLVED NUMERICAL PROBLEMS**

**Problem 1:** Find the TON when odor is just barely detected in a flask containing 40 ml of sample water.

\[
TON = \frac{A + B}{A} = \frac{200 \text{ ml}}{200} = 5
\]

**Solution:**

**Problem 2:** The BOD6 of a wastewater is determined to be 400 mg/L at 20°C. The k value at 20°C is known to be 0.23 per day. What would be BOD8 value if tests were run at 15°C?

**Answer:** Solved using MATHCAD, however, can be solved otherwise also.

\[
\begin{align*}
BOD_{t,T} &= BOD_6 \left(1 - \exp(-k_T t)\right) \\
k_T &= k_{20} \left(\theta^{(T-20)} = k_{20} \left(1.047\right)^{(T-20)}\right)
\end{align*}
\]

Given that: \( BOD_{6,20} := 400 \text{ mg/L} \), \( k_{20} := 0.23 \text{ d}^{-1} \)

\[
BOD_u := \frac{BOD_{6,20}}{\left(1 - \exp\left(-k_{20} \cdot 6\right)\right)} = 534.458 \text{ mg/L}
\]

\[
k_{15} := k_{20} \cdot 1.047^{(15-20)} = 0.183 \text{ d}^{-1}
\]

\[
BOD_{8,15} := BOD_u \left(1 - \exp\left(-k_{15} \cdot 8\right)\right) = 410.643 \text{ mg/L}
\]

**Problem 3:** 6 ml of wastewater is diluted to 300 ml distilled water in standard BOD bottle. Initial DO in the bottle is determined to be 8.5 mg/l. DO after 5 days at 20°C is found to be 5 mg/l. Determine BOD5 of wastewater and compute the ultimate BOD.

**Soln.** We know,

\[
BOD_5 = \frac{(DO_0 - DO_5)}{V_w} \times (V_w + V_d) = \frac{(8.5 - 5)}{6} \times 300 = 175 \text{ mg/l}
\]

Since \( BOD_t = BOD_u \left(1 - e^{-kt}\right) \) at any particular temperature

\[
BOD_u = \frac{BOD_5}{1 - e^{-kt}} = 175 / \left(1 - e^{-5 \times 0.23}\right) = 256 \text{ mg/l}
\]
Problem 4: A 50 ml sample of water has an initial pH of 11.2. Determine the species and the quantity of each species of alkalinity if the 8.3 equivalence point is reached at 8 ml of 0.01 N H2SO4 and 4.5 equivalence point is reached at 18 ml of 0.01 N H2SO4.

Answer: Solved using MATHCAD, however, can be solved otherwise also.

\[ 1N \text{H}_2\text{SO}_4 = \frac{1N \text{H}_2\text{SO}_4}{L} \times \frac{1 \text{equiv}}{N \text{H}_2\text{SO}_4} \times 50000 \text{mg CaCO}_3 \times \frac{1 \text{equiv}}{1 \text{equiv}} = 50000 \text{mg/L as CaCO}_3 \]

If normality of H2SO4 used for titration is N_H2SO4

\[ N_{\text{H}_2\text{SO}_4} \text{NH}_2\text{SO}_4 = \frac{N_{\text{H}_2\text{SO}_4} \text{N}_2\text{SO}_4}{L} \times \frac{1 \text{equiv}}{N \text{H}_2\text{SO}_4} \times 50000 \text{mg CaCO}_3 \times \frac{1 \text{equiv}}{1 \text{equiv}} = N_{\text{H}_2\text{SO}_4} \times 50000 \text{mg/L as CaCO}_3 \]

If volume of N_H2SO4 Normal H2SO4 required to lower the pH of V volume solution to 4.5 is V_H2SO4,4.5 in litre, then

\[ A_T = \text{Totalalkalinity (in mg/L as CaCO}_3) = [\text{OH}^-] + [\text{CO}_3^{2-}] + [\text{HCO}_3^-] = \frac{50000V_{\text{H}_2\text{SO}_4,4.5}N_{\text{H}_2\text{SO}_4}}{\text{Volume of sample}} \text{mg/L as CaCO}_3 \]

\[ A_{OH} = [\text{OH}^-] \text{alkalinity (in mg/L as CaCO}_3) = \frac{10^{-\text{pOH}} \text{mol OH}^-}{L} = \frac{10^{-\text{pOH} + 14}}{L} \times \text{equiv} \times \frac{50000 \text{mg CaCO}_3}{1 \text{equiv}} \]

If volume of N_H2SO4 Normal H2SO4 required to lower the pH of V volume solution to 8.3 is V_H2SO4,8.3 in litre, then

\[ A_{OH+0.5 \text{CO}_3} = [\text{OH}^-] + \frac{1}{2} [\text{CO}_3^{2-}] \text{alkalinity (in mg/L as CaCO}_3) = \frac{50000V_{\text{H}_2\text{SO}_4,8.3}N_{\text{H}_2\text{SO}_4}}{\text{Volume of sample}} \text{mg/L as CaCO}_3 \]

\[ A_{\text{CO}_3} = [\text{CO}_3^{2-}] \text{alkalinity (in mg/L as CaCO}_3) = 2 \times \frac{50000V_{\text{H}_2\text{SO}_4,8.3}N_{\text{H}_2\text{SO}_4}}{\text{Volume of sample}} \times A_{OH} = 2 \times [A_{OH+0.5 \text{CO}_3} - A_{OH}] \]

Given that: N_H2SO4 := 0.01 \quad V_{\text{new}} := \frac{50}{1000} \text{ L} \quad \text{pH} := 11.2 \quad V_{\text{H}_2\text{SO}_4,4.5} := \frac{18}{1000} \text{ L} \quad V_{\text{H}_2\text{SO}_4,8.3} := \frac{8}{1000} \text{ L}

\[ AT := \frac{[0000 \cdot 18 \cdot 0.01]}{50} \text{ mg/L as CaCO}_3 \]

\[ A_{OH} := 50000 \cdot 10^{-1 \cdot (11 - \text{pH})} = 7924; \quad A_{OH} = 9245 \text{ mg/L as CaCO}_3 \]

\[ (A_{OH} + 0.5 A_{\text{CO}_3}) := \frac{[50000 \cdot 8 \cdot 0.01]}{50} = 80 \text{ mg/L as CaCO}_3 \]

\[ A_{\text{CO}_3} = 2 \times \frac{[50000 \cdot 8 \cdot 0.01]}{50} - 50000 \cdot 10^{-1 \cdot (14 - \text{pH})} = 1.511 \text{ mg/L as CaCO}_3 \]

\[ AHCO_3 := 180 - 1.511 - 7924 = 9224 \text{ mg/L as CaCO}_3 \]
UNSOLVED PROBLEMS

1. Write a review of India’s environmental legislations directly related to chemical process industries (use other references also).

2. Write various standards which have to be met for discharge of various types of pollutants from Pulp and Paper industry.

3. Write various standards which have to be met for discharge of various types of pollutants from a thermal power plant of 440 MW.

4. Which are the major polluting chemical process industries? Write their major environmental concerns and affect on the regional and global climate changes.

5. Write full forms of
   a. CPCB
   b. MoEF
   c. BIS
   d. EIA
   e. BOD
   f. COD
   g. TKN
   h. TDS
   i. VOC
   j. TOC
   k. TOCl
   l. PAN
   m. HPLC
   n. AAS
   o. AES
   p. ICP
   q. NDIR
   r. TOEM
   s. XRF
   t. ppm
   u. ppt
   v. JTU
   w. NTU
   x. TON
   y. MPN
   z. PAH
   aa. MINAS
   bb. NAAQS

6. Write short notes on the following:
   a. Environmental ethics
   b. EIA
   c. BOD
   d. COD
   e. Water quality monitoring
   f. TON
g. Alkalinity, its types and significance  

h. Fecal indicator bacteria  
i. MPN  
j. Primary water quality criterion  

7. Write in short importance of various physical constituents in wastewaters.  

8. Differentiate between the followings:  
a. Apparent and true color  
b. BOD, COD and TOC  
c. Total, dissolved, and suspended solids  
d. SPM, RSPM, PM$_{10}$ and PM$_{2.5}$  

9. Write in brief about various water quality parameters need to be determined to assess the quality of water.  

10. What is air pollution? What are the various sources of air pollution? Classify various types of air pollutants.  

11. Write about particulate matter and their types, sources and effects on environment.  

12. Write about gaseous air pollutants, their properties and significance.  

13. Fugitive emissions and their sources. What are the various methods for measuring and controlling fugitive emissions?  

14. Write about water use minimization in and out-side process industries. Write about methods for minimizing boiler water.  

15. Explain in detail water recycling and its quality. Write different motivational factors, benefits and uses of recycled water.  

16. The BOD$_{5}$ of a wastewater is determined to be 150 mg/l at 20°C. The k value at 20°C is known to be 0.23 per day. What would be BOD$_{8}$ value if tests were run at 15°C?  

17. Answer all questions:  
i. Forest Conservation Act was passed in the year__________________ .  
ii. Ozone is a primary/secondary pollutant. Choose the correct one.  
iii. Arsenic can be measured by FTIR/AAS/NMR/HPLC. Choose the correct one.  
iv. Annual ARSENIC maximum concentration in the new NAAQS is ____ ng/m$^3$. 
v. Annual PM$_{2.5}$ maximum concentration in the new NAAQS is ___ µg/m$^3$.

vi. Old notification of EIA was notified in the year ____________________.

vii. Noise limits for motor-cycle (from at 7.5 metre in dB(A) at the manufacturing stage) is 70/75/80/85 dB. Choose the correct one.