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.

Solution: $$TON = \frac{A+B}{A} = \frac{200\text{ ml}}{\text{Sample volume (ml)}} = \frac{200}{40} = 5$$

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.

$$BOD_{t,T} = BOD_u\left(1-\exp\left(-k_T t\right)\right)$$

$$k_T = k_{20}(\theta)^{(T-20)} = k_{20}(1.047)^{(T-20)}$$

Given that: $\text{BOD}_{6,20} := 400\ \frac{\text{mg}}{\text{L}}$ $\text{k}_{20} := 0.23\ \text{d}^{-1}$

$$\text{BODu} := \frac{\text{BOD}_{6,20}}{\left(1-\exp\left(-\text{k}_{20}\cdot 6\right)\right)} = 534.458\ \frac{\text{mg}}{\text{L}}$$

$$\text{k}_{15} := \text{k}_{20}\cdot 1.047^{(15-20)} = 0.183\ \text{d}^{-1}$$

$$\text{BOD}_{8,15} := \text{BODu}\cdot\left(1-\exp\left(-\text{k}_{15}\cdot 8\right)\right) = 410.643\ \frac{\text{mg}}{\text{L}}$$

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 BOD_5 of wastewater and compute the ultimate BOD.

Soln. We know,

$$\text{BOD}_5 = \frac{(\text{DO}_0 - \text{DO}_5)}{\text{V}_w}\times(\text{V}_w + \text{V}_d) = \frac{(8.5-5)}{6}\times(300) = 175\text{ mg/l}$$

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

$BOD_u = BOD_5/(1-e^{-5k}) = 175/(1-e^{-5\times 0.23}) = 256$ 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.

$$1N\,H_2SO_4 = \frac{1N\,H_2SO_4}{L} \text{ X } \frac{1\,equiv}{N\,H_2SO_4} \text{ X } \frac{50000\,mg\,CaCO_3}{1\,equiv} = 50000\,mg/\text{L as } CaCO_3$$

If normality of H_2SO_4 used for titration is N_{H2SO4}

$$N_{H2SO4}\,NH_2SO_4 = \frac{N_{H2SO4}N\,H_2SO_4}{L} \text{ X } \frac{1\,equiv}{N\,H_2SO_4} \text{ X } \frac{50000\,mg\,CaCO_3}{1\,equiv} = N_{H2SO4} \text{ X } 50000\,mg/\text{L as } CaCO_3$$

If volume of N_{H2SO4} Normal H_2SO_4 required to lower the pH of V volume solution to 4.5 is $V_{H2SO4,4.5}$ in litre, then

$$A_T = Total alkalinity\ (in\,mg/\text{L as } CaCO_3) = \left[OH^-\right] + \left[CO_3^{2-}\right] + \left[HCO_3^-\right] = \frac{50000\,V_{H2SO4,4.5}\,N_{H2SO4}}{Volume\ of\ sample}\,mg/\text{L as } CaCO_3$$

$$A_{OH} = \left[OH^-\right] alkalinity\ (in\,mg/\text{L as } CaCO_3) = \frac{10^{-pOH}\,mol\,OH^-}{L} = \frac{10^{-(14-pH)}\,mol\,OH^-}{L} \text{ X } \frac{1\,equiv}{mol\,OH^-} \text{ X } \frac{50000\,mg\,CaCO_3}{1\,equiv}$$

If volume of N_{H2SO4} Normal H_2SO_4 required to lower the pH of V volume solution to 8.3 is $V_{H2SO4,8.3}$ in litre, then

$$A_{OH+0.5CO3} = \left[\left[OH^-\right] + \left[\frac{1}{2}CO_3^{2-}\right]\right] alkalinity (in\,mg/\text{L as } CaCO_3) = \frac{50000\,V_{H2SO4,8.3}\,N_{H2SO4}}{Volume\ of\ sample}\,mg/\text{L as } CaCO_3$$

$$A_{CO3} = \left[CO_3^{2-}\right] alkalinity\ (in\,mg/\text{L as } CaCO_3) = 2*\left[\frac{50000V_{H2SO4,8.3}\,N_{H2SO4}}{Volume\ of\ sample} - A_{OH}\right] = 2*\left[A_{OH+0.5CO3} - A_{OH}\right]$$

Given that: $N_{H2SO4} := 0.01$ $V := \frac{50}{1000}$ L pH := 11.2

$V_{H2SO4,4.5} := \frac{18}{1000}$ L $V_{H2SO4,8.3} := \frac{8}{1000}$ L

$$AT := \frac{(50000 \cdot 18 \cdot 0.01)}{50} \quad AT = 180 \ \frac{mg}{L}\text{as}\,CaCO_3$$

$$AOH := 50000 \cdot 10^{-1 \cdot (14-pH)} = 79.245 \quad AOH = 79.245 \ \frac{mg}{L}\text{as}\,CaCO_3$$

$$(AOH + 0.5ACO3) := \frac{(50000 \cdot 8 \cdot 0.01)}{50} = 80 \ \frac{mg}{L}\text{as}\,CaCO_3$$

$$ACO3 := 2 \cdot \left[\frac{(50000 \cdot 8 \cdot 0.01)}{50} - \left[50000 \cdot 10^{-1 \cdot (14-pH)}\right]\right] = 1.511 \ \frac{mg}{L}\text{as}\,CaCO_3$$

$$AHCO3 := 180 - 1.511 - 79.245 = 99.244 \ \frac{mg}{L}\text{as}\,CaCO_3$$

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 me met for discharge of various types of pollutants from Pulp and Paper industry.
3. Write various standards which have to me 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 BOD5 of a wastewater is determined to be 150 mg/l at 20oC. The k value at 20oC is known to be 0.23 per day. What would be BOD8 value if tests were run at 15oC
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 ___ $\mu g/m^3$.

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.