Advanced Water Chemistry and Treatment, 11.9.1998

Please answer questions 1-4 (Munter) and 5-6 (Hirvonen) separate papers. (Maximum 36 p)

Prof. Munter's questions:

1. Ozone second order reaction rate constant with phenol is k_2 = 103 $M^{-1}s^{-1}$. Phenol initial concentration in water solution is [Ph]o=0.05 M. Taking the dissolved ozone initial concentration $[0_3]_0$ =0.1 M, calculate the residual concentrations of both components after 1 min of contact in solution. Take the initial stoichiometric ratio n=1.0 mol 0_3/mol Ph.

2. Ozonized air is bubbled through a water layer in a semibatch laboratory reactor (D=10 cm; H=30 cm) with the flow-rate Q=1 l/min. Ozone concentration in the inlet gas in $[0_3]_0$ = 25 mg/l. Ozone absorption coefficient at 20 °C is α=0.3. Calculate and draw in a figure dissolved ozone saturation curves at its physical absorption (pH $\leq$ 3) according to the relationships:

   $K_La = 0.45 \times W_G^{0.6}$

   ($K_La \rightarrow s^{-1}$) ($W_G \rightarrow$ m/s)

   $$\ln \frac{C_L^* - C_L}{C_L^*} = K_L a \times t$$

   Taking now the ozone decomposition rate constant in the basic water solution k_1 = 0.1 s^{-1}, calculate the same curve according to the relationship:

   $$C_L = C_L^* \times (1 - e^{-K_L a \times t})/\xi \text{ where } \xi = (1 + k_1/K_L a)$$

   How high is the saturation coefficient ζ of water solution now? ($\zeta = C_L/C_L^*$)

3. Determine the time required for the benzene concentration spilled in a shallow lake, to be reduced to 0 (= 100 % reduction) its initial value at 25 °C. Average lake depth is 1,5 m. Use the data in Table 7.1.

4. Two lakes V_1 = 30 000 m^3 and V_2 = 10 000 m^3 behave like CFSTRs. Initial BOD to the first lake is 50 g/m^3. k_1 = 0.5 d^{-1}, $r_A = -k_1 \times BOD$, Q = 5000 m^3/d of water. Calculate the outlet BOD_1 and BOD_2 of the both lakes.

Hirvonen:

5. Describe three examples of applications of ozone in drinking water treatment. (6 p)

6. You have wastewater stream containing biodegradable organic compounds, nitrogenous organics and ammonia. Treatment target is to purify water to be acceptable in terms of BOD-reduction, removal of possible pathogenic microorganisms and NH_{4+} Describe the effect of ozonation for achieving these treatment targets. Any need of some additional treatment steps? (6p)

TABLE 7.1
Evaporation Parameters for Various Compounds at 25 ° C

COMPOUND	MOLECULAR MASS. g/mol	SOLUBILITY IN WATER. g/m^3	VAPOR PRESSURE. mmHg	K. m/hr
Alcanes				
n-octane (C_8H_{18})	114.0	0.66	14.1	0.124
2,2.4-trimethyl pentane(C_8H_{18})	114.0	2.44	49.3	0.124
Aromatics				
Benzene (C_6H_6)	78.0	1780	95.2	0.144
Toluene(C_7H_8)	92.0	515	28.4	0.133
o-Xylene (C_8H_{10})	106.0	175	6.6	0.123
Cumene (C_9H_{12})	120.0	50	4.6	0.119
Naphihalene ($C_{10}H_8$)	128.0	33	0.23	0.096
Biphenyl ($C_{12}H_{10}$)	154.0	7.48	0.057	0.092
Pesticides				
DDT ($C_{14}H_9Cl_5$)	354.5	0.0012	1×10^{-7}	9.34×10^{-3}
Lindane($C_6H_6Cl_6$)	291.0	7.3	9.4×10^{-6}	1.5×10^{-4}
Dieldrin ($C_{12}H_8Cl_60$)	381.0	0.25	1×10^{-7}	5.33×10^{-5}
Aldrin ($C_{12}H_8Cl_6$)	365.0	0.2	6×10^{-6}	3.72×10^{3}
Polychloinated biphenyls (PCBs)				
Aroclor 1242 ($C_{12}H_7Cl_3$)	257.5	0.24	4.06×10^{-4}	0.057
Aroclor 1248 ($C_{12}H_6Cl_4$)	292.0	5.4×10^{-2}	4.94×10^{-4}	0.072
Aroclor 1254($C_{12}H_5Cl_5$)	326.5	1.2×10^{-2}	7.71×10^{-5}	0.067
Aroclor 1260 ($C_{12}H_4Cl_6$)	361.0	2.7×10^{-3}	4.05×10^{-5}	0.067
Other				
Mercury (Hg)	200.6	3×10^{-2}	1.3×10^{-3}	0.092

Source: Adapted from Ref. [7.14)