Introduction to Chemical Transport in the Environment

Errata

Changes to the text are given in **bold.** Equations have been corrected, but not given in bold.

1. Pg. 11: Table 1.3
   ppb(v) =>… **µL/m³**
   ppt (v) =>… **nL/m³**
2. Pg. 26:

$$C = C_0 e^{-\sqrt{k/D}z} \qquad \text{(E2.1.5)}$$

3. Pg. 28:
   a) Boundary condition #2:

$$@\, z \Rightarrow \infty \qquad e^{-z^2/4Dt} \Rightarrow 0 \qquad \therefore\ C \Rightarrow 0$$

   Boundary condition #2 is satisfied by Eq. E2.2.3.

4. Pg. 29:

   ii. $$\frac{\partial C}{\partial z} = \frac{-2z}{4Dt}\frac{2M / A}{\sqrt{4\pi Dt}}\, e^{-z^2/4Dt}$$

5. Pg. 31:

$$D = \sigma^2/(2t) \qquad \text{(E2.2.11)}$$

(E2.2.12)

$$z_m = \frac{\int_{-\infty}^{\infty} z\,C\,dz}{\int_{-\infty}^{\infty} C\,dz} \cong \frac{\Sigma z\ C\Delta z}{\Sigma C\,\Delta z}$$

$$\sigma^2 = \frac{\int_{-\infty}^{\infty} (z - z_m)^2\, C\,dz}{\int_{-\infty}^{\infty} C\,dz} \cong \frac{\sum (z - z_m)^2 C\Delta z}{\sum C\,\Delta z} \qquad \text{(E2.2.13)}$$

6. Pg. 32:

$$S = -\frac{\rho_b}{\varepsilon}\frac{\partial S_p}{\partial t} \qquad \text{(2.22)}$$

7. Pg. 41:

(E2.5. 3)

$$C_2 = \frac{M_2}{\left(4\pi \frac{D}{R}(t - t_1)\right)^{3/2}} \exp\left[-\frac{R\left[(x-\Delta x)^2 + y^2 + z^2\right]}{4D(t - t_1)}\right]$$

8. Pg. 43:
   Then Eq. E2.7.1 becomes

$$\frac{\eta}{2t}\frac{\partial C}{\partial \eta} + \frac{D}{R}\left(\frac{R}{4Dt}\frac{\partial^2 C}{\partial \eta^2}\right) = 0$$

9. Pg. 44:

1.	$t > 0, z = 0$	$\eta = 0$	$C = C_0$
2.	$t = 0, z \neq 0$	$\eta = \infty$	$C = 0$

10. Pgs. 45 & 46:

$$\text{TDCB}(z) = \boldsymbol{\varepsilon}\, C(z) + (1\text{-}\varepsilon)\, \rho_s\, S \qquad \text{(E2.7.7)}$$

$$\text{TDCB}(z) = C(z)[\boldsymbol{\varepsilon} + (1\text{-}\varepsilon)\, \rho_s\, K_d] = C(z)[\mathbf{0.4}+0.6(2.5\ \text{g/cm}^3)(15\ \text{cm}^3/\text{g})]$$

$$\text{TDCB} = \mathbf{22.9}\ C(z)$$

Thus, the total dichlorobenzene per volume of sediment and water would be **22.9** times the concentrations given in Table E2.7.1.

11. Pg. 46:

Relevant data: For radioactive Cesium and Cobalt, $K_d = 7\text{x}10^{\mathbf{6}}$ and 10^7, respectively.

12. Pg. 47:

^{137}Cesium $= M_1 = (C_1 + C_1')\Delta z = 0.3(10^{-7}\ \text{g/m}^3)(0.00\mathbf{2}\ \text{m}) = \mathbf{6} \text{ x } 10^{\mathbf{-11}}\ \text{g/m}^2$

^{60}Colbalt $= M_2/A = (C_2 + C_2')\Delta z = 0.7(10^{-7}\ \text{g/m}^3)(0.00\mathbf{2}\ \text{m}) = \mathbf{1.4} \text{ x } 10^{-10}\ \text{g/m}^2$

13. Pg. 50:

$$S = \mathbf{-}\, k_2\, (\, C - C_e\,) \qquad (2.38)$$

14. Pg. 51:

$$\frac{\partial C_b}{\partial t} + U\frac{\partial C_b}{\partial x} = D_x \frac{\partial^2 C_b}{\partial x^2} + Dy\frac{\partial^2 C_b}{\partial y^2} + D_z \frac{\partial^2 C_b}{\partial z^2} - k_1' C_b \qquad \text{(E2.9.4)}$$

15. Pg. 55:

$$J = [-1/2\ (C_0 + \Delta C\, \mathbf{L} / \boldsymbol{\Delta x})\, v_x^- + 1/2\ C_0\, v_x^+\ ] \quad + \text{secondary effects} \qquad (3.1)$$

16. Pg. 57:

Then setting the right hand side of equation 3.7 equal to the left-hand-side of equation 2.2, gives

17. Pg. 59, Example 3-1:

$v = 351\ m/s$ and $v/L = 6 \text{ X } 10^8$ collisions per second.

18. Pg. 60:

where Ω is a collision integral that must be found from look-up tables, such as that given in Tables 3.2 and 3.3 **using the energy of interaction, ε,**

19. Pg. 61:

How does the diffusivity of water vapor in air at 5°C compare to that at **20**°C?

20. Pg. 63:

Air-**benzene**

21. Pg. 68:

2. Use table 3.**6** to compute the additive increments:

V_b' = 118.2 cm^3/mole

22. Pg. 75:

The boundary conditions, while not exact, are close to those of Example **2.7**.
Making the appropriate substitutions in Eq. **E2.7.5**, the solution to Eq. E4.1.1 is

23. Pg. 77:

Figure E4.2.1. Illustration of solution to example **4.2**,

24. Pg. 79:

and ∇ is a gradient operator in the direction of the vector $\vec{V}$ **, which can be expressed as components in the chosen coordinate system.**

25. Pg. 80:

$$\frac{\partial v_z}{\partial t}+v_r\frac{\partial v_z}{\partial r}+\frac{v_\theta}{r}\frac{\partial u}{\partial \theta}+v_z\frac{\partial v_z}{\partial z}=\nu\left[\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial v_z}{\partial r}\right)+\frac{1}{r^2}\frac{\partial^2 v_z}{\partial \theta^2}+\frac{\partial^2 v_z}{\partial z^2}\right]+g_z-\frac{1}{\rho}\frac{\partial P}{\partial z} \quad (4.16)$$

$$\frac{\partial v_r}{\partial t}+v_r\frac{\partial v_r}{\partial r}+\frac{v_\theta}{r}\frac{\partial v_r}{\partial \theta}+v_z\frac{\partial v_r}{\partial z}=\nu\left[\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial v_r}{\partial r}\right)+\frac{1}{r^2}\frac{\partial^2 v_r}{\partial \theta^2}+\frac{\partial^2 v_r}{\partial z^2}\right]+g_r-\frac{1}{\rho}\frac{\partial P}{\partial r}-\frac{{v_\theta}^2}{r} \quad (4.17)$$

$$\frac{\partial v_\theta}{\partial t}+v_r\frac{\partial v_\theta}{\partial r}+\frac{v_\theta}{r}\frac{\partial v_\theta}{\partial \theta}+v_z\frac{\partial v_\theta}{\partial z}=\nu\left[\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial v_\theta}{\partial r}\right)+\frac{1}{r^2}\frac{\partial^2 v_\theta}{\partial \theta^2}+\frac{\partial^2 v_\theta}{\partial z^2}\right]+g_\theta-\frac{1}{\rho}\frac{\partial P}{\partial \theta}-\frac{v_r v_\theta}{r} \quad (4.18)$$

26. Pg. 81:

$$\frac{\upsilon}{r}\frac{\partial}{\partial r}\left(r\frac{\partial v_z}{\partial r}\right)=\frac{1}{\rho}\frac{\partial P}{\partial z}-g_z \quad \text{(E4.3.1)}$$

The right-hand side of Eq. E4.3.1 is a constant because of the linear pressure gradient. The left-hand side can thus be written as an ordinary differential equation,

$$\frac{\upsilon}{r}\frac{d}{dr}\left(r\frac{dv_z}{dr}\right)=\frac{1}{\rho}\frac{\partial P}{\partial z}-g_z=\frac{1}{\rho}\frac{\partial P^*}{\partial z} \quad \text{(E4.3.2)}$$

27. Pg. 88:

$$Pe_x\frac{\partial \tilde{C}}{\partial \tilde{T}}+Pe_xU\frac{\partial \tilde{C}}{\partial X}+Pe_y\frac{{L_x}^2}{{L_y}^2}V\frac{\partial \tilde{C}}{\partial Y}+Pe_z\frac{{L_x}^2}{{L_z}^2}W\frac{\partial \tilde{C}}{\partial Z}=\left(\frac{\partial^2 \tilde{C}}{\partial X^2}+\frac{{L_x}^2}{{L_y}^2}\frac{\partial^2 \tilde{C}}{\partial Y^2}+\frac{{L_x}^2}{{L_z}^2}\frac{\partial^2 \tilde{C}}{\partial Z^2}\right)+N_R\left(\tilde{C}-1\right) \quad (4.23)$$

where $Pe_x = U_r L_x / D$, $Pe_y = V_r L_y / D$ and $Pe_z = W_r L_z / D$ are Peclet numbers, and $N_R = k\, \boldsymbol{L_x}^{\boldsymbol{2}} / D$ is a dimensionless reaction number, which could also be a Sherwood number if k **=> *KA/~~V~~*, where *K*** is an interface mass transfer rate coefficient**, *A* is the surface area of transfer, and ~~*V*~~ is the liquid volume associated with *A*.**

28. Pg. 93:

$$\frac{\partial U}{\partial \tilde{T}}+U\frac{\partial U}{\partial X}+\frac{V_r}{U_r}\frac{L_x}{L_y}V\frac{\partial U}{\partial Y}+\frac{W_r}{U_r}\frac{L_x}{L_z}W\frac{\partial U}{\partial Z}=\frac{1}{Re}\left(\frac{\partial^2 U}{\partial X^2}+\frac{{L_x}^2}{{L_y}^2}\frac{\partial^2 U}{\partial Y^2}+\frac{{L_x}^2}{{L_z}^2}\frac{\partial^2 U}{\partial Z^2}\right)-\frac{1}{Fr^2}\frac{dH}{dX}-Eu\frac{\partial \tilde{P}}{\partial X} \quad (4.26)$$

29. Pg. 94:

$$\frac{\partial U}{\partial \tilde{T}}+U\frac{\partial U}{\partial X}=\frac{1}{Re}\left(\frac{\partial^2 U}{\partial X^2}+\frac{L^2}{h^2}\frac{\partial^2 U}{\partial Y^2}+\frac{L^2}{b^2}\frac{\partial^2 U}{\partial Z^2}\right)-\frac{1}{Fr^2}\frac{dH}{dX}-Eu\frac{\partial \tilde{P}}{\partial X} \quad \text{(E4.7.1)}$$

30. Pg. 95:

$$\frac{1}{Re}\frac{L^2}{h^2}\frac{\partial^2 U}{\partial Y^2}=\frac{1}{Fr^2}\frac{dH}{dX}+Eu\frac{\partial \tilde{P}}{\partial X} \quad \text{(E4.7.4)}$$

$$\frac{1}{Re_h}\frac{\partial^2 U}{\partial Y^2} = \frac{1}{Fr_h{}^2}\frac{dH}{dX} + \frac{h}{L}Eu\frac{\partial P}{\partial X} \quad \text{(E4.7.5)}$$

31. Pg. 101, line 1:

Continuity is given by $\frac{\partial \bar{u}}{\partial x} + \frac{\partial \bar{v}}{\partial y} + \frac{\partial \bar{w}}{\partial z} = 0$

$$-\overline{u'C'} = \varepsilon_x \frac{\partial \bar{C}}{\partial x} \quad \text{(5.19a)}$$

$$-\overline{v'C'} = \varepsilon_y \frac{\partial \bar{C}}{\partial y} \quad \text{(5.19b)}$$

$$-\overline{w'C'} = \varepsilon_z \frac{\partial \bar{C}}{\partial z} \quad \text{(5.19c)}$$

32. Pg. 104, Eq. 5.24

$$-\rho\, \overline{w'u'} = \mu_{tz} \frac{\partial \bar{u}}{\partial z} \quad \text{(5.24)}$$

33. Pg. 105

where $\overline{w'u'}^{+}$ has a value when w' is positive, and is equal to zero when w' is negative. $\overline{w'u'}^{-}$ has a value when w' is negative and is equal to zero when w' is positive.

34. Pg. 106:

$$w' \sim L\frac{\partial \overline{u'}}{\partial z} \quad \text{(5.34)}$$

35. Pg. 109:

$$z = 8x10^{-5}\,m = 0.08mm = 80\mu m \quad \text{(E5.1.6)}$$

In example 5.1, equation E5.1.6 gives z = 80 $\boldsymbol{\mu m}$

36. Pg. 114:

Eq. **E5.2.2**		Eq. E5.3.2
t	$\Rightarrow$	x/U
z	$\Rightarrow$	y
D	$\Rightarrow$	ε_y.

37. Pg. 115:

$$\hat{C} = \frac{2\dot{M}}{h(4\pi\bar{\varepsilon}_y\, xU)^{1/2}}\left[\exp\left(\frac{-Uy^2}{4\bar{\varepsilon}_y\, x}\right) + \exp\left(\frac{-U(y-2b)^2}{4\bar{\varepsilon}_y\, x}\right)\right] \quad \text{(E5.3.5)}$$

$$\frac{\hat{C}}{\hat{C}_i} = \frac{Q_i}{h(\pi\bar{\varepsilon}_y\, xU)^{1/2}}\left[\exp\left(\frac{-Uy^2}{4\bar{\varepsilon}_y\, x}\right) + \exp\left(\frac{-U(y-2b)^2}{4\bar{\varepsilon}_y\, x}\right)\right] \quad \text{(E5.3.7)}$$

38. Pg.119:

$$\frac{C}{C_o}=\frac{1}{4}\left\{erf\left(\frac{(z+\Delta z)}{\sqrt{4\bar{\varepsilon}_z x/U}}\right)-erf\left(\frac{(z-\Delta z)}{\sqrt{4\bar{\varepsilon}_z x/U}}\right)\right\}$$
$$\times\left\{erf\left(\frac{(y+\Delta y)}{\sqrt{4\bar{\varepsilon}_y x/U}}\right)-erf\left(\frac{(y-\Delta y)}{\sqrt{4\bar{\varepsilon}_y x/U}}\right)\right\} \quad \text{(E5.5.7)}$$

Now, if we use Δz = 10m, Δy = 100m, U = 3m/s, the only remaining parameter to find is $\bar{\varepsilon}$. Using the equation given in example 5.1:

$$\bar{\varepsilon}_z=\bar{\varepsilon}_y=\kappa u_* z \quad \text{(E5.1.1)}$$

Note that the logarithmic boundary equation can be written as,

$$\frac{\bar{u}}{u_*}=\frac{1}{\kappa}\ln\left(\frac{z}{z_o}\right) \quad \text{(E5.5.8)}$$

where z_0 is the dynamic roughness, assumed to be 0.2 m for the crop land between the plant and Scream Hollow. Then,

$$u_*=\frac{\kappa\bar{u}}{\ln(z/z_o)}=\frac{(0.4)3m/s}{\ln\left(\frac{3m}{0.2m}\right)}=0.44\ m/s \quad \text{(E5.5.9)}$$

and

$$\bar{\varepsilon}_z = 0.4(0.44\text{ m/s})(3\text{ m}) = 0.52\text{ m}^2/\text{s} \quad \text{(E5.5.10)}$$

If we now plug all of the parameters for the industrial plant into Eq. E5.5.7, we get C = **0.19** μg/m^3 = **1.9 X 10^{-7}** g/m^3. In terms of ppm(v), we will use ρ_{air} = 1.2 g/m^3, and the molecular weights of air and Acrolein of 29 and 56 g/mole, respectively. Then,

$$C=\frac{1.9\times10^{-7}\ g/m^3}{\rho_{air}}\frac{MW_{air}}{MW_{C_3H_40}}=\frac{1.9\times10^{-7}\ g/m^3}{1.2\,g/m^3}\frac{20\,g/mole}{56\,g/mole}$$
$$=0.82\times10^{-7}\ \frac{moles\,C_3H_40}{mole\,air} \quad \text{(E5.5.11)}$$

This is **close to** the threshold for continuous exposure, and the pollution from the plant should be investigated in more detail.

39. Pg. 120:
ρ_{air} = 1.2 **k**g/m^3, and the molecular weights of air and Acrolein of 29 and 56 g/mole, respectively.

4. A 0.5 mg/m^3 concentration of total PCBs are discharged at 1m^3/s. from a St. Paul manufacturing plant into the Mississippi River. Assuming the problem can be modeled as a point source, plot the concentration isopleths versus horizontal distance downstream of the

plant, with no reaction rates, to **100m and to** the end of the mixing zone. River Data: Q= $20 m^3$/sec.; mean width = 200 m, mean depth = 2 m; slope = 10^{-4}.

40. Pg. 125:

$$C = C_0 + \frac{Q}{\forall} C_i t \tag{E6.2.3}$$

41. Pg. 128:

$$\left(\lambda + \frac{k_2}{U}\right)C = \frac{-k_1 L_0}{U} e^{-k_1 x/U} + \frac{k_2}{U} C_E \tag{E6.4.6}$$

42. Pg. 138:

From Eq. **6.13**, there are

$$n_1 = t_{r1}^2 / \sigma_{t1}^2 = 75 \tag{E6.7.5}$$

tanks-in-series for the main channel, of volume

$$\forall_1 = \frac{Q_1 t_r}{n} = 58{,}750\ m^3 \tag{E6.7.6}$$

If the diversion is to have the same number of tanks-in-series, then Eq. **6.13** gives the mixed tank residence time for the diversion:

$$t_{rm} = \sqrt{n_1}\sigma_{t2} = 13.3\ hrs \tag{E6.7.7}$$

with the remainder of the residence time,

$$t_{rp} = t_{r2} - t_{rm} = 21.2 - 13.3 = 7.9\ hrs \tag{E.6.7.8}$$

43. Pg. 139:

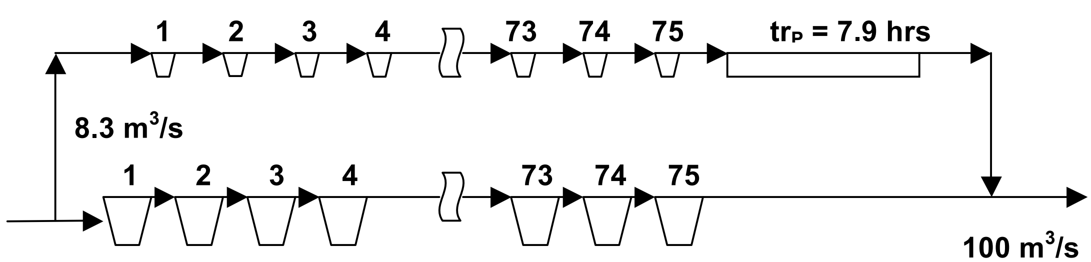

Fig. E6.7.4. Reactor model for the Platte River at the bypassed reach.

44. Pg. 140:

$$\forall_d \frac{dC_d}{dt} = Q_d (C - C_d) + k(C_e - C_d) \tag{6.15}$$

45. Pg. 141:

We will solve equations (6.14) and (6.15) for a conservative tracer, where **k = 0**.

Boundary condition No. 1 results in $\boldsymbol{\beta_1 + \beta_2 = - C_0}$.

46. Pg. 142:

$$\lim_{t_d \to 0} \lambda_2 = \frac{-1}{2\beta t_1}\left[1 - \sqrt{1 - 4\beta}\right] = -1 / t_1 \tag{E6.8.4}$$

47. Pg. 143:
Thus, in Eq. 6.17, $\boldsymbol{C_i = 0}$. The new boundary conditions are:
48. Pg. 146:

$$\frac{\partial \hat{C}}{\partial t}+\frac{\partial C'}{\partial t}+\left(U+u'\right)\frac{\partial(\hat{C}+C')}{\partial x}=D\left[\frac{\partial^2(\hat{C}+C')}{\partial r^2}+\frac{1}{r}\frac{\partial(\hat{C}+C')}{\partial r}+\frac{\partial^2(\hat{C}+C')}{\partial x^2}\right]+S \qquad (6.27)$$

49. Pg. 153:

$\tilde{C} = C / C_0$ or $C = \tilde{C} C_0$

$X = x / L$ or $x = X L$, and

50. Pg. 154:

$$\lambda = \frac{-b}{2a}\left[1 \pm \sqrt{1-4ac/b^2}\right] \qquad \text{(E6.10.10)}$$

and,

$a = 1/Pe$ $\quad b = -1$ $\quad c = -\boldsymbol{St}$ (E6.10.11)

51. Pg. 159:

$$D_x = 9\, R\, \sigma_x^{\,2} / (\,2\, t\,) \qquad (6.51a)$$

$$D_y = 9\, R\, \sigma_y^{\,2} / (\,2\, t\,) \qquad (6.51b)$$

$$D_z = 9\, R\, \sigma_z^{\,2} / (\,2\, t\,) \qquad (6.51c)$$

where σ_x^2, σ_y^2 and σ_z^2 are the variance of concentration in the x, y and z directions, respectively.
52. Pg. 160:

$$D_t / D_{\boldsymbol{L}} \sim 0.1 \qquad (6.56)$$

53. Pg. 162:

$$\frac{D_y}{D} = \frac{D_z}{D} \cong 0.1\, Pe \qquad \text{or} \qquad D_y, D_z = \mathbf{0.1}(10^{-7}\ \mathrm{m^2/s}) = 10^{-8}\ \mathrm{m^2/s}$$

54. Pg. 163:
Table E6.12.1. Estimated concentration over time and space with transport through a uniformly porous sandstone.

Time	C_{max}	X_{max}	$4\sigma_x$	$4\sigma_y$
	(g/m^3)	**(m)**	**(m)**	**(m)**
1 hr	**4.0x10^8**	0.32	0.04	0.014
1 day	**3.4X10^6**	7.6	0.17	0.054
1 month	**2.1X10^4**	229	0.90	0. 29
1 year	**500**	2800	3.1	0.98
2 years	**180**	5500	4.4	1.39
10 years	**16**	27,000	9.9	3.13

Note that in the above table, the concentrations at **1 hr, 1 day and 1 month** are above the initial Atrazine concentration (1000 g/m3).
55. Pg. 164
Supply of TCE = **100** kg/day

$$Y = \frac{Q}{\varepsilon H U} = 1740m \qquad \text{(E6.13.1)}$$

$$\hat{C} = \frac{2\dot{M}}{h(4\pi\bar{\varepsilon}_y\, xU)^{1/2}}\left[\exp\left(\frac{-Uy^2}{4\bar{\varepsilon}_y\, x}\right) + \exp\left(\frac{-U(y-2b)^2}{4\bar{\varepsilon}_y\, x}\right)\right] \tag{E5.3.5}$$

56. Pg. 165:

$$C = \frac{\dot{M}}{H\varepsilon(4\pi xUD_t\,)^{1/2}}\exp\left(\frac{-Uy^2}{4D_t\; x}\right) \tag{E6.13.2}$$

57. Pg. 166

$$\begin{matrix}\mathrm{Re}\mathit{lative}\\ \mathit{rms\ Error}\end{matrix} = \sqrt{\frac{1}{n}\sum_n\left(1-\frac{D_{LP}}{D_L}\right)^2} \tag{6.58}$$

58. Pg. 167, Table 6.4 headings:

Depth,
h(m) $D_L/(h\,u_*)$

59. Pg. 168:

You have decided that the most cost-effective means of determining these parameters would be to perform a conservative tracer pulse test, and adjust the parameters from discharge on the day of the tracer test (**8** m^3/s) to discharge on the day of the spill (**3** m^3/s) with some equations that have been developed.

60. Pg. 170:

$$\frac{\Delta\sigma_t^2}{\Delta t_r^2} = \frac{2D_L}{UDx} = \frac{2D_L\,\Delta t_r}{\Delta x^2} \tag{E6.14.3}$$

While σ_t^2 and t_r vary linearly with distance along the reactor (river), the dimensionless $\sigma^2 = \sigma_t^2/t_r^2$ does not so a $\Delta\sigma^2$ does not apply in Eq. E6.14.3.

$$\sigma_t^2\Big|_1 = \frac{\int Ct^2\,dt}{\int C\,dt} - t_{r1}^{\;2} \cong \frac{\Sigma\, Ct^2\,\Delta t}{\Sigma\, C\,\Delta t} - t_{r1}^{\;2} \tag{E6.14.6}$$

$$\sigma_t^2\Big|_1 = \frac{2.59\,hr^2\,g/m^3}{0.666\,g/m^3} - (1.94\,hr)^2 = 0.125\,hr^2 \tag{E6.14.7}$$

61. Pg. 171:

$$\sigma_t^2\Big|_2 = \frac{14\;hr^2\;g/m^3}{0.105\,g/m^3} - (11.54\;hr)^2 = 0.162\;hr^2 \tag{E6.14.13}$$

$$D_L = \frac{\Delta\sigma_t^2\Delta x^2}{2\Delta t_r^3} = \frac{(0.162-0.125)hr^2(27{,}000\,m)^2}{2(11.54-1.94)^3\;hr^3} \tag{E6.14.15}$$

or,

$$D_L = 15{,}200\ m^2/hr = 4.2\ m^2/s \tag{E6.14.16}$$

$$D_{LS} = D_{Lt}\left(\frac{Q_s}{Q_t}\right)^2\left(\frac{h_t}{h_s}\right)^{7/2} = 4.2\frac{m^2}{s}\left(\frac{3\;m^3/s}{8\;m^3/s}\right)\left(\frac{0.6\;m}{0.4\;m}\right) = 2.4\;m^2/s \tag{E6.14.18}$$

62. Pg. 172:
    Exchange between reactors: ~ 1,000 **m**^{3}/sec
63. Pg. 182:

$$FluxIn - FluxOut = \boldsymbol{D}\frac{C_{k+1,n} - 2C_{k,n} + C_{k-1,n}}{\Delta z}\Delta x \Delta y \qquad \text{(E7.2.2)}$$

64. Pg. 183:

$$C_{k,n+1} = \mathrm{Di}\left(C_{k+1,n} + C_{k-1,n}\right) + \left(1 - 2\mathbf{Di} - k\Delta t\right)C_{k,n} \qquad \text{(E7.2.5)}$$

65. Pg. 187:
    References to Example 2.10 should be Example 2.7.
    Reference to equation (2.36) should be to equation E2.7.6
66. Pg. 188:
    The analytical solution of Equation (E7.4.7) is compared with the computational solution **of Example 7.3** with…
67. Pg. 193:
    2. Assume that the solubility of a spilled compound for problem **1** in water is 5 kg/m^3, so that an impulse solution will not be accurate.
68. Pg. Pg. 194:
    4. Solve **problem 3, chapter 6**, using an appropriate computational routine, and compare the results to the analytical solution.
69. 199:

$$J_A = K_B\left(C_{Aw}^{\infty} - C_{Aa}^{\infty} / H_A\right) \qquad \text{(8.8)}$$

    Equations 8.4, 8.8 and 8.9 can be combined with the assumption that all resistance to transfer occurs in the diffusive sublayer, as illustrated in **Fig. 8.4**, to show that
70. Pg. 207:

$$m_{ba} = \frac{P_{ba}^{*}\,\rho_a \forall_a}{P}\frac{M_b}{M_a} \qquad \text{(E8.4.2)}$$

    In Eq. E8.4.2, P_{ba}^{*} is the partial pressure of benzene at equilibrium with the water, ρ_a is the density of the air (1.2 kg/m^3), $\forall_a$ is the volume of the air (10m^3), P is the air pressure in the tank (~ 1 atm), **and M_b and M_a are the molecular weight of benzene and air, respectively.**

$$H_b = \frac{P^{*}{}_{ba}}{C_{bw}^{*}} \qquad \text{(E8.4.4)}$$

    and Eq. E8.4.2 becomes

$$m_{ba} = C^{*}{}_{bw} H_b \frac{\rho_a V_a M_b}{P M_a} \qquad \text{(E8.4.5)}$$

71. Pg. 208:

$$m_{bs} = C_{bs}^{*}\forall_s = C_{bw}^{*}\,K_d\,\rho_s \forall_s \qquad \text{(E8.4.6)}$$

    Using **an equation of Kenaga and Goring (1978)**:

$$\log K_d = f\left[0.544\log K_{ow} + 1.377\right] \qquad \text{(E8.4.7)}$$

$$m_b = C_{bw}{}^{*}\left(H_b\,\rho_a \forall_a \boldsymbol{M_b/(PM_a)} + \forall_b + \boldsymbol{K_d}\,\rho_s \forall_s + BCF_f\,\rho_f \forall_f\right) = 100 \text{ g} \qquad \text{(E8.4.11)}$$

72. Pg. 210:

Fig. E8.5.2. Concentration profiles for the example problem, assuming that $K_L >> H_t \boldsymbol{K_G}$

73. Pg. 211:

The **Chapman-Enskog** relationship, described in Chapter 3, allows us to compute a value of D_{ta} = 5 X 10^{-6} m^2/s.

74. Pg. 229:

$$V_b \frac{dC_{bO}}{dt} = -K_{LO} A_b \left(C_O^* - C_O \right) \tag{8.93a}$$

$$V_b \frac{dC_{bN}}{dt} = -K_{LN} A_b \left(C_N^* - C_N \right) \tag{8.93b}$$

75. Pg. 231:

$$\frac{\partial C_{bO}}{\partial z} = -\frac{K_{LO} A_b}{Q_a h_d} \left(C_O^* - C_O \right) \tag{8.100a}$$

$$\frac{\partial C_{bN}}{\partial z} = -\frac{K_{LN} A_b}{Q_a h_d} \left(C_N^* - C_N \right) \tag{8.100b}$$

76. Pg. 233:

Table 8.3. Environmentally significant compounds that react with water

								k (s^{-1})
CO_2	+	H_2O	⇒	H_2CO_3				3.7 X 10^{-2}
Cl_2	+	H_2O	⇒	HOCl	+	H^+	+ Cl^-	28
H_2S	+	H_2O	⇒	HS^-	+	H_3O^+		4. X 10^2
CH_3COOH + H_2O			⇒	CH_3COO^- +		H_3O^+		1. X 10^5
(Methyl formate)								

77. Pg. 236, Problem 12:

Recognizing that $K_{GA} \sim \boldsymbol{D_{aA}}^{1/2}$ and $K_{LA} \sim \boldsymbol{D_{wA}}^{1/2}$

78. Pg.278, Appendix A-6

Trichloromethane	**$CHCl_3$**	20	5.39E-03	81.8	91.8	97.1	8
Trichloroethene	C_2HCl_3	20	9.86E-03	89.1	95.4	98.4	8