3.9 $$-\ln\left(1-\frac{x_A}{x_{Ae}}\right) = (k_1+k_2)\,t.$$

How?

$$\frac{k_1}{k_2} = \frac{m + x_{Ae}}{1-x_{Ae}} = \frac{C_{Re}}{C_{Ae}}$$

$$k_2 = \left(\frac{1-x_{Ae}}{m+x_{Ae}}\right)k_1$$

$$k_1+k_2 = k_1\left[1 + \frac{1-x_{Ae}}{m+x_{Ae}}\right]$$

$$= k_1\left[\frac{m+1}{m+x_{Ae}}\right].$$

Rev Rate equation

$$-\ln\left(1-\frac{x_A}{x_{Ae}}\right) = \left(\frac{m+1}{m+x_{Ae}}\right)k_1 \times t$$

$$k_1\left(\frac{m+1}{m+x_{Ae}}\right) = k_1+k_2.$$

$$-\ln\left(1-\frac{x_A}{x_{Ae}}\right) = (k_1+k_2)\,t$$

$t = 8$ mins for $x_A = 1/3$, $x_{Ae} = 2/3$

$$\therefore \quad -\ln\left(1 - \frac{1/3}{2/3}\right) = (k_1 + k_2)\, 8$$

$$\therefore \quad k_1 + k_2 = \frac{\ln 2}{8} = 0.086625 \text{ min}^{-1} \quad -(1)$$

$$\frac{k_1}{k_2} = \frac{C_{Re}}{C_{Ae}} = \frac{C_{A0}\, x_{Ae}}{C_{A0}(1 - x_{Ae})} = \frac{0.5 \times 2/3}{0.5 \times 1/3} = 2$$

$$\therefore \quad k_1 = 2k_2 \quad -(2)$$

Solving (1) and (2)

$$k_1 = 0.0577 \quad , \quad k_2 = 0.028875$$

$\therefore$

$$-r_A = k_1 C_A - k_2 C_R$$

$$= 0.05775\, C_A - 0.028875\, C_R$$

3.11

$C_{A0} = 500$

From table if $C_{A0} = 500$ $t_0 = 100$ min

$\therefore$ For 5 hrs. $t = 100 + 300 = 400$ min

$$\therefore \quad x_A = 1 - \frac{C_A}{C_{A0}} = 1 - \frac{200}{500} = 0.6$$

or

Plot graph, find k, then find $C_A$

Then find $x_A$.

3.15

$$-r_A = \frac{k_3 C_A C_{E0}}{C_A + m}$$

$$-\frac{dC_A}{dt} = \underline{k_3 C_{E0}} \cdot \frac{C_A}{(C_A + m)}$$

$$-dC_A \left( \frac{C_A + m}{C_A} \right) = k_3 C_{E0}\, dt$$

Integrating on both sides

$$-dC_A \left[ 1 + \frac{m}{C_A} \right] = k_3 C_{E0}\, dt$$

$$(C_{A0} - C_A) + m \ln \frac{C_{A0}}{C_A} = k_3 C_{E0}\, t$$

$$\frac{1}{m} + \frac{\ln \frac{C_{A0}}{C_A}}{C_{A0} - C_A} = \frac{k_3 C_{E0}}{M} \left( \frac{t}{C_{A0} - C_A} \right)$$

Plot graph $\frac{\ln \frac{C_{A0}}{C_A}}{C_{A0} - C_A}$ vs $\frac{t}{C_{A0} - C_A}$

slope $= \frac{k_3 C_{E0}}{m}$

intercept $= -1/m$

$k_3 = 19.7\ hr^{-1}$

$m = 0.197\ \frac{mmol}{lit}$

3.18 $-r_A = \frac{200\, C_A C_{E0}}{2+C_A} \Rightarrow k_3 = 200.$

$m = 2.$

$C_{E0} = 0.001$ mol/lit

$$(C_{A0} - C_A) + m \ln \frac{C_{A0}}{C_A} = k_3 C_{E0}\, t$$

For $C_A = 0.025$ mol/lit & $C_{A0} = 10$ mol/lit

$$(10 - 0.025) + 2 \ln \left(\frac{10}{0.025}\right) = 200 \times 0.001 \times t$$

$$9.975 + 11.9829 = 0.2 \times t.$$

$$\frac{21.9579}{0.2} = t$$

$$t = 109.7895 \text{ min}$$

5.

$$C = C_0 e^{-kt} \quad \text{or} \quad \frac{C}{C_0} = e^{-kt}$$

$$\text{or } t = \frac{1}{k} \ln\left(\frac{C_0}{C}\right)$$

$$\frac{C}{C_0} = 0.6 \qquad k = 3.546 \times 10^{-4}\ \text{hr}$$

$$t = \frac{1}{k} \ln\left(\frac{C_0}{C}\right) = \frac{1}{3.546 \times 10^{-4}} \ln\left(\frac{1}{0.6}\right)$$

$$= 1440.56 \text{ hr}$$

$$= 60.02 \text{ days}$$

6.

**Solution:**

First order reaction, $\ln(Co/C) = k*t$ or $k = 1/t*\ln(Co/C)$ or $t = (1/k)*\ln(Co/C)$

At 298 K ($T_1$), $k_1 = 1/(300*24*60) * \ln(2) = 1.6045 \times 10^{-6}\ min^{-1}$.

Using the Arrhenius equation for temperature dependency,

$\ln(k_2/k_1) = E/R*[1/T_1 - 1/T_2]$

or $k2 = k1*\exp(E/R*[1/T_1 - 1/T_2])$

where $T_2$ = 523 K, E=60,000 J/mol, R= 8.314 J/mol-K

Plugging in values for the terms on the right hand side of the above equation,

**$k_2$ = 0.0537 min$^{-1}$**

From the 1$^{st}$ order rate equation,

$C/Co = \exp(-k_2*t)$

Plugging in $k_2$ and t=30 min., C/Co = 0.1996 so **approximately 80% of the initial aspartame is lost after baking for 30 minutes.**