Chemistry 236
Inversion of Sucrose Lab Study Problems -- Answers

2. a. $\alpha_0 = [\alpha]_\lambda^T$ [sucrose]$_0$ ℓ = 66.4˚ dm^{-1} mL g^{-1} × 0.100 g/mL × 2.00 dm
   = 13.2$_8$˚ (13.3˚).

   b. $\alpha_\infty \approx {}^1/_2$ [sucrose]$_0$ ℓ $\{[\alpha]_{\lambda,\text{gluc}}^T + [\alpha]_{\lambda,\text{fruc}}^T\}$ = –3.6˚.
   More precisely, 100.00 g sucrose → 52.63 g glucose + 52.63 g fructose, so
   α_∞ = 0.05263 g/mL × 2.00 dm × (52.5 – 88.5) dm^{-1} mL g^{-1} = –3.7$_9$˚ (–3.8˚).
   (This still assumes that there is no volume change on reaction, which cannot be exactly true.)

3. $\alpha(t) = \alpha_\infty + (\alpha_0 - \alpha_\infty)\exp(-k_{\text{eff}}\, t)$.
   half-life: $\exp(-k_{\text{eff}}\,\tau_{1/2}) = {}^1/_2 \rightarrow \tau_{1/2} = \ln 2/k_{\text{eff}}$.
   inversion: $\alpha(t_{\text{inv}}) = \alpha_\infty + (\alpha_0 - \alpha_\infty)\exp(-k_{\text{eff}}\, t_{\text{inv}}) = 0 \rightarrow$
   $\exp(-k_{\text{eff}}\, t_{\text{inv}}) = 3.79/(13.28+3.79) = 0.222 \rightarrow$
   $t_{\text{inv}} = 1.505/k_{\text{eff}} \rightarrow t_{\text{inv}}/\tau_{1/2} = 2.17$.
   Thus it takes 2.17 half-lives to reach the inversion point.

4. $k = A\exp(-E_a/RT) \rightarrow k_1/k_2 = \exp[E_a/R\,(T_2^{-1} - T_1^{-1})] \rightarrow$
   E_a = 55.1 kJ/mol.
   Let $Y = k_1/k_2$. Then $(s_Y/Y)^2 = [(s_{k1}/k_1)^2 + (s_{k2}/k_2)^2] \rightarrow s_Y/Y = 0.141$.
   Let $z = \ln Y$. Then $s_z = s_Y/Y = 0.141$. Since we take T_1 and T_2 as error-free,
   $s_{E_a}/E_a = s_z/|z| = 0.133 \rightarrow s_{E_a} = 7.3$ kJ/mol $\rightarrow E_a$ = 55(7) kJ/mol.

5. [HCl] = 0.80 mol/L; [sucrose] = 80.0 g/L

6. <u>sucrose</u>: 32 mL stock + 8 mL water 160 g/L sucrose 80 g/L on mixing.
   <u>HCl</u>: 30 mL 4.0 M + 10 mL water 3.0 M HCl 1.5 M on mixing.

7. $k_{\text{eff}} = k_{\text{H}}\,[\text{H}^+]$ = 0.0585 min^{-1}. Let ℓ = length of polarimeter tube (dm). Then, from Prob. 2, $\alpha_0 = 5.31° \,\ell$ and $\alpha_\infty = -1.52° \,\ell$. Proceeding as in Prob. 3, we solve $0 = \alpha_\infty + (\alpha_0 - \alpha_\infty)\exp(-k_{\text{eff}}\, t)$ for t and obtain 25.7 min.

8. $w_i \quad \sigma_i^{-2}$. We fit $\ln[\alpha(t) - B]$. Let $y = \alpha(t) - B$. Since s_α is constant, so is s_y. From the referenced problem, if $z = \ln y$, $s_z = s_y/y$. We fit z, so $w_i \quad y_i^2$.

9. We fooled KG into doing this calculation by doubling the number of points from 2 to 4. Since the computed standard errors incorporate a factor of $n^{-1/2}$, KG has made these a factor of $\sqrt{2}$ too small.