

Chemistry 236
Inversion of Sucrose Lab Study Problems -- Answers

2. a. $\alpha_0 = [\alpha]_{\lambda}^T [\text{sucrose}]_0 \mid = 66.4^{\circ} \text{ dm}^{-1} \text{ mL g}^{-1} \times 0.100 \text{ g/mL} \times 2.00 \text{ dm}$
 $= 13.28^{\circ} (13.3^{\circ}).$

b. $\alpha_{\infty} \approx 1/2 [\text{sucrose}]_0 \mid \{[\alpha]_{\lambda, \text{gluc}}^T + [\alpha]_{\lambda, \text{fruc}}^T\} = -3.6^{\circ}.$

More precisely, 100.00 g sucrose \rightarrow 52.63 g glucose + 52.63 g fructose, so
 $\alpha_{\infty} = 0.05263 \text{ g/mL} \times 2.00 \text{ dm} \times (52.5 - 88.5) \text{ dm}^{-1} \text{ mL g}^{-1} = -3.79^{\circ} (-3.8^{\circ}).$

(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. $k = A \exp(-E_a / RT) \rightarrow k_1 / k_2 = \exp[E_a / R (T_2^{-1} - T_1^{-1})] \rightarrow$
 $E_a = 55.1 \text{ kJ/mol}.$

5. $[\text{HCl}] = 0.80 \text{ mol/L}$
 $[\text{sucrose}] = 80.0 \text{ g/L}$

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

7. $k_{\text{eff}} = k_{\text{H}} [\text{H}^+] = 0.0585 \text{ min}^{-1}.$ Let \mid = length of polarimeter tube (dm). Then,
 from Prob. 2, $\alpha_0 = 5.31^{\circ} \mid$ and $\alpha_{\infty} = -1.52^{\circ} \mid.$ 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.