Inversion of Sucrose

A. Reaction and Kinetics

1. $S + H^+ + H_2O \rightarrow F + G + H^+$ (*i.e.*, acid-catalyzed)

2. *Rate Law*: $r = -d[S]/dt = k_H [H^+] [S] \equiv k_{eff} [S]$

   (*pseudo-first order* — because $[H^+]$ doesn't change)

3. *Integrate*: $-d[S]/[S] = k_{eff} dt \Rightarrow \ln [S] = \text{const} - k_{eff} t$

4. *Boundary Condition*: @ $t = 0$, $[S] = [S]_0 \Rightarrow \text{const} = \ln [S]_0$

   $\Rightarrow [S] = [S]_0 \exp(-k_{eff} t)$ (first-order decay law)

B. Experiment

1. Measure α with polarimeter. But all 3 sugars are optically active, so α doesn't vanish when S is 100% converted.

2. Rather, $\alpha = A \exp(-k_{eff} t) + B$ (exponential + background)

3. $t = 0$: $\alpha (\equiv \alpha_0) = A + B$; $\qquad t = \infty$: $\alpha_\infty = B$ (α for F + G)

4. *Specific rotation*: $\alpha = [\alpha]_\lambda^T [\ ]\ \ell$

   units of $[\alpha]_\lambda^T$: degree L g^{-1} dm^{-1}

5. Need one "completion" run to get α_∞ .

C. Temperature Dependence

1. *Arrhenius*: $k = A \exp(-E_a/RT) \Rightarrow \ln k = \ln A - E_a/RT$

2. *Typical*: Have k at two Ts $\Rightarrow$ $k_2/k_1 = \exp[(E_a/R)(1/T_1 - 1/T_2)]$

   $\ln(k_2/k_1) = (E_a/R)(1/T_1 - 1/T_2)$ (don't need A)

3. *Note*: This is our second encounter with $\ln(\ ) = a + b/T$.
   We will see it again in analyzing the T dependence of
   equilibrium constants (Expt. 5) and vapor pressure
   (Expt. 6).

   In all such thermodynamic applications, T is in K.