Quiz 17.2 – The Arrhenius Equation

Name: Key

A reaction's rate constant is measured at different temperatures. Data are summarized in the table below:

Trial	k ($1/s$)	T ($°C$)
1	1.4×10^{-4}	25 → 298 K
2	3.7×10^{-4}	75 → 348 K

$k = A \cdot e^{\frac{-E_a}{RT}}$

Use these data to find the activation energy for this reaction

$$\ln\left(\frac{k_2}{k_1}\right) = -\frac{E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right) \rightarrow \ln\left(\frac{3.7 \cdot 10^{-4}\,s^{-1}}{1.4 \cdot 10^{-4}\,s^{-1}}\right) = -\frac{E_a}{8.314\ J/mol \cdot K}\left(\frac{1}{348\,K} - \frac{1}{298\,K}\right)$$

$$E_a = 16{,}800\ J/mol$$

What would you expect the rate constant to be at $-10°C$? 263 K

$$\ln\left(\frac{k_2}{1.4 \cdot 10^{-4}\,s^{-1}}\right) = -\frac{16{,}800\ \frac{J}{mol}}{8.314\ J/mol \cdot K}\left(\frac{1}{263\,K} - \frac{1}{298\,K}\right) \rightarrow k_2 = 5.68 \cdot 10^{-5}\ \frac{1}{s}$$

What is the Arrhenius pre-factor or frequency factor, A, for this reaction?

$$A = \frac{k}{e^{\frac{-E_a}{RT}}} = \frac{1.4 \cdot 10^{-4}\,s^{-1}}{e^{\frac{-16{,}800\ J/mol}{8.314\ J/mol \cdot K \cdot 298\,K}}} = 0.123\ s^{-1}$$

The Arrhenius equation is based on a fairly simple model of reaction rates. What are some real factors which might make reaction rates deviate from the Arrhenius equation?

1) Reverse reaction rates in equilibrium reactions

2) E_A will be dependent on T (Just like ΔH, ΔS, and ΔG are)

3) Encounter frequency could depend on T, making A a function of T