16. Given these data for the reaction of Fe\(^{3+}\) with I\(^-\):

<table>
<thead>
<tr>
<th>Exp#</th>
<th>[Fe(^{3+})] (M)</th>
<th>[I(^-)] (M)</th>
<th>Initial rate (M/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0400</td>
<td>0.0300</td>
<td>8.10 \times 10^{-4}</td>
</tr>
<tr>
<td>2</td>
<td>0.0800</td>
<td>0.0300</td>
<td>1.62 \times 10^{-3}</td>
</tr>
<tr>
<td>3</td>
<td>0.0400</td>
<td>0.0600</td>
<td>3.24 \times 10^{-3}</td>
</tr>
</tbody>
</table>

2 Fe\(^{3+}\) (aq) + 2 I\(^-\) (aq) → 2 Fe\(^{2+}\) (aq) + I\(_2\) (aq)

Be sure to explain the logic for your answers.

a) Write a general rate law for the reaction.
b) Use the initial rate data to write the specific rate law consistent with the data. Make sure you solve to obtain a numerical value for \(k\).
c) Write a chemical rxn. for the reactant side of the rate limiting step in the rxn. mechanism.
d) What is the initial rate of the rxn. with 0.090 M Fe\(^{3+}\) and 0.50 M I\(^-\)?
e) If I told you that the value of \(k\) that you obtained is relatively large, what height hill would you draw for this reaction on a reaction progress diagram (vertical axis = \(G^0\)).

a) Rate = \(k\) [Fe\(^{3+}\)]\(^m\) [I\(^-\)]\(^n\)

b) Compare trials 1 and 2:

\[
\text{Rate}_2 = \frac{k [\text{Fe}^{3+}]^m [\text{I}^-]^n}{[\text{I}^-]^n} = \frac{1.62 \times 10^{-3}}{8.10 \times 10^{-4}} = \frac{k [0.0800]^m [0.0300]^n}{[0.0300]^n} \quad \text{or} \quad 2 = 2^m, \ m = 1
\]

k/k cancels as does [0.0300]/[0.0300], so

\[
\frac{1.62 \times 10^{-3}}{8.10 \times 10^{-4}} = \frac{0.0800}{0.0400} \quad \text{or} \quad 2 = 2^m, \ m = 1
\]

Compare trials 1 and 3:

\[
\text{Rate}_3 = \frac{k [\text{Fe}^{3+}]^m [\text{I}^-]^n}{[\text{I}^-]^n} = \frac{3.24 \times 10^{-3}}{8.10 \times 10^{-4}} = \frac{k [0.0400]^m [0.0600]^n}{[0.0300]^n} \quad \text{or} \quad 4 = 2^m, \ m = 2
\]

k/k cancels as does [0.0400]/[0.0400], so

\[
\frac{3.24 \times 10^{-3}}{8.10 \times 10^{-4}} = \frac{0.0600}{0.0300} \quad \text{or} \quad 4 = 2^m, \ m = 2
\]

\[
k = \frac{\text{Rate}}{[\text{Fe}^{3+}]^m [\text{I}^-]^n} \quad \text{filling in data from trial 1} \quad k = \frac{8.10 \times 10^{-4}}{[0.0400]^1[0.0300]^2} = 22.5
\]

Specific rate law is \(\text{Rate} = 22.5[\text{Fe}^{3+}]^1[\text{I}^-]^2\)

c) Fe\(^{3+}\) + 2I\(^-\)

d) Rate = 22.5[0.090]^1[0.50]^2 = 0.50625 or 0.51 M/s

e) If \(k\) is relatively large, than the rate is relatively fast and the activation energy hill would be relatively small.