1. For parts of the free-response question that require calculations, clearly show the method used and the steps involved in arriving at your answers. You must show your work to receive credit for your answer. Examples and equations may be included in your answers where appropriate.

\[2 \text{NO}_2(g) + \text{F}_2(g) \rightarrow \text{NO}_2\text{F}(g)\]
\[\Delta H_{\text{rxn}}^\circ = -284 \text{ kJ/mol}_{\text{rxn}}\]

\(\text{NO}_2(g)\) and \(\text{F}_2(g)\) can react to produce \(\text{NO}_2\text{F}(g)\), as represented above. A proposed mechanism for the reaction has two elementary steps, as shown below.

<table>
<thead>
<tr>
<th>Step 1: (\text{NO}_2 + \text{F}_2 \rightarrow \text{NO}_2\text{F} + \text{F})</th>
<th>(slow)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 2: (\text{NO}_2 + \text{F} \rightarrow \text{NO}_2\text{F})</td>
<td>(fast)</td>
</tr>
</tbody>
</table>

(a) Write a rate law for the overall reaction that is consistent with the proposed mechanism.

\[\text{Rate} = k [\text{NO}_2][\text{F}_2]\]

(b) On the incomplete reaction energy diagram below, draw a curve that shows the following two details.

- The relative activation energies of the two elementary steps
- The enthalpy change of the overall reaction

2 peaks
- 1st peak higher
2.

\[
\begin{align*}
\text{cis-2-butene} & \quad \text{↔} \quad \text{trans-2-butene} \\
\begin{array}{c}
\text{H}_3\text{C} = \text{C} - \text{CH}_3 \\
\text{H} & \quad \text{H} \\
\end{array}
\end{align*}
\]

The half-life \((t_{1/2})\) of the catalyzed isomerization of \textit{cis}-2-butene gas to produce \textit{trans}-2-butene gas, represented above, was measured under various conditions, as shown in the table below.

<table>
<thead>
<tr>
<th>Trial Number</th>
<th>Initial (P_{\text{cis-2-butene}}) (torr)</th>
<th>(V) (L)</th>
<th>(T) (K)</th>
<th>(t_{1/2}) (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>300</td>
<td>2.00</td>
<td>350</td>
<td>100.</td>
</tr>
<tr>
<td>2</td>
<td>600</td>
<td>2.00</td>
<td>350</td>
<td>100.</td>
</tr>
<tr>
<td>3</td>
<td>300</td>
<td>4.00</td>
<td>350</td>
<td>100.</td>
</tr>
<tr>
<td>4</td>
<td>300</td>
<td>2.00</td>
<td>365</td>
<td>50.</td>
</tr>
</tbody>
</table>

\(ΔT\) change in the reaction.

a. The reaction is first order. Explain how the data in the table are consistent with a first-order reaction.

\(Δt\) change in the reaction.

b. Calculate the rate constant, \(k\), for the reaction at 350. K. Include appropriate units with your answer.

\[
\frac{t_{1/2}}{K} = 0.693 \\
K = \frac{0.693}{t_{1/2}} = \frac{0.693}{100.5} \\
K = 0.00693 \text{torr}^{-1}
\]

c. Is the initial rate of the reaction in trial 1 greater than, less than, or equal to the initial rate in trial 2? Justify your answer.

\(Δt\) change in the reaction.

d. The half-life of the reaction in trial 4 is less than the half-life in trial 1. Explain why, in terms of activation energy.

\(ΔT\) change in the reaction.
goalie