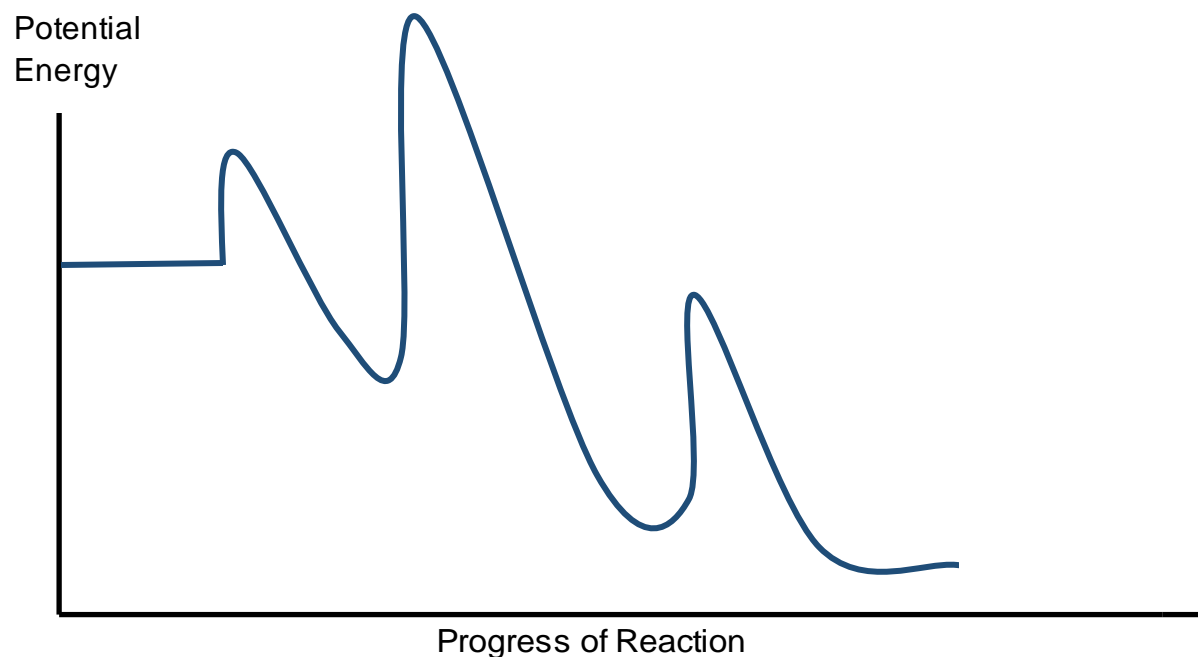


Reaction Mechanism Examples

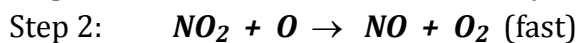
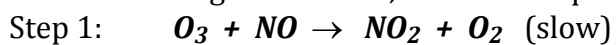
Name: _____

1. Given the reaction: $\text{HCOOH} \rightarrow \text{CO} + \text{H}_2\text{O}$
- a) This reaction, without a catalyst, is *very slow* at room temperature. Suggest why.
Reaction has a large activation energy and particles do not possess sufficient KE at room temperature to overcome E_a and have a successful collision.
- b) This reaction is thought to take place by means of the following mechanism when the catalyst H^+ is added:
- Step 1: $\text{HCOOH} + \text{H}^+ \rightarrow \text{HCOOH}_2^+$ (fast)
- Step 2: $\text{HCOOH}_2^+ \rightarrow \text{H}_2\text{O} + \text{HCO}^+$ (slow)
- Step 3: $\text{HCO}^+ \rightarrow \text{CO} + \text{H}^+$ (fast)
- c) Identify the two *intermediates* HCOOH_2^+ , HCO^+
- d) Identify the *catalyst* in this mechanism H^+
- e) Another catalyst is discovered which increases the rate of only Step 1. How will this affect the rate of the *overall reaction*?
NO EFFECT.
Explain your answer.
RATE OF THE OVERALL REACTION IS DETERMINED BY THE SLOWEST STEP, FOR THIS REACTION, THIS IS STEP 2.
- f) Which step has the greatest *activation energy*? **STEP 2**
- g) How many "bumps" will the potential energy diagram for the catalyzed reaction?
3
- h) Which step is called the *rate determining step* in this mechanism? **STEP 2**
- i) In order to have successful collisions, the colliding particles must have **both** the proper amount of *energy* and the proper **GEOMETRY**

On the set of axes below, draw the shape of the curve you might expect for the reaction in this question. The overall reaction is exothermic! Make sure you get the "bumps" the correct relative sizes.



2. Given the following mechanism, answer the questions below:



a) Give the equation for the **overall reaction**.



b) What could the **catalyst** be in this mechanism? **NO**

c) What is an **intermediate** in this mechanism? **NO₂**

The following are proposed reaction mechanisms. For each, either find the overall reaction or the missing step. In addition, list all reaction intermediates and catalysts for each reaction.

- Step 1 : $A + B \rightarrow I_1$

Step 2 : $I_1 + A \rightarrow I_2$

Step 3 : $I_2 + C \rightarrow D$

Overall Reaction :
- Step 1 : $H + I \rightarrow J$

Step 2 : $J + K \rightarrow L + H$

Step 3 : $2L \rightarrow M + N$

Overall Reaction :
- Step 1 : $Se + O_2 \rightarrow SeO_2$

Step 2 : $SeO_2 + O_2 \rightarrow SeO_4$

Overall Reaction :
- Overall reaction : $OCI^- + I^- \rightarrow OI^- + Cl^-$

Step 1 : $OCI^- + H_2O \rightarrow HOCl + OH^-$

Step 2 : $I^- + HOCl \rightarrow HOI + Cl^-$

Step 3 :
- Step 1 : $HCOOH + H^+ \rightarrow HCOOH_2^+$

Step 2 : $HCOOH_2^+ \rightarrow HCO^+ + H_2O$

Step 3 : $HCO^+ \rightarrow H^+ + CO$

Overall Reaction :
- Overall reaction : $H_2 + Cl_2 \rightarrow 2HCl$

Step 1 :

Step 2 : $Cl + H_2 \rightarrow HCl + H$

Step 3 : $H + Cl_2 \rightarrow HCl + Cl$

Step 4 : $Cl + Cl \rightarrow Cl_2$
- Step 1 : $NO + O_2 \rightarrow NO_3$

Step 2 : $NO_3 + NO \rightarrow 2NO_2$

Overall reaction :
- Overall reaction : $2Ce^{4+} + Tl^+ \rightarrow 2Ce^{3+} + Tl^{3+}$

Step 1 : $Ce^{4+} + Mn^{2+} \rightarrow Ce^{3+} + Mn^{3+}$

Step 2 :

Step 3 : $Mn^{4+} + Tl^+ \rightarrow Tl^{3+} + Mn^{2+}$

9. Step 1 : $\text{H}^+ + \text{H}_2\text{O}_2 \rightarrow \text{H}_3\text{O}_2^+$
 Step 2 : $\text{Br}^- + \text{H}_3\text{O}_2^+ \rightarrow \text{HOBr} + \text{H}_2\text{O}$
 Step 3 : $\text{HOBr} + \text{H}^+ \rightarrow \text{H}_2\text{OBr}^+$
 Step 4 : $\text{Br}^- + \text{H}_2\text{OBr}^+ \rightarrow \text{H}_2\text{O} + \text{Br}_2$
 Overall reaction :
10. Overall reaction : $\text{NH}_4^+ + \text{HNO}_2 \rightarrow \text{N}_2 + 2\text{H}_2\text{O} + \text{H}^+$
 Step 1 : $\text{HNO}_2 + \text{H}^+ \rightarrow \text{H}_2\text{O} + \text{NO}^+$
 Step 2 :
 Step 3 : $\text{NO}^+ + \text{NH}_3 \rightarrow \text{NH}_3\text{NO}^+$
 Step 4 : $\text{NH}_3\text{NO}^+ \rightarrow \text{H}_2\text{O} + \text{H}^+ + \text{N}_2$
11. Overall reaction : $\text{I}^- + \text{OCl}^- \rightarrow \text{Cl}^- + \text{OI}^-$
 Step 1 :
 Step 2 : $\text{HOCl} + \text{I}^- \rightarrow \text{Cl}^- + \text{HOI}$
 Step 3 : $\text{HOI} + \text{OH}^- \rightarrow \text{H}_2\text{O} + \text{OI}^-$

ANSWERS :

	Missing Step/Reaction	Reaction Intermediates	Catalysts
1	$2\text{A} + \text{B} + \text{C} \rightarrow \text{D}$	I_1, I_2	
2	$\text{I} + \text{K} + \text{L} \rightarrow \text{M} + \text{N}$	J, L	H
3	$\text{Se} + 2\text{O}_2 \rightarrow \text{SeO}_4$	SeO_2	
4	$\text{OH}^- + \text{HOI} \rightarrow \text{H}_2\text{O} + \text{OI}^-$	$\text{HOCl}, \text{OH}^-, \text{HOI}$	H_2O
5	$\text{HCOOH} \rightarrow \text{H}_2\text{O} + \text{CO}$	$\text{HCOOH}_2^+, \text{HCO}^+$	H^+
6	$\text{Cl}_2 \rightarrow 2\text{Cl}$	Cl, H	Cl_2
7	$2\text{NO} + \text{O}_2 \rightarrow 2\text{NO}_2$	NO_3	
8	$\text{Ce}^{4+} + \text{Mn}^{3+} \rightarrow \text{Ce}^{3+} + \text{Mn}^{4+}$	$\text{Mn}^{3+}, \text{Mn}^{4+}$	Mn^{2+}
9	$2\text{H}^+ + 2\text{Br}^- + \text{H}_2\text{O}_2 \rightarrow 2\text{H}_2\text{O} + \text{Br}_2$	$\text{H}_3\text{O}_2^+, \text{HOBr}, \text{H}_2\text{OBr}^+$	
10	$\text{NH}_4^+ \rightarrow \text{NH}_3 + \text{H}^+$	$\text{NO}^+, \text{NH}_3, \text{NH}_3\text{NO}^+$	H^+
11	$\text{H}_2\text{O} + \text{OCl}^- \rightarrow \text{HOCl} + \text{OH}^-$	$\text{HOCl}, \text{HOI}, \text{OH}^-$	H_2O

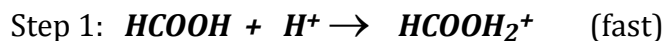
Reaction Mechanism Examples

Name: _____

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a) This reaction, without a catalyst, is *very slow* at room temperature. Suggest why.

c) This reaction is thought to take place by means of the following mechanism when the catalyst H^+ is added:



c) Identify the two *intermediates* _____

d) Identify the *catalyst* in this mechanism _____

f) Another catalyst is discovered which increases the rate of only Step 1.
How will this affect the rate of the *overall reaction*?

Explain your answer. _____

f) Which step has the greatest *activation energy*? _____

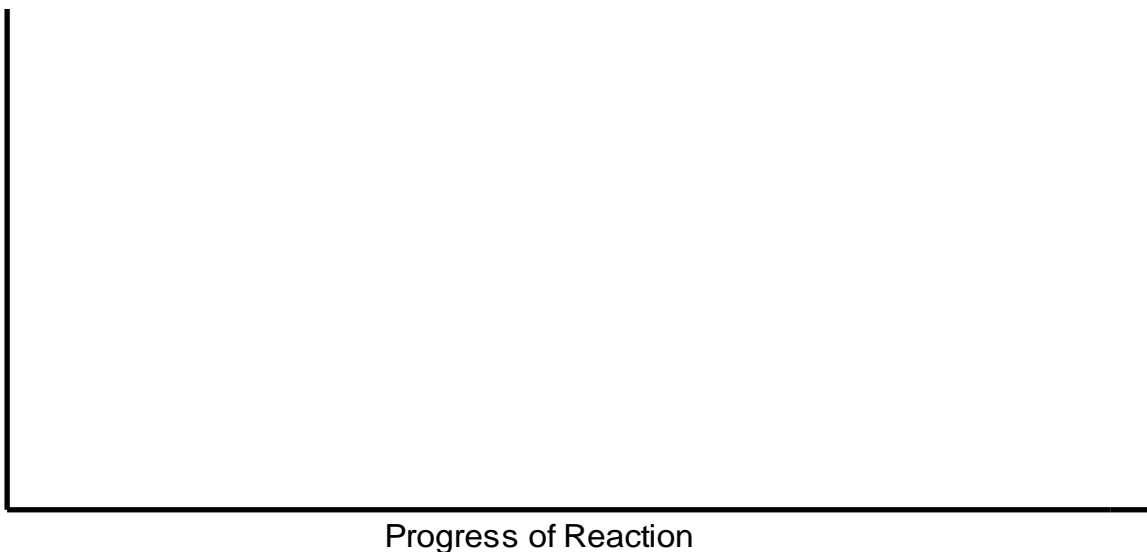
h) How many "bumps" will the potential energy diagram for the catalyzed reaction?

h) Which step is called the *rate determining step* in this mechanism? _____

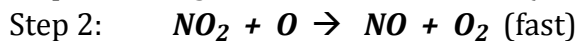
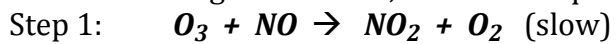
ii) In order to have successful collisions, the colliding particles must have **both** the proper amount of *energy* and the proper _____

On the set of axes below, draw the shape of the curve you might expect for the reaction in this question. The overall reaction is exothermic! Make sure you get the "bumps" the correct relative sizes.

Potential
Energy



2. Given the following mechanism, answer the questions below:



a) Give the equation for the **overall reaction**.

b) What could the **catalyst** be in this mechanism? _____

c) What is an **intermediate** in this mechanism? _____