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.
   
   ______________________________________________________________________
   
   b) This reaction is thought to take place by means of the following mechanism when the catalyst $\text{H}^+$ 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**
   
   __________________________
   
   d) Identify the **catalyst** in this mechanism
   
   __________________________
   
   e) Another catalyst is discovered which increases the rate of only **Step 1**.
   
   How will this affect the rate of the **overall reaction**?
   
   No, step 1 is not the slowest rate determining step.
   
   Explain your answer. __________________________________________________________________________
   
   f) Which step has the greatest **activation energy**?
   
   __________________________
   
   g) How many "bumps" will the potential energy diagram for the catalyzed reaction? __________
   
   h) Which step is called the **rate determining step** in this mechanism?
   
   __________
   
   i) 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

Progress of Reaction

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

   Step 1: \[ \text{O}_3 + \text{NO} \rightarrow \text{NO}_2 + \text{O}_2 \] (slow)

   Step 2: \[ \text{NO}_2 + \text{O} \rightarrow \text{NO} + \text{O}_2 \] (fast)

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

      \[ \text{O}_3 + \text{O} \rightarrow 2\text{O}_2 \]

   b) **What could the catalyst be in this mechanism?** \[ \text{NO} \]

   c) **What is an intermediate in this mechanism?** \[ \text{NO}_2 \]