Practice Questions Section 4.4

Factors Influencing Reaction Rate – Catalysts

1. Phosgene, $COCl_2$, one of the poison gases used during World War I, is formed from chlorine and carbon monoxide. The mechanism is thought to proceed by:

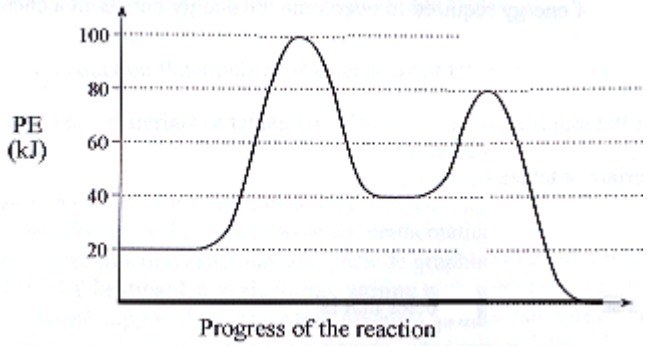
   step 1: $Cl + CO \rightarrow COCl$

   step 2: $COCl + Cl_2 \rightarrow COCl_2 + Cl$

   a. Write the overall reaction equation.
   b. Identify any reaction intermediates.
   c. Identify any catalysts.

2. We have typically been simplifying our potential energy curves somewhat; for multistep reactions, potential energy curves are more accurately shown with multiple peaks. Each peak represents the activated complex for an individual step.

   Consider the PE curve for a two-step reaction:



Answers

   a. What is ΔH for the overall reaction?
   b. What is ΔH for the first step of the reaction mechanism?
   c. What is ΔH for the second step of the reaction mechanism?
   d. What is ΔH for the overall reverse reaction?
   e. What is E_a for the first step?
   f. What is E_a for the second step?
   g. Which is the rate-determining step - step 1 or step 2? How do you know?
   h. What is E_a for the reverse of step 1?
   i. Is the overall reaction endothermic or exothermic?

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   a. Write the overall reaction equation.
   b. Identify any reaction intermediates.
   c. Identify any catalysts.

   Solution

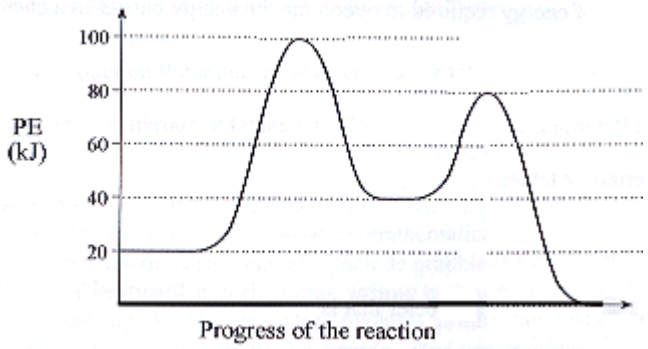
   a. The overall reaction: $CO + Cl_2 \rightarrow COCl_2$

   b. The reaction intermediate is COCl - it is produced during the first step but immediately used up in the second step.

   c. The catalyst is Cl - a catalyst can be identified by the fact that it is added as a reactant but emerges (as a product) unchanged; thus it will always first appear as a reactant but will later (not necessarily the next step) appear as a product in the reaction. Since it appears on both sides of the equation it will be cancelled out of the net or overall equation, just as are reaction intermediates.

2. We have typically been simplifying our potential energy curves somewhat; for multistep reactions, potential energy curves are more accurately shown with multiple peaks. Each peak represents the activated complex for an individual step.

   Consider the PE curve for a two-step reaction:



Answers

a.	What is ΔH for the overall reaction?	-20 kJ
b.	What is ΔH for the first step of the reaction mechanism?	+ 20 kJ
c.	What is ΔH for the second step of the reaction mechanism?	-40 kJ
d.	What is ΔH for the overall reverse reaction?	+20 kJ
e.	What is E_a for the first step?	+80 kJ
f.	What is E_a for the second step?	+40 kJ
g.	Which is the rate-determining step - step 1 or step 2? How do you know?	step 1 because it has the largest activation energy, E_a
h.	What is E_a for the reverse of step 1?	+60 kJ
i.	Is the overall reaction endothermic or exothermic?	exothermic