

Chapter 11 Activation Energy and Catalysts

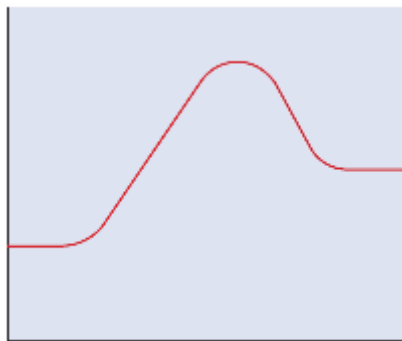
Solutions to Practice Problems

1.

Problem

Complete the potential energy diagram by adding the following labels. Is the reaction endothermic or exothermic?

$E_{a(\text{fwd})}$ $E_{a(\text{rev})}$ $\Delta_r H$
appropriate x -axis label appropriate y -axis label



What is Required?

You must label a potential energy diagram with the following: $E_{a(\text{fwd})}$, $E_{a(\text{rev})}$, $\Delta_r H$, the appropriate x -axis label, and the appropriate y -axis label.

What is Given?

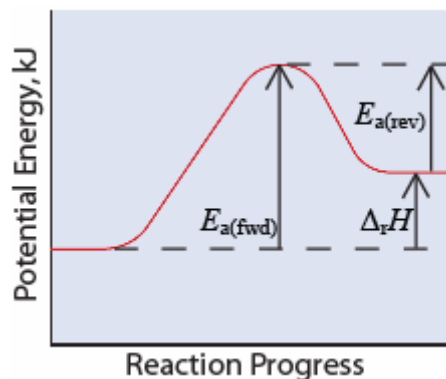
The outline of a potential energy diagram is given.

Plan Your Strategy

Use the definitions of $E_{a(\text{fwd})}$, $E_{a(\text{rev})}$, and $\Delta_r H$ to label the diagram.

Act on Your Strategy

The reaction is endothermic because the potential energy of the products is greater than the potential energy of the reactants.



Check Your Solution

The labels correspond to the definitions of $E_{a(\text{fwd})}$, $E_{a(\text{rev})}$, and $\Delta_r H$.

2.

Problem

Consider the following reaction:



Draw and label a potential energy diagram for this reaction. Calculate and label $E_{a(\text{fwd})}$.

What is Required?

You must draw and label a potential energy diagram for the given reaction and calculate and label $E_{a(\text{fwd})}$.

What is Given?

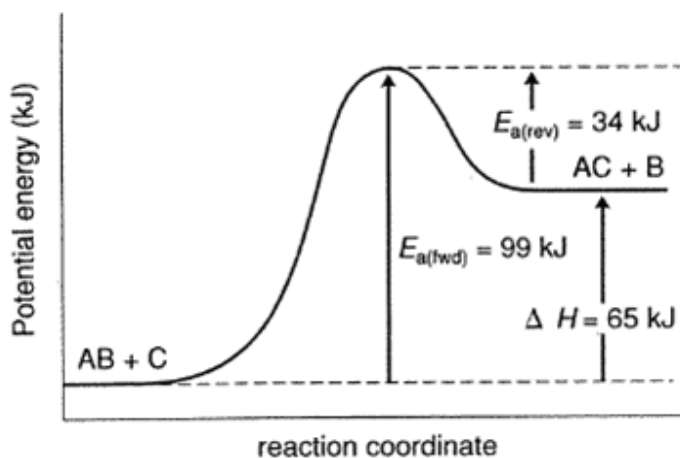


Plan Your Strategy

Use the appropriate definitions of $E_{a(\text{fwd})}$, $E_{a(\text{rev})}$, and $\Delta_r H$ to determine the value of $E_{a(\text{fwd})}$ and use these values to draw and label the corresponding potential energy diagram.

Act on Your Strategy

$$E_{a(\text{fwd})} = E_{a(\text{rev})} + |\Delta_r H| = 34 \text{ kJ} + | +65 \text{ kJ} | = 99 \text{ kJ}$$



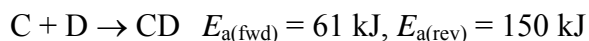
Check Your Solution

The values correspond to the definitions of $E_{a(\text{fwd})}$, $E_{a(\text{rev})}$, and $\Delta_r H$.

3.

Problem

Consider the reaction below:

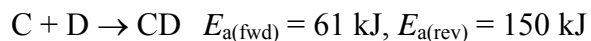


Draw and label a potential energy diagram for this reaction. Calculate and label ΔH .

What is Required?

You must draw and label a potential energy diagram for the given reaction and calculate and label ΔH .

What is Given?



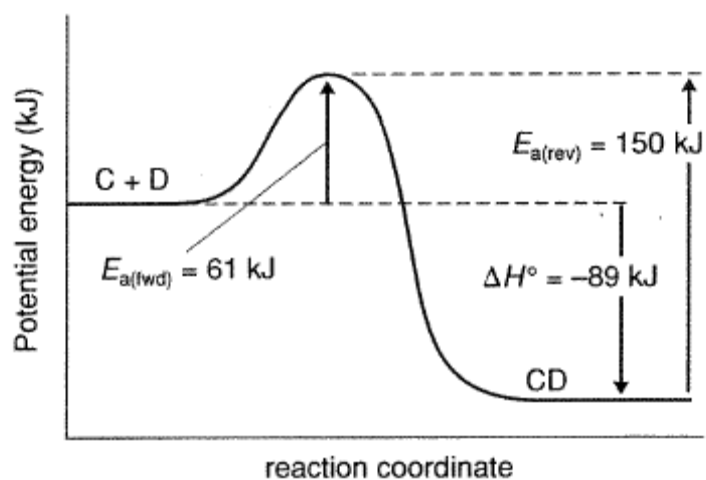
Plan Your Strategy

Use the appropriate definitions of $E_{a(\text{fwd})}$, $E_{a(\text{rev})}$, and ΔH° to determine the value of ΔH and use these values to draw and label the corresponding potential energy diagram. Since

$E_{a(\text{rev})} > E_{a(\text{fwd})}$, the reaction is exothermic.

Act on Your Strategy

$$\Delta H^\circ = E_{a(\text{fwd})} - E_{a(\text{rev})} = 61 \text{ kJ} - 150 \text{ kJ} = -89 \text{ kJ}$$



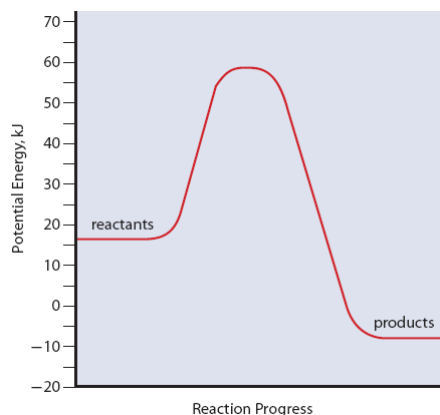
Check Your Solution

The values correspond to the definitions of $E_{a(\text{fwd})}$, $E_{a(\text{rev})}$, and ΔH .

4.

Problem

Using the potential energy diagram below, estimate the values at $E_{a(\text{fwd})}$, $E_{a(\text{rev})}$ and $\Delta_r H$. Is the reaction endothermic or exothermic?



What is Required?

You must use the potential energy diagram to determine the following: $E_{a(\text{fwd})}$, $E_{a(\text{rev})}$ and $\Delta_r H$.

What is Given?

The outline of a potential energy diagram showing the relative potential energy of the reactants and products is given.

Plan Your Strategy

Use the appropriate definitions and the potential energy diagram to determine the values of $E_{a(\text{fwd})}$, $E_{a(\text{rev})}$, and $\Delta_r H$.

Act on Your Strategy

Using the potential energy diagram:

$$E_{a(\text{fwd})} = 60 \text{ kJ} - 15 \text{ kJ} = 45 \text{ kJ}$$

$$E_{a(\text{rev})} = 60 \text{ kJ} - (-15 \text{ kJ}) = 75 \text{ kJ}$$

$$\begin{aligned} \Delta_r H &= \text{potential energy of products} - \text{potential energy of reactants} \\ &= -15 \text{ kJ} - (15 \text{ kJ}) = -30 \text{ kJ} \end{aligned}$$

Check Your Solution

The values correspond to the definitions of $E_{a(\text{fwd})}$, $E_{a(\text{rev})}$, and $\Delta_r H$. Student answers may vary slightly.

5.

Problem

In the upper atmosphere, oxygen exists in forms other than $\text{O}_2(\text{g})$. For example, it exists as ozone, $\text{O}_3(\text{g})$, and as individual oxygen atoms, $\text{O}(\text{g})$. Ozone and atomic oxygen react to form two molecules of oxygen gas. For this reaction, the enthalpy change is -392 kJ and the activation energy is 19 kJ . Draw and label a potential energy diagram. Include a value for $E_{a(\text{rev})}$.

What is Required?

You must draw and label a potential energy diagram for the given reaction between $\text{O}_3(\text{g})$ and $\text{O}(\text{g})$ to produce $\text{O}_2(\text{g})$ and calculate $E_{a(\text{rev})}$.

What is Given?

$$\Delta H = -392 \text{ kJ}$$

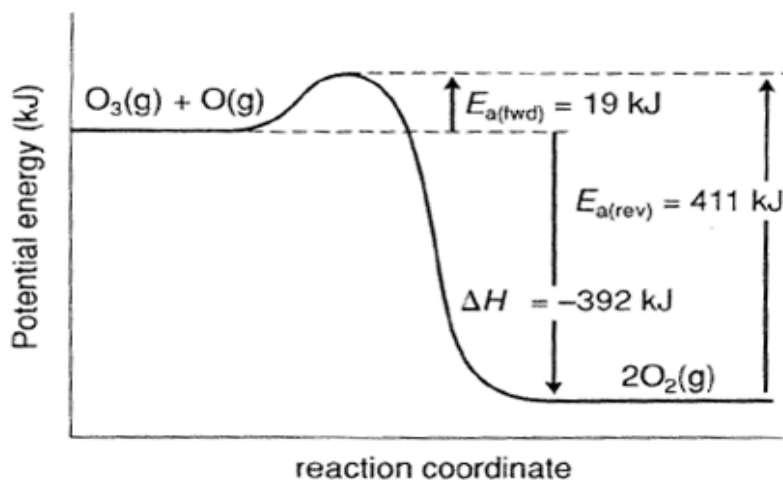
$$E_{a(\text{fwd})} = 19 \text{ kJ}$$

Plan Your Strategy

Use the appropriate definitions of $E_{a(\text{fwd})}$, $E_{a(\text{rev})}$, and ΔH to determine the value of $E_{a(\text{rev})}$ and use these values to draw and label the corresponding potential energy diagram. Since the enthalpy change is negative, the reaction is exothermic.

Act on Your Strategy

$$E_{a(\text{rev})} = E_{a(\text{fwd})} + |\Delta H| = 19 \text{ kJ} + |-392 \text{ kJ}| = +411 \text{ kJ}$$



Check Your Solution

The values correspond to the definitions of $E_{a(\text{fwd})}$, $E_{a(\text{rev})}$, and ΔH .