

## 12.15: Mechanisms and Potential Energy Diagrams

For some, a roller coaster is the epitome of excitement, while for others it is a torture device to be avoided at all costs (and some folks are in-between). For a roller coaster, the rate-limiting step is the climb up to the top at the beginning of the ride, where the cars are hauled slowly to the peak of the ride. This peak must be the highest because the potential energy at this point must be enough to cause the roller coaster to move through the smaller peaks without stopping.

### Potential Energy Diagrams

The potential energy diagram can illustrate the mechanism for a reaction by showing each elementary step of the reaction with distinct activation energy (see figure below).

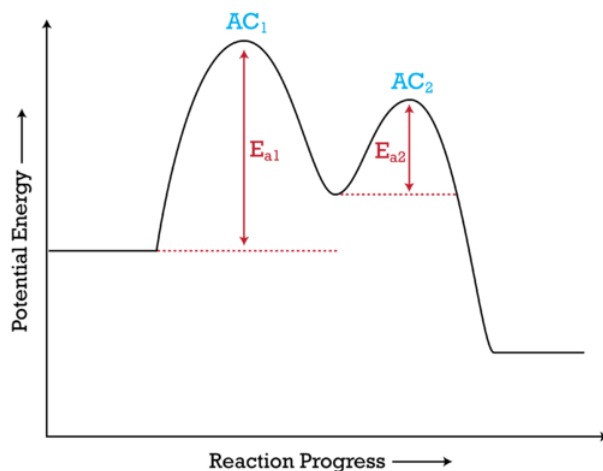


Figure 12.15.1: The potential energy diagram shows an activation energy peak for each of the elementary steps of the reaction. The valley between represents the intermediate for the reaction. (CC BY-NC; CK-12)

The reaction whose potential energy diagram is shown in the figure is a two-step reaction. The activation energy for each step is labeled  $E_{a1}$  and  $E_{a2}$ . Each elementary step has its own activated complex, labeled  $AC_1$  and  $AC_2$ . Note that the overall enthalpy change of the reaction ( $\Delta H$ ) is unaffected by the individual steps, since it depends only on the initial and final states.

In this example, the rate-limiting step in the reaction is the first step, leading to the formation of the activated complex  $AC_1$ . The activation energy is higher for this step than for step two, which has a considerably lower activation energy. If the rate-limiting step were the second step, the peak labeled  $AC_2$  would be the higher peak than  $AC_1$  and  $E_{a2}$  would be greater than  $E_{a1}$ . The same approach can be taken for a potential energy diagram with more than two peaks.

### Summary

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