REB, The Course
Class 8 Practice Assignment Solution

Example 5.1.1 considered the irreversible, exothermic reaction, A → Z, taking place adiabatically starting with only A present. Suppose instead that the reaction is endothermic. Sketch the concentration of A, and the temperature versus reaction time for isothermal operation and for adiabatic operation. Describe the shape of each graph noting slopes, curvature, inflection points, etc. Then explain the shapes and the differences between the adiabatic and isothermal plots on a physical basis.

The reaction is irreversible, so the concentration of Z won't affect the rate. When the reaction occurs isothermally, only the concentration of A will be important, but when it operates adiabatically, both the temperature and the concentration of A will affect the reaction rate.

For both modes of operation, the concentration of A will initially be positive and decreasing. For isothermal operation, the temperature will be positive and constant, while for adiabatic operation it will be positive and decreasing. During the first brief interval of operation, the concentration of A will decrease, and for adiabatic operation, the temperature will decrease, too. In both cases, the rate will therefore be smaller at the start of the next brief interval of time. Because the rate is smaller, the changes during the next interval will also be smaller. In other words, the concentration will initially be positive and decreasing with a curvature that is concave upward. This will be true for both modes of operation, and it will also be true for the temperature when the reaction takes place adiabatically. Of course, for isothermal operation the temperature will be constant. This behavior is sketched in Figure 1. In all cases, the initial trend can continue for as long as needed until the concentration of A asymptotically approaches zero and the adiabatic reaction asymptotically approaches its final temperature.

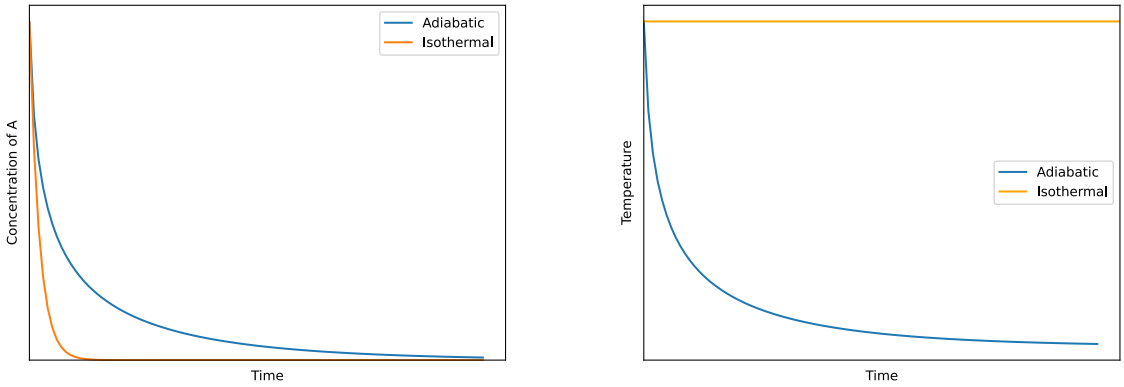

Figure 1. Concentration (left) and temperature (right) profiles during a typical endothermic reaction occurring isothermally and adiabatically.

Figure 1 shows that the concentration in the adiabatic system is always greater than that in the isothermal system, and consequently it takes longer for the reactant concentration in the adiabatic system to reach zero. This is easily understood by considering the factors that affect the rate. When the reactor operates isothermally, the only factor causing the rate to decrease with time is the concentration of A. However when it operates adiabatically, both the reactant concentration and the temperature contribute, and so the rate decreases by more than during isothermal operation. Because the rate is lower during adiabatic operation, it takes longer for the reaction to reach complete conversion.