

### 2.1.3.1: The "Speed" of a Chemical Reaction

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How long does it take for a chemical reaction to occur under a given set of conditions? As with many "simple" questions, no meaningful answer can be given without being more precise. In this case,

How do we define the point at which the reaction is "completed"?

A reaction is "completed" when it has reached equilibrium — that is, when concentrations of the reactants and products are no longer changing.

If the equilibrium constant is quite large, then the answer reduces to a simpler form: the reaction is completed when the concentration of a reactant falls to zero. In the interest of simplicity, we will assume that this is the case in the remainder of this discussion.

"How long?" may be too long

If the reaction takes place very slowly, the time it takes for every last reactant molecule to disappear may be too long for the answer to be practical. In this case, it might make more sense to define "completed" when a reactant concentration has fallen to some arbitrary fraction of its initial value — 90%, 70%, or even only 20%.

The particular fraction one selects depends on the cost of the reactants in relation to the value of the products, balanced against the cost of operating the process for a longer time or the inconvenience of waiting for more product. This kind of consideration is especially important in industrial processes in which the balances of these costs affect the profitability of the operation.

The half-life of a reaction

Instead of trying to identify the time required for the reaction to become completed, it is far more practical to specify the time required for the concentration of a reactant to fall to half of its initial value. This is known as the *half-life* (or half-time) of the reaction.

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