**TABLE 3.2**   Cofactors (Metal Ions) and Coenzymes of Some Enzymes

| | *Coenzyme* | *Entity transferred* |
|---|---|---|
| $Zn^{2+}$ | Nicotinamide adenine dinucleotide | Hydrogen atoms (electrons) |
|   Alcohol dehydrogenase | Nicotinamide adenine dinucleotide | Hydrogen atoms (electrons) |
|   Carbonic anhydrase |   phosphate | Hydrogen atoms (electrons) |
|   Carboxypeptidase | Flavin mononucleotide | Hydrogen atoms (electrons) |
| $Mg^{2+}$ | Flavin adenine dinucleotide | Hydrogen atoms (electrons) |
|   Phosphohydrolases | Coenzyme Q | Aldehydes |
|   Phosphotransferases | Thiamin pyrophosphate | Acyl groups |
| $Mn^{2+}$ | Coenzyme A | Acyl groups |
|   Arginase | Lipoamide | Alkyl groups |
|   Phosphotransferases | Cobamide coenzymes | Carbon dioxide |
| $Fe^{2+}$ or $Fe^{3+}$ | Biocytin | Amino groups |
|   Cytochromes | Pyridoxal phosphate | Methyl, methylene, formyl, |
|   Peroxidase | Tetrahydrofolate coenzymes |   or formimino groups |
|   Catalase | | |
|   Ferredoxin | | |
| $Cu^{2+}$ ($Cu^{+}$) | | |
|   Tyrosinase | | |
|   Cytochrome oxidase | | |
| $K^{+}$ | | |
|   Pyruvate kinase (also requires $Mg^{2+}$) | | |
| $Na^{+}$ | | |
|   Plasma membrane ATPase (also | | |
|     requires $K^{+}$ and $Mg^{2+}$) | | |

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## 3.3. ENZYME KINETICS

### 3.3.1. Introduction

A mathematical model of the kinetics of single-substrate-enzyme-catalyzed reactions was first developed by V. C. R. Henri in 1902 and by L. Michaelis and M. L. Menten in 1913. Kinetics of simple enzyme-catalyzed reactions are often referred to as Michaelis–Menten kinetics or *saturation* kinetics. The qualitative features of enzyme kinetics are similar to Langmuir–Hinshelwood kinetics (see Fig. 3.3). These models are based on data from batch reactors with constant liquid volume in which the initial substrate, $[S_0]$, and enzyme, $[E_0]$, concentrations are known. More complicated enzyme-substrate interactions such as multisubstrate–multienzyme reactions can take place in biological systems. An enzyme solution has a fixed number of active sites to which substrates can bind. At high substrate concentrations, all these sites may be occupied by substrates or the enzyme is *saturated*. Saturation kinetics can be obtained from a simple reaction scheme that involves a reversible step for enzyme–substrate complex formation and a dissociation step of the ES complex.

$$E + S \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} ES \xrightarrow{k_2} E + P \tag{3.1}$$