TABLE 8.3

Typical Oxidation Numbers of Carbon

Functional Group	Example	Oxidation Number of Carbon in the Example
Alkane	CH_4	−4
Alkyl lithium	CH_3Li	−4
Alkene	$H_2C{=}CH_2$	−2
Alcohol	CH_3OH	−2
Ether	CH_3OCH_3	−2
Alkyl halide	CH_3Cl	−2
Amine	CH_3NH_2	−2
Alkyne	HC CH	−1
Aldehyde	H_2CO	0
Carboxylic acid	HCO_2H	2
Carbon dioxide	CO_2	4

An alkene is reduced, for example, when it reacts with hydrogen to form the corresponding alkane.

$$CH_2{=}CHCH_3 + H_2 \xrightarrow{Ni} CH_3CH_2CH_3 \tag{8.14}$$

The scheme that follows Equation 8.15 provides a useful guide to the oxidation–reduction reactions of organic compounds. Each of the arrows in this figure involves a two-electron oxidation of a carbon atom along the path toward carbon dioxide. A line is drawn through the first arrow, because it is impossible to achieve this transformation in a single step.

$$\begin{array}{ccccccc} CH_4 & \not\longrightarrow & CH_3OH & \longrightarrow & HC(=O)H & \longrightarrow & HC(=O)OH \longrightarrow CO_2 \\ -4 & & -2 & & 0 & & +2 \qquad +4 \end{array} \tag{8.15}$$

8.2.4.2.1 Kinetics of Degradation

In real-time stability tests, a product is stored at recommended storage conditions and monitored for a period of time (t_{test}). The product will degrade below its specification, at some time, denoted t_s, and it must also be ensured that t_s is less than or equal to t_{test}. The estimated value of t_s can be obtained by modeling the degradation pattern. Good experimental design and practices are needed to minimize the risk of biases and reduce the amount of random error during data collection. Testing should be performed at time intervals that encompass the target shelf life and must be continued for a period after the product degrades below specification. It is also required that at least three lots of material be used in stability testing to capture lot-to-lot variation, which is an important source of product variability.