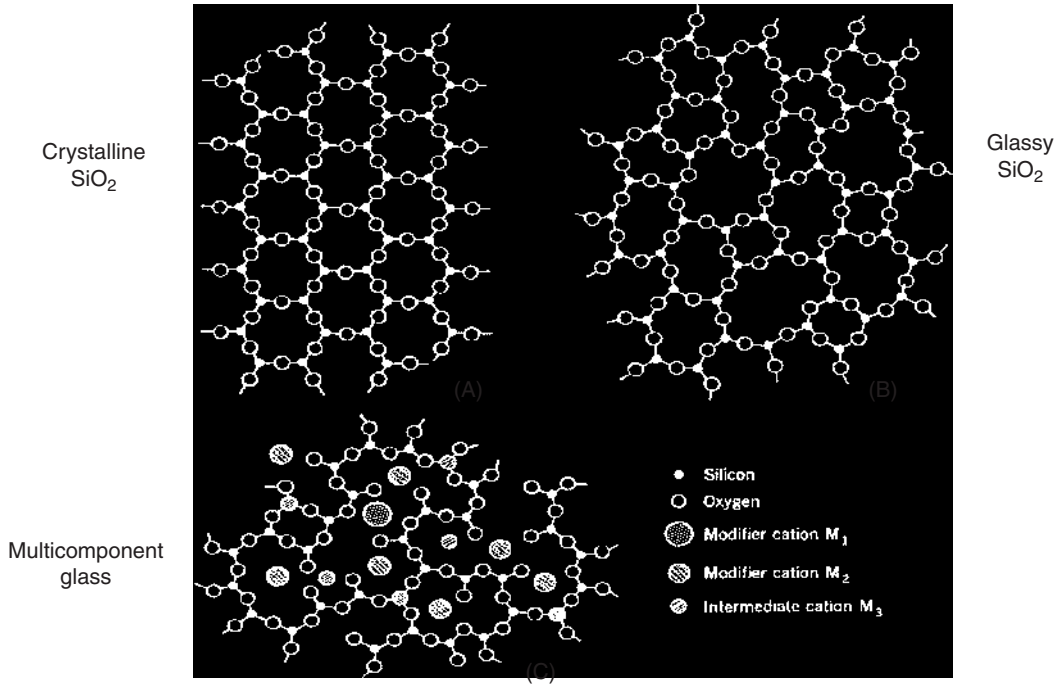

Figure 7-1 Molecular structures of glass. *Source*: Courtesy of Schott Glass.

Types of glass used in parenteral packaging are mixtures of crystalline oxides and carbonates (Fig. 7-1). Glass is melted by heating into a viscous liquid state becoming increasingly resistant to flow as it is cooled. Glass is considered a solid below ~500°C. Glass is composed of the network former—SiO_2 tetrahedron plus network modifiers (disodium oxide, boron oxide, and lead oxide) that lower the melting point. Stabilizers such as calcium oxide, aluminum oxide, and more disodium oxide are added to improve durability. Some glass contains colorants such as iron or titanium oxides.

Types

The United States Pharmacopeia <661> provides four classifications of glass based on chemical resistance:

- Type I, a borosilicate glass
- Type II, a soda-lime treated glass
- Type III, a soda-lime glass
- NP, a soda-lime glass not suitable for containers for parenterals.

Type I glass is composed principally of silicon dioxide (~81%) and boric oxide (~13%), with low levels of the non-network-forming oxides (such as sodium and aluminum oxides) (Fig. 7-2). It is a chemically resistant glass (low leachability) also having a low thermal coefficient of expansion (33×10^{-7} cm/cm/°C or $49–54 \times 10^{-7}$ cm/cm/°C). The former is called "Type I 33 expansion glass" and the latter is called "Type × (typically 51) expansion glass."

Types II and III glass types (both are soda-lime glass with Type II being chemically treated to reduce alkali leachables) are composed of relatively high proportions of sodium oxide (~14%) and calcium oxide (~8%) (Fig. 7-3). This makes the glass chemically less resistant. Both types melt at a lower temperature, are easier to mold into various shapes, and have a higher thermal coefficient of expansion than Type I (e.g., 90×10^{-7} cm/cm/°C for Type III). While there is no one standard formulation for glass among manufacturers of these United States Pharmacopeia (USP) type categories, Type II glass usually has a lower concentration of the migratory oxides than Type III. In addition, Type II has been treated under controlled temperature and humidity