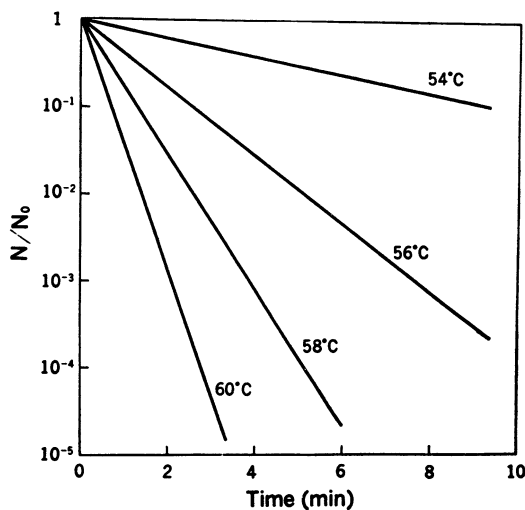


(a)



(b)

Figure 10.12. (a) Typical death-rate data for spores of *Bacillus stearothermophilus* Fs 7954 in distilled water, where N = number of viable spores at any time, N_0 = original number of viable spores. (b) Typical death rate for *E. coli* in buffer, where N = number of viable cells at any time and N_0 = original number of viable cells. (With permission, from S. Aiba, A. E. Humphrey, and N. F. Millis, *Biochemical Engineering*, 2d ed., University of Tokyo Press, Tokyo, 1973, p. 241.)

much preferred for the economic, large-scale sterilization of equipment and liquids. However, heat-sensitive equipment must be sterilized with chemical agents or radiation.

The use of ultraviolet (UV) radiation is effective to sterilize surfaces, but UV cannot penetrate fluids easily, particularly those with high amounts of suspended material. Although x-rays can penetrate more deeply, cost and safety considerations preclude their use in large-scale systems.

A chemical agent for sterilization must leave no residue that would be toxic to the desired culture. Ethylene oxide, a gas, can be used to sterilize equipment. A 70% ethanol–water mixture acidified to a pH of 2 with HCl kills virtually all vegetative cells