in its energy density locally in the region of transfer.[32] Thus the end result of the energy exchange process is a nonequilibrium isolated system. Initially the macrostate sequence of such a system is not governed by pure chance; it begins in an improbable nonequilibrium macrostate.

How long a microstate sequence is necessary before the long time probability takes over and the properties become those of the equilibrium group? This question can be answered intuitively by considering a physical example. When a tuning fork is struck, it is placed in a nonequilibrium state. Its vibrating prongs indicate a high energy density in these localized regions and the single frequency, in-phase vibration of the fork prongs indicate the presence of an ordered nonequilibrium macrostate. After the strike, the fork evolves toward equilibrium. The energy, initially localized in the vibrating prongs, is distributed throughout the material by means of particle collisions. The redistributed energy is manifest primarily in multifrequency and multidirection (i.e., highly disordered) vibration of the atoms in the metallic lattice. Equilibrium macrostates are achieved and the fork ceases to ring. Our experience is that this redistribution occurs quite rapidly. And that once the vibration stops, it never starts again spontaneously. Thus an isolated tuning fork goes from its initial improbable macrostate to more probable equilibrium macrostates in a continuous irreversible sequence.[33] This is the qualitative manner in which equilibrium is obtained. A more quantitative description of the process can be obtained through a detailed consideration of the collision processes of a small model system.

Note to the Student. The following quantitative illustration establishes the inevitability of a rapid approach to equilibrium through the study of transition probabilities, Table IIIA-8. Neither the determination nor the use of these probabilities is an objective of the unit. This section is intended to help the student recognize the processes which lead to equilibrium macrostates are overwhelmingly probable.

The mechanism of microstate change is collisions between particles. These collisions are restricted by the requirement that the energy and number of particles are conserved during each collision.[34] Each macrostate can be reached from every other as a result of

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[32]Electric and magnetic polarization work processes penetrate the boundary and are performed throughout the system's interior. In that sense, they can leave the energy density in the system spatially uniform. Yet they are still apt to terminate in a low-probability nonequilibrium macrostate. For example, microwaves penetrate the receiver, distributing the energy they deliver; but they promote particle vibration at a single frequency. This corresponds to ordered nonequilibrium macrostates.

[33]In fact, the tuning fork is not isolated. As it rings, it emits sound. A more rigorous statement of this example would place the vibrating fork in a vacuum. It would then be isolated. The processes and description for these circumstances are otherwise the same.

[34]Momentum must be conserved as well; but our discussion has omitted its consideration