We propose a consistent thermodynamical treatment of a massless scalar field (a "photon") confined to a fractal spatial manifold. The equation of state, which relates pressure to internal energy, is \( PV = U/d_s \), where \( d_s \) is the spectral dimension, and we introduce the notion of the "spectral volume", \( V_s \), as the natural thermodynamically defined volume. For regular manifolds, \( V_s \) coincides with the usual geometric spatial volume, but on a fractal this is not the case. We express the thermodynamical quantities, such as the partition function, in terms of the heat kernel, because on a fractal there is no well-defined mode decomposition nor phase space. Nevertheless, using known results for the Weyl expansion of the heat kernel, we show that the thermodynamic limit exists. Our analysis also provides a natural definition of the vacuum (Casimir) energy of a fractal. Spontaneous emission of atoms embedded in such fractal volumes can be strongly enhanced in a more efficient (but reminiscent) way than for the Purcell effect. Implications for photon statistics in these structures will be mentioned. We suggest ways that these unusual properties might be probed experimentally.