GROUP PARTICLE BEHAVIOR

The examples and exercises of this section have used the pseudopressure of the 4 particle example to illustrate the determination of properties. Table IIIA-4 summarizes these results for comparison. It demonstrates that the statistics dependent macrostate probabilities (p_i^{MB}, p_i^{BE}, and p_i^{FD}) influence the ensemble average (i.e., observable) property. While our very small and unrealistic example shows these differences to be slight, certain real systems exhibit behaviors sufficiently different to merit the distinctions between distinguishable, Boltzons, versus indistinguishable— symmetric, Bosons, and indistinguishable— antisymmetric, Fermions. A case in point is the remarkable properties of the Boson, He^4, in its liquid state below 2.172 K. This liquid exhibits unique properties, a so-called superfluidity, that are quite different from the ordinary liquid properties of the very similar Fermion, He^3. Superconductivity, a similar phenomenon, is a manifestation of Boson-type behavior exhibited by free electron pairs that occur in some conductors. Other effects of particle type are considered in more detail in Units IIID and IIIE.

Our present interest is not to explore the differences of the three types of particle behavior. Rather, it is the development of the concept and conditions of equilibrium attained by all isolated systems.

Note to the Student. The preceding section has developed operational procedures for calculation of distributions, probabilities, and properties in small systems. This provides necessary background for extension to real systems. On the basis of these concepts, we will build an understanding of the nature of, and processes that lead to equilibrium. This is the primary objective of Unit IIIA. Students who are not confident of the operational techniques so far developed may find the following comprehensive exercise helpful.

Exercise 12. Consider a system of 4 independent particles of total energy 8 C (where C is a constant with units of energy). Three energy levels are accessible to the particles, 1 C, 2 C, and 3 C their degeneracies are $g_1 = 1$, $g_2 = 2$, $g_3 = 3$, respectively. Answer the following questions:

I. Macrostate Determination (Trial and Error)

a. Determine the macrostates of this system.

b. Calculate the pseudopressure for each macrostate, $\overline{\varepsilon_i^{\frac{1}{2}}}$.

II. Determination of Particle Type. For each of the following particle descriptions, classify the particles as Boltzons, Bosons, or Fermions. (M is molecular weight).

a. System "A" is composed of four He^4 molecules, M = 4.

b. System "B" is composed of four particles. Each of them is a diatomic molecule composed of one atom of deuterium (1 proton, 1 neutron and 1 electron) and one atom of normal hydrogen, M = 3.

c. System "C" is composed of 4 particles all of the same molecular weight, M = 3. These 4 particles are: a He^3 atom; a molecule of deuterium; a cluster of 3 neutrons, and an "extra" heavy hydrogen atom (1 proton, 2 neutrons, 1 electron).

Verify your answers to parts I and II before proceeding.

III. Determination of Systems Characteristics. For one or more of the systems "A", "B" and "C".

a. Determine the number of microstates per macrostate, (W_i), and the total number