

**EE Qualifying Examination**  
***January 2008***

1. The average particle occupation number per state in the Bose-Einstein distribution is given by

$$n_{\text{BE}}(E) = \frac{1}{\exp[(E - \mu)/k_B T] - 1}$$

where  $E$ ,  $\mu$  and  $T$  are the energy of the particle state, chemical potential and temperature of the gas. If  $n_{\text{BE}}(E)$  becomes greater than one in the ground state, such a situation is called quantum degeneracy.

- (1) Derive the condition of quantum degeneracy.
- (2) If the system has a fixed number of particles, which (higher or lower) temperature is required to reach quantum degeneracy?

2. The average photon number per state in the photon statistics is given by

$$n_{\text{PH}}(\hbar\omega) = \frac{1}{\exp(\hbar\omega/k_B T) - 1}$$

where  $\hbar\omega$  is the energy of photon.

- (1) What is a fundamental difference from the BE distribution?
- (2) If the photon energy  $\hbar\omega$  is fixed, which (higher or lower) temperature is required to reach quantum degeneracy?