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Features and Limitations of MB Statistics

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Abstract:

This article is about the features and limitations of classical or Maxwell Boltzmann statistics.

The classical on Maxwell Boltzmann statistics every bearded as MB statistics does not take any Quantum principle into consideration. The uncertainty relation of Heisenberg and the exclusion principle of Pauli the two important Quantum principles do not apply to classical particles which are considered to be distinguished from one another.

The basic features of MB statistics may therefore be stated as follows:

1. The particles of the system are spinless, identifiable and distinguishable.
2. Neither the Heisenberg uncertainty relation, nor the exclusion principle of Pauli applies to the particles.
3. As a consequence of the above there is no multiplicity of energy staes and no a priori restriction as to the number of particles that could be accommodated in an energy state.

For the in the system is isolated the total number of particles N in it is constant.

Limitations of MB Statistics:

The MB statistics suffer from number of limitations some of them are:

- This statistics is applicable only to an isolated gas molecular system in equilibrium when the mean potential energy due to mutual interaction between the molecules is negligible compared to their mean kinetic energy and the gas is dilute. For dilute gases, the number of molecules per unit volume is small so that the average separation between the molecules is large. Individual molecules could then be distinguished(non degenerate).
- The expression for MB count does not lead to the correct expression for entropy of an ideal gas is leads to the Gibbs paradox which can be resolved if the expression is divided by N!
- If we put T = 0 in the expression for entropy of an ideal gas, the entropy is becomes a negative quantity which is at variance with the third law of thermodynamics.

- When the MB statistics is applied to electron gas in metals in number of discrepancies arise between the theory and observation:
  - Electrons do not appear to share at all the thermal energy of a conductor. While according to MB statistics free electrons should make a contribution of 3R/2 to heat capacity, the observed molar specific heat of a metal is 3R, equal to that of the metal lattice alone.
  - The predicted velocity distribution of photoelectrons does not agree with experimental results.
- When MB statistics is applied to photon gas i.e., a batch of electromagnetic radiant energy, it predicts a continuously increasing number of photons per unit range of frequency, as frequency increases. The actual distribution however is the well-known planck's law that shows a maximum falling off asymptotically on either side.

All these difficulties with MB statistics have been satisfactorily resolved by the quantum statistics. The difference between the classical MB statistics and the newer Quantum statistics lies essentially in the method of defining a microstate and counting the number of microstates for a given macrostate.

Reference:

Thermal physics —A.B. Gupta , H.P. Roy.