

Física Estadística I
Tarea 04: Gases Ideales Cuánticos — Gas de Bose-Einstein

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Nombre del Estudiante: _____

Problem 1 *Entropy of an ideal gas*

Show that the entropy of an ideal gas in thermal equilibrium is given:

1. In the case of bosons by the following expression,

$$S = k_B \sum_k [\langle \hat{n}_k + 1 \rangle \ln \langle \hat{n}_k + 1 \rangle - \langle \hat{n}_k \rangle \ln \langle \hat{n}_k \rangle].$$

2. In the case of fermions as:

$$S = k_B \sum_k [-\langle 1 - \hat{n}_k \rangle \ln \langle 1 - \hat{n}_k \rangle - \langle \hat{n}_k \rangle \ln \langle \hat{n}_k \rangle].$$

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Problem 2 *Occupation number fluctuations*

1. Derive, for all three statistics, the following expressions for the occupation number's fluctuation $\sigma_{\hat{n}_k}^2 = \langle \hat{n}_k^2 \rangle - \langle \hat{n}_k \rangle^2$:

$$\text{Bose-Einstein: } \sigma_{\hat{n}_k}^2|_{BE} = \langle \hat{n}_k \rangle + \langle \hat{n}_k \rangle^2.$$

$$\text{Fermi-Dirac: } \sigma_{\hat{n}_k}^2|_{FD} = \langle \hat{n}_k \rangle - \langle \hat{n}_k \rangle^2.$$

$$\text{Maxwell-Boltzmann: } \sigma_{\hat{n}_k}^2|_{MB} = \langle \hat{n}_k \rangle.$$

2. Show that, quite generally:

$$\sigma_{\hat{n}_k}^2 = \langle \hat{n}_k^2 \rangle - \langle \hat{n}_k \rangle^2 = k_B T \left. \frac{\partial \langle \hat{n}_k \rangle}{\partial \mu} \right|_T.$$

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