

## Exercises in Statistical Mechanics

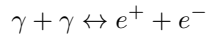
Based on course by Doron Cohen, has to be proofed  
*Department of Physics, Ben-Gurion University, Beer-Sheva 84105, Israel*

This exercises pool is intended for a graduate course in “statistical mechanics”. Some of the problems are original, while other were assembled from various undocumented sources. In particular some problems originate from exams that were written by B. Horovitz (BGU), S. Fishman (Technion), and D. Cohen (BGU).

### ===== [Exercise 4441]

#### Equilibrium for $\gamma \rightleftharpoons e^+ + e^-$

Consider the reaction



where the net charge of the system is fixed by the density difference  $n_0 = n_+ - n_-$ ;  $\gamma$  is a photon and  $e^\pm$  are the positron and electron, respectively.

- Derive equations from which the densities  $n_+$  and  $n_-$  can be determined in terms of  $n_0$ , temperature  $T$ , and the mass  $m$  of either  $e^+$  or  $e^-$ .
- Find the Fermi momentum  $p_F$  at  $T = 0$  for non-relativistic  $e^+$ ,  $e^-$  and the condition on  $n_0$  that allows a non-relativistic limit.
- Solve (a) for  $p_F^2/2m \ll k_B T \ll mc^2$ . (Hint: Find first an expression for the product  $n_+ n_-$ ).