PHY831 Statistical Mechanics
Chapter 2: 2.6 - 2.7 (Conceptual)

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1. ***(2.6 Grand Canonical vs. Canonical)***
Suppose you are studying an open system with many moles in number count. Is it reasonable to approximate a canonical ensemble as a grant canonical ensemble in this case? Why?

Solution: Yes. Although the grand canonical ensemble assumes a spread of particle number around an average $\bar{N}$, the fluctuation goes as

$$\frac{(\Delta\bar{N})}{\bar{N}} = \frac{1}{\sqrt{N}}$$

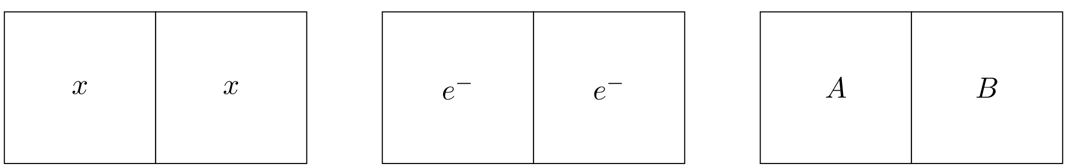
which goes to 0 as $\bar{N} \to \infty$. For an open single mole system where $\bar{N}$ is on the order of 10^{24}, the fluctuation of particle number is around 10^{-12} and the ensemble can be thought of as canonical, i.e., has constant particle count.

2. ***(2.7 Gibb's Paradox)***
Consider three equally parted boxes that are kept under constant temperature, with each partition containing $N/2$ number of the following particles:

(a) identical spinless particles x in both sides;

(b) electrons in both sides;

(c) 2 types of identical spinless particles A and B in each side.



(a) *(b)* *(c)*

After removing the partitions from all these boxes, which of the following relation correctly describes their respective changes in entropy?

(A) $0 = \Delta S_a < \Delta S_b < \Delta S_c$

(B) $0 < \Delta S_a = \Delta S_b < \Delta S_c$

(C) $0 < \Delta S_a < \Delta S_b = \Delta S_c$

(D) $0 = \Delta S_a = \Delta S_b < \Delta S_c$

(E) None of the above.

Solution: Both (a) and (b) have zero change in entropy (recall Gibb's paradox). For (c), after removal of the partition, the box will evolve into a mixed system, increasing the entropy. Hence, (D) $0 = \Delta S_a = \Delta S_b < \Delta S_c$.