Answers to problem set 6
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6.4

a) T (on average; fluctuations are allowed, but large decreases are suppressed by having very small probabilities), FFFT

b) TFFT

6.6

–

6.9

a) $\mu = \frac{\partial G}{\partial N}\big|_{T,P}$

b) –

c) $G = \mu N$. This is proportional to N since μ is independent of N, as we argued in b).

6.10

a) –

b) $\mathrm{d}P/\mathrm{d}T = \frac{L}{T(v_1 - v_2)}$

6.13

a)

$$\begin{aligned} A(\infty) \equiv A(Q \gg 0) &= (L-b)^2 - (B+b)^2 \\ A(0) &= (L-b)^2 - B(B+b) \\ A(0) - A(\infty) &= b(B+b) \\ A(Q) &= (L-b)^2 - (B+b)^2 + (b-Q)(B+b)\Theta(Q-b), \end{aligned}$$

where Θ is the Heaviside step function.

b)

$$\begin{aligned} \Omega(Q) &= \frac{A^N(Q)}{N!} \\ S(Q) &= k_\mathrm{B} \ln(\Omega(Q)) = N k_\mathrm{B} \ln(A(Q)) - \ln(N!) \end{aligned}$$

c) $F = -\frac{\partial \mathcal{F}}{\partial Q} = -Nk_{\mathrm{B}}T\frac{B+b}{A(Q)}$, acting towards the wall (the free energy decreases with decreasing Q).

d) Ideal gas pressure $P = \frac{Nk_{\mathrm{B}}T}{A(Q)}$. The force on the far side is $F = -(B+b)P$, where the additional b comes from the fact that squares colliding with their centers within $b/2$ of the pollen square's corners also exert pressure. There is no balancing force from the side nearest the wall because no gas molecules can enter this space. The effective length is $(B+b)$.