1. Evaluate:
$$\langle 0|(a^\dagger)^m a(a^\dagger)^n a^{m+n-1}|0\rangle$$

2. Consider two states:
$$|\alpha\rangle = e^{\alpha a^\dagger}|0\rangle, \qquad |\beta\rangle = e^{\beta a^\dagger}|0\rangle.$$

   Find the overlap, $\langle \alpha|\beta\rangle$.

3. Consider the isotherm (fixed temperature) on the $P - V$ diagram below. List all pairs of points that coexist at equilibrium.