3.36 a) If \( N \) and \( q \) are both much greater than 1, then we can use the results we obtained in problem 3.25.

\[
S = k(q+N)\ln(q+N) - kq\ln q - Nk\ln N
\]

\[
\left( \frac{\partial S}{\partial N} \right)_{u,v} = k\left( \frac{q+N}{q+N} \right) + \frac{k \ln (q+N)}{N} - \frac{k \ln N}{N}
\]

\[
\left( \frac{\partial S}{\partial N} \right)_{u,v} = k \ln \left( \frac{q+N}{N} \right)
\]

\[
\Rightarrow \mu = -T \left( \frac{\partial S}{\partial N} \right)_{u,v} = -kT \ln \left( \frac{N+q}{N} \right)
\]

b) In limit \( N \gg q \), (low \( T \) limit)

\[
\mu = -kT \ln \left( 1 + \frac{q}{N} \right) \approx -kT \left( \frac{q}{N} \right)
\]

In limit \( N \ll q \), 1 + \( q/N \approx q/N \)

\[
\Rightarrow \mu = -kT \ln \left( \frac{q}{N} \right)
\]

Since \( \Delta S = \mu \Delta N \), entropy doesn't change much when you add a particle in low \( T \) limit (since \( q/N \) is small). But entropy changes a lot when you add a particle in high \( T \) limit. (Since \( \ln \left( q/N \right) \) is large change when \( N \)).