3.36

(a) $S = kq \ln\left(1+\frac{N}{q}\right) + kN\ln\left(1+\frac{q}{N}\right)$ [Eq. (2.18)].

$$\mu \equiv -T\left(\frac{\partial S}{\partial N}\right)_{U,V} = -T\left(\frac{\partial S}{\partial N}\right)_q =$$

$$= -Tk\left\{ q\,\frac{1/q}{1+N/q} + \ln\left(1+\frac{q}{N}\right) + \frac{N}{1+q/N}\left(-\frac{q}{N^2}\right)\right\}$$

$$= -kT\left\{\frac{1}{1+N/q} + \ln\left(1+\frac{q}{N}\right) - \frac{1}{1+N/q}\right\}$$

$$= -kT\ln\left(1+\frac{q}{N}\right).$$

(b) $N \gg q$ $\qquad \mu = -\frac{kTq}{N}$

Thus, $\Delta S = -\frac{\mu}{T}\cdot\Delta N = \frac{kq}{N} \ll k.$ when we add 1 particle.
This is small!

$q \gg N$, $\quad \mu \approx -kT\ln\left(\frac{q}{N}\right)$

So ΔS is much larger here.

$\Delta S = -\frac{\mu}{T}\Delta N \approx k\ln\left(\frac{q}{N}\right).$ when we add a single particle.
This is much larger than $\frac{kq}{N}$ earlier.

In the second case μ is a more negative number.