Physics 213 **Problem 5** **Week 7**

Gas Purification

Suppose that some gas (helium) is present at five parts per million in the atmosphere, at 300K. You want a 99% pure sample of it at 1 atm. About how much work must be done per mole to get that? (Ignore changes of F due to the other constituents.)

a) What's the difference in mu between the inside of the sample tan (containing the pure helium) and the outside? Which has a bigger mu?

$\mathrm{mu}(n,T) = kT \ln (n / n_T(T))$
$n_{in}/n_{out} = 0.99/5 \times 10^{-6} = 2 \times 10^5$
$\mathrm{mu}_{in} - \mathrm{mu}_{out} = kT \ln(n_{in} / n_{out}) = (4 \times 10^{-21} \text{ J}) \ln (2 \times 10^5) = 5 \times 10^{-20}$ J

b) How much work is needed per mole of purified helium?

$(5 \times 10^{-20} \text{ J}) (6 \times 10^{23}) = 3 \times 10^4$ J

c) Suppose we want to take advantage of semipermeable membrane technology. Can we avoid having to do any work to obtain our helium?

Consider this apparatus:

1) What is the equilibrium pressure of the helium in the box?

The helium pressure must be the same inside and outside: $p=5 \times 10^{-6}$ atm.

2) How much work is needed to produce 1 mole of He at 1 atm?

You'll need to start with a vacuum box that is 2×10^5 times larger than you want, then compress it to get 1 atm.

Using W= \int[P dV] $= nkT \ln(2 \times 10^5) = 6.02 \times 10^{23}\ k\ (300) \ln (2 \times 10^{-5}) = 3 \times 10^4$ J