

Chemistry 236
Physical Adsorption Study Problems -- Answers

1. c
2. (a) $n = 0.005727$ mol.
 (b) $n = n_1 + n_2 = \frac{PV_1}{RT_1} + \frac{PV_2}{RT_2} = \frac{P}{R} \left(\frac{V_1}{T_1} + \frac{V_2}{T_2} \right)$. [Note that P is the same in both bulbs, even though T is not. Also, $V_1 = V_2 = 0.250$ L.]
 $P = 0.1153$ atm = 87.6 torr.
 (c) $n_{77} = 0.00456$ mol; $n_{301} = 0.001167$ mol. [Note that the cold bulb now contains almost 80% of the He.]
3. Excepting H₂, He, CO, N₂, O₂, F₂, Ne, and Ar, all other gases have very low vapor pressures at 77 K and thus are either liquified or frozen out of the gas phase when cooled to this T . Thus all the CO₂ would be frozen on the walls of the cold bulb, and the pressure in the apparatus would be $\ll 1$ torr. (Kr and methane are borderline; Kr's vapor P is ~ 2 torr at 77 K, while methane's is ~ 10 torr.)
5. Plot $\ln(P)$ vs. $1/T$ for the N₂ vapor P data on p. 520 of GNS. [See Eq. (6) in Experiment 4.] For $\ln(P) = 6.59987$, read " x " = 0.0129734 $T = 77.081$ K.
6. (a) From $P_1V_1 = P_2V_2$, the final volume is 144.2 cc. This is less than the combined volumes of manifold and cell, 144.9 cc, by 0.7 cc. If we assume that both P s are uncertain by 0.05 torr, then error propagation yields a relative uncertainty of 0.002 in the final V , or 144.2 ± 0.3 cc. Thus the volume of the silica gel is 0.7 ± 0.3 cc.
 (b) If the "cold volume" is 5.5 cc, then the room- T V is $144.2 - 5.5$ cc = 138.7 cc. The amount of N₂ initially admitted to the manifold ($V_{\text{man}} = 131.2$ cc, $P = 36.7$ torr) is calculated to be 2.617×10^{-4} mol, or 5.866 STP cc. After the equilibrium is established, the amount of N₂ remaining in the gas phase is calculated from the equation given in 3(b) above, with $P = 7.7/760$ atm, $V_1 = 0.1387$ L, $V_2 = 0.0055$ L, $T_1 = 295$ K, $T_2 = 77$ K. The result is $n = 6.69 \times 10^{-5}$ mol, or 1.50 STP cc. By difference the amount of adsorbed N₂ is 4.37 STP cc.
 (c) The amount of N₂ added is calculated from the pressure increment, $P = 42.5 - 7.7 = 34.8$ torr. The relevant V here is $V_{\text{man}} = 0.1312$ L, and the T is still 295 K. The increment is 2.482×10^{-4} mol or 5.56 STP cc, bringing the cumulative amount of N₂ admitted to the active volume of the apparatus to 11.43 STP cc. The amount remaining in the gas phase is calculated as before, giving 3.33 STP cc. (Note that the quantity in square brackets from 3(b) remains the same in this and all similar calculations.) Thus, by difference the adsorbed N₂ is now 8.10 STP cc.
7. Weights w_i should be proportional to $1/i^2$. Thus an unweighted fit to Eq. (1) is appropriate, while the fit to (2) should employ weights $1/i^4$. (This is very strong weighting.)