Chemistry 236
Physical Adsorption Study Problems -- Answers

1. c

2. (a) $n = 0.00572_7$ mol.

   (b) $n = n_1 + n_2 = \dfrac{PV_1}{RT_1} + \dfrac{PV_2}{RT_2} = \dfrac{P}{R}\left[\dfrac{V_1}{T_1} + \dfrac{V_2}{T_2}\right]$. [Note that P is the same in both bulbs, even though T is not. Also, $V_1 = V_2 = 0.250$ L.]

   $\rightarrow P = 0.115_3$ 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 H_2, He, CO, N_2, O_2, F_2, 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 CO_2 would be frozen on the walls of the cold bulb, and the pressure in the apparatus would be << 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 the vapor P data for N_2 on p. 512 of the lab text as ln(P) *vs.* 1/T. [See Eq. (6) on p. 15 of the ClassPak.] For ln(P) = 6.59987, read 1.29734 off the "x" axis, from which T = 77.081 K.

6. (a) From $P_1V_1 = P_2V_2$, the final volume is 144.2 cc. This is less that the combined volumes of manifold and cell, 144.9 cc, by 0.7 cc. However, this determination is quite uncertain, limited by the precision of the two P measurements. If we assume that both 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 N_2 initially admitted to the manifold (V_{man} = 131.2 cc, P = 36.7 torr) is calculated to be 2.617×10^{-4} mol, or 5.86_6 STP cc. After the equilibrium is established, the amount of N_2 <u>remaining</u> 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 $n = 6.69\times10^{-5}$ mol, or 1.50 STP cc. By difference the amount of adsorbed N_2 is 4.37 STP cc.

   (c) The amount of N_2 <u>added</u> is calculated from the pressure <u>increment</u>, ΔP = 42.5 – 7.7 = 34.8 torr. The relevant V here is V_{man} = 0.1312 L, and the T is still 295 K. The increment is $2.48_2\times10^{-4}$ mol or 5.56 STP cc, bringing the <u>cumulative</u> amount of N_2 admitted to the active volume of the apparatus to 11.43 STP cc. The amount remaining in the gas phase after equilibrium is established 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 N_2 is now 8.10 STP cc.