CH 421 HW 4 Max Shi

SA 8a) 9a) 10a) 11a)

I pledge my honor that I have abided by the Stevens Honor System
_Max Shi

8a) $p_A = x_A K_A$

$\frac{32.0 \text{ kPa}}{0.005} = 6.40 \text{ MPa}$ $\frac{76.9 \text{ kPa}}{0.012} = 6.41 \text{ MPa}$ $\frac{121.8 \text{ kPa}}{0.019} = 6.41 \text{ MPa}$

K_A is constant so it obeys Henry's Law with the constant 6.41 MPa.

9a) $P_{N_2} = \cancel{0.980 \text{ atm}}$ 0.780 atm

$K_{N_2} = 1.87 \times 10^4 \text{ kPa kg mol}^{-1}$

$0.780 \text{ atm} \times \frac{101.325 \text{ kPa}}{1 \text{ atm}} \times \frac{1}{1.87 \times 10^4 \text{ kPa kg/mol}}$

$= 4.23 \times 10^{-3} \text{ mol kg}^{-1}$ solvent

$\rho_{benzene} = 876 \text{ kg/m}^3$

$4.23 \times 10^{-3} \text{ mol kg}^{-1} \times \frac{1 \text{ kg}}{1000 \text{ g}} \times \frac{0.876 \text{ g}}{1 \text{ mL}} \times \frac{1000 \text{ mL}}{1 \text{ L}} = 3.70 \times 10^{-3} \text{ mol/L}$

10a) (i) 0.10 atm CO_2 $K_{CO_2} = 3.01 \times 10^3 \text{ kPa kg mol}^{-1}$

$0.10 \text{ atm } CO_2 \times \frac{101.325 \text{ kPa}}{1 \text{ atm}} \times \frac{1}{3.01 \times 10^3 \text{ kPa kg mol}^{-1}} = 3.4 \times 10^{-3} \text{ mol/kg}$

(ii) $1.00 \text{ atm} \times \frac{101.325 \text{ kPa}}{1 \text{ atm}} \times \frac{1}{3.01 \times 10^3 \text{ kPa kg mol}^{-1}} = 3.4 \times 10^{-2} \text{ mol/kg}$

11a) 5.0 atm CO_2 $K_{CO_2} = 3.01 \times 10^3 \text{ kPa kg mol}^{-1}$

$5.0 \text{ atm } CO_2 \times \frac{101.325 \text{ kPa}}{1 \text{ atm}} \times \frac{1}{3.01 \times 10^3 \text{ kPa kg mol}^{-1}} = 0.17 \text{ kg/mol}$

5B 2a) 3a) 5a)

2a) ~~P_A~~ $P_A = x_A P_A^*$

51.5 ~~x_A~~ 83.3)

$x_A = \dfrac{51.5}{83.3} = 0.966$

$1 - 0.966 = 0.034$

78.11 g/mol benzene

$\dfrac{500 \text{ g benzene}}{78.11 \text{ g/mol}} = 6.40 \text{ mol}$

$\dfrac{6.40}{0.966} = 6.628 \text{ mol} - 6.4 = 0.228 \text{ mol compound}$

$\dfrac{19.0 \text{ g}}{0.228 \text{ mol}} = 84.35 \text{ g/mol}$

3a) 750 g CCl_4 $-10.5\,K = \Delta T_f$

$K_f = 30 \text{ K kg mol}^{-1}$

$b = \dfrac{\Delta T_f}{K_f} \Rightarrow \dfrac{10.5 K}{30 K \text{ kg/mol}} = b$

$b = 0.35 \text{ mol/kg}$

$0.35 \text{ mol/kg} \times 0.75 \text{ kg} = 0.2625 \text{ mol}$

$\dfrac{100 \text{ g}}{0.2625 \text{ mol}} = 381 \text{ g/mol}$

5a) $\dfrac{120 \text{ kPa}}{8.3148 \text{ J K}^{-1}\text{mol}^{-1}} = \dfrac{120 \times 10^3 \text{ Pa}}{8.3148 \text{ J/K mol} \cdot 300 K} = [B]$

$[B] = 48 \text{ mol/m}^3 \times \dfrac{0.001 \text{ m}^3}{1 L} =$

$\dfrac{0.048 \text{ mol}}{L} \approx \dfrac{0.048 \text{ mol}}{1 \text{ kg solvent}}$

$K_f = 1.86 \text{ K kg/mol}$

$1.86 \dfrac{K \text{ kg}}{\text{mol}} \cdot 0.048 \dfrac{\text{mol}}{\text{kg}} = 0.08928 K$

Freezing point $= -0.089\,^\circ C$

SP: 1a) 2a) 5a) 7a)

1a) $a_A = \frac{P_A}{P^*_A} = \frac{1.381}{2.3393} = 0.590$

2a) $a_B = \frac{P_B}{K_B} = 0.125$

$a_A = \frac{P_A}{P_A^*} = \frac{250}{300} = 0.8\overline{3}$

5a) $I = \frac{1}{2}\sum z_i^2\left(\frac{b_i}{b^\circ}\right)$

$= \frac{1}{2}\left(1^2(0.10) + 1^2(0.10) + 2^2(0.20) + 2^2(0.20)\right)$
$\quad K^+ \quad Cl^- \quad Cu^{2+} \quad SO_4^{2-}$

$I = 0.9$

7a) $I = \frac{1}{2}\sum z_i^2\left(\frac{b_i}{b^\circ}\right)$

$= \frac{1}{2}\left(2^2(0.010) + 1^2(0.020) + 1^2(0.030) + 1^2(0.030)\right)$
$\quad Ca^{2+} \quad Cl^- \quad Na \quad F$

$= \frac{1}{2}(0.12) = 0.06$

$\log \gamma = -A|z_+ z_-| I^{1/2}$

$\log \gamma = -0.509 |1 \cdot 2| 0.06^{1/2}$

$\gamma = 0.563$

Bonus

15A) $P_B = x_B k_B$

8b) $\frac{82.0 kPa}{0.010} = k_b = 8200 kPa$ $\quad \frac{122.0}{0.015} = 8.2 MPa$

$\frac{166.1}{0.020} = k_b = 8.3 MPa$ $\quad k_b \approx 8.2 MPa$

Follows Henry's law as k_b is equal thru all equations

9b) $P_{CH_4} = 1.0 bar$

$K_{CH_4} = 44.4 \times 10^3 kPa\,kg/mol$

$4.0 bar \times \frac{100 kPa}{1.0 bar} \times \frac{1}{44.4 \times 10^3 kPa\,kg/mol} = 2.25 \times 10^{-3} mol/kg$

$2.25 \times 10^{-3} mol/kg \times \frac{1 kg}{1000 g} \times \frac{0.876 g}{1 mL\ benzene} \times \frac{1000 mL}{1 L} = 1.97 \times 10^{-3} mol/L$

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5B

2b) $P_a = x_A P_a^* \Rightarrow x_a = \frac{49.62}{50.00} = 0.9924$

60.1 g/mol $\quad \frac{250}{60.1} = 4.16 mol$

$\frac{4.16}{0.9924} = 4.1915 mol\ total - 4.16 = 0.0319 mol$ solute

$\frac{8.69}{0.0319} = 273 g/mol$ solute

3b) $K_f = 6.94\ K\,kg\,mol^{-1}$ $\Delta T_f = 0.780K$

$b = \frac{\Delta T_f}{K_f} = \frac{0.780K}{6.94\ K\,kg\,mol^{-1}} = 0.112\ mol/kg$

$\frac{0.112\ mol}{1\ kg} \cdot 0.25 \Rightarrow \frac{0.028\ mol}{250g\ \text{naphthalene}}$

$\frac{5.00g}{0.028\ mol} = 178\ g/mol$ compound

5F

1b) $1.00\ atm \times \frac{101.325\ kPa}{1\ atm} = 101.325\ kPa$

$a_a = \frac{p_a}{p_a^*} = \frac{90.00\ kPa}{101.325\ kPa} = 0.888$

5b) $I = \frac{1}{2} \sum z_i^2 \frac{b_i}{b_0}$

$= \frac{1}{2}\Big(\underset{K^+}{1(0.040 \times 3)} + \underset{[Fe(CN)_6]^{3-}}{3^2(0.040)} + \underset{K^+}{1(0.030)} + \underset{Cl^-}{1(0.030)} + \overset{NaCl}{1(0.050)} + 1(0.050)\Big)$

$= \frac{1}{2}(0.64) = 0.32$