Josh Whitehead
ChEn 3853

Hw 9

1.) a) $\Pi = -\frac{RT}{V^L} \ln(x_w)$

$R = 8.314 \frac{m^3 Pa}{mol\,K}$

$T = 298 K$

$V^L = 0.001003 \frac{m^3}{kg} \cdot 0.018 \frac{kg}{mol}$

$= 1.805 \times 10^{-5} \frac{m^3}{mol}$

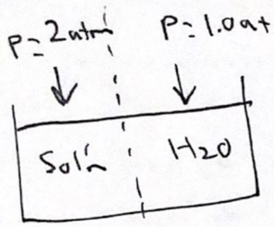
$x_w = 0.999$

$\Pi = -\frac{8.314 \cdot 298}{1.805 \times 10^{-5}} \ln(0.999)$

$= 137299$ Pa.

$\boxed{= 1.37 \text{ Bar}}$

b.)



Water will flow from left to right by reverse osmosis

Since $P_L > P_R$, water has to move to the right so ~~the~~ P_L decreases and P_R increases to reach equilibrium

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1) a.) $P = P_W^{sat} + P_B^{sat} \rightarrow \underbrace{\text{Iterate } T \text{ until } P_W^{sat} + P_B^{sat} = 1}$

Using Antoine: $\boxed{T = 69.1\,°C}$

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b) $y_B = \frac{P_B^{sat}}{P}$, $y_W = \frac{P_W^{sat}}{P}$ $\Big\}$ $\frac{y_W}{y_B} = \frac{P_W^{sat}}{P_B^{sat}} \rightarrow \frac{y_W}{1-y_W} = \frac{P_W^{sat}}{P_B^{sat}} \rightarrow y_W = \frac{P_W^{sat}/P_B^{sat}}{\left(1 + \frac{P_W^{sat}}{P_B^{sat}}\right)}$

$\therefore$ $\boxed{y_W = 0.295}$

$\boxed{y_B = 1 - y_W = 0.705}$

3.) guess:

$x_{1,P} = 0$ $\quad x_{2,P} = 0.7$

$x_{1A} = 0$ $\quad x_{2A} = 0.15$

$x_{1M} = 0$ $\quad x_{2M} = 0.13$

$x_{1W} = 1$ $\quad x_{2W} = 0.02$

$$A_{12} = \frac{(\alpha_2 - \alpha_1)(\beta_2 - \beta_1)(V_1 + V_2)}{4RT}$$

$\downarrow$

$$\gamma_i = \exp\left(A_{12}(1-x_i)^2\right)$$

$\downarrow$

$$K_i = \frac{\gamma^2}{\gamma^1}$$

$\downarrow$

$$\sum \frac{z_i(1-K_i)}{1 + \frac{L^\alpha}{F}(K_i - 1)} = 0$$

$$x_i^1 = \frac{z_i K_i}{1 + \frac{L}{F}(K-1)}$$

$$x_i^2 = \frac{z_i}{1 + \frac{L}{F}(K-1)}$$

Repeat

$K_P = 3.65 \times 10^{-5}$

$K_A = 0.179$

$K_M = 46.9$

$K_W = 2.74 \times 10^4$

Phase I

$x_P = 3.08 \times 10^{-5}$

$x_A = 2.75 \times 10^{-2}$

$x_M = 0.154$

$x_W = 0.818$

Phase 2

$x_P = 0.843$ $\quad x_M = 3.29 \times 10^{-3}$

$x_A = 0.154$ $\quad x_W = 2.99 \times 10^{-5}$

$$\frac{L^2}{F} = 1 - \frac{L^1}{F} = 1 - 0.404$$

$\Rightarrow$ $\boxed{\frac{L^2}{F} = 0.596}$

Book1 - Excel

Joshua Whitehead

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I14

	A	B	C	D	E	F	G	H	I	J	K
1		x2	x1	z	alpha	beta	V	A12 2	A12 1		
2	Pentane	0.7	0	0.42	0	0	116.13	0	10.21791594		
3	Acetone	0.15	0	0.09	0	11.14	73.4	0	1.812356759		
4	methanol	0.13	0	0.078	17.43	14.49	40.5	3.991668299	0.110025208		
5	water	0.02	1	0.412	50.13	15.06	18	10.21791594	0		
6											
7		x2	x1	gam2	gam1	k	L/F	new x1	new x2	sum	
8	Pentane	0.7	0.001	1	26835.75	3.72637E-05	0.49855162	3.121E-05	0.83754272	1.38233E-05	
9	Acetone	0.15	0.001	1	6.102716	0.163861477		0.025289789	0.154336393		
10	methanol	0.13	0.001	20.51782	1.116061	18.38414241		0.148337548	0.008068777		
11	water	0.02	0.997	18274.95	1	18274.94852		0.826348384	4.52175E-05		
12											
13											
14											
15		x2	x1	z	gam2	gam1	k	L/F	new x1	new x2	sum
16	Pentane	0.837543	3.121E-05	0.502538	1	27372.06228	3.65336E-05	0.403874109	3.07973E-05	0.842985829	5.29525E-08
17	Acetone	0.154336	0.0252898	0.102718	1	5.59485627	0.178735601		0.027471156	0.153697171	
18	methanol	0.008069	0.1483375	0.064176	50.7805	1.08307527	46.88547596		0.154051941	0.003285707	
19	water	4.52E-05	0.8263484	0.330566	27364.23	1	27364.22826		0.818444775	2.99093E-05	

3

Sheet1

Ready 100%

HW 9

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4) a) $\Delta H^{vap} = 2256.4 \frac{kJ}{kg} \cdot \frac{0.018\ kg}{mol} = 40615.2 \frac{J}{mol}$

$n_w = 1000\ g \cdot \frac{1\ mol}{18\ g} = 55.5\ mol$ $\quad x_w = \frac{55.5}{55.5+5.99} = 0.9026$

$n_s = 350 \cdot \frac{1}{58.44} = 5.99\ mol$ $\quad x_s = 0.09739$

assume $\gamma_1 = 1$ $\quad T_r = 373.15$

$R = 8.314$

$$T = \frac{T_r}{\frac{\ln(x_w) \cdot T_r \cdot R}{\Delta H_{vap}} + 1} \boxed{= 376\ K}$$

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b) $n_s = 2 \cdot 5.99 = 11.98\ mol$

$x_w = \frac{55.5}{55.5 + 11.98} = 0.823$ $\quad x_s = 0.177$

$$T = \frac{T_r}{\frac{\ln(x_w) \cdot T_r \cdot R}{\Delta H_{vap}} + 1} \boxed{= 379\ K}$$

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5) $T = \dfrac{T_n}{1 - \dfrac{\ln(x_w) R T_n}{\Delta H_{fus}}}$

$\Delta H_{fus} = 6006.78 \ \frac{J}{mol}$

$T_n = 273.15 \ K$

$m_s = 0.01$
$m_w = 0.99$

$n_s = \frac{m_s}{M_{ws}} \cdot 2$

$n_w = \frac{m_w}{M_{ws}}$

n_s	n_w
0.342	55
0.684	54.4
1.711	52.78
3.422	50

x_s	x_w
0.00618	0.994
0.0124	0.9876
0.0314	0.9686
0.0641	0.9359

wt%	T (K)	ΔT (K)
1.0	273 K	0.639
2.0	272	1.28
5.0	270.	3.26
10.0	266	6.67

The more salt the lower the T_F

Both methods yield similar ΔT

The greatest deviation is @ 5% NaCl

Book1 - Excel

Sheet2

	A	B	C	D	E	F	G
1	dh		Tn				
2	6006.78		273.15				
3							
4	ms	mw					
5	0.01	0.99		1			
6	0.02	0.98		2			
7	0.05	0.95		5			
8	0.1	0.9		10			
9							
10	ns	nw					
11	0.342231	55					
12	0.684463	54.44444					
13	1.711157	52.77778					
14	3.422313	50					
15							
16	xs	xw		T	dT		dT_kf
17	0.006184	0.993816		272.5109	0.639091153		0.593
18	0.012416	0.987584		271.8659	1.284117284		1.186
19	0.031404	0.968596		269.8942	3.255777733		3.046
20	0.064061	0.935939		266.48	6.67003614		6.564