

**CHE 305 – Separation Processes
Spring 2010 – Homework # 2**

Construct phase diagrams for a system of ethanol (1) and water (2),

- Pxy diagram at 85°C
- Txy diagram at 1.4 bar
- xy diagram at 1.4 bar

Use the Antoine Equation (P in mm Hg, T in °C) for calculation of vapor pressures. Coefficients for ethanol and water are as follows for $\log_{10}P_1^{\text{sat}} = A - B/(T + C)$:

	Ethanol	Water
A	8.04494	7.96681
B	1554.30	1668.21
C	222.65	228.00

Due to the interactions between ethanol and water, ideal behavior is a poor assumption. Use the Wilson model for activity coefficients with the following parameters:

$$\Lambda_{12} = 0.20022$$

$$\Lambda_{21} = 0.81564$$

From your Txy diagram, determine: (1) azeotropic composition, and (2) at what temperature the azeotrope occurs for a system at 1.4 bar.

ChemCAD is not allowed and will not be accepted.

Azeotropic comp: ~ 0.88

Azeotropic temp: $\sim 86.4^\circ\text{C}$

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Antoine Equation Coefficients (log10, P in mm Hg, T in centigrade)

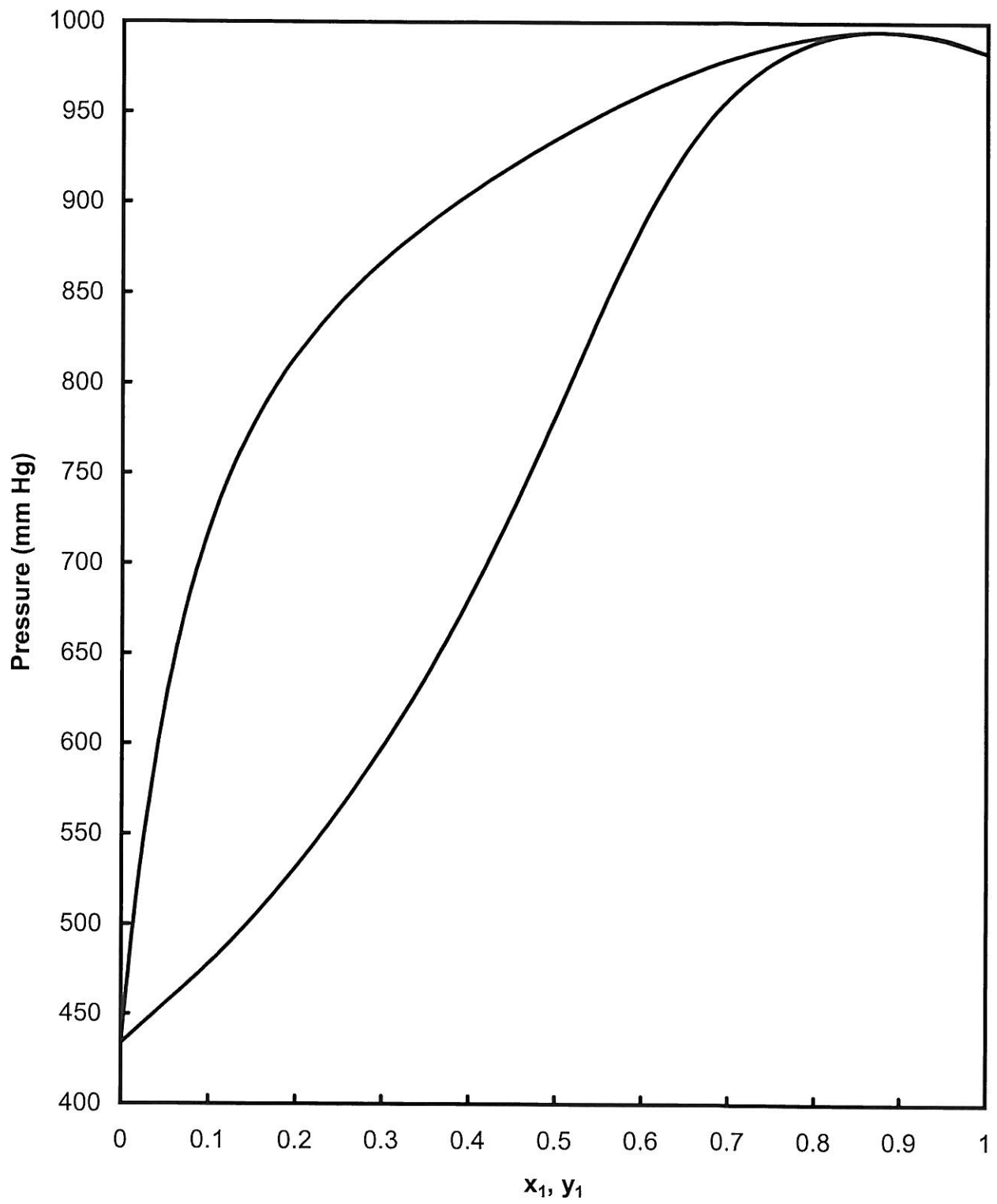
	ethanol	water
A	8.04494	7.96681
B	1554.3	1668.21
C	222.65	228
Psat (85 oC)	983.5	433.6 mm Hg
Tsat (1.4 bar)	86.7	109.3 oC

Wilson Equation Parameters

Λ_{12}	0.20022
Λ_{21}	0.81564

PXY	x1	x2	ln γ_1	γ_1	ln γ_2	γ_2	P1sat	P2sat	p1	p2	P	y1
	0	1	1.7927	6.0056	0.0000	1.0000	983.4909	433.5764	0.0000	433.5764	433.5764	0.0000
	0.01	0.99	1.7122	5.5410	0.0004	1.0004	983.4909	433.5764	54.4949	429.4127	483.9076	0.1126
	0.02	0.98	1.6367	5.1382	0.0015	1.0015	983.4909	433.5764	101.0665	425.5626	526.6291	0.1919
	0.03	0.97	1.5658	4.7864	0.0034	1.0034	983.4909	433.5764	141.2223	421.9853	563.2076	0.2507
	0.04	0.96	1.4990	4.4773	0.0058	1.0058	983.4909	433.5764	176.1352	418.6463	594.7815	0.2961
	0.05	0.95	1.4360	4.2040	0.0087	1.0088	983.4909	433.5764	206.7278	415.5158	622.2436	0.3322
	0.06	0.94	1.3765	3.9609	0.0122	1.0123	983.4909	433.5764	233.7330	412.5682	646.3012	0.3616
	0.07	0.93	1.3201	3.7438	0.0161	1.0163	983.4909	433.5764	257.7386	409.7814	667.5199	0.3861
	0.08	0.92	1.2666	3.5488	0.0205	1.0207	983.4909	433.5764	279.2199	407.1358	686.3556	0.4068
	0.09	0.91	1.2158	3.3731	0.0252	1.0255	983.4909	433.5764	298.5644	404.6144	703.1788	0.4246
	0.1	0.9	1.1675	3.2140	0.0302	1.0307	983.4909	433.5764	316.0903	402.2021	718.2924	0.4401
	0.11	0.89	1.1215	3.0694	0.0356	1.0363	983.4909	433.5764	332.0608	399.8857	731.9465	0.4537
	0.12	0.88	1.0776	2.9376	0.0413	1.0422	983.4909	433.5764	346.6947	397.6531	744.3479	0.4658
	0.13	0.87	1.0357	2.8171	0.0473	1.0485	983.4909	433.5764	360.1756	395.4937	755.6693	0.4766
	0.14	0.86	0.9957	2.7065	0.0536	1.0550	983.4909	433.5764	372.6578	393.3979	766.0557	0.4865
	0.15	0.85	0.9574	2.6048	0.0601	1.0619	983.4909	433.5764	384.2720	391.3569	775.6288	0.4954
	0.16	0.84	0.9207	2.5110	0.0668	1.0691	983.4909	433.5764	395.1294	389.3628	784.4922	0.5037
	0.17	0.83	0.8855	2.4243	0.0737	1.0765	983.4909	433.5764	405.3252	387.4085	792.7336	0.5113
	0.18	0.82	0.8518	2.3439	0.0809	1.0843	983.4909	433.5764	414.9410	385.4872	800.4282	0.5184
	0.2	0.8	0.7884	2.1998	0.0958	1.1005	983.4909	433.5764	432.7051	381.7200	814.4251	0.5313
	0.25	0.75	0.6498	1.9153	0.1359	1.1455	983.4909	433.5764	470.9082	372.5042	843.4123	0.5583
	0.3	0.7	0.5347	1.7069	0.1794	1.1966	983.4909	433.5764	503.6148	363.1592	866.7740	0.5810
	0.35	0.65	0.4380	1.5496	0.2259	1.2535	983.4909	433.5764	533.4007	353.2591	886.6598	0.6016
	0.4	0.6	0.3563	1.4280	0.2749	1.3163	983.4909	433.5764	561.7789	342.4417	904.2206	0.6213
	0.45	0.55	0.2870	1.3324	0.3260	1.3854	983.4909	433.5764	589.7032	330.3735	920.0768	0.6409
	0.5	0.5	0.2282	1.2564	0.3791	1.4610	983.4909	433.5764	617.8173	316.7271	934.5444	0.6611
	0.55	0.45	0.1784	1.1953	0.4341	1.5436	983.4909	433.5764	646.5866	301.1655	947.7521	0.6822
	0.6	0.4	0.1365	1.1462	0.4908	1.6337	983.4909	433.5764	676.3721	283.3299	959.7020	0.7048
	0.65	0.35	0.1014	1.1067	0.5493	1.7320	983.4909	433.5764	707.4735	262.8290	970.3025	0.7291
	0.7	0.3	0.0724	1.0751	0.6093	1.8392	983.4909	433.5764	740.1565	239.2284	979.3849	0.7557
	0.75	0.25	0.0490	1.0502	0.6710	1.9562	983.4909	433.5764	774.6698	212.0410	986.7108	0.7851
	0.8	0.2	0.0306	1.0311	0.7343	2.0840	983.4909	433.5764	811.2570	180.7150	991.9721	0.8178
	0.85	0.15	0.0168	1.0170	0.7992	2.2237	983.4909	433.5764	850.1658	144.6225	994.7882	0.8546
	0.9	0.1	0.0073	1.0074	0.8657	2.3766	983.4909	433.5764	891.6542	103.0442	994.6984	0.8964
	0.95	0.05	0.0018	1.0018	0.9338	2.5441	983.4909	433.5764	935.9971	55.1541	991.1512	0.9444
	1	0	0.0000	1.0000	1.0036	2.7280	983.4909	433.5764	983.4909	0.0000	983.4909	1.0000

PXY Diagram for ethanol (1) and water (2) at 85°C



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Antoine Equation Coefficients (log10, P in mm Hg, T in centigrade)

	ethanol	water
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Wilson Equation Parameters

Λ_{12}	0.20022
Λ_{21}	0.81564

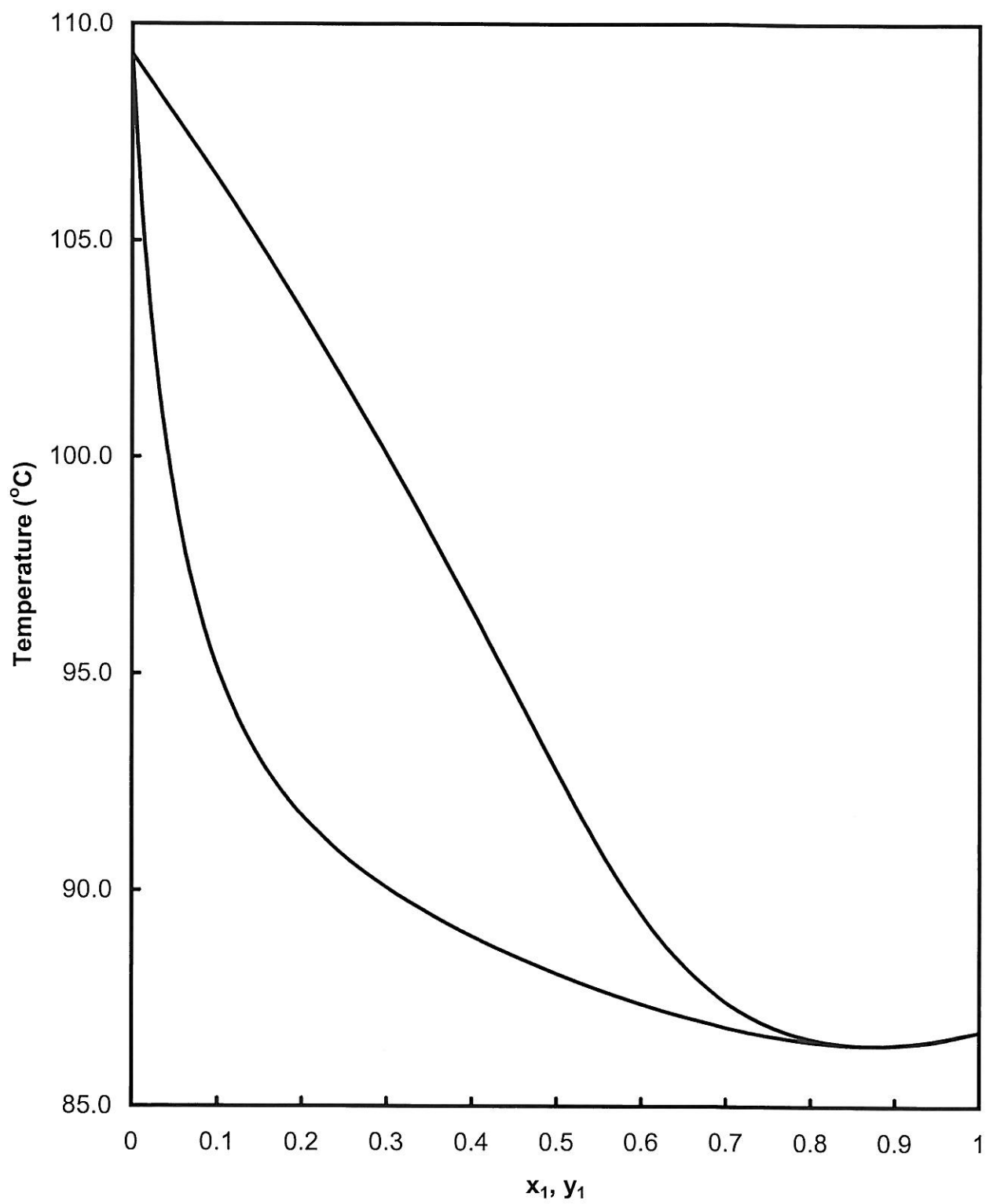
TXY

x1	x2	T (oC)	ln γ_1	γ_1	ln γ_2	γ_2	P1sat	P2sat	p1	p2	P	y1	y2
0	1	109.3	1.7927	6.0056	0.0000	1.0000	2305.4570	1050.0000	0.0000	1050.0000	1050.0000	0.0000	0.0000
0.01	0.99	106.2	1.7122	5.5410	0.0004	1.0004	2080.6116	943.7771	115.2860	934.7140	1050.0000	0.1098	0.1098
0.02	0.98	103.8	1.6367	5.1382	0.0015	1.0015	1920.9728	868.6502	197.4050	852.5950	1050.0000	0.1880	0.1880
0.03	0.97	101.9	1.5658	4.7864	0.0034	1.0034	1802.2428	812.9436	258.7893	791.2107	1050.0000	0.2465	0.2465
0.04	0.96	100.4	1.4990	4.4773	0.0058	1.0058	1710.7775	770.1330	306.3863	743.6137	1050.0000	0.2918	0.2918
0.05	0.95	99.1	1.4360	4.2040	0.0087	1.0088	1638.3384	736.2949	344.3754	705.6246	1050.0000	0.3280	0.3280
0.06	0.94	98.1	1.3765	3.9609	0.0122	1.0123	1579.6650	708.9324	375.4176	674.5824	1050.0000	0.3575	0.3575
0.07	0.93	97.2	1.3201	3.7438	0.0161	1.0163	1531.2456	686.3833	401.2859	648.7141	1050.0000	0.3822	0.3822
0.08	0.92	96.4	1.2666	3.5488	0.0205	1.0207	1490.6494	667.5002	423.2057	626.7943	1050.0000	0.4031	0.4031
0.09	0.91	95.7	1.2158	3.3731	0.0252	1.0255	1456.1430	651.4663	442.0503	607.9497	1050.0000	0.4210	0.4210
0.1	0.9	95.2	1.1675	3.2140	0.0302	1.0307	1426.4585	637.6854	458.4584	591.5416	1050.0000	0.4366	0.4366
0.11	0.89	94.6	1.1215	3.0694	0.0356	1.0363	1400.6484	625.7128	472.9077	577.0923	1050.0000	0.4504	0.4504
0.12	0.88	94.2	1.0776	2.9376	0.0413	1.0422	1377.9916	615.2103	485.7620	564.2380	1050.0000	0.4626	0.4626
0.13	0.87	93.8	1.0357	2.8171	0.0473	1.0485	1357.9299	605.9166	497.3033	552.6967	1050.0000	0.4736	0.4736
0.14	0.86	93.4	0.9957	2.7065	0.0536	1.0550	1340.0256	597.6271	507.7536	542.2464	1050.0000	0.4836	0.4836
0.15	0.85	93.1	0.9574	2.6048	0.0601	1.0619	1323.9307	590.1792	517.2895	532.7105	1050.0000	0.4927	0.4927
0.16	0.84	92.8	0.9207	2.5110	0.0668	1.0691	1309.3657	583.4424	526.0536	523.9464	1050.0000	0.5010	0.5010
0.17	0.83	92.5	0.8855	2.4243	0.0737	1.0765	1296.1037	577.3110	534.1620	515.8380	1050.0000	0.5087	0.5087
0.18	0.82	92.2	0.8518	2.3439	0.0809	1.0843	1283.9589	571.6983	541.7103	508.2897	1050.0000	0.5159	0.5159
0.2	0.8	91.7	0.7884	2.1998	0.0958	1.1005	1262.4335	561.7557	555.4310	494.5690	1050.0000	0.5290	0.5290
0.25	0.75	90.8	0.6498	1.9153	0.1359	1.1455	1220.0474	542.1978	584.1745	465.8255	1050.0000	0.5564	0.5564
0.3	0.7	90.1	0.5347	1.7069	0.1794	1.1966	1187.8815	527.3740	608.2769	441.7231	1050.0000	0.5793	0.5793
0.35	0.65	89.5	0.4380	1.5496	0.2259	1.2535	1161.7943	515.3635	630.1043	419.8957	1050.0000	0.6001	0.6001
0.4	0.6	88.9	0.3563	1.4280	0.2749	1.3163	1139.6814	505.1912	650.9963	399.0037	1050.0000	0.6200	0.6200
0.45	0.55	88.5	0.2870	1.3324	0.3260	1.3854	1120.4180	496.3363	671.8051	378.1949	1050.0000	0.6398	0.6398
0.5	0.5	88.1	0.2282	1.2564	0.3791	1.4610	1103.3946	488.5161	693.1395	356.8605	1050.0000	0.6601	0.6601
0.55	0.45	87.7	0.1784	1.1953	0.4341	1.5436	1088.2940	481.5893	715.4885	334.5115	1050.0000	0.6814	0.6814
0.6	0.4	87.4	0.1365	1.1462	0.4908	1.6337	1074.9796	475.4738	739.2913	310.7087	1050.0000	0.7041	0.7041
0.65	0.35	87.1	0.1014	1.1067	0.5493	1.7320	1063.4368	470.1796	764.9826	285.0174	1050.0000	0.7286	0.7286
0.7	0.3	86.8	0.0724	1.0751	0.6093	1.8392	1053.7438	465.7356	793.0276	256.9724	1050.0000	0.7553	0.7553
0.75	0.25	86.6	0.0490	1.0502	0.6710	1.9562	1046.0599	462.2139	823.9538	226.0462	1050.0000	0.7847	0.7847
0.8	0.2	86.5	0.0306	1.0311	0.7343	2.0840	1040.6262	459.7241	858.3865	191.6135	1050.0000	0.8175	0.8175
0.85	0.15	86.4	0.0168	1.0170	0.7992	2.2237	1037.7755	458.4181	897.0914	152.9086	1050.0000	0.8544	0.8544
0.9	0.1	86.4	0.0073	1.0074	0.8657	2.3766	1037.9548	458.5003	941.0324	108.9676	1050.0000	0.8962	0.8962
0.95	0.05	86.5	0.0018	1.0018	0.9338	2.5441	1041.7613	460.2442	991.4536	58.5464	1050.0000	0.9442	0.9442
1	0	86.7	0.0000	1.0000	1.0036	2.7280	1050.0000	464.0196	1050.0000	0.0000	1050.0000	1.0000	1.0000

Azeotropic Composition: 0.88

Azeotrope Temperature: 86.4 oC

TXY Diagram for ethanol (1) and water (2) at 1.4 bar



XY Diagram for ethanol (1) and water (2) at 1.4 bar

