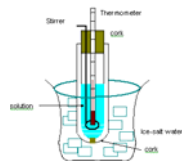


Chemistry BC2001x: General Chemistry I



Lecture 10: Tuesday October 13, 2009

Topics: Colligative Properties. Ionic solutes

Effect #4: Osmotic pressure.

P-X and T-X diagrams and Distillation.

Pick up Graded Problem Set 4; answers on Courseworks

On back of colligative effects handout:

P-X diagrams and distillation

note: this topic is not covered in Chang.

1

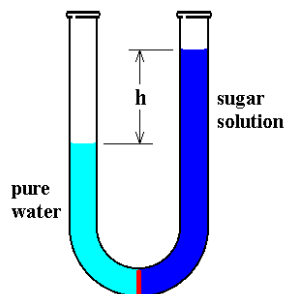
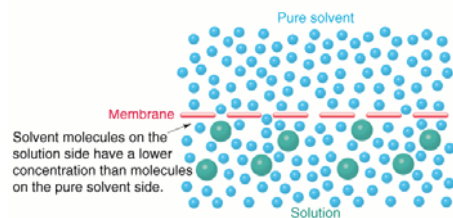
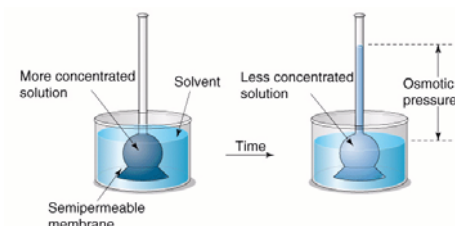
Colligative properties: some data

K_f for water = 1.86 deg/molal

Non-electrolytes			Strong electrolytes			
dissolved substance	concentration (molality)	ΔT_f (K)	ion types	dissolved substance	concentration (molality)	ΔT_f (K)
glycerine	0.100	0.187	(1:1)	HCl	0.100	0.352
ethanol	0.100	0.183		LiCl	0.0100	0.0360
sucrose	0.100	0.188		NaCl	0.00500	0.0182
	0.200	0.376			0.0100	0.0360
dextrose	0.100	0.186			0.0150	0.0538
	0.200	0.372		KCl	0.100	0.345
	0.300	0.558	KNO ₃	0.1000	0.0359	
				0.100	0.331	
			(2:2)	AgNO ₃	0.0100	0.0360
			(1:2)	MgSO ₄	0.0100	0.0285
			(1:2)	Na ₂ SO ₄	0.0100	0.0504
			(2:1)		0.100	0.434
			(2:1)	CaCl ₂	0.0100	0.0511
acetic acid	0.0100	0.0194			0.100	0.494
nitrous acid	0.0750	0.150		NiCl ₂	0.100	0.538
			(1:3)	K ₃ Fe(CN) ₆	0.0100	0.0626

2

Osmotic Pressure Π (upper-case pi)



$$\Pi V = n RT \quad \text{or} \quad \Pi = (n/V) RT \quad \text{or} \quad \Pi = c RT \quad \text{where } c = \text{molarity}$$

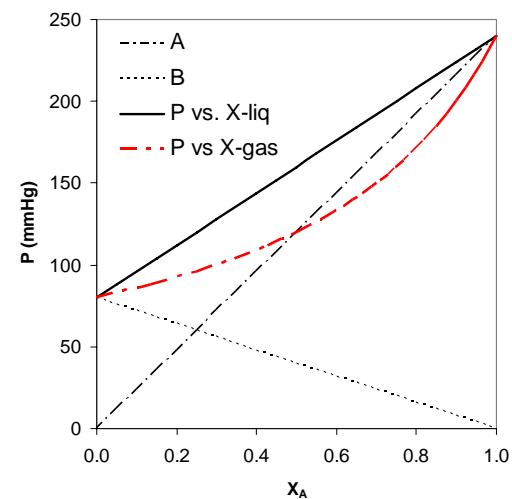
3

P-X diagram for an ideal Binary Solution

$$P_A^\circ = 240 \text{ mmHg}$$

$$P_B^\circ = 80 \text{ mmHg}$$

"Ideal solution" means
Raoult's law for both



4

P-X diagram for an ideal Binary Solution

$$P_A^\circ = 240 \text{ mmHg}$$

$$P_B^\circ = 80 \text{ mmHg}$$

"Ideal solution" means Raoult's law for both

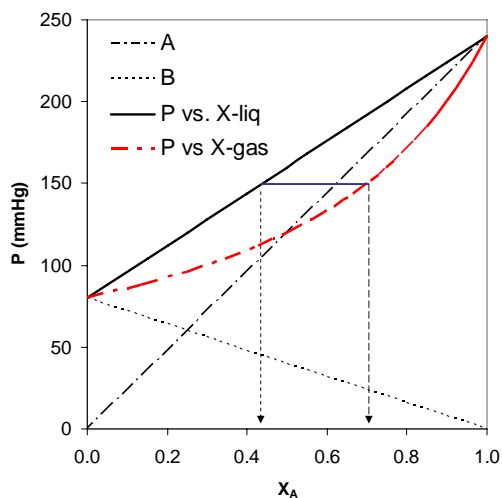
at $P = 150 \text{ mmHg}$:

the liquid is ~ 45% A

the gas is ~ 70% A

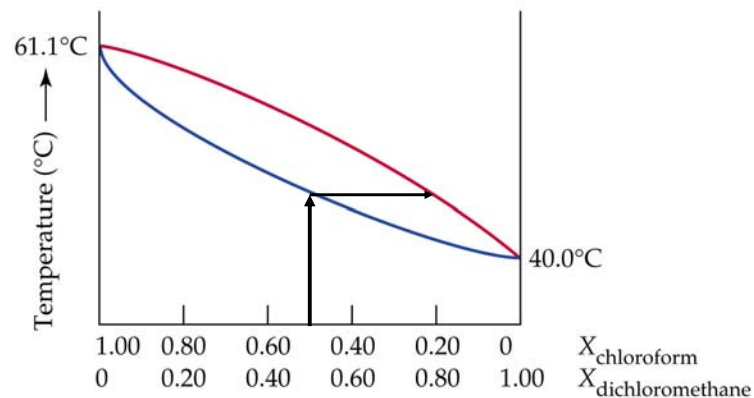
The gas is richer in the **more volatile** component, A

$$(P_A^\circ > P_B^\circ)$$



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T-X diagram for an ideal Binary Solution

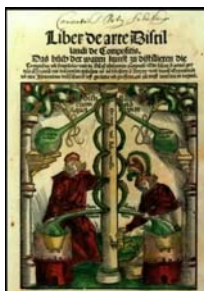
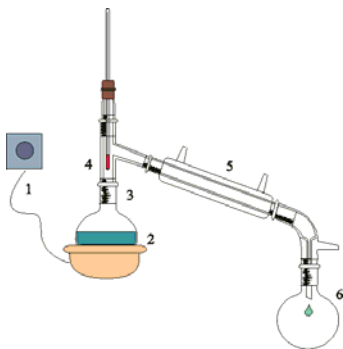


Heat a 50 mole% solution: it starts to boil at about 48°C
(hard to read precisely without a grid).

The first bubble of gas has composition ~ 80 mole% CH₂Cl₂.

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Distillation:
ancient and modern
separation technique



7

P-X diagram for a non-ideal Binary Solution

Acetone and CS₂ at 35°C.

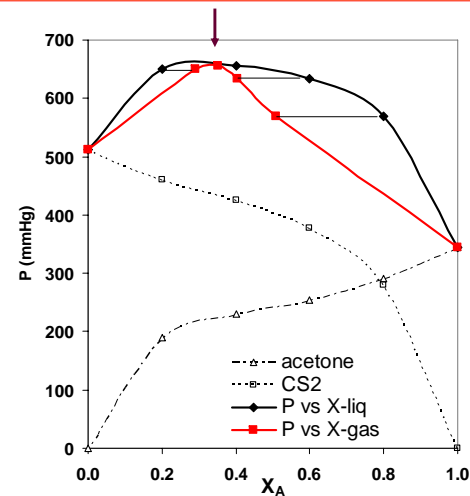
$$P_A^\circ = 344.28 \text{ mmHg}$$

$$P_C^\circ = 512.30 \text{ mmHg}$$

In some extreme cases the P vs X curves meet at a **maximum**.
(The corresponding T-X curves have a minimum).

The solution at the maximum is called an **azeotrope**.

An azeotropic mixture boils at a fixed T; it cannot be separated by distillation.



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