Azeotrope

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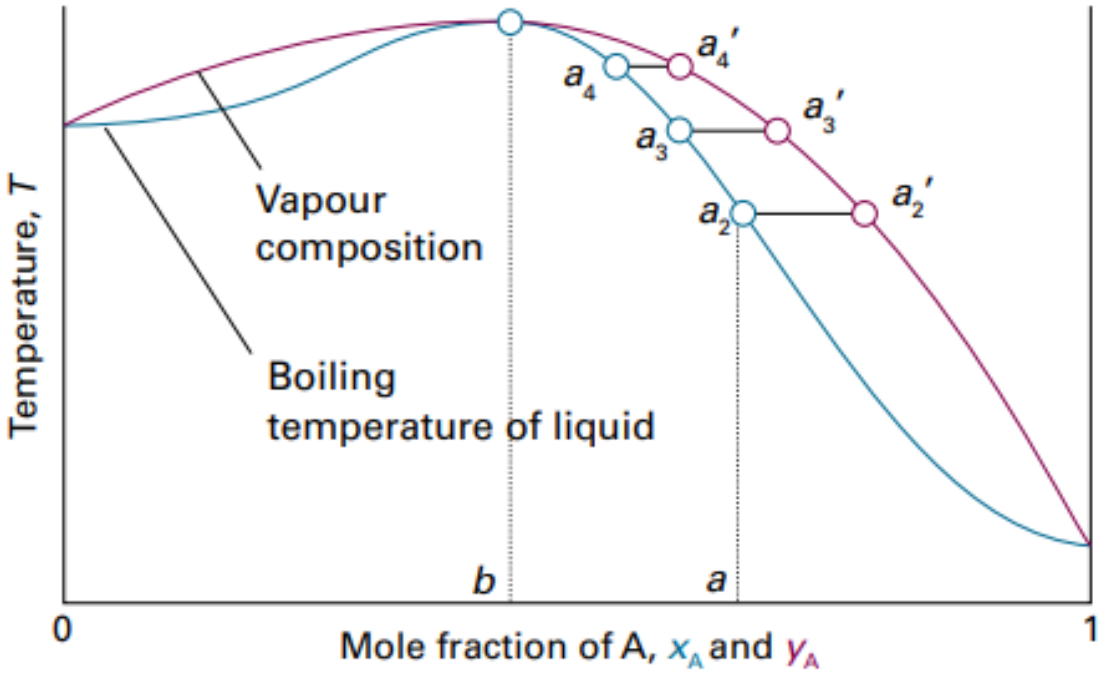
However, at the azeotropic composition, the liquid and vapor have the same composition.

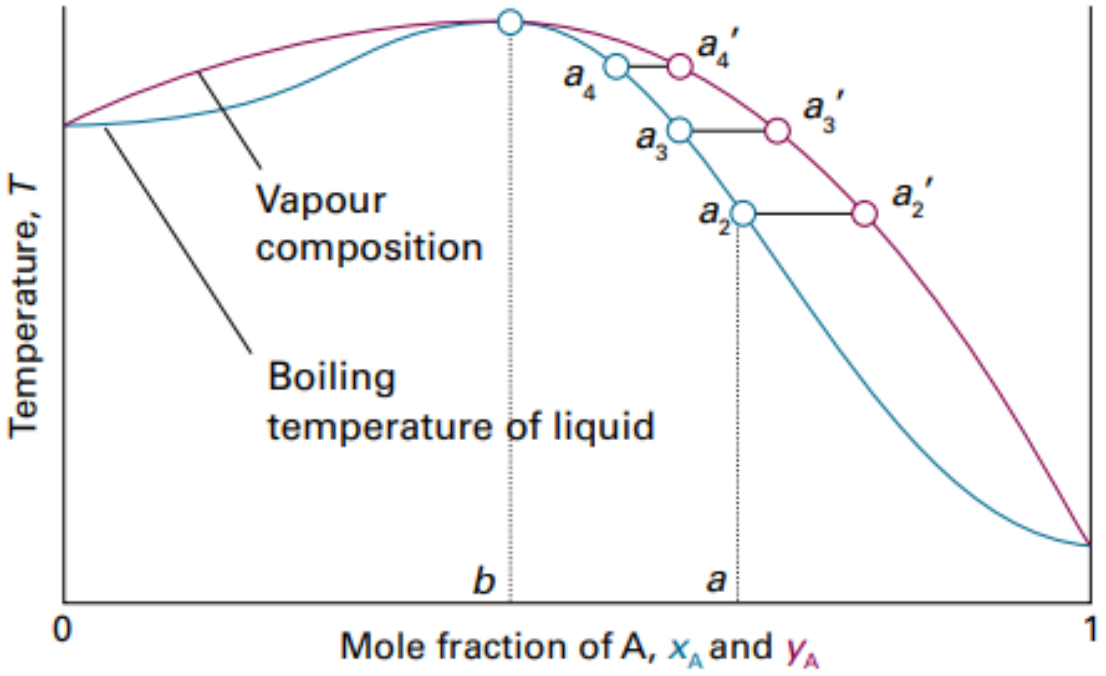
As a result, you can't further enrich either component using regular distillation—no more separation is possible at that point.

Azeotrope



Ex: HCl/Water

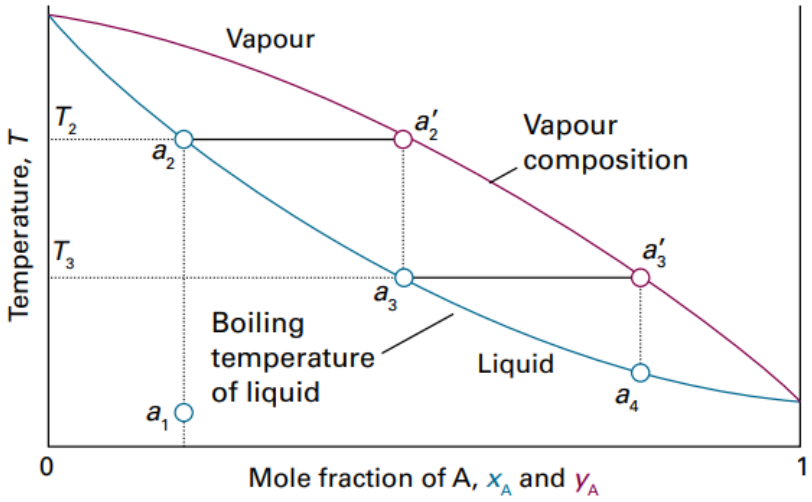
Azeotrope



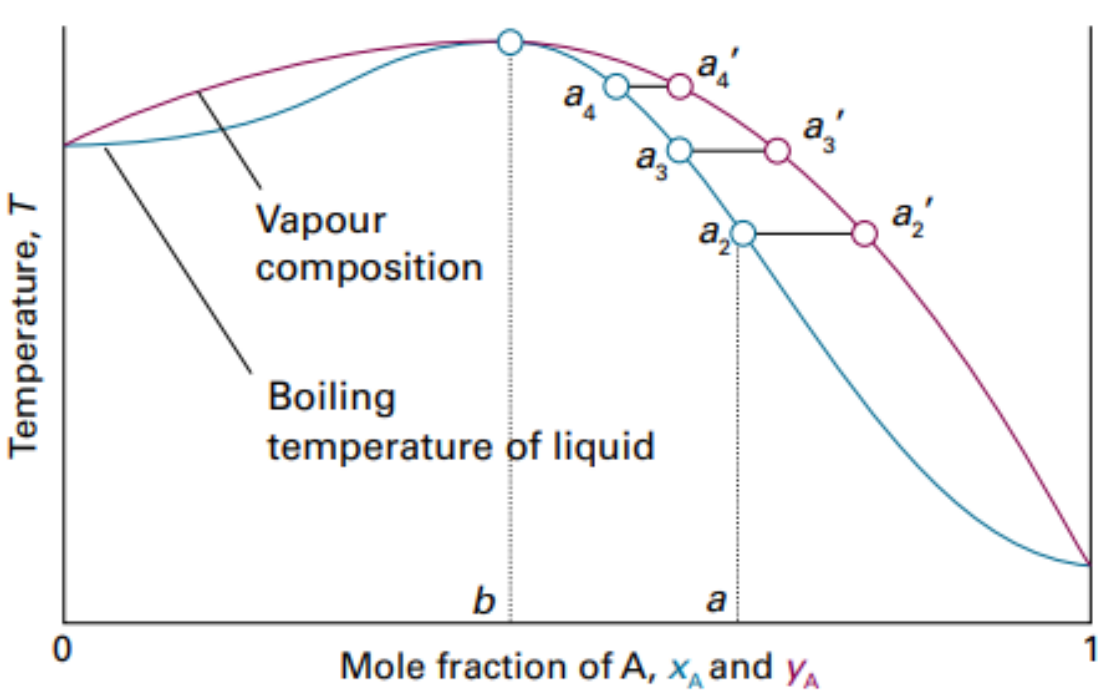
$X_B = 1$

$X_A = 1$

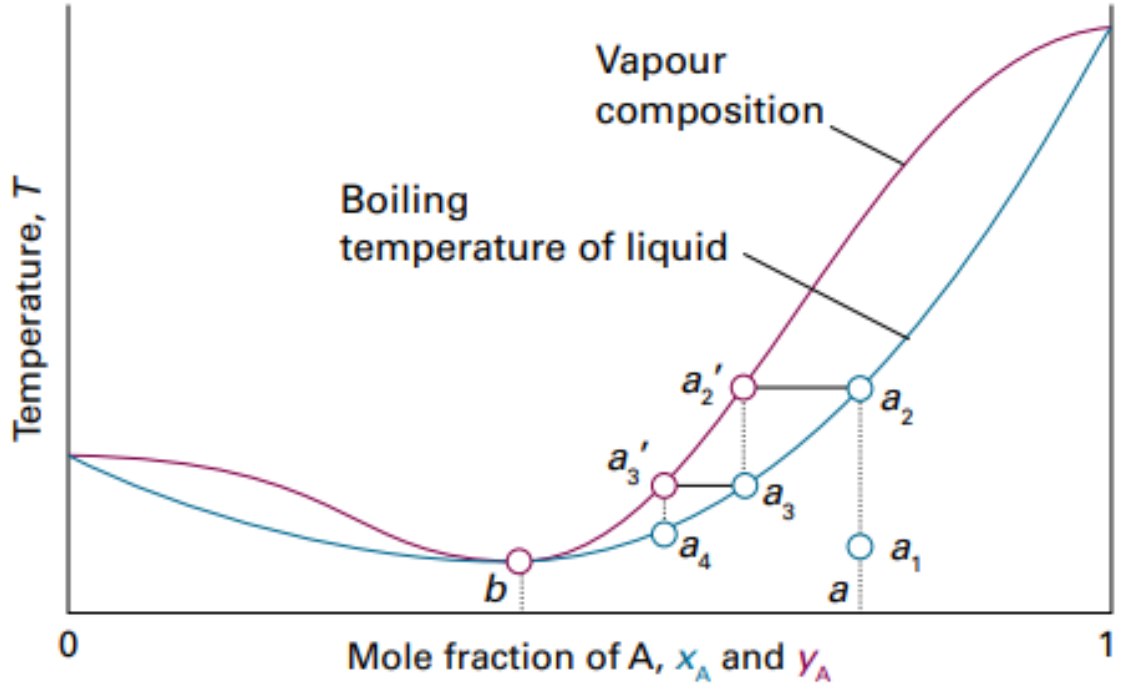
Ideal solution of A and B



Azeotrope



$X_B = 1$ $X_A = 1$



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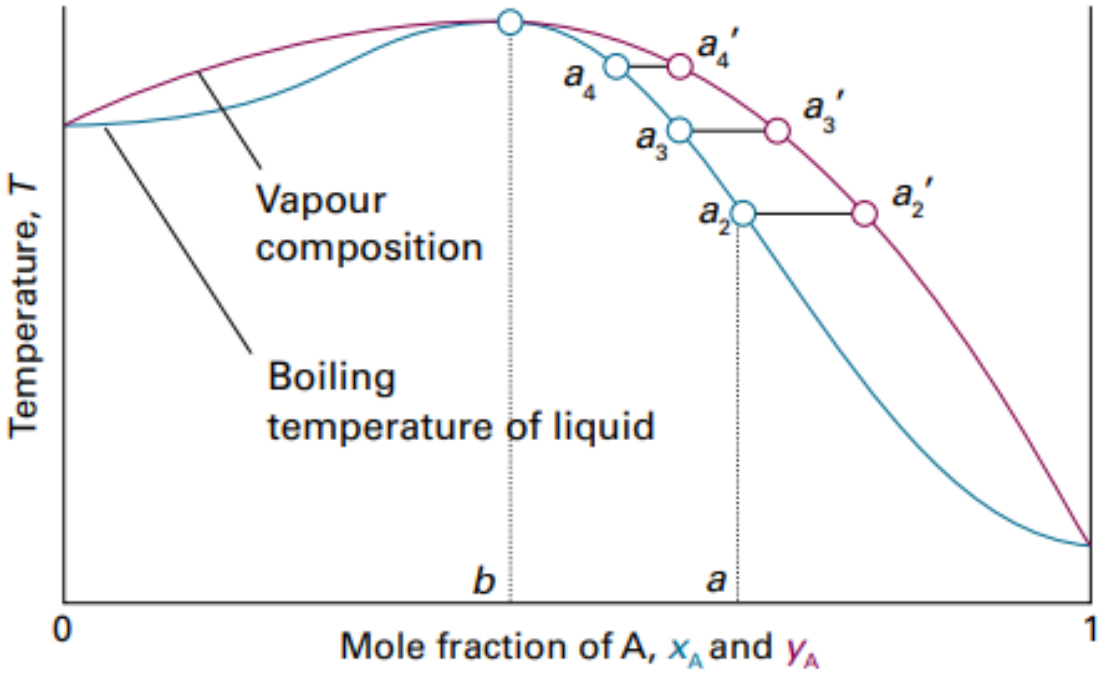

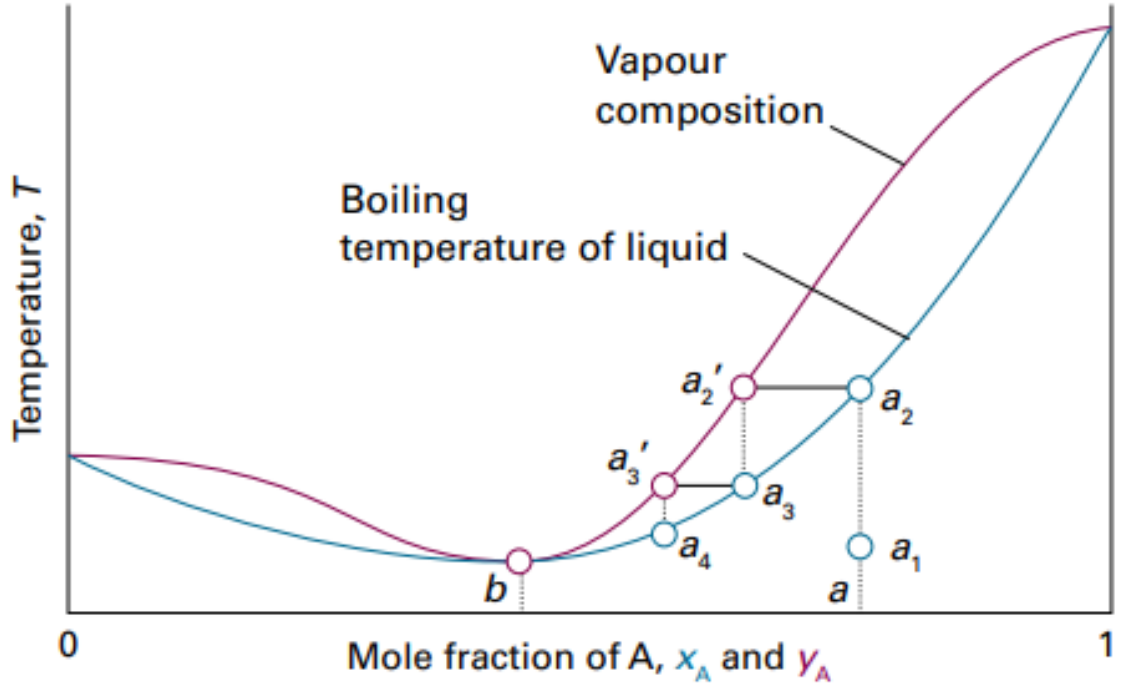

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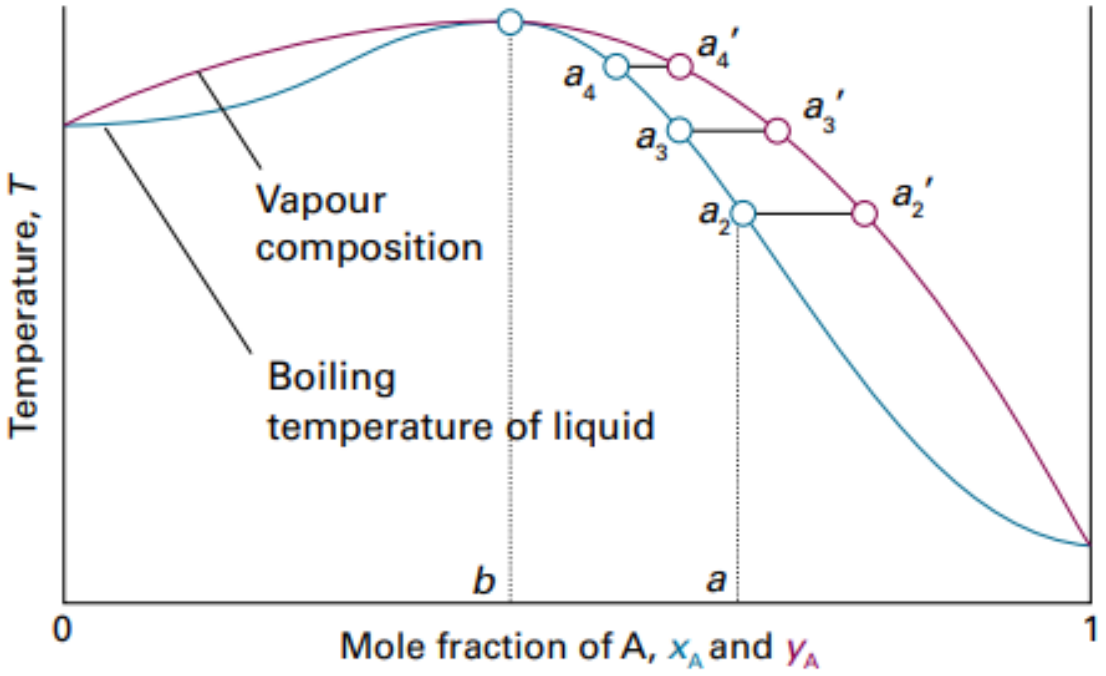
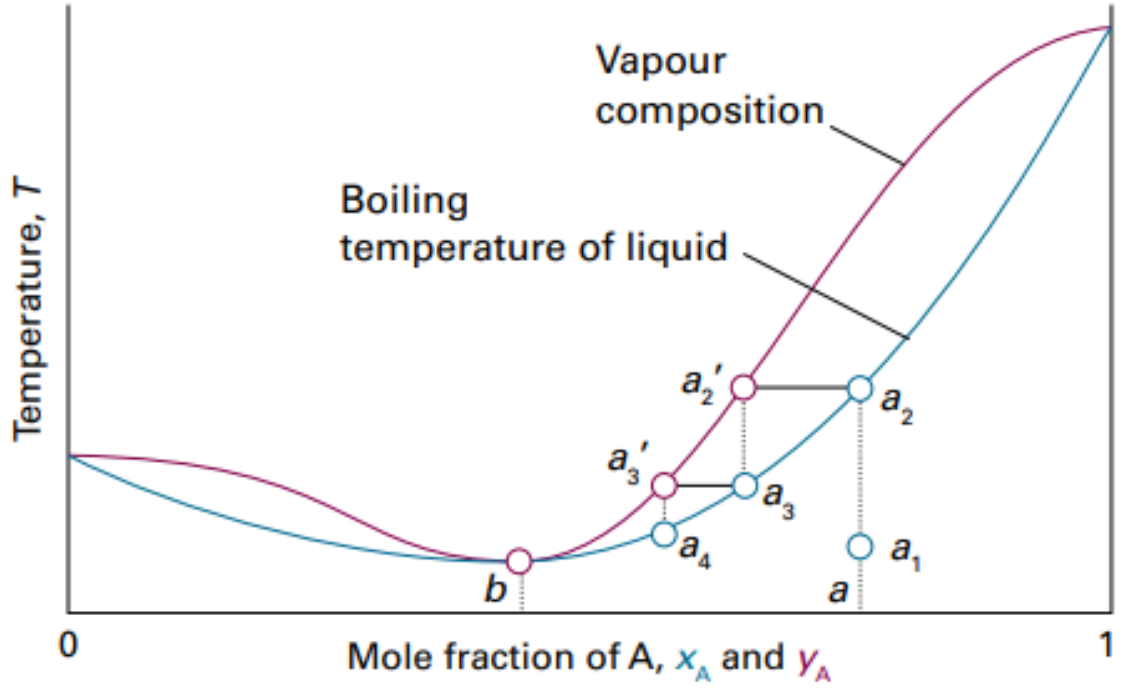


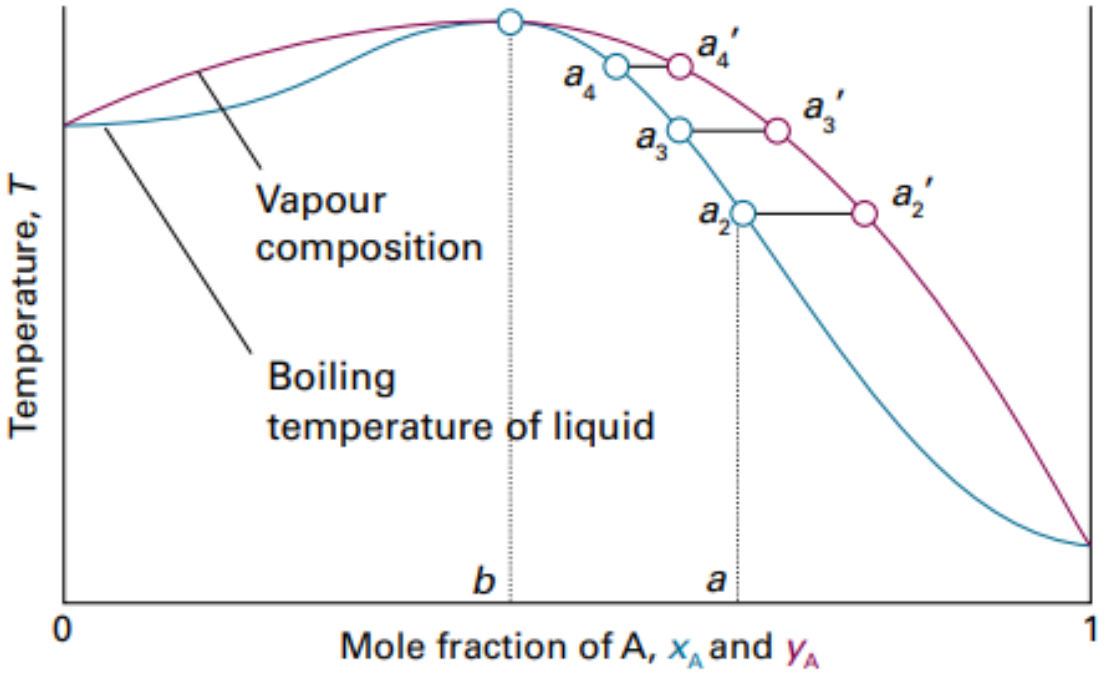


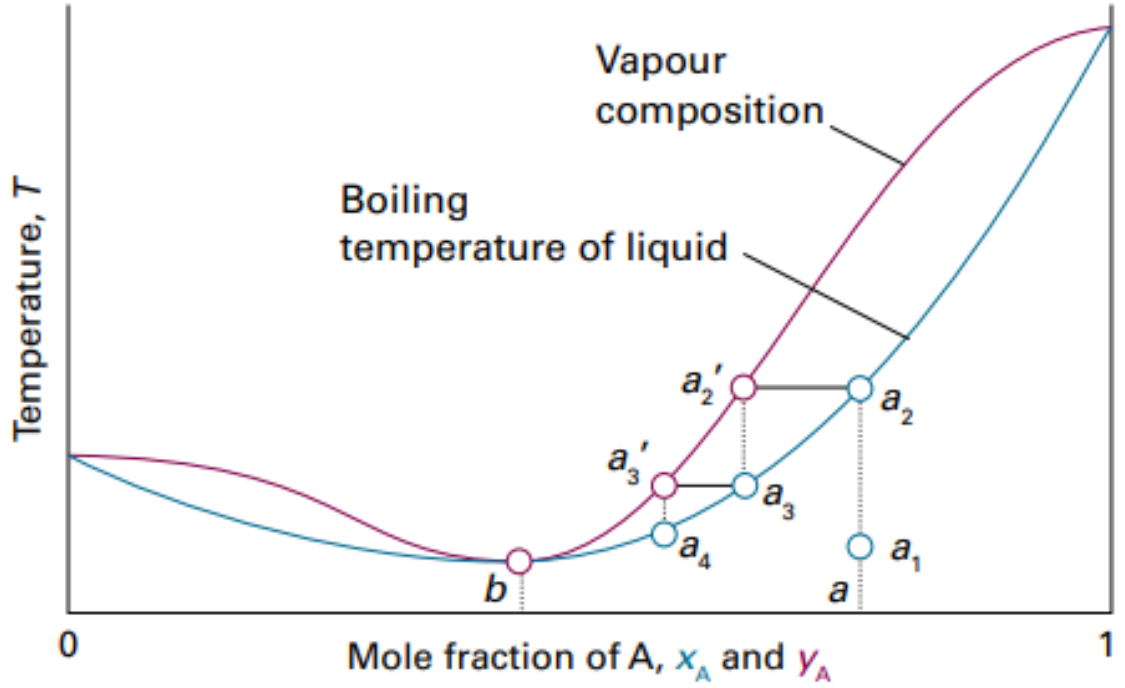
A-B > AA or B-B ΔG<0

HCl/water

compared to an ideal solution

Azeotrope





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HCl/water

ethanol/water

compared to an ideal solution

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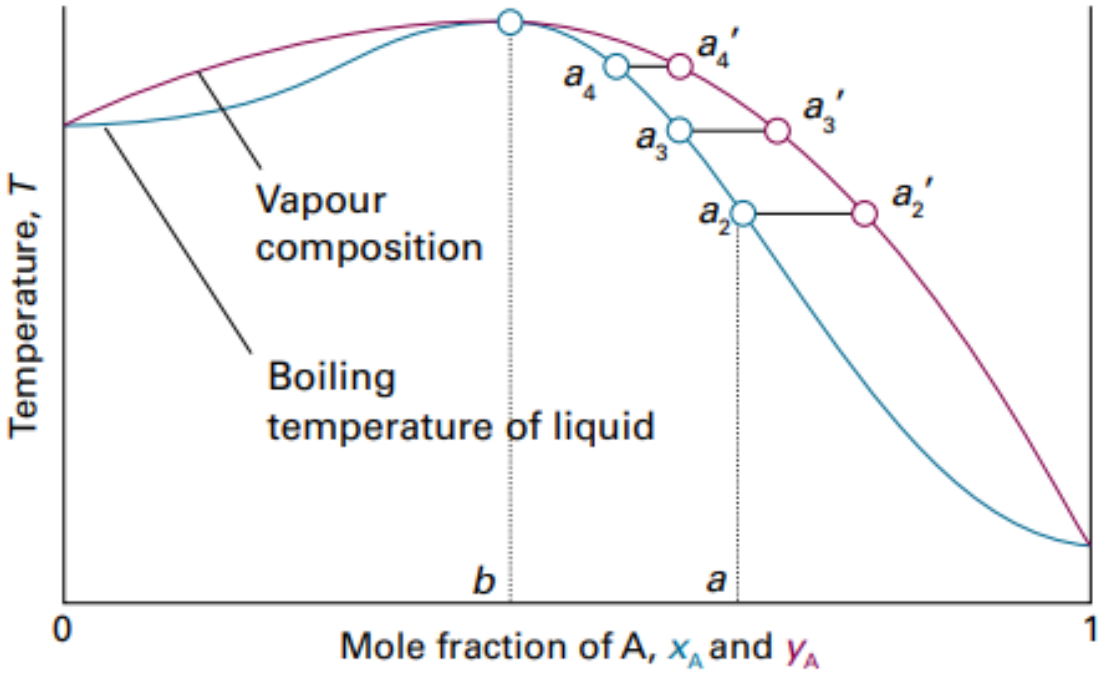

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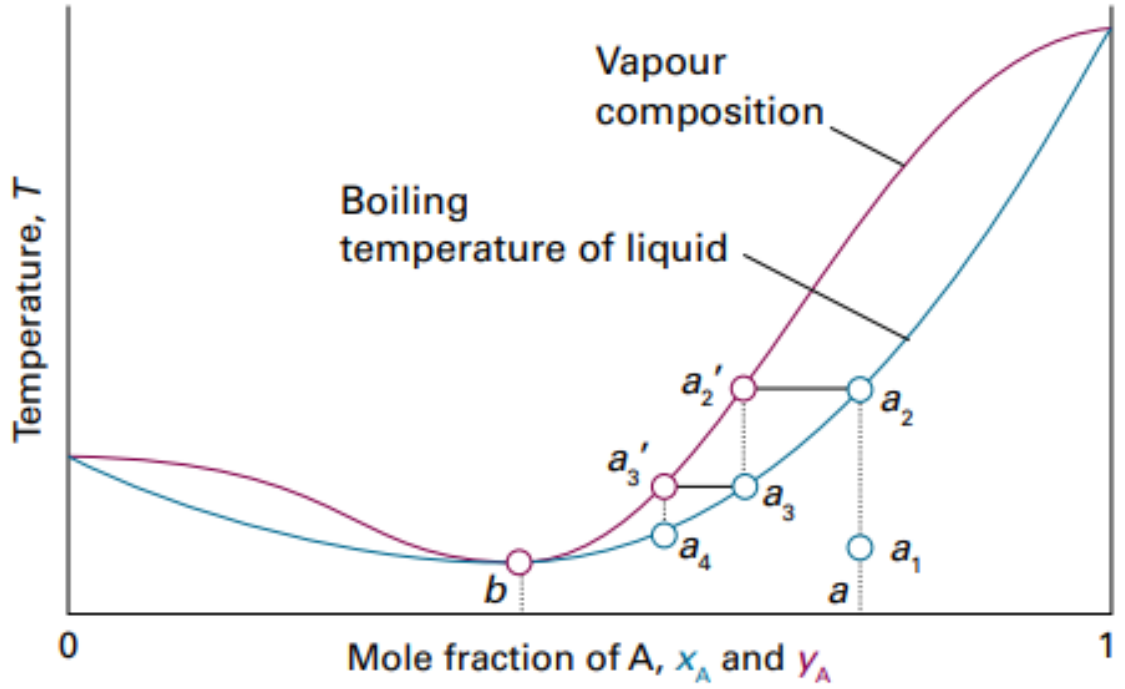

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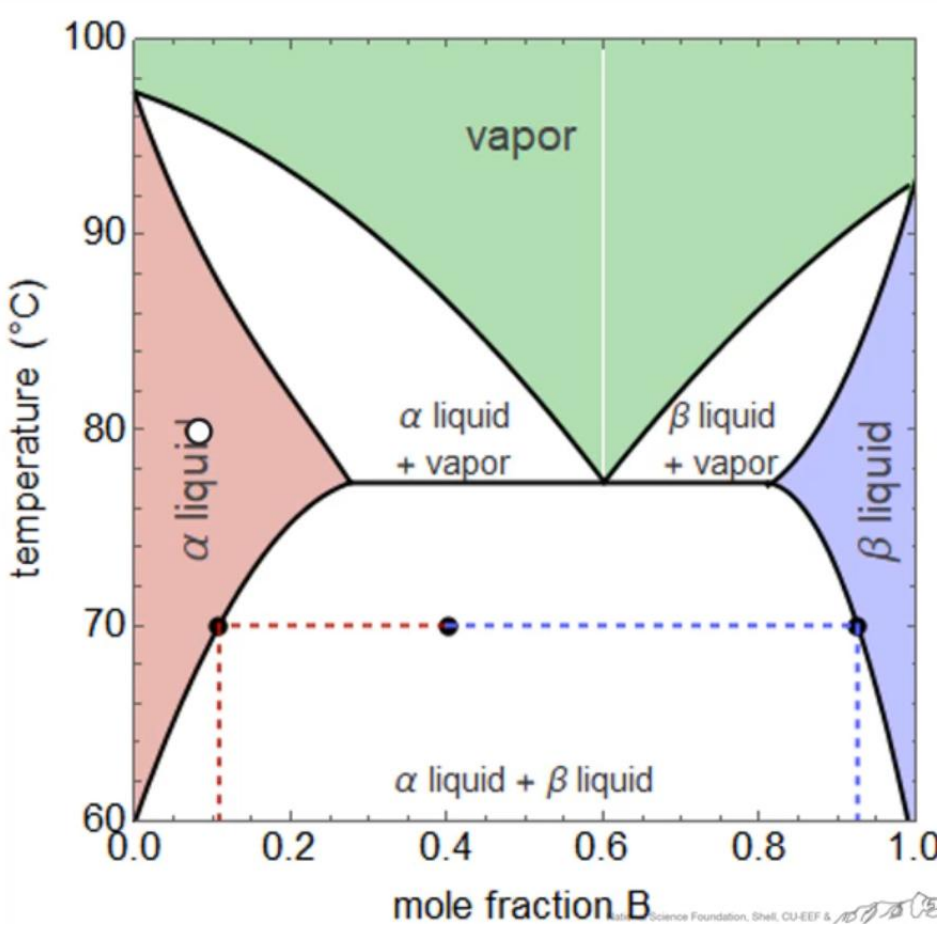
Larger deviation from ideal behavior

Phase diagram of a binary system (A, B) that forms two partially miscible liquids (α, β)



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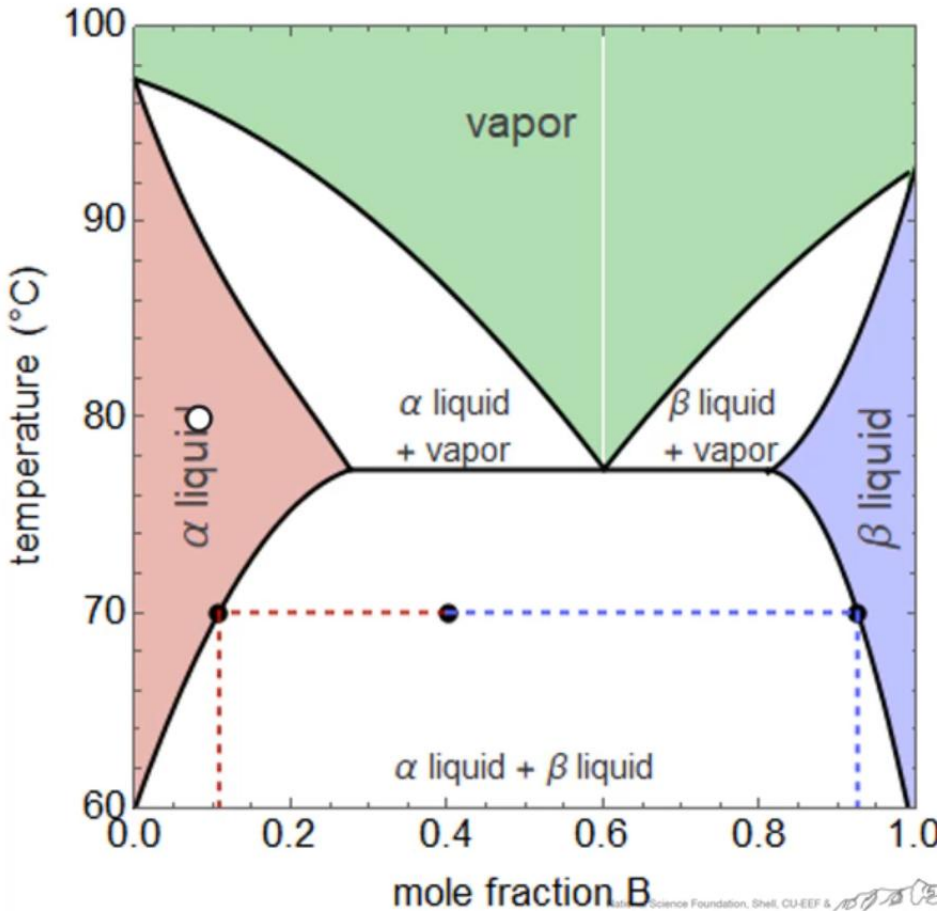
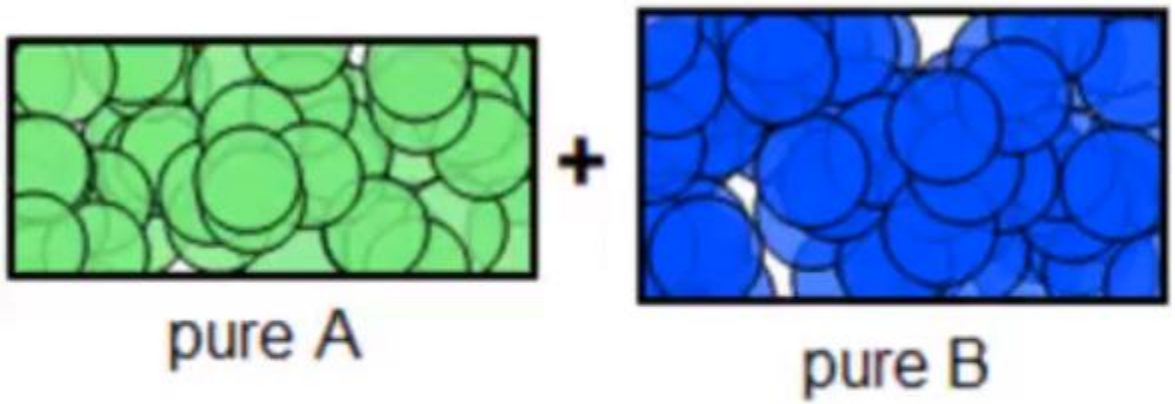
  - They do not mix because the components repel each other strongly



Phase separation



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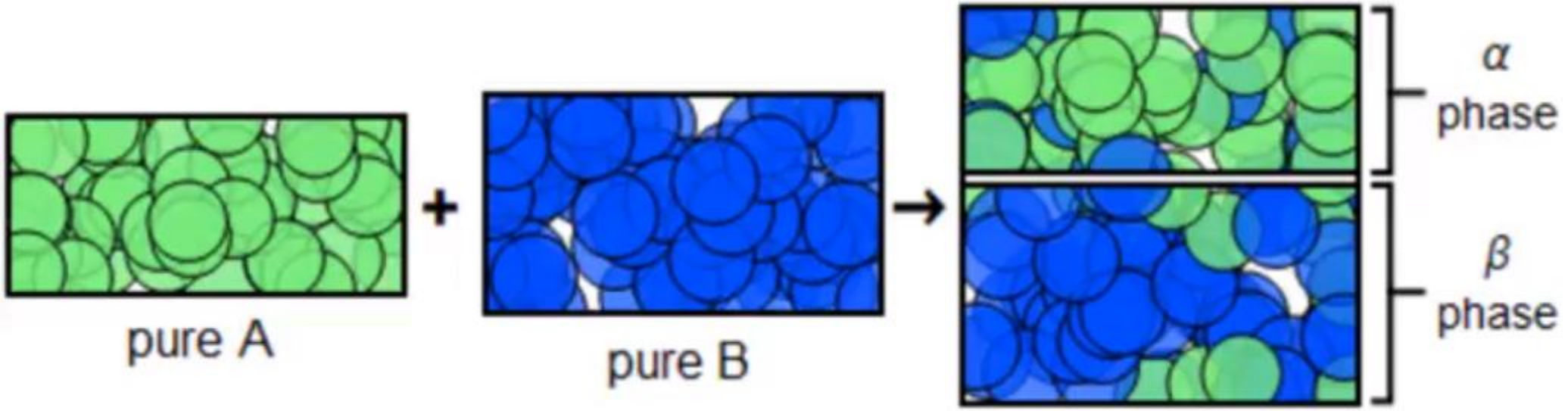

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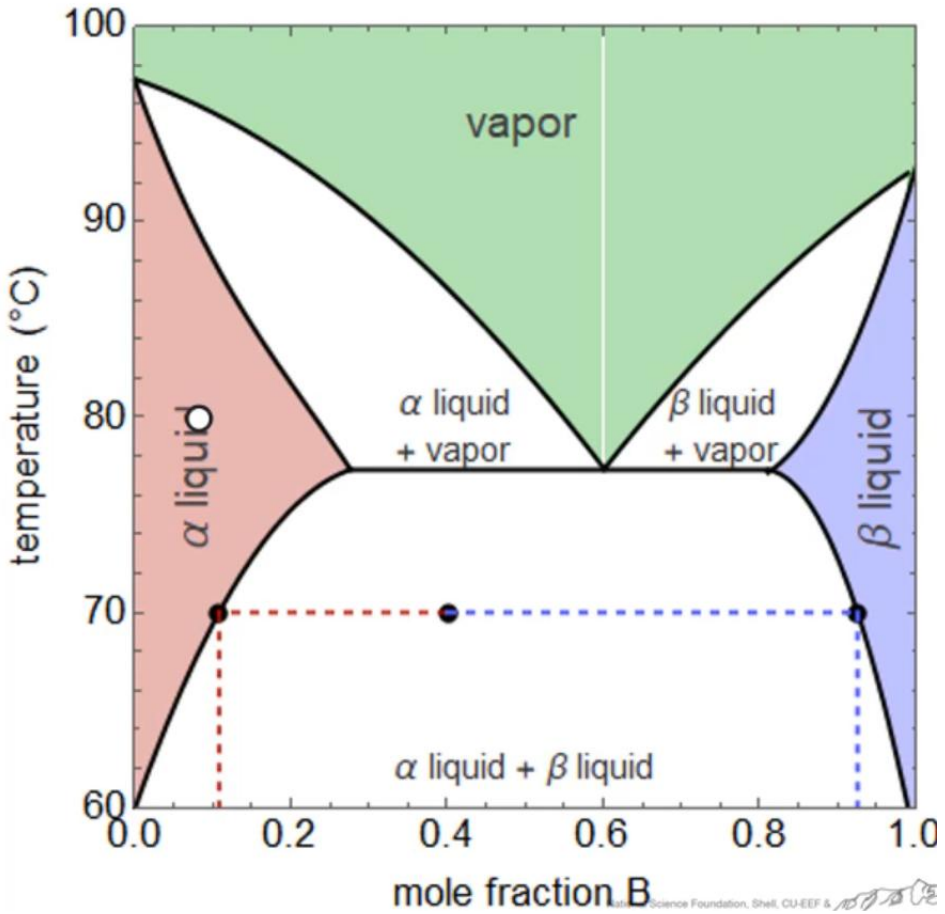
- Only one vapor phase: Unlike the liquid phase, the vapor phase is completely miscible



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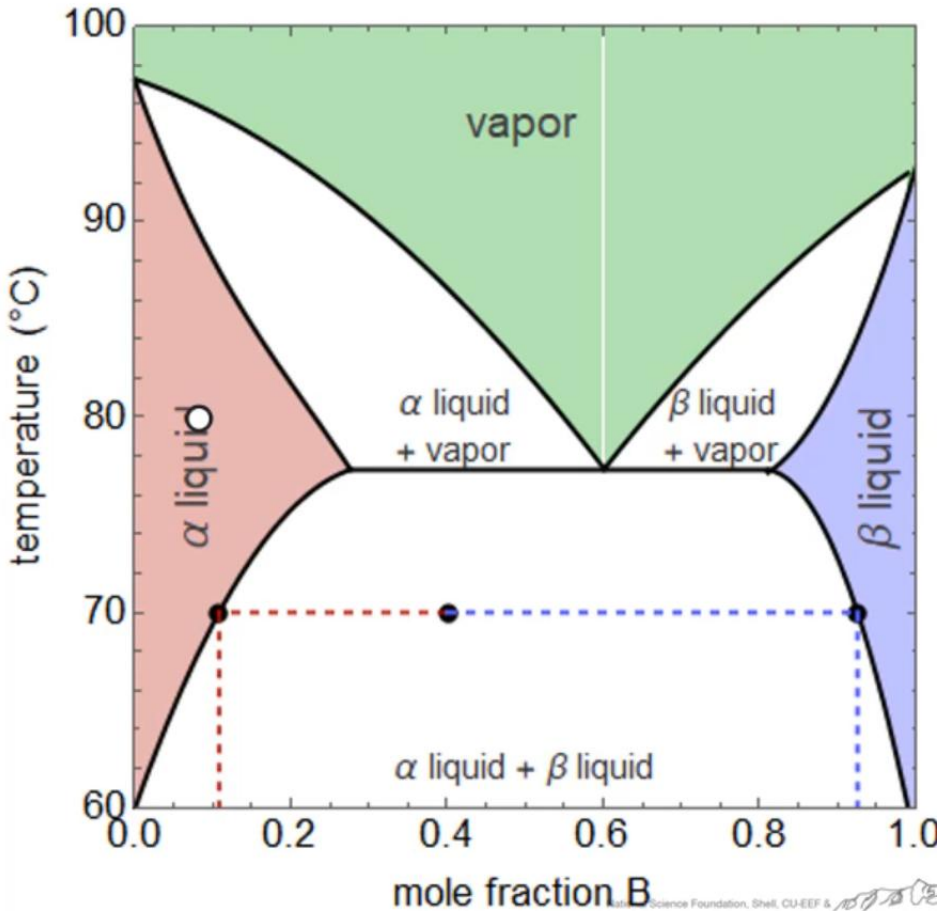
- Bottom middle region: two-phase region where the mixture splits into both α and β liquids
  - Thermodynamically more stable for the system to exist as two immiscible liquids



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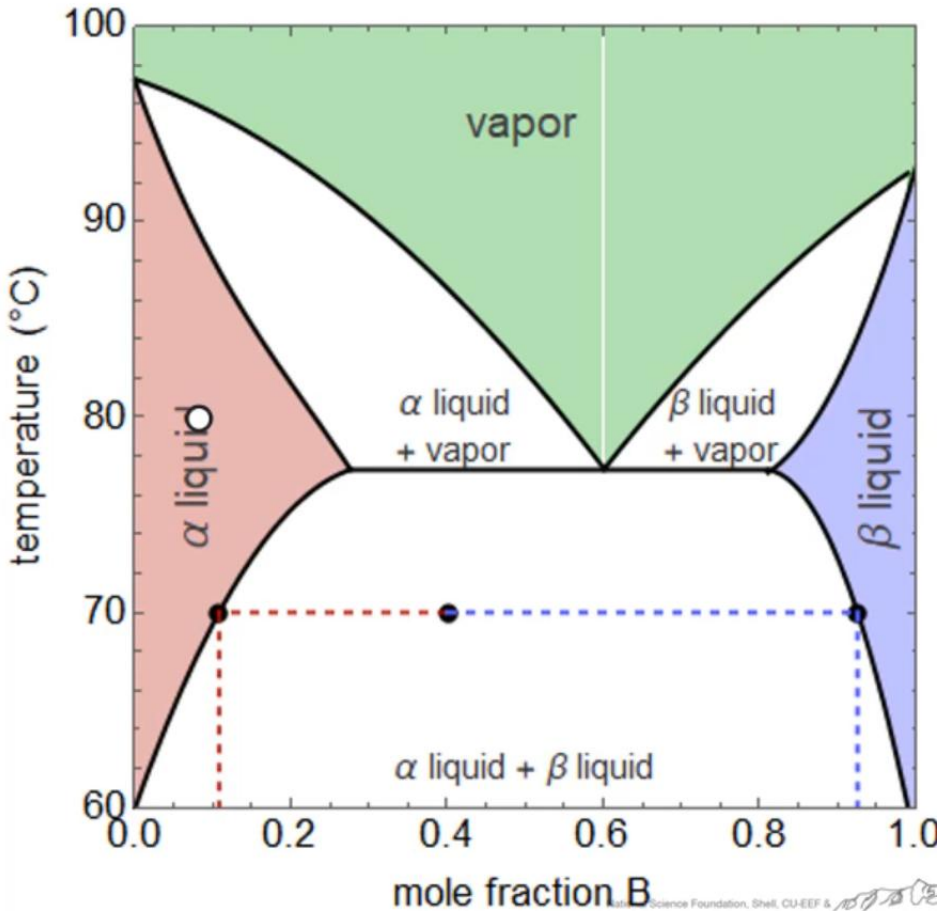
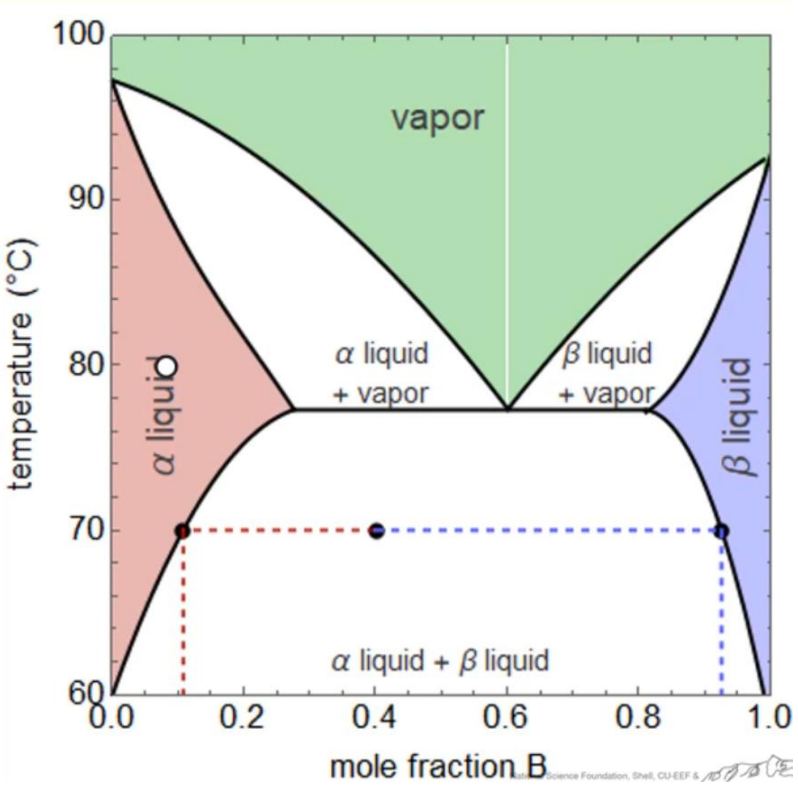
- Boiling regions where one of the liquids coexists with its vapor



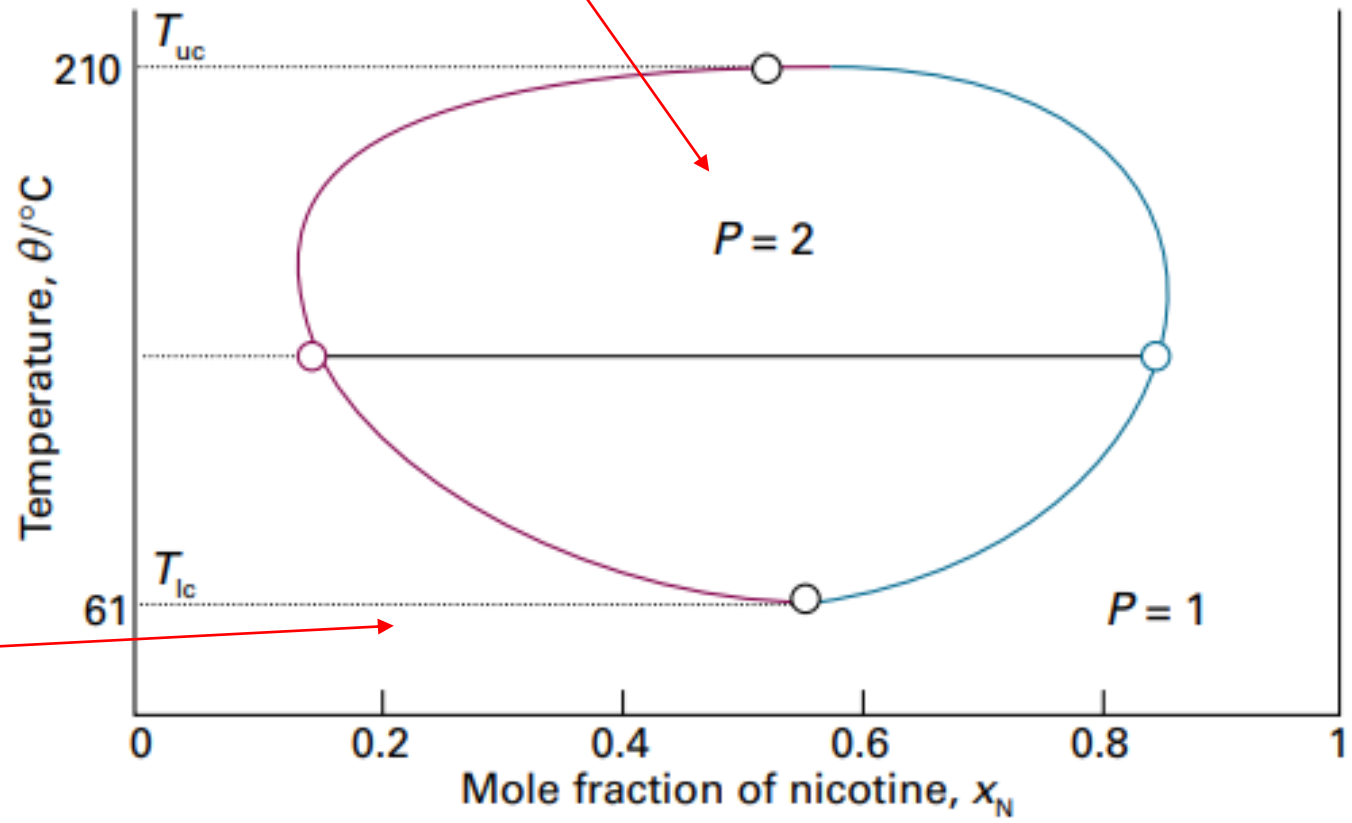
Larger deviation from ideal behavior

Interaction Type	Behavior	Phase Separation?
Unfavorable / repulsive	Strong positive deviation	Yes, possible
Favorable / attractive	Strong negative deviation	No, stays mixed



Upper and lower critical temperature

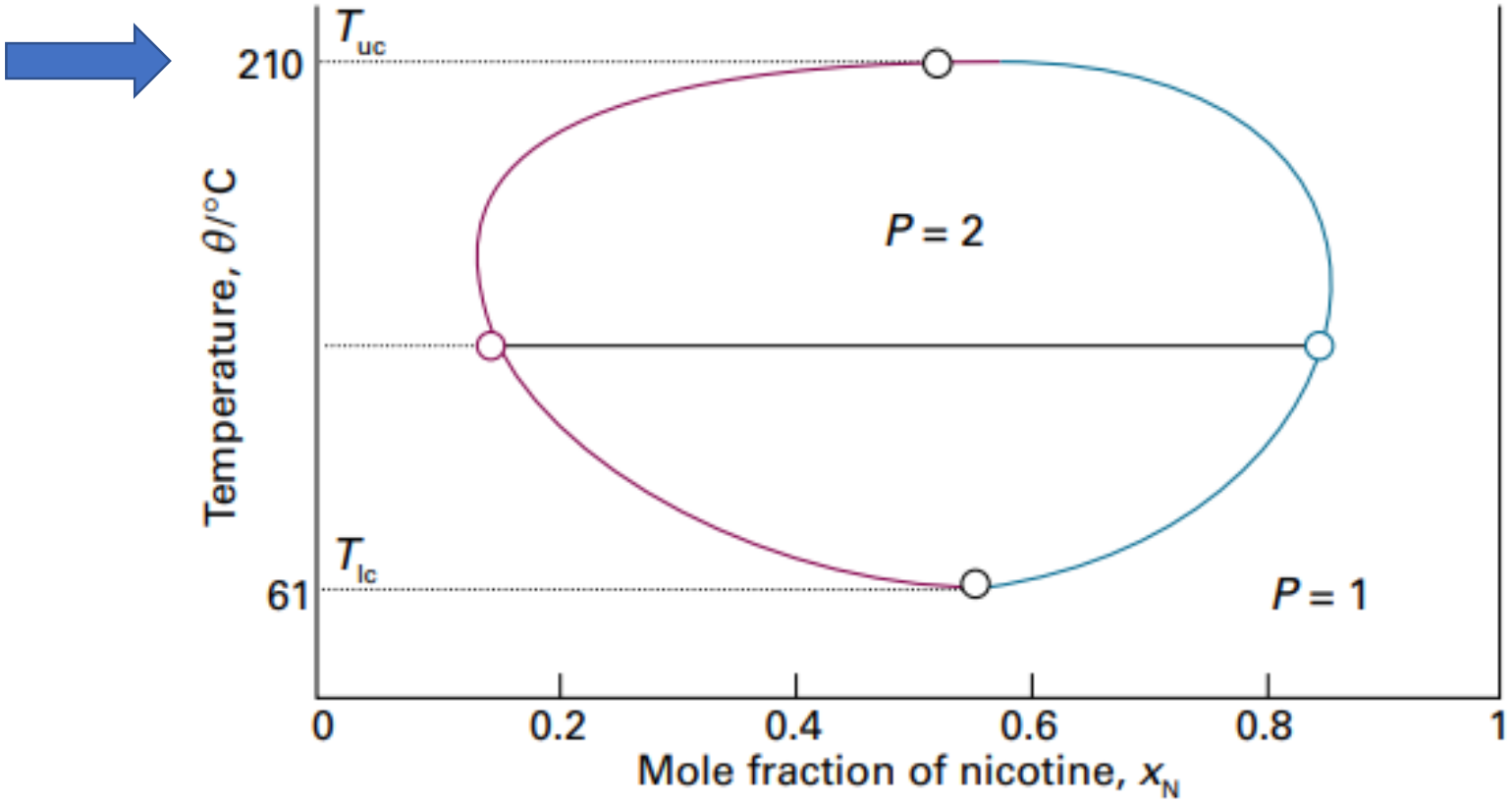
Inside the enclosed region (between the red and blue curves), the system consists of two immiscible liquid phases (hence P=2)



Outside the envelope, the system is a single homogeneous liquid phase

Upper and lower critical temperature

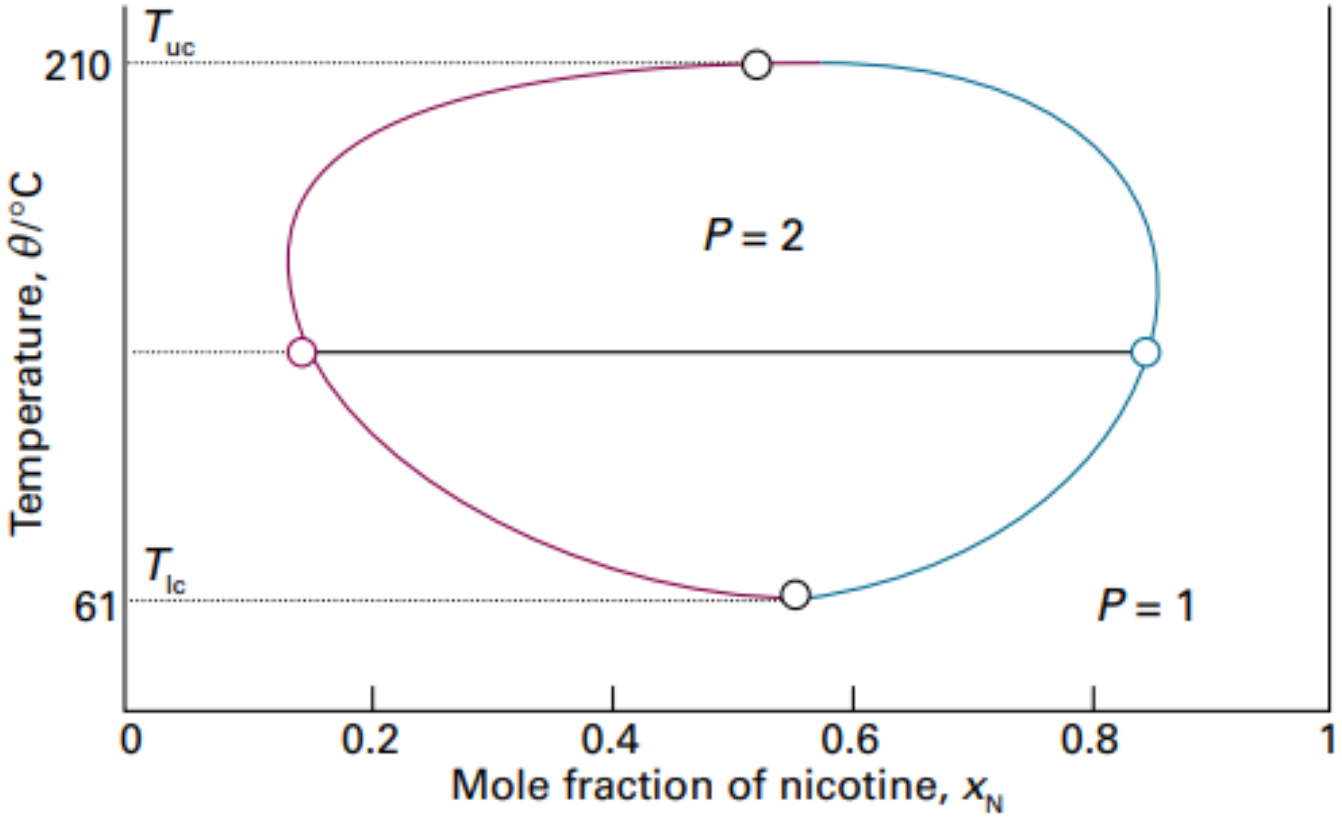
highest temperature at which phase separation occurs



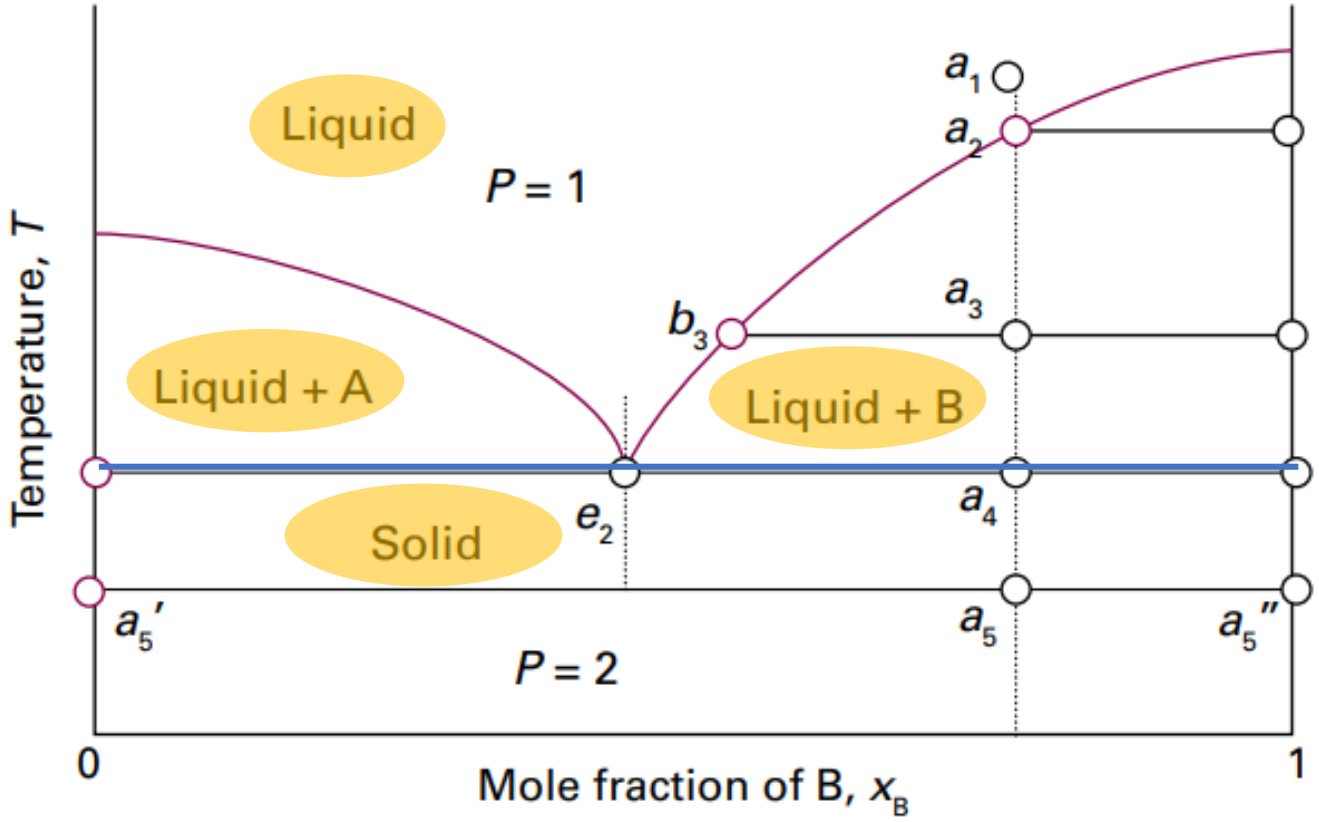
Upper and lower critical temperature

highest temperature at which phase separation occurs

lowest temperature at which phase separation occurs



Binary solid mixtures



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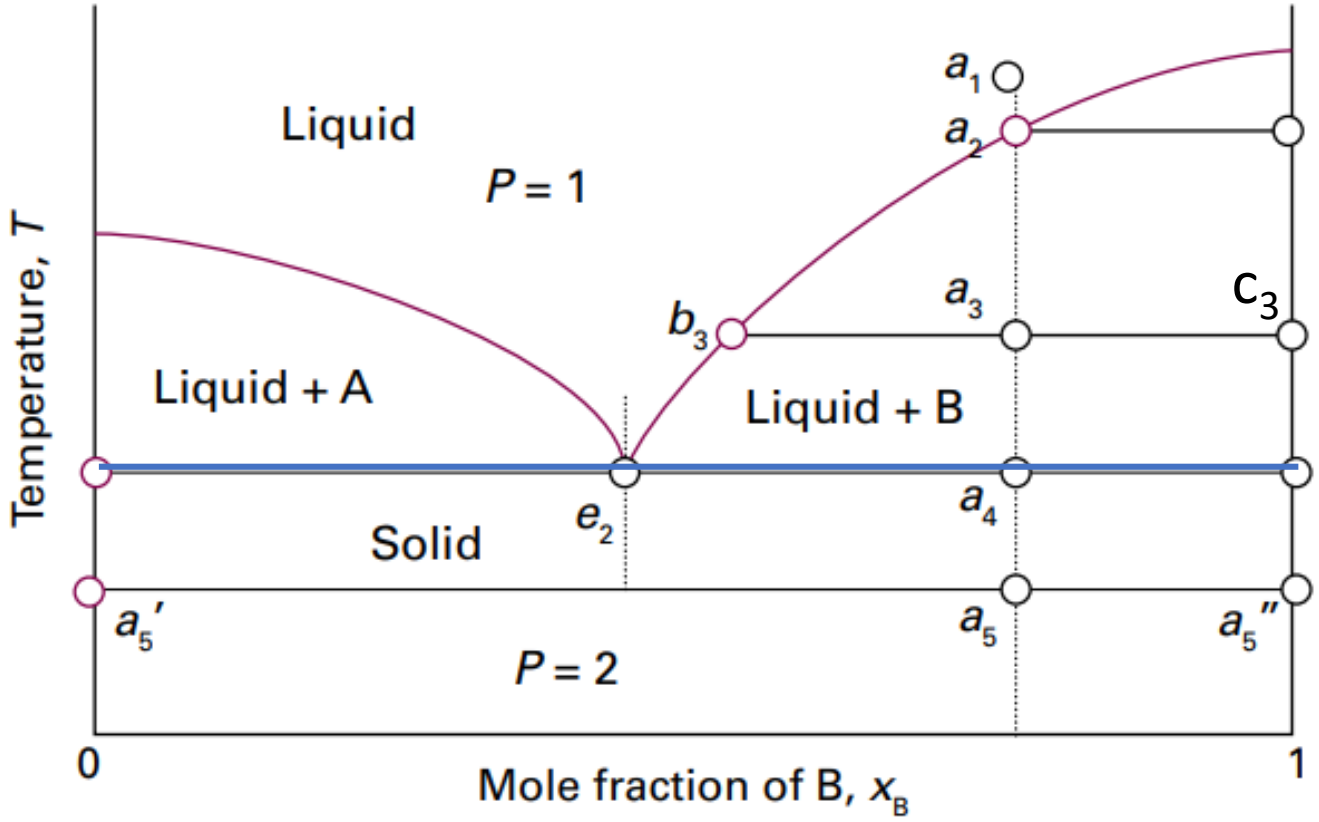

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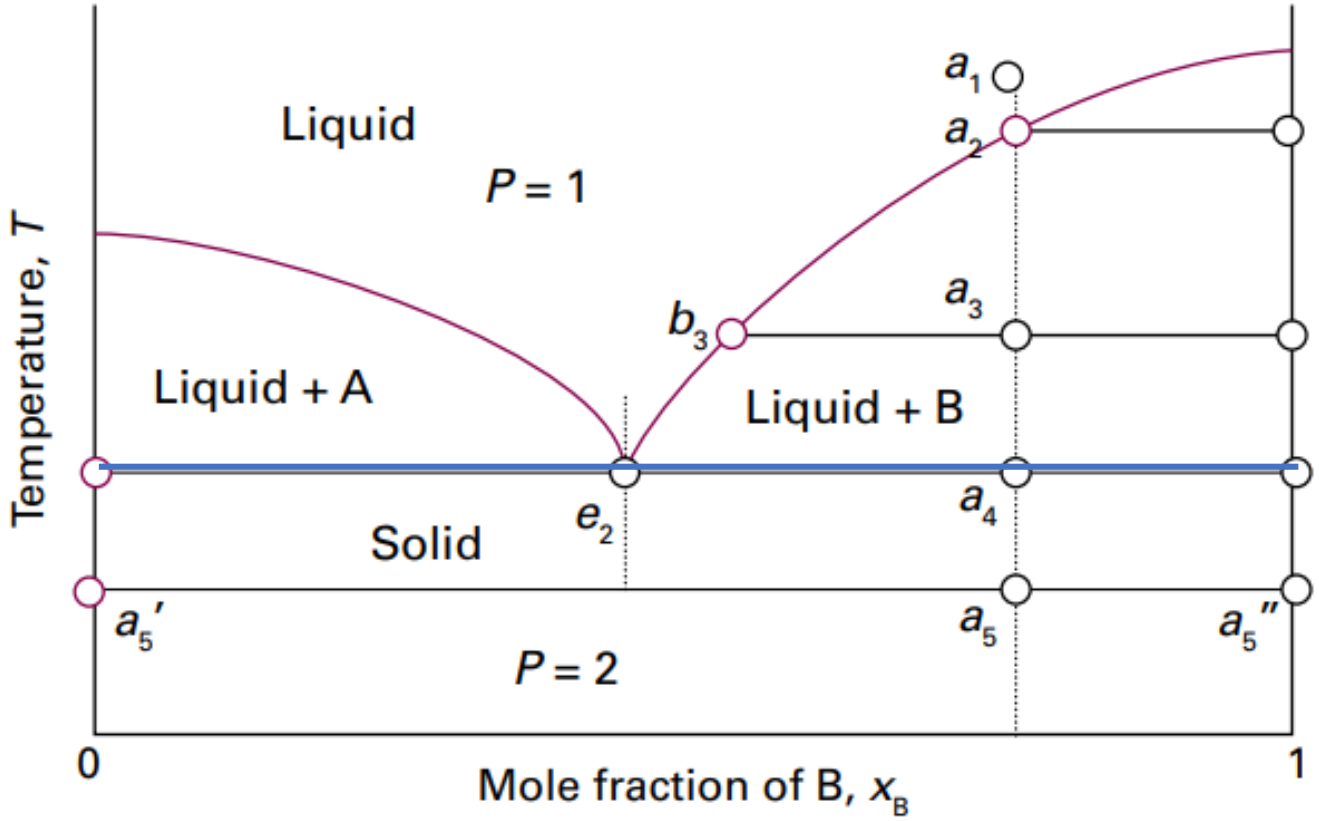

The eutectic formed by 23% NaCl and 77% H_2O by mass melts at −21.1 °C
(when salt is spread on an icy road)