Conditions for Equilibrium

- **In equilibrium, all thermodynamic potentials must be equal in all phases.**

$$T^{\alpha} = T^{\beta} = \ldots = T^{\gamma}$$

$$P^{\alpha} = P^{\beta} = \ldots = P^{\gamma}$$

$$\mu_a^{\alpha} = \mu_a^{\beta} = \ldots = \mu_a^{\gamma}$$

$$\mu_b^{\alpha} = \mu_b^{\beta} = \ldots = \mu_b^{\gamma}$$

.

.

$$\mu_n^{\alpha} = \mu_n^{\beta} = \ldots = \mu_n^{\gamma}$$

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Phase Rule

(P-1) equations

(C+2) lines

$$T^{\alpha} = T^{\beta} = \ldots = T^{\gamma}$$

$$P^{\alpha} = P^{\beta} = \ldots = P^{\gamma}$$

$$\mu_a^{\alpha} = \mu_a^{\beta} = \ldots = \mu_a^{\gamma}$$

$$\mu_b^{\alpha} = \mu_b^{\beta} = \ldots = \mu_b^{\gamma}$$

.

.

$$\mu_n^{\alpha} = \mu_n^{\beta} = \ldots = \mu_n^{\gamma}$$

Number of Equations:
(C+2)(P-1)=CP+2P-C-2

Number of Variables:
(C-1)P composition variables
P temperatures
P pressures
CP-P+2P=CP+P variables

Variables-Equations= Degrees of Freedom
CP+P-(CP-C+2P-2)=F
C-P+2=F
For an extensive system the size is an additional variable
C-P+3=F

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Diagram Topology (binaries)

- **Two potentials**
- **One potential**
- **No potential (two thermodynamic functions)**

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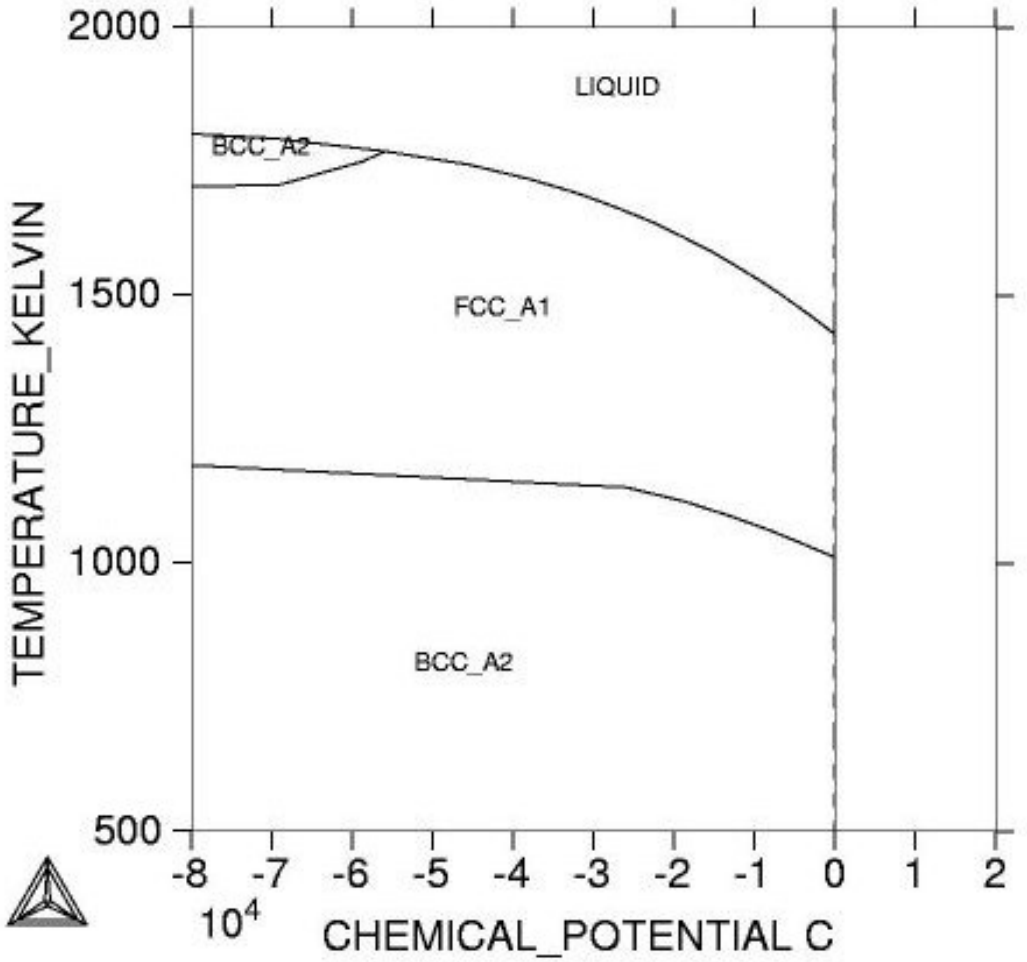
Equilibrium in Fe-C



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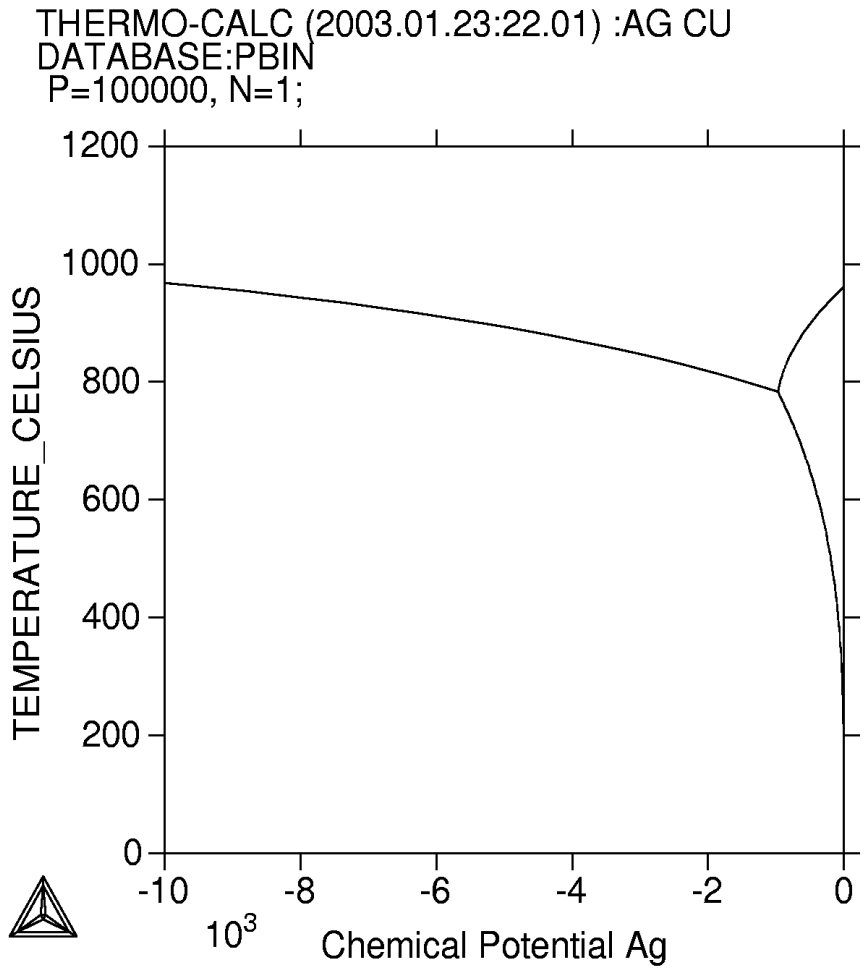
Equilibrium in Ag-Cu



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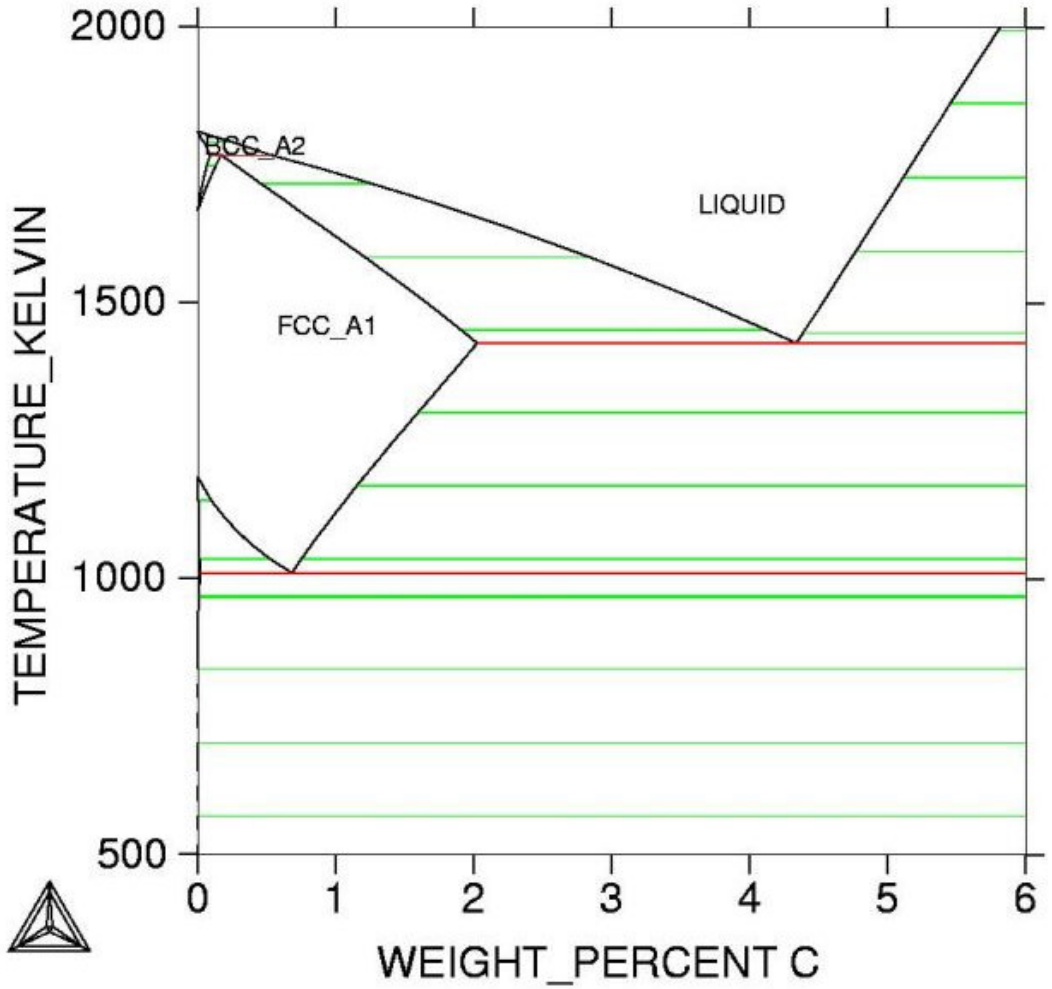
T (potential) vs %C (non-potential)



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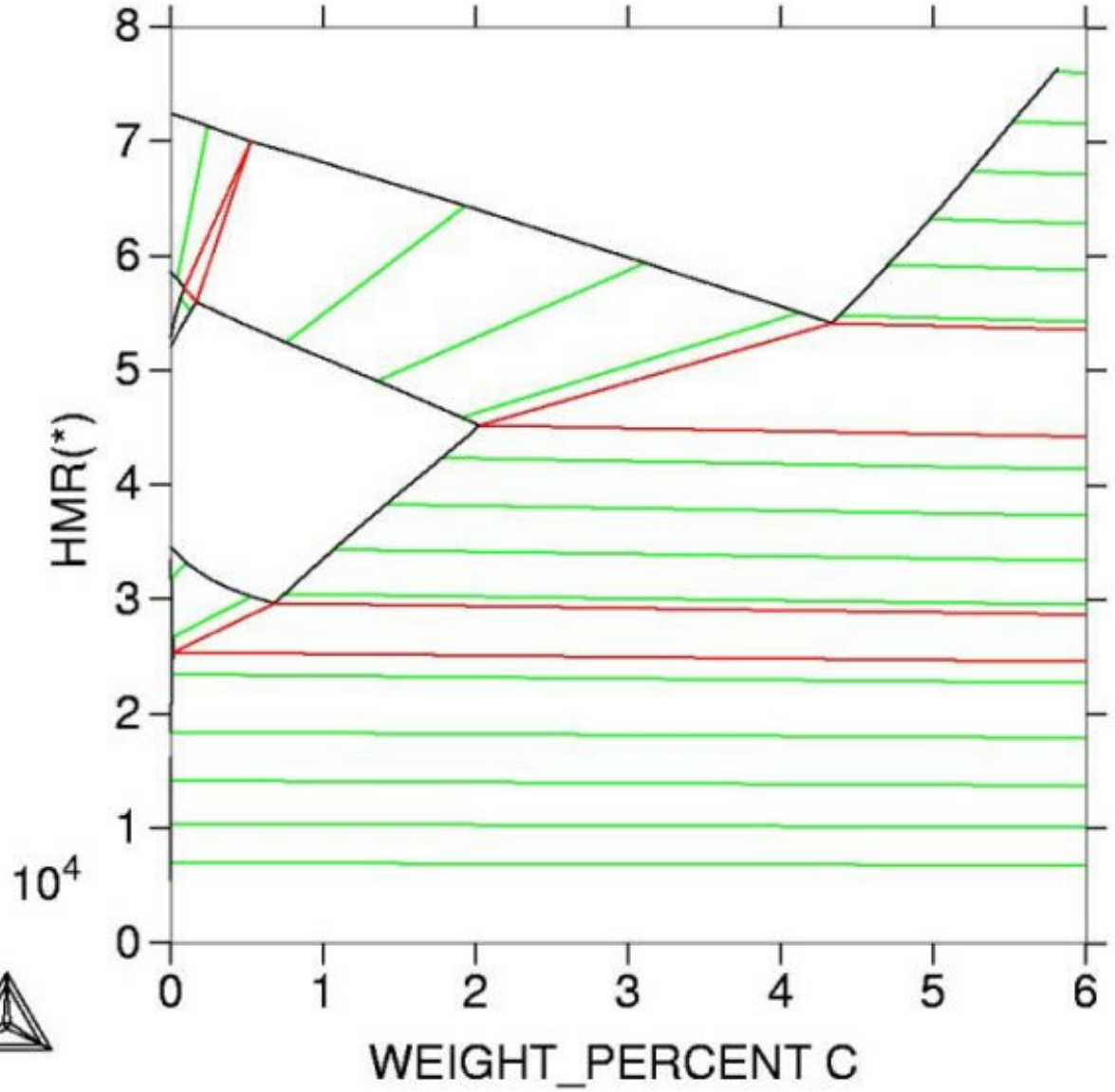
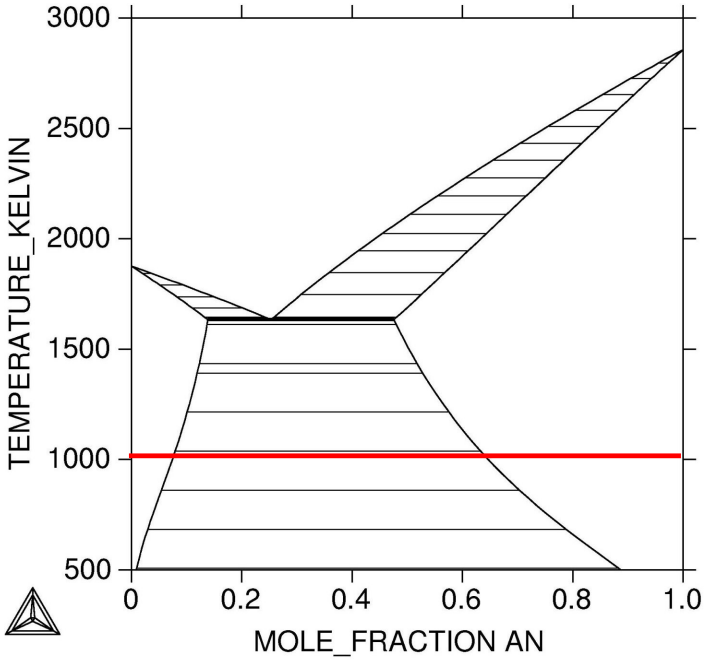
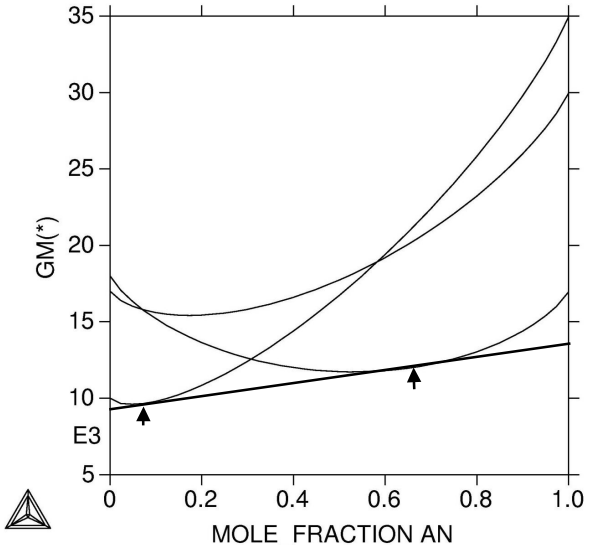
Enthaply vs Composition (no potential)



Complexity (1 to n)





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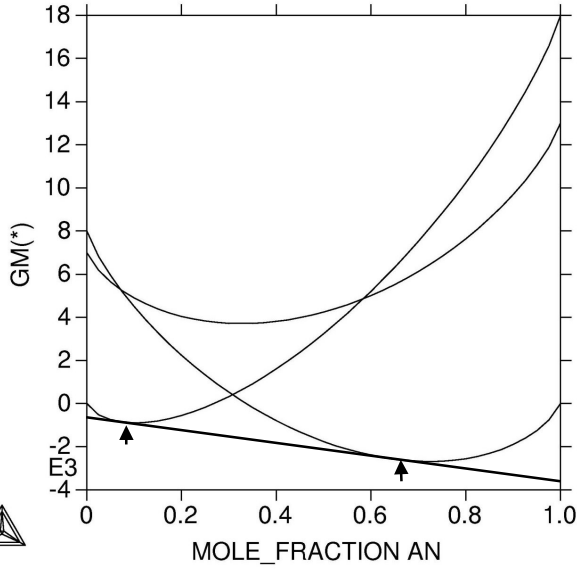

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