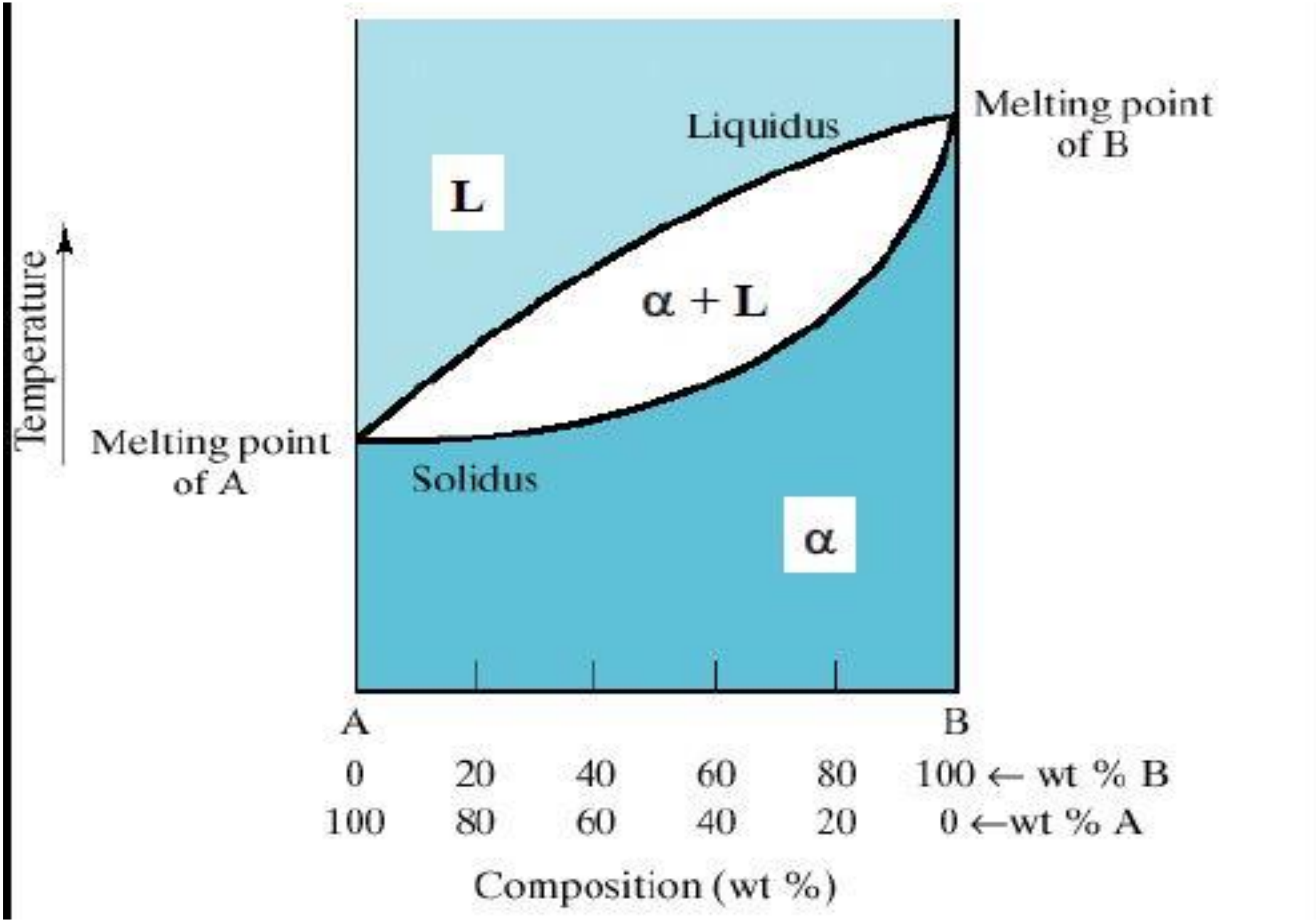
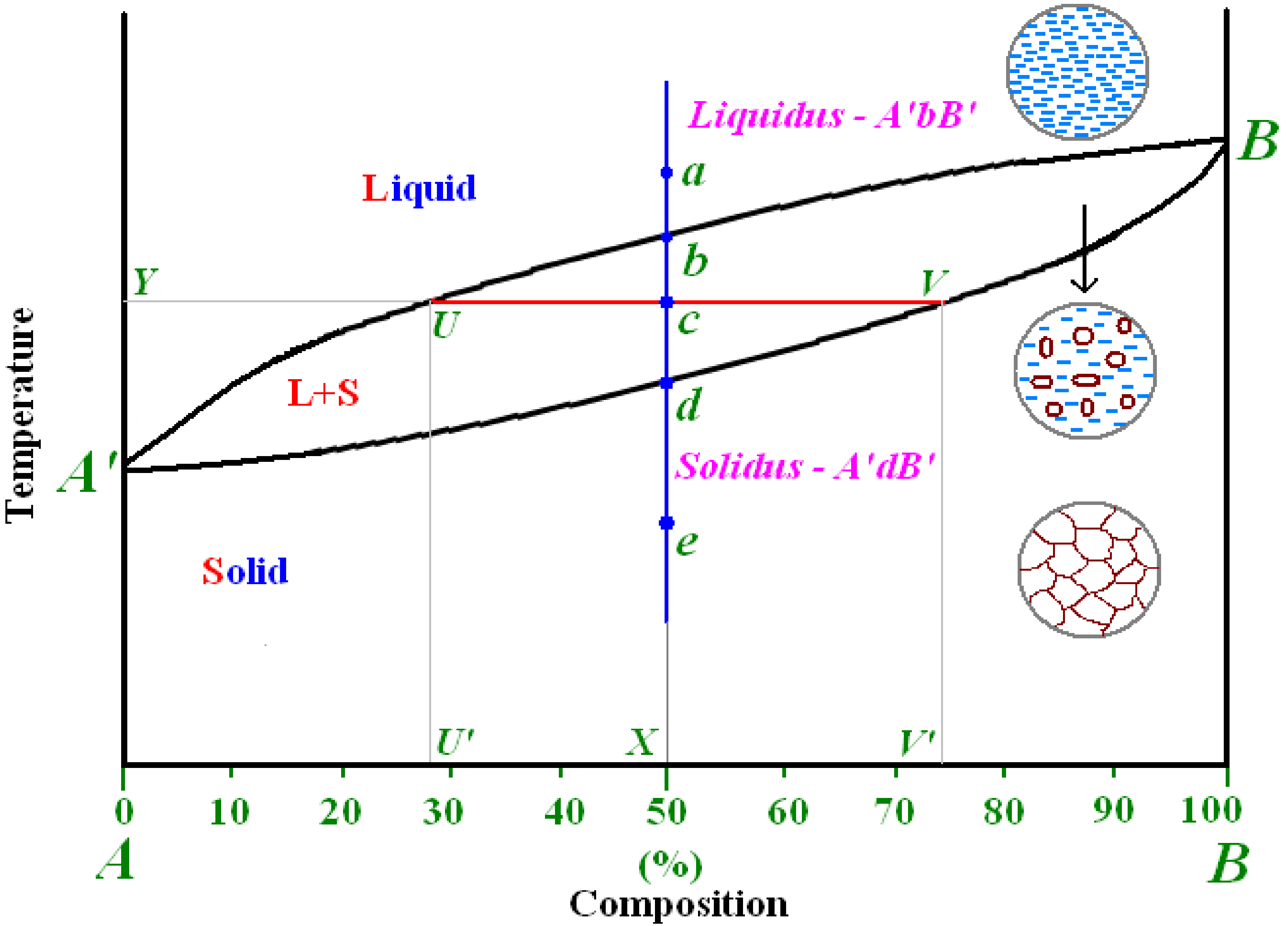
BINARY ISOMORPHOUS SYSTEMS

- Isomorphous system - complete solid solubility of the two components (both in the liquid and solid phases).
- Such a phase diagram forms when there is complete solid and liquid solubility.
- The solid mentioned is crystalline.
- The solid + liquid region is not a semi-solid (like partly molten wax or silicate glass). It is a crystal of well defined composition in equilibrium with a liquid of well defined composition.
- Both the solid and the liquid and the solid (except pure A and pure B) have both A and B components in them.
- A and B components could be pure elements (like in the Ag-Au, Au-Pd, Au-Ni, Ge-Si) or compounds (like Al_2O_3-Cr_2O_3).

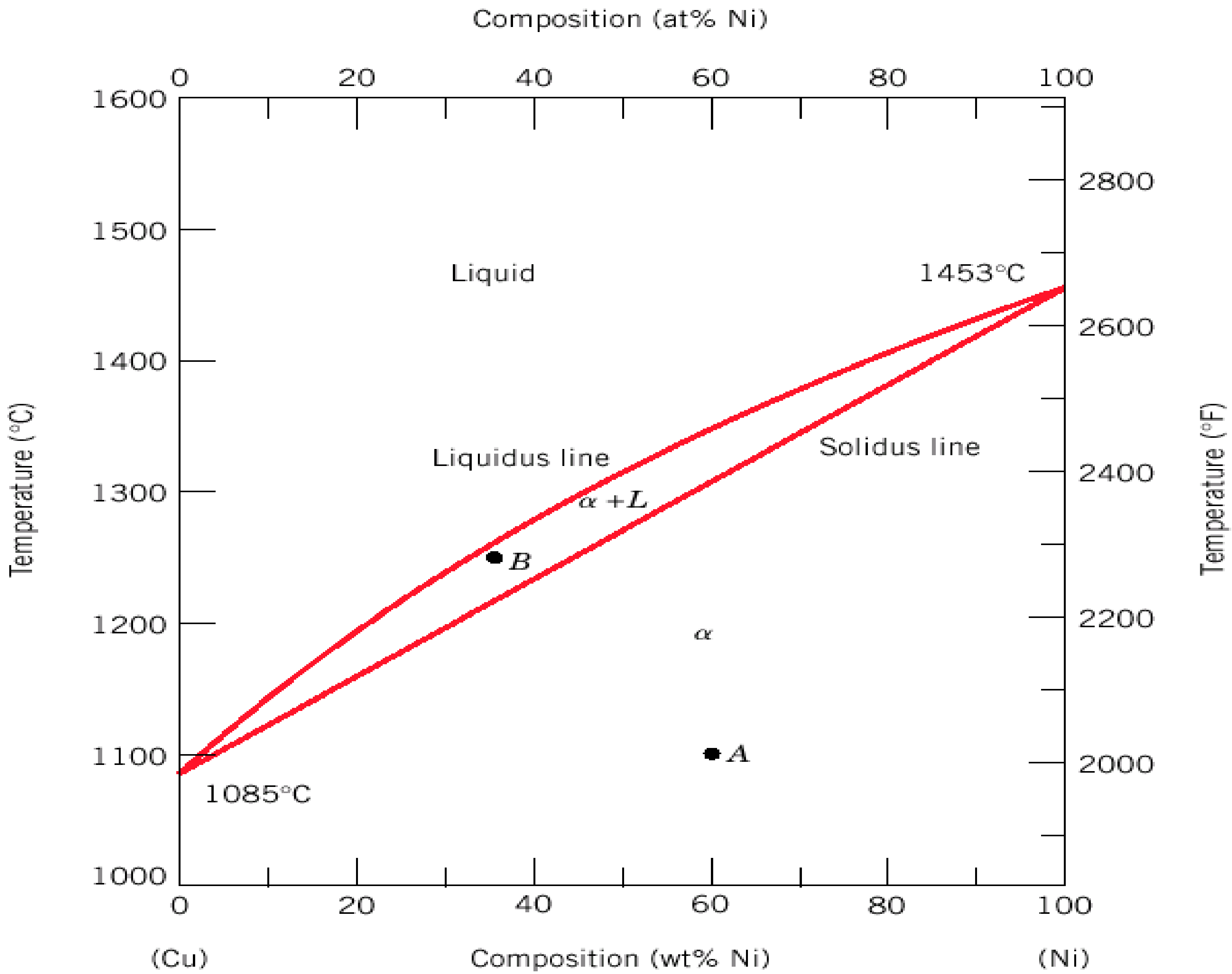

Melting point
of B
Liquidus
L
α + L
Temperature
Melting point
of A
Solidus
α
A
B
0 20 40 60 80 100 ← wt % B
100 80 60 40 20 0 ←wt % A
Composition (wt %)



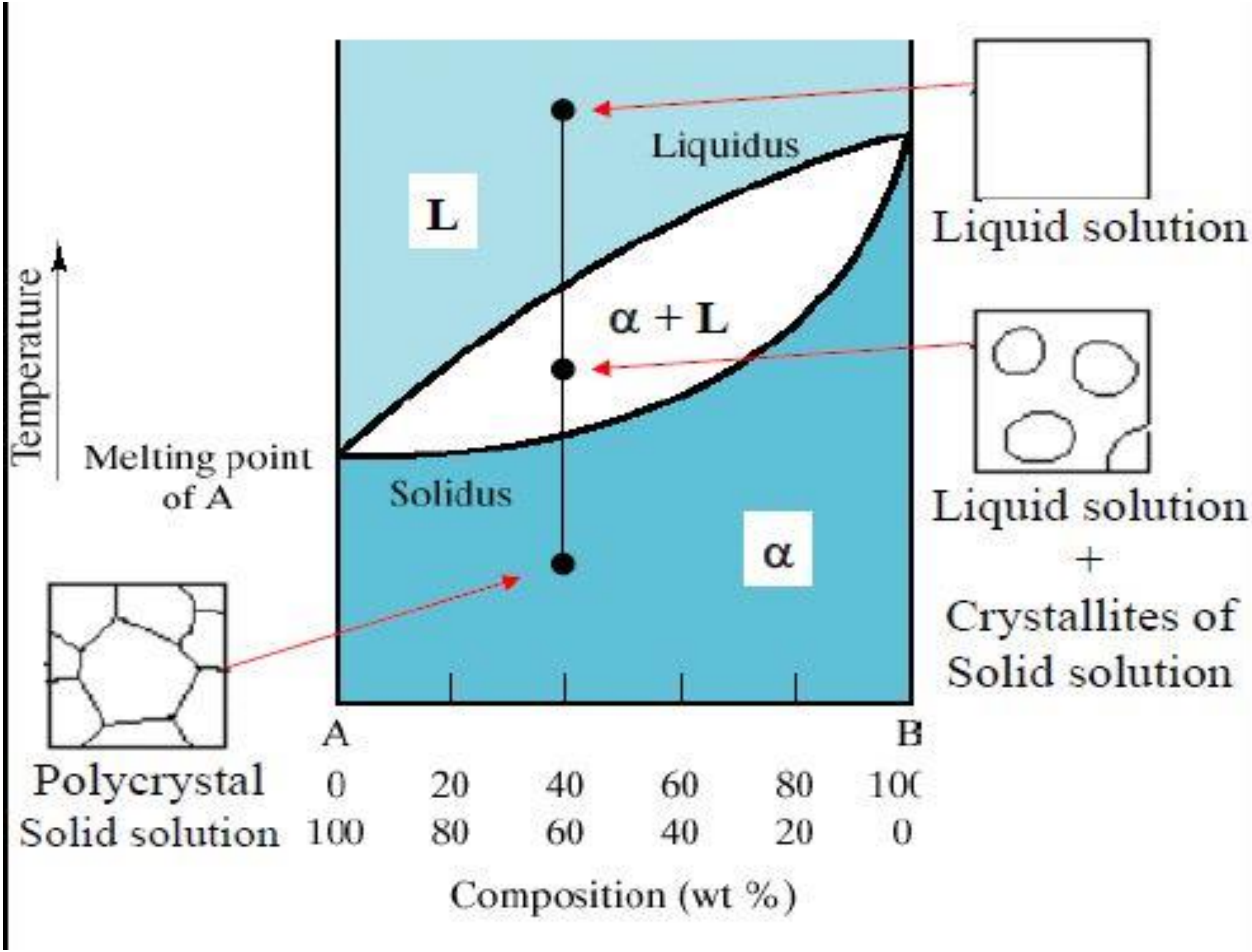
Liquidus - A'bB'
B'
a
Liquid
b
Y
V
U
c
L+S
d
A'
Solidus - A'dB'
e
Solid
U'
X
V'
0
10
20
30
40
50
60
70
80
90
100
A
B
(%)
Composition
Temperature

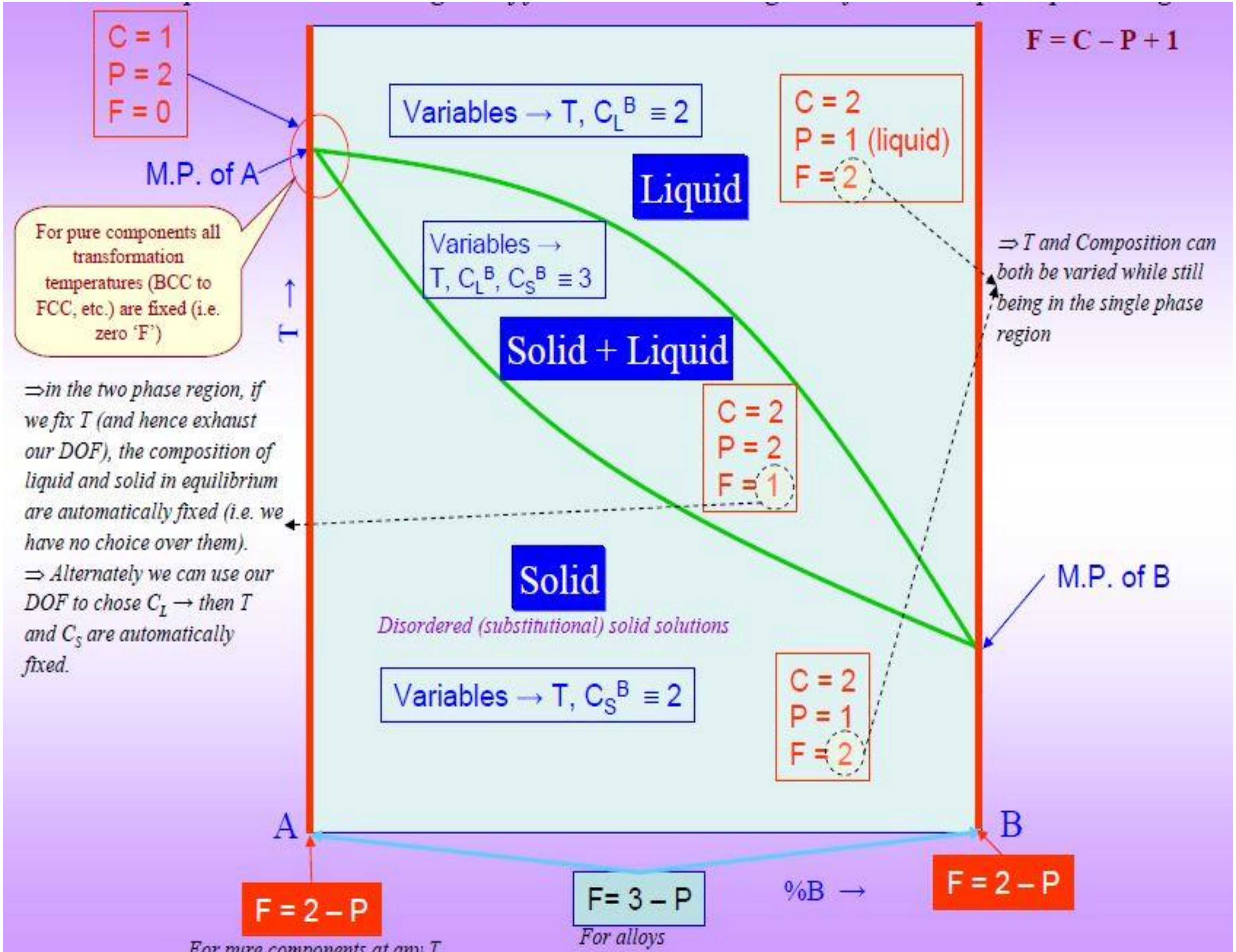
- Three phase region can be identified on the phase diagram:-
- Liquid (L) , solid + liquid (α +L), solid (α)
- Liquidus line separates liquid from liquid + solid
- Solidus line separates solid from liquid + solid

- Example of isomorphous system: Cu-Ni (the complete solubility occurs because both Cu and Ni have the same crystal structure, FCC, similar radii, electro negativity and valence).


Composition (at% Ni)
0
20
40
60
80
100
1600
1500
1400
1300
1200
1100
1000
2800
2600
2400
2200
2000
Temperature (°C)
Temperature (°F)
Liquid
1453°C
Liquidus line
Solidus line
α + L
B
α
A
1085°C
0
20
40
60
80
100
(Cu)
Composition (wt% Ni)
(Ni)

- In one-component system melting occurs at a well-defined melting temperature.
- In multi-component systems melting occurs over the range of temperatures, between the solidus and liquidus lines.
- Solid and liquid phases are in equilibrium in this temperature range.


Liquidus
L
α + L
Temperature
Melting point of A
Solidus
α
Liquid solution
Liquid solution
+
Crystallites of Solid solution
Polycrystal
Solid solution
A
B
0 20 40 60 80 100
100 80 60 40 20 0
Composition (wt %)



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- Pure components (A,B) melt at a single temperature. (General) Alloys melt over a range of temperatures.
- Isomorphous phase diagrams form when there is complete solid and liquid solubility.
- Complete solid solubility implies that the crystal structure of the two components have to be same and Hume-Rothery rules have to be followed.
- In some systems (e.g. Au-Ni system) there might be phase separation in the solid state (i.e. the complete solid solubility criterion may not be followed) →these will be considered later in this chapter as a variation of the isomorphous system (with complete solubility in the solid and the liquid state).

- Both the liquid and solid contain the components A and B.
- In Binary phase diagrams between two single phase regions there will be a two phase region →In the isomorphous diagram between the liquid and solid state there is the (Liquid + Solid) state.
- The Liquid + Solid state is NOT a 'semi-solid' state →it is a solid of fixed composition and structure, in equilibrium with a liquid of fixed composition.
- In the single phase region the composition of the alloy is 'the composition'. In the two phase region the composition of the two phases is different and is NOT the nominal composition of the alloy (but, is given by the lever rule).

HUME-ROTHERY RULES

- The **Hume-Rothery rules**, named after William Hume-Rothery, are a set of basic rules that describe the conditions under which an element could dissolve in a metal, forming a solid solution. There are two sets of rules; one refers to substitutional solid solutions, and the other refers to interstitial solid solutions.