Contents of Today

Review previous

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Ternary system

Review of phase diagrams

etc.

Summary of Binary Phase Diagrams

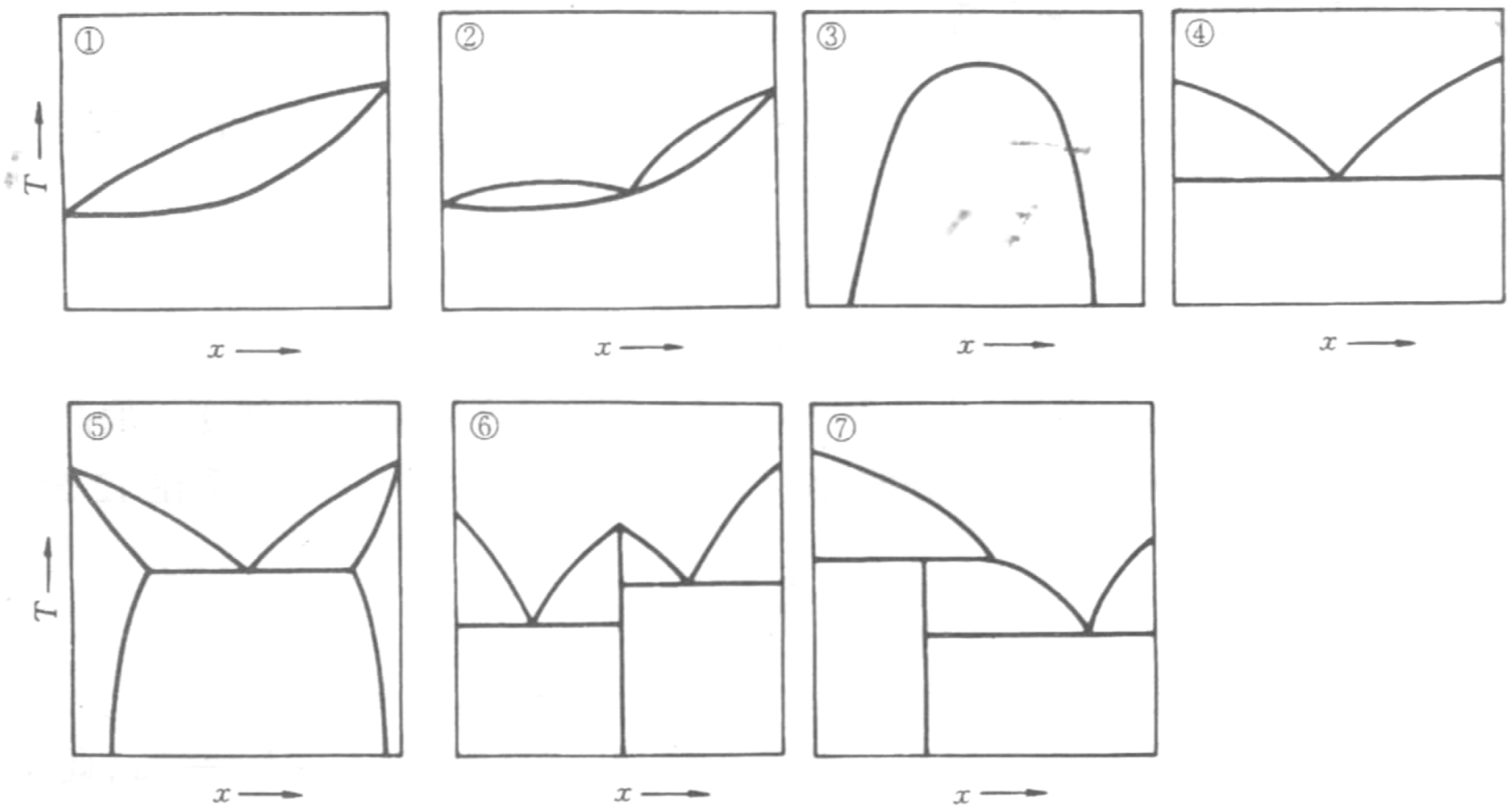
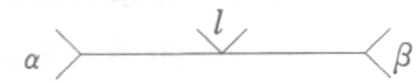
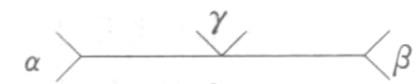
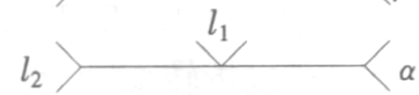
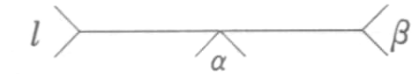
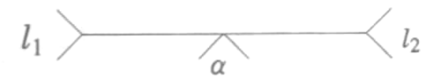


图 6－25　二元相图的 7 种基本类型

Ternary Phases Reaction in Binary Systems

表 6-1　二元系的各种三相平衡反应

转变类型		反应式	图型特征
共晶型	共晶转变	$l \rightleftharpoons \alpha + \beta$	
	共析转变	$\gamma \rightleftharpoons \alpha + \beta$	
	偏晶转变	$l_1 \rightleftharpoons l_2 + \alpha$	
	熔晶转变	$\delta \rightleftharpoons l + \gamma$	
包晶型	包晶转变	$l + \beta \rightleftharpoons \alpha$	
	包析转变	$\gamma + \beta \rightleftharpoons \alpha$	
	合晶转变	$l_1 + l_2 \rightleftharpoons \alpha$	

相图的用处

- 处理系统是多种物质的复杂系统
  - 相律
  - 相图

    说明系统在不同条件下以哪几相共存；当温度、压力、组成改变时会出现什么相变化各相存在的范围，相变发生的条件等

探索新材料

分析合金组织、化学成分、制定生产和热处理工艺的重要依据！

相图的用处 2

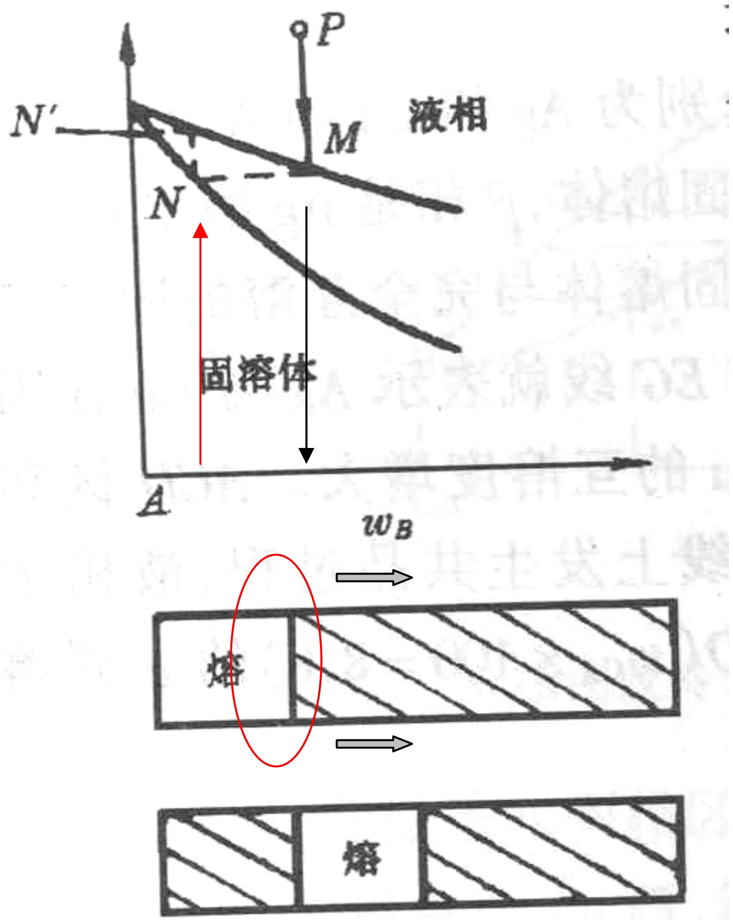


图 5－15 区域熔炼示意图

区域熔炼提纯

析出固溶体杂质的含量比平衡液相的少

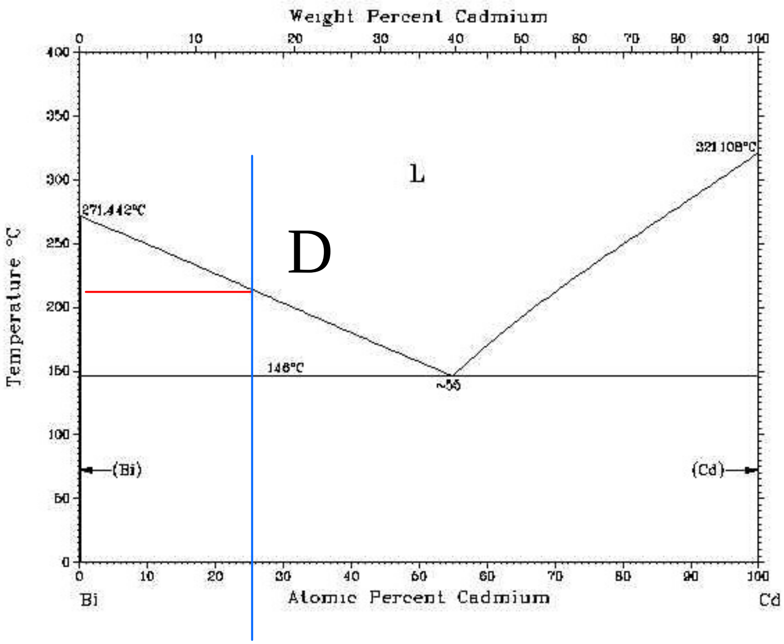
相图的用处 3

- 估算热力学数据，如熔化热
  - 从相图上查出一定成分的合金系统中，作为溶剂的金属熔点降低了多少度，然后用稀溶液凝固点下降的依数性公式，即可估算溶剂金属的摩尔熔化焓

$$x_B = \frac{L(T_m - T)}{RT_m^2}$$

相图的用处 4

- 求出活度数据
  - 在两相共存区，某组分在这两个共存相中的化学势应相等



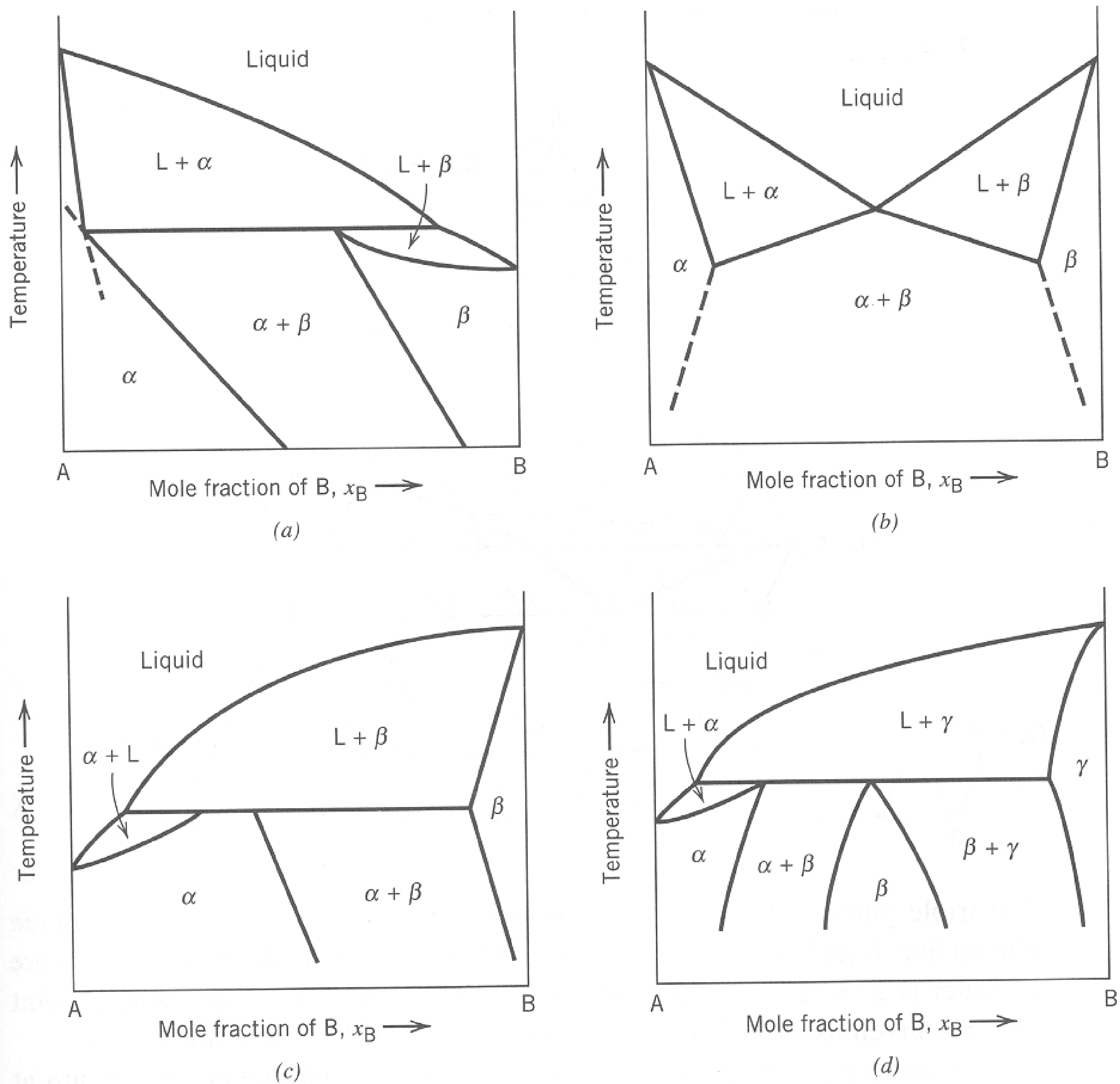
$$\mu_{Bi}(s\ln) = \mu^*_{Bi(s)}$$

$$\mu_{Bi}(s\ln) = \mu^0_{Bi} + RT\ln a_{Bi} = \mu^*_{Bi(l)} + RT\ln a_{Bi}$$

$$\Delta G = \mu^*_{Bi(l)} - \mu^*_{Bi(s)} \qquad T \to T_m$$

Solid -> liquid

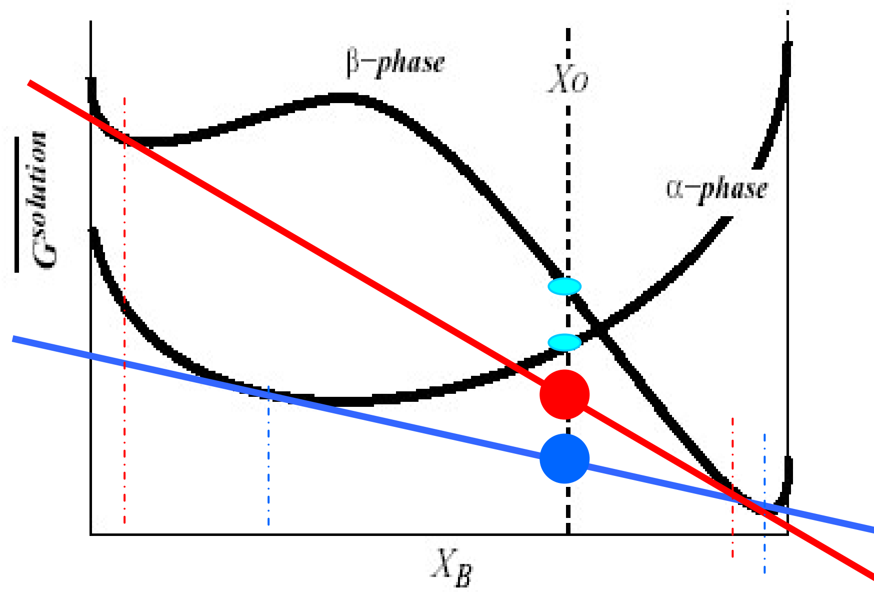
$$\Delta G = \Delta H_m - T\Delta S_m = \Delta H_m(1 - \frac{T}{T_m})$$


Liquid
L + α
L + β
α + β
α
β
Temperature
A
B
Mole fraction of B, x_B
(a)
Liquid
L + α
L + β
α
β
α + β
Temperature
A
B
Mole fraction of B, x_B
(b)
Liquid
α + L
L + β
β
α
α + β
Temperature
A
B
Mole fraction of B, x_B
(c)
Liquid
L + α
L + γ
γ
α
α + β
β
β + γ
Temperature
A
B
Mole fraction of B, x_B
(d)

二元例题 2b

- What is the most stable state of the system at an average composition of X_0?
- Suppose the α-phase was somehow prevented from forming (i.e., consider the equilibrium under the constraint that the α-phase is absent). In this case, what would be the equilibrium state of the system with average composition X_0?

Molar Gibbs free energy of solution, drawn at T and P constant for an α phase and β phase.



Ternary Diagrams

Degrees of freedom available in the system (F):

$$F = C - P + 1$$

F: the number of system variables that we may freely vary, or arbitrarily fix
C: components
P: phase

$$C = 3$$

$$P = 1, F = 3$$
$$P = 2, F = 2$$
$$P = 3, F = 1$$
$$P = 4, F = 0$$

Binary 2D

↓

Ternary 3D

Quaternary

Ternary Diagrams

Ternary 3D

A series of isothermal sections, stacked up vertically

Gibbs triangle

Lines of constant A content are parallel to the line connecting the points representing pure B and pure C

All the combinations of D and E fall on the line between two

The lever rule applied to these system

Ternary Diagrams

Gibbs triangle

Lines of constant A content are parallel to the line connecting the points representing pure B and pure C

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The lever rule applied to these system

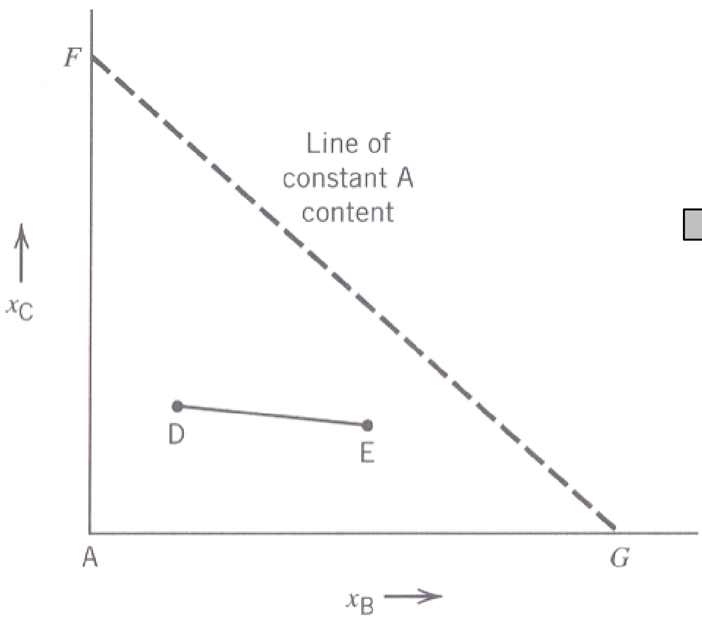


Figure 9.19 Ternary diagram axes: dilute solutions.

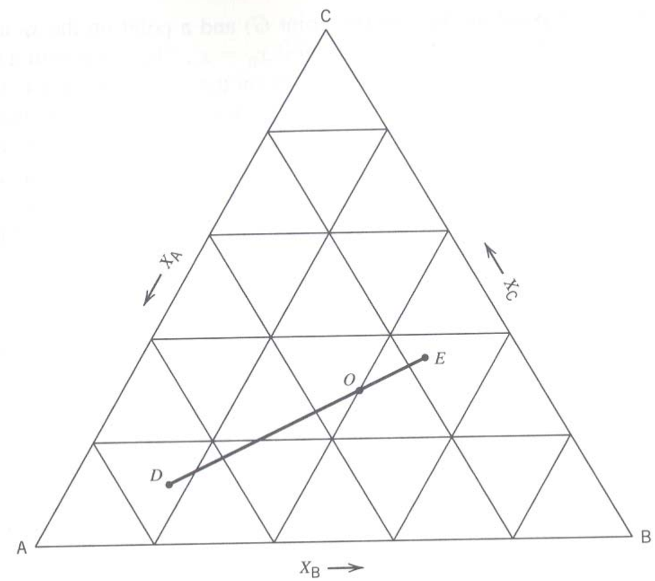


Figure 9.20 Example of the Gibbs triangle.

Ternary Diagrams

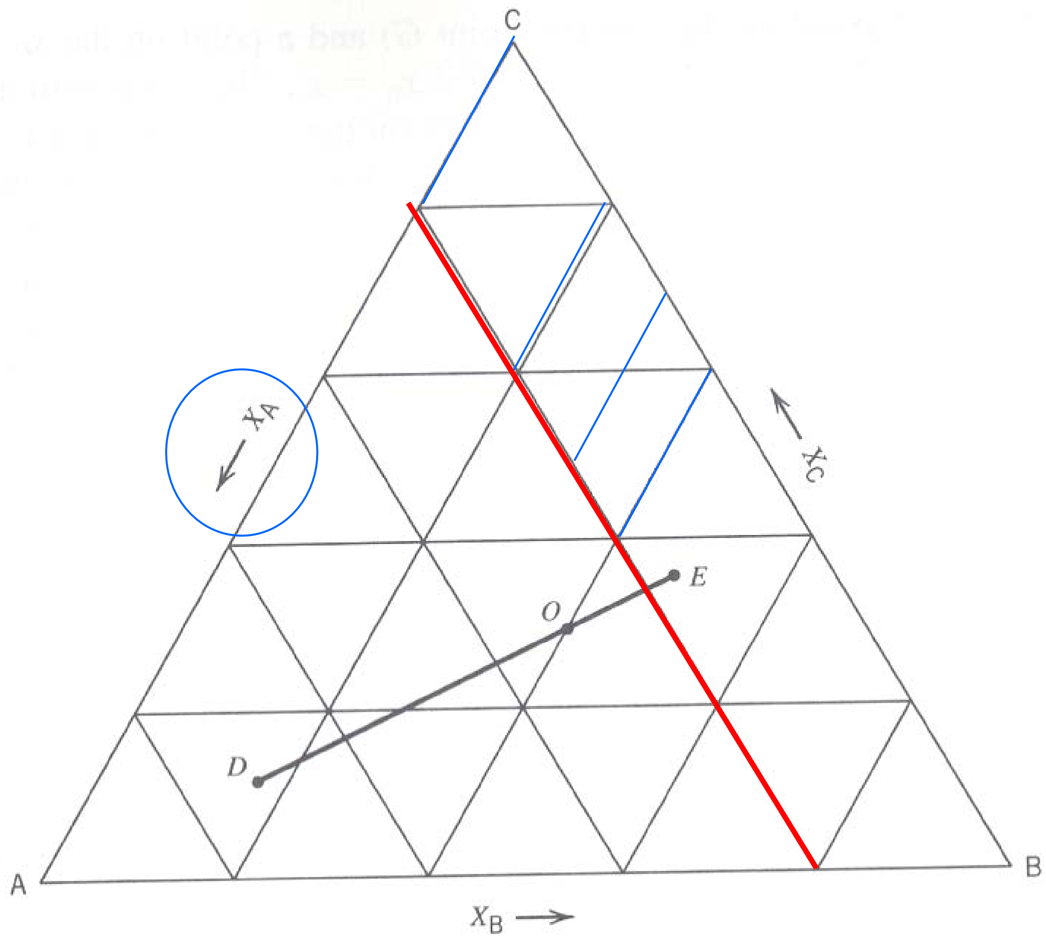


Figure 9.20 Example of the Gibbs triangle.

底线平行线

$$x_A = constant$$

Ternary Diagrams

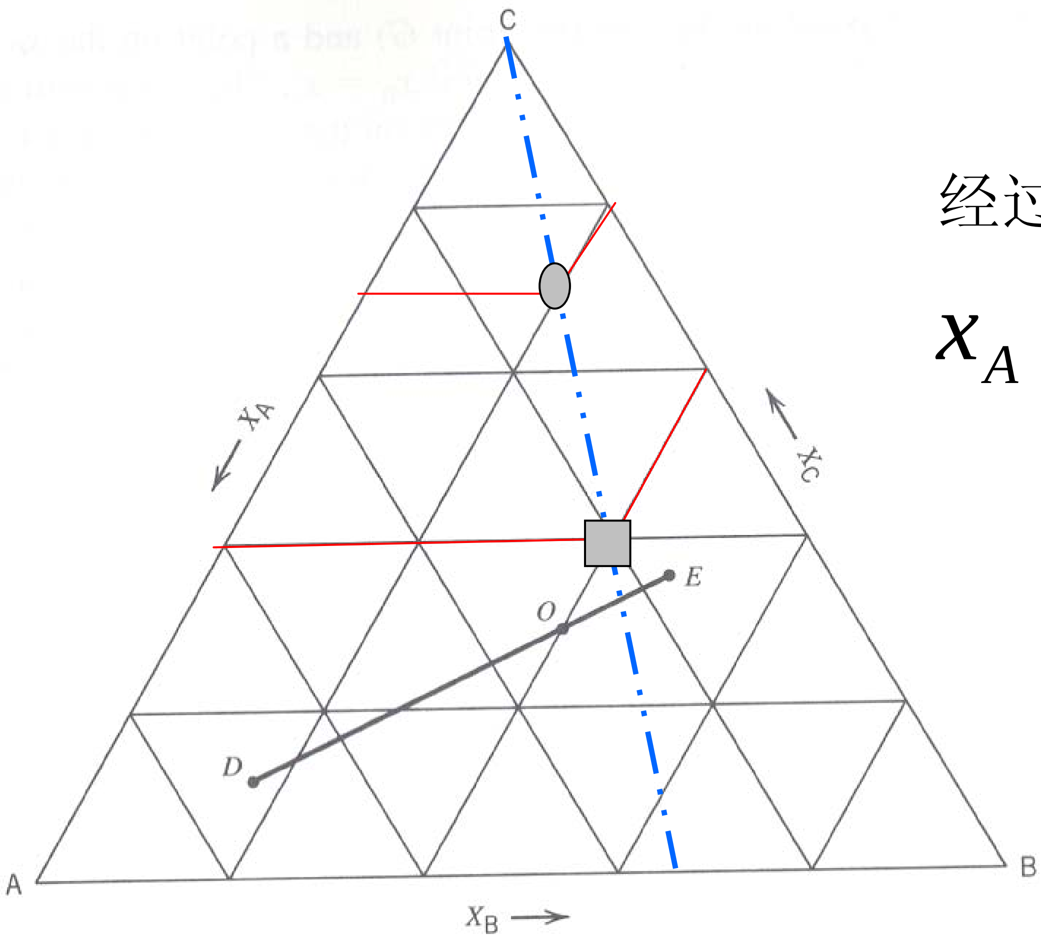


Figure 9.20 Example of the Gibbs triangle.

经过某一顶点c的线

$$x_A / x_B = constant$$

Ternary Diagrams

In an isothermal section

Three-phase field may exist: no degrees of freedom, and the composition of those phases will be fixed

$$F = C - P + 1$$

$$F = C - P$$

$$x_A = F_\alpha x_{A,\alpha} + F_\beta x_{A,\beta} + F_\gamma x_{A,\gamma}$$

$$x_B = F_\alpha x_{B,\alpha} + F_\beta x_{B,\beta} + F_\gamma x_{B,\gamma}$$

$$x_C = F_\alpha x_{C,\alpha} + F_\beta x_{C,\beta} + F_\gamma x_{C,\gamma}$$

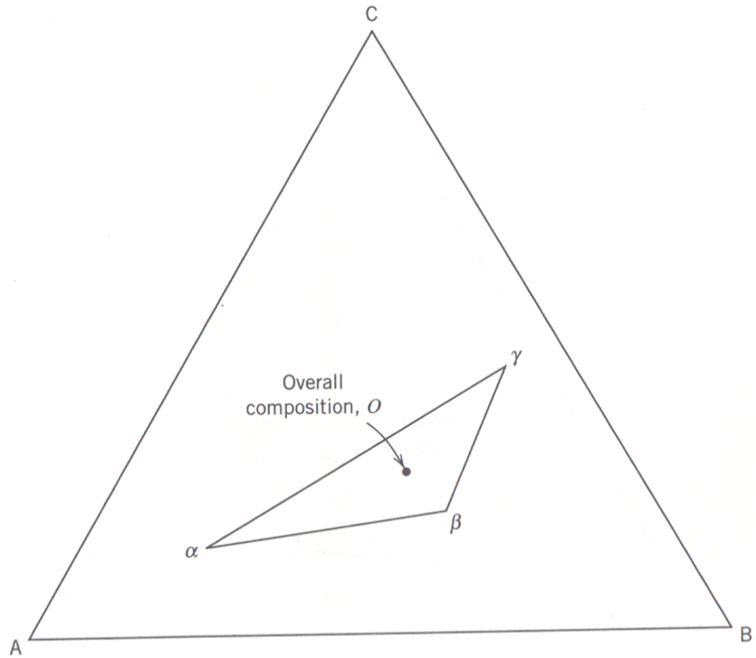


Figure 9.21 Three-phase equilibrium.

Ternary Diagrams

Lever rule

$$F_{\gamma} = \frac{O - \gamma'}{\gamma' - \gamma}$$

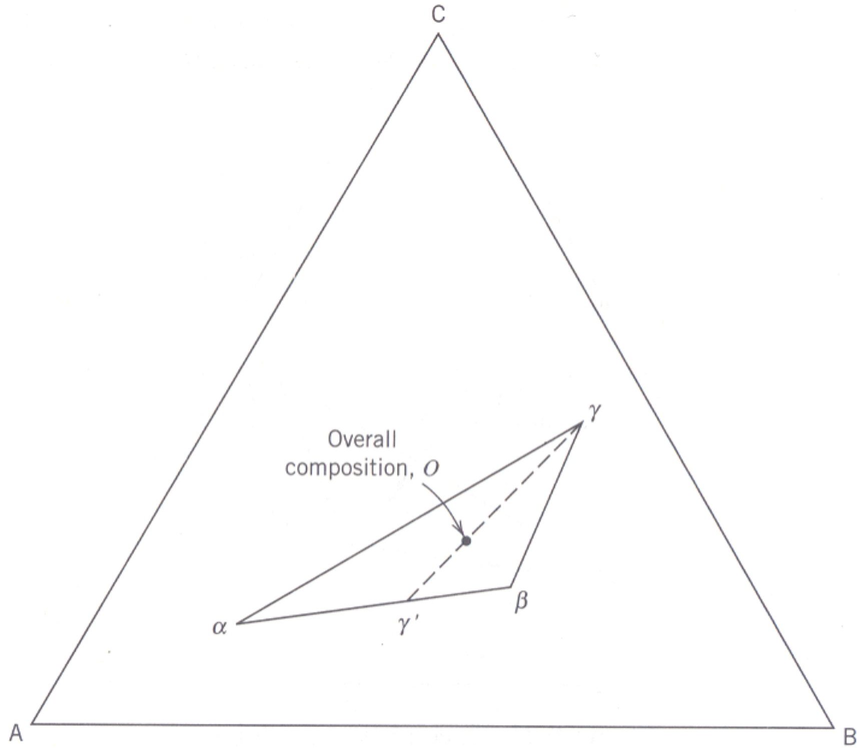


Figure 9.22 The lever rule.

Ternary Diagrams

Three components is completely miscible in the others in both solid and liquid states

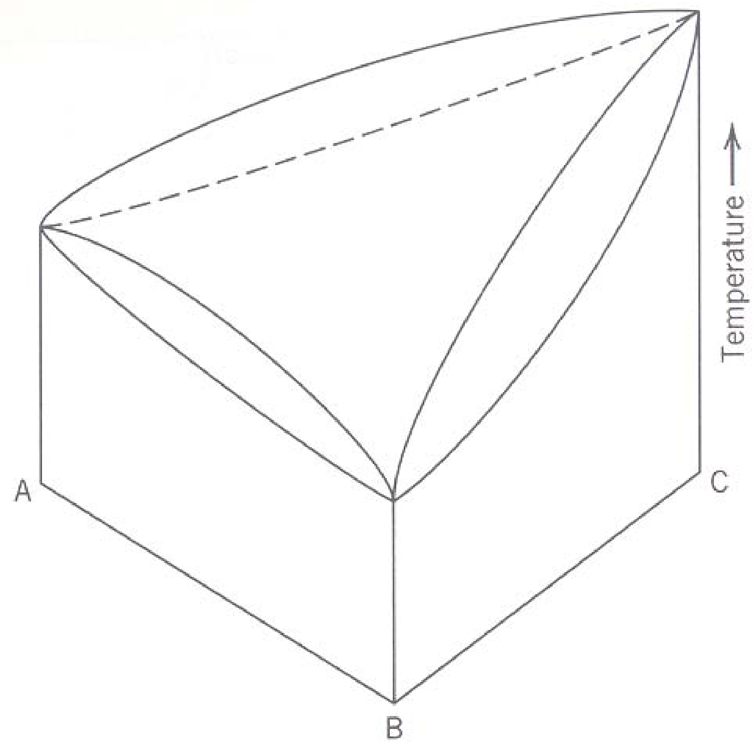


Figure 9.23 A completely miscible system.

Ternary Diagrams

Tie-lines: join the compositions of the solid and liquid that are in equilibrium

单元

双元：等温线

三元：结线

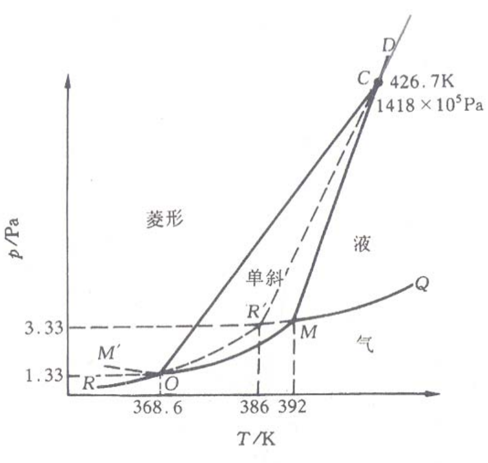


图 6-4　硫系相图

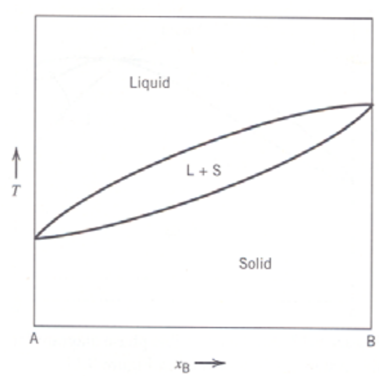
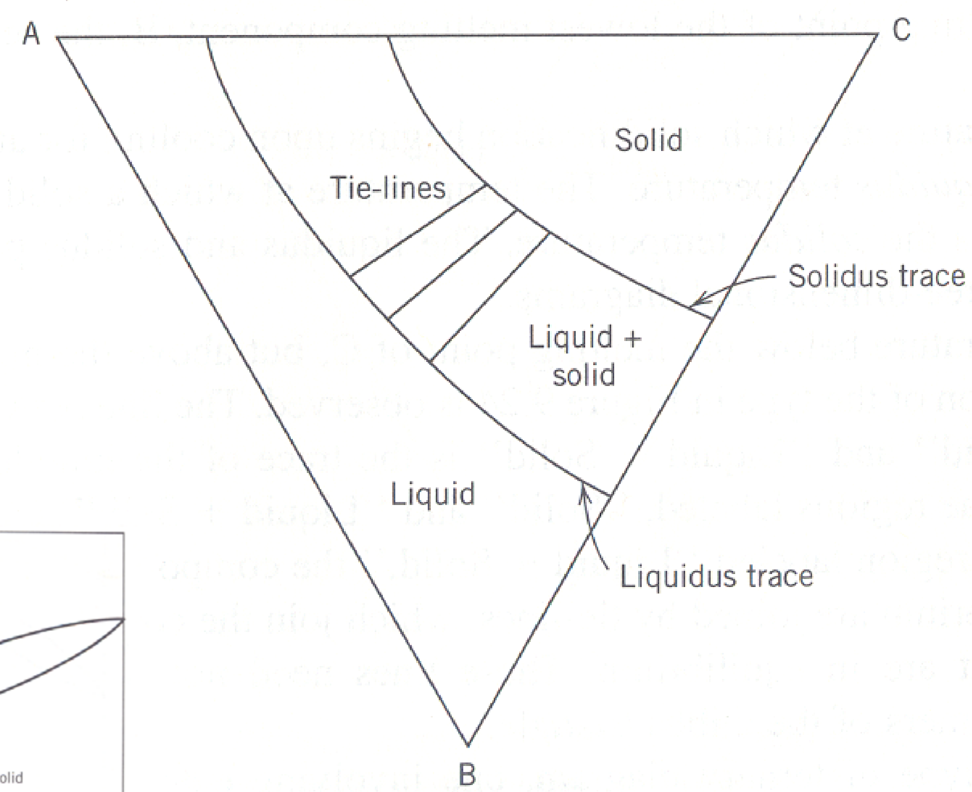


Figure 9.10 Phase diagram for a system A–B: ideal solutions, solid and liquid.



e 9.24 Isothermal section of Figure 9.23.

Ternary Diagrams

Tie-lines: *join the compositions of the solid and*

单元

双元：等温线

三元：结线

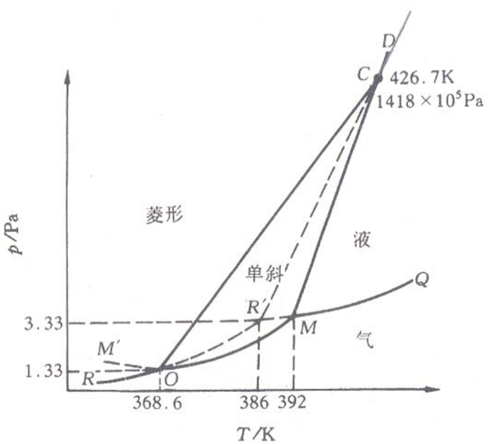


图 6-4 硫系相图

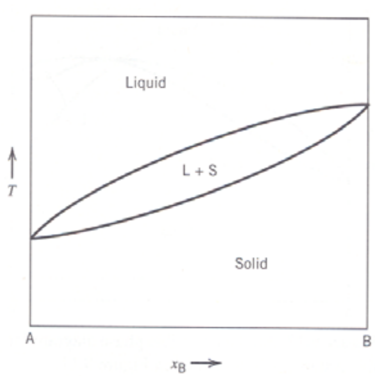
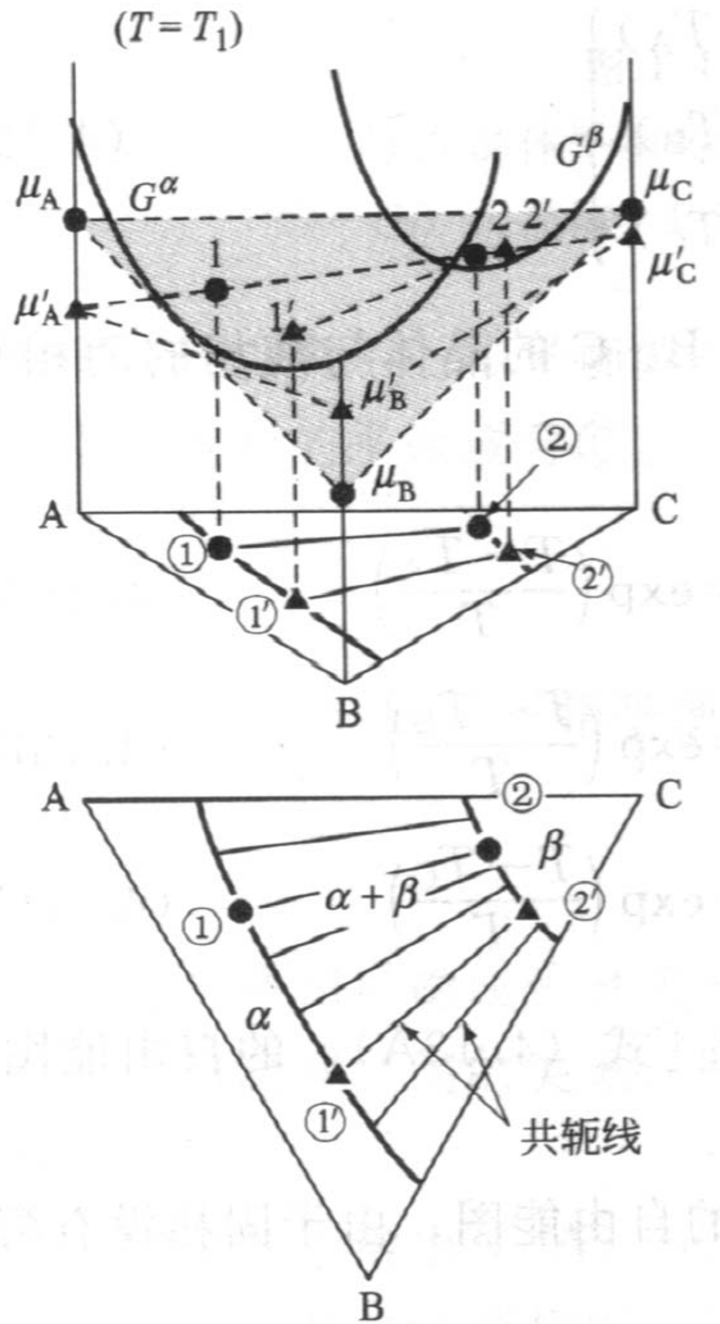


Figure 9.10 Phase diagram for a system A–B: ideal solutions, solid and liquid.



(a) α / β 两相平衡

Ternary Diagrams

Ternary eutectic phase dia

固态不溶

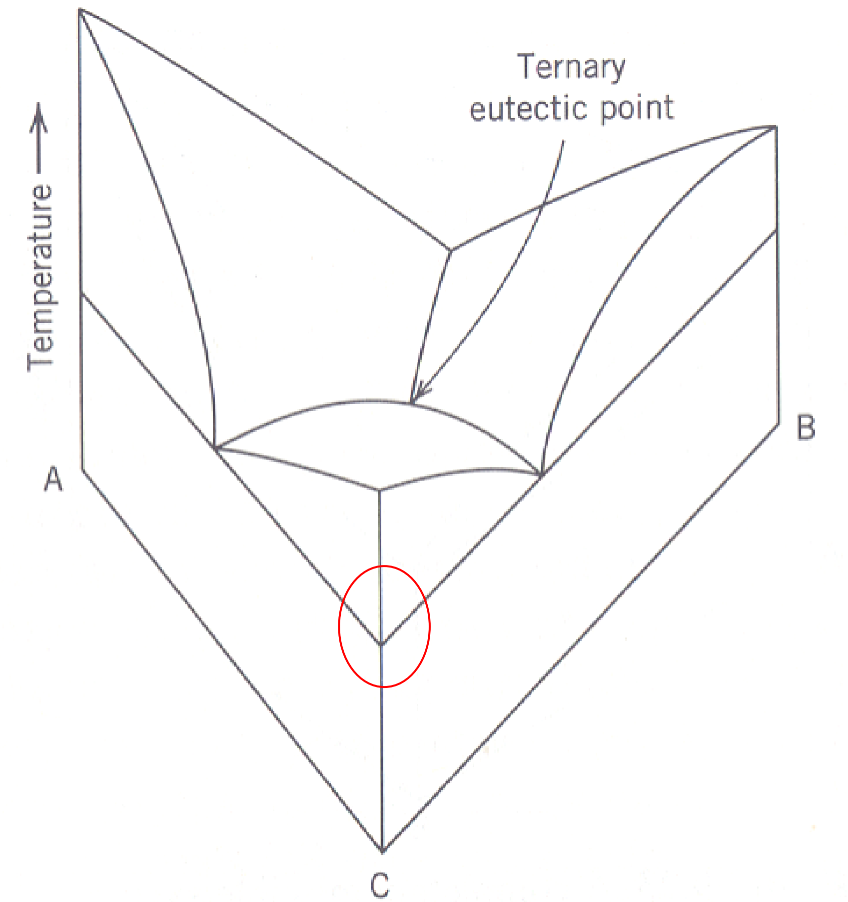


Figure 9.25 Ternary diagram for a eutectic system with no solid solubility.

Ternary Diagrams

Solidification path of material

A projection of the liquidus surface

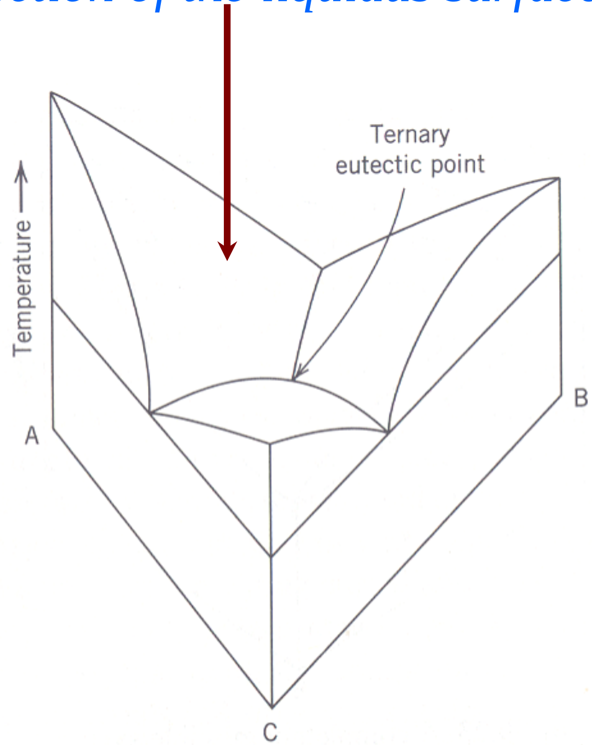


Figure 9.25 Ternary diagram for a eutectic system with no solid solubility.

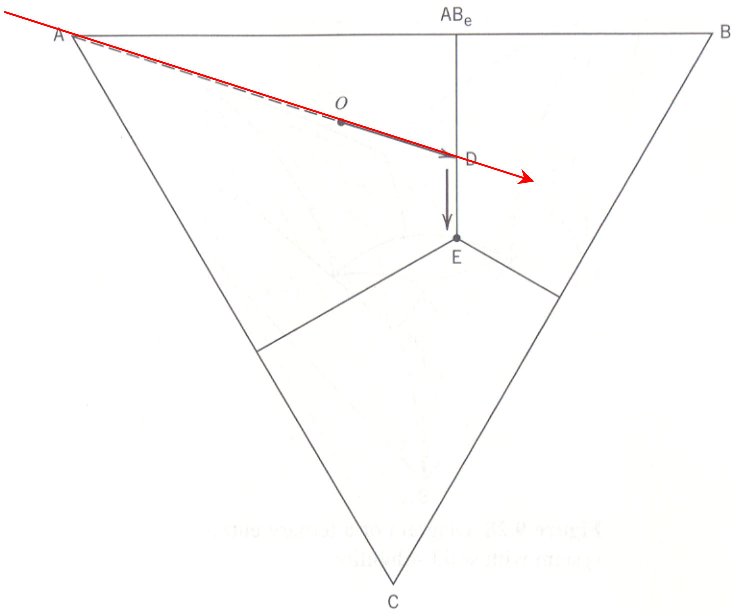


Figure 9.26 Solidification path of material from Figure 9.25.

Ternary Diagrams

Isothermal section of a ternary system
Phase diagram rule

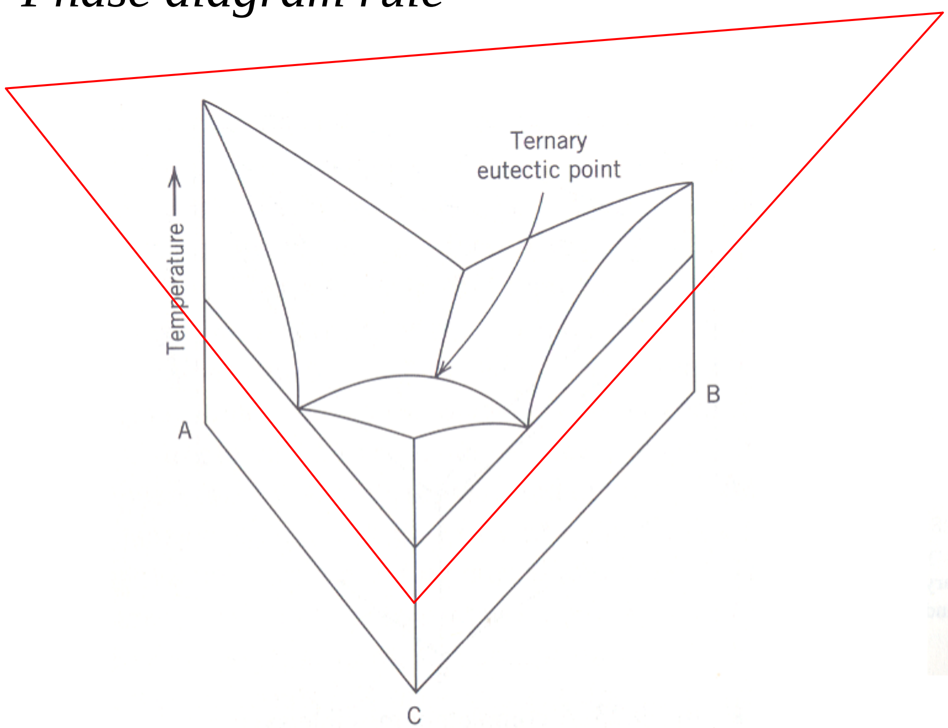


Figure 9.25 Ternary diagram for a eutectic system with no solid solubility.

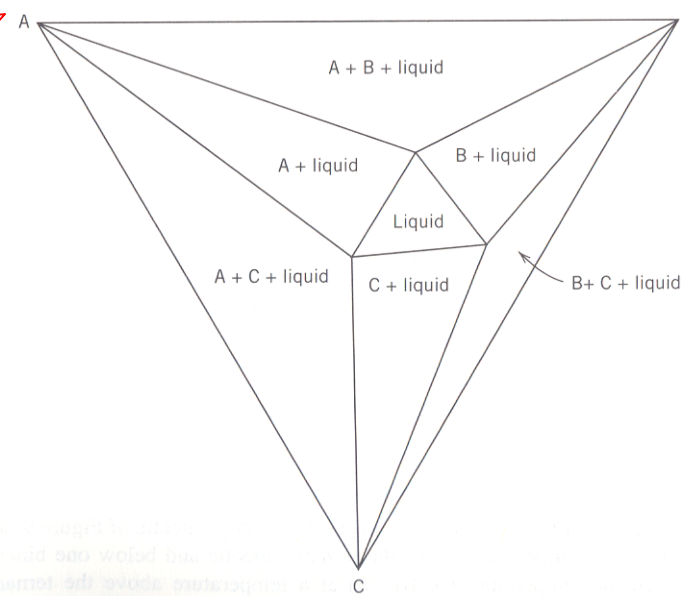
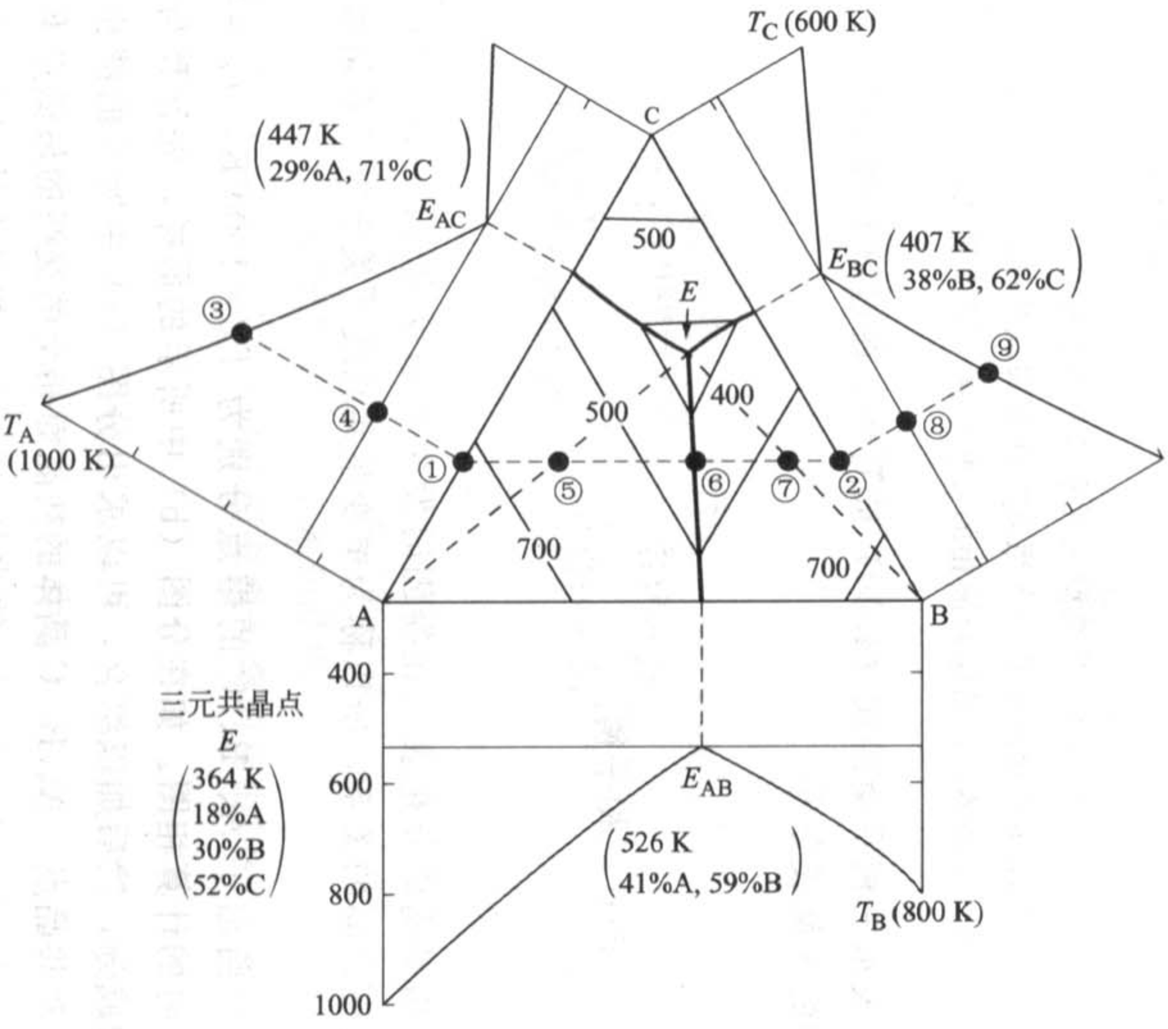
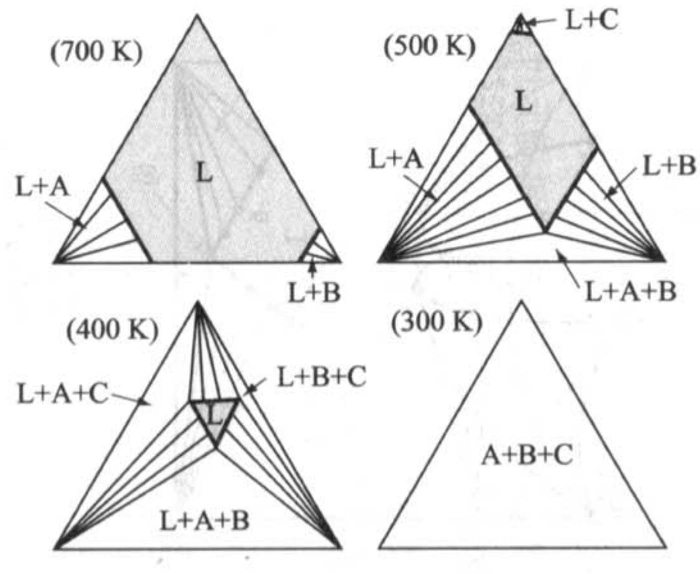


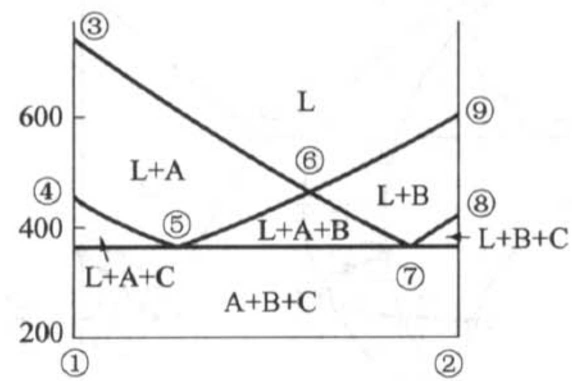
Figure 9.27 Isothermal section of a ternary system (Figure 9.25) at a temperature above the ternary eutectic temperature, but below binary eutectic temperatures.



(a) 初晶面的投影图



(b) 等温截面图



(c) 垂直截面图(30%C)

Ternary Diagrams

A ternary eutectic system with solid solubility

固态部分溶解

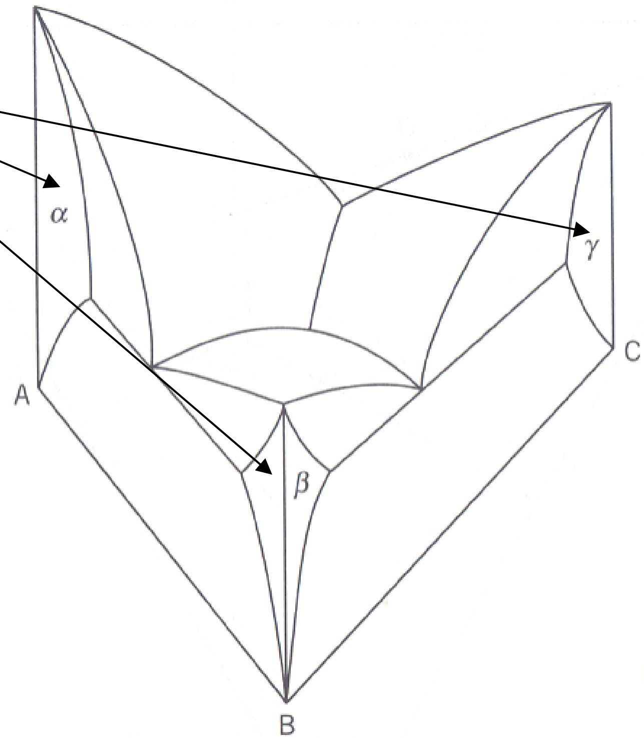


Figure 9.28 Diagram of a ternary eutectic system with solid solubility.

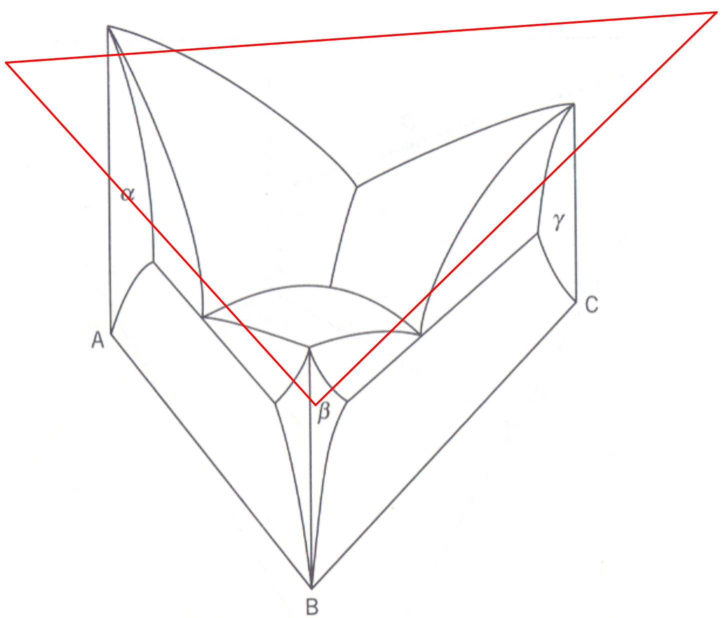
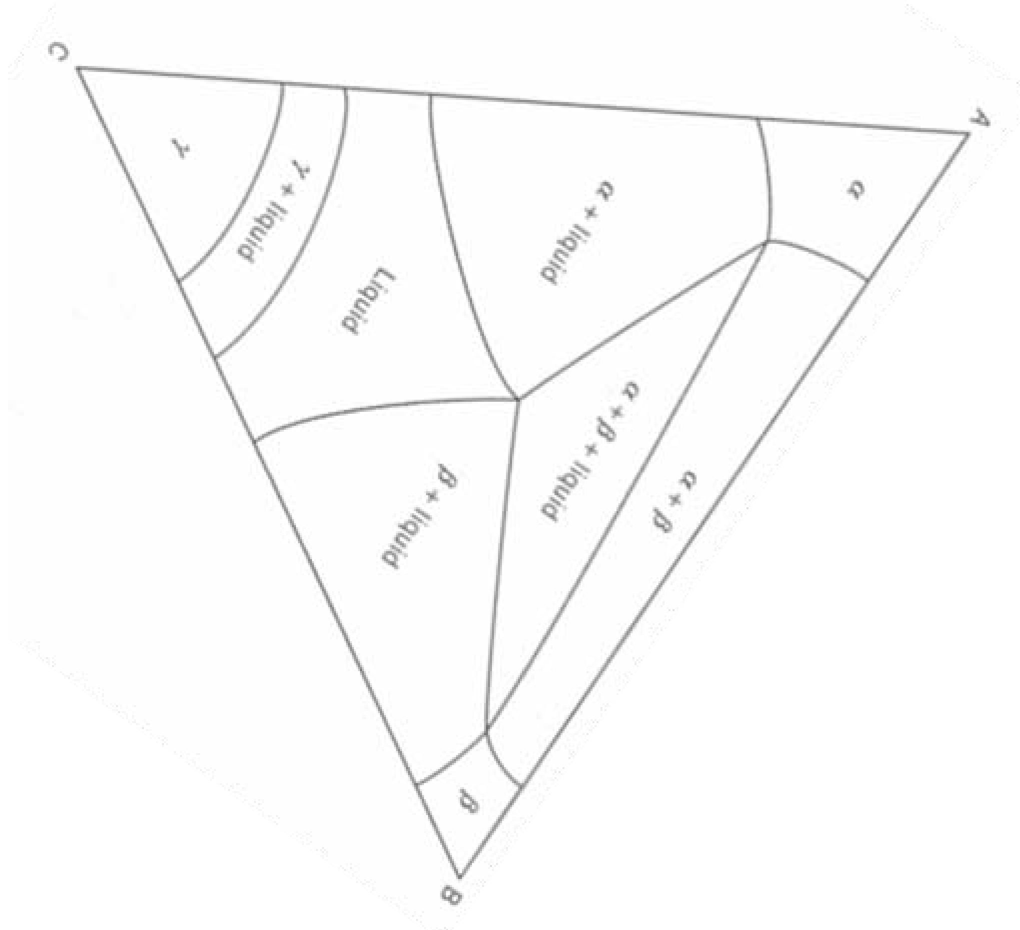
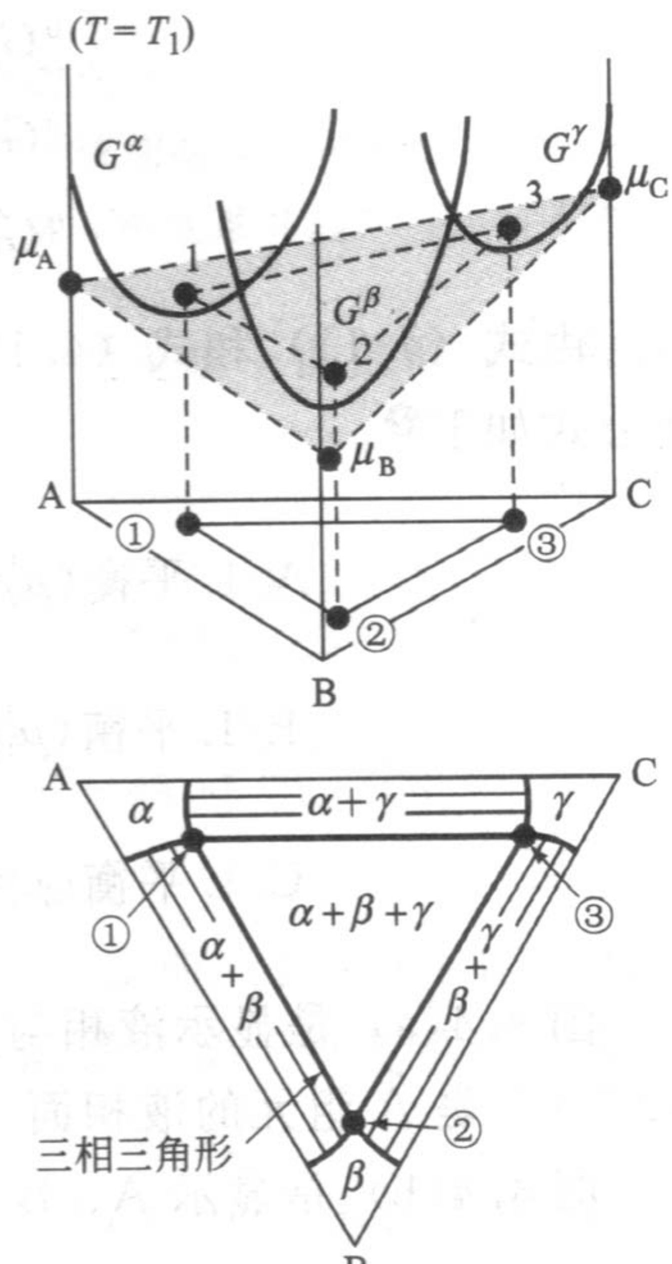
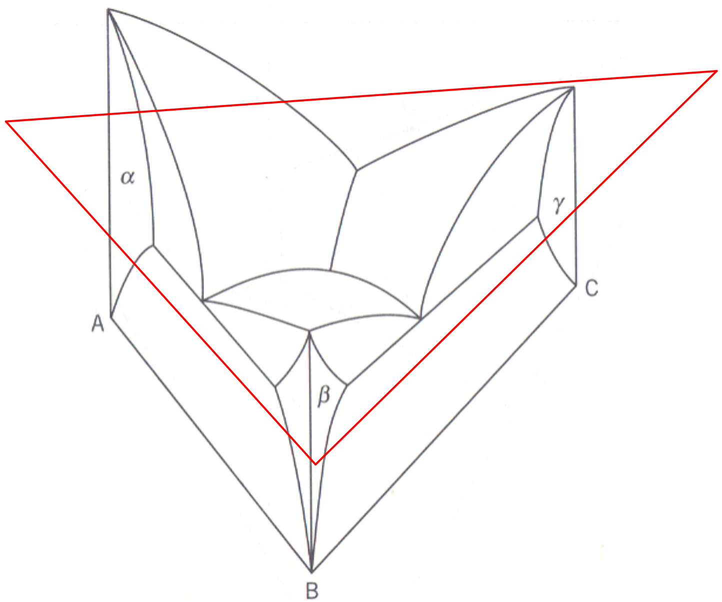


Figure 9.28 Diagram of a ternary eutectic system with solid solubility.





(b) $\alpha/\beta/\gamma$ 三相平衡



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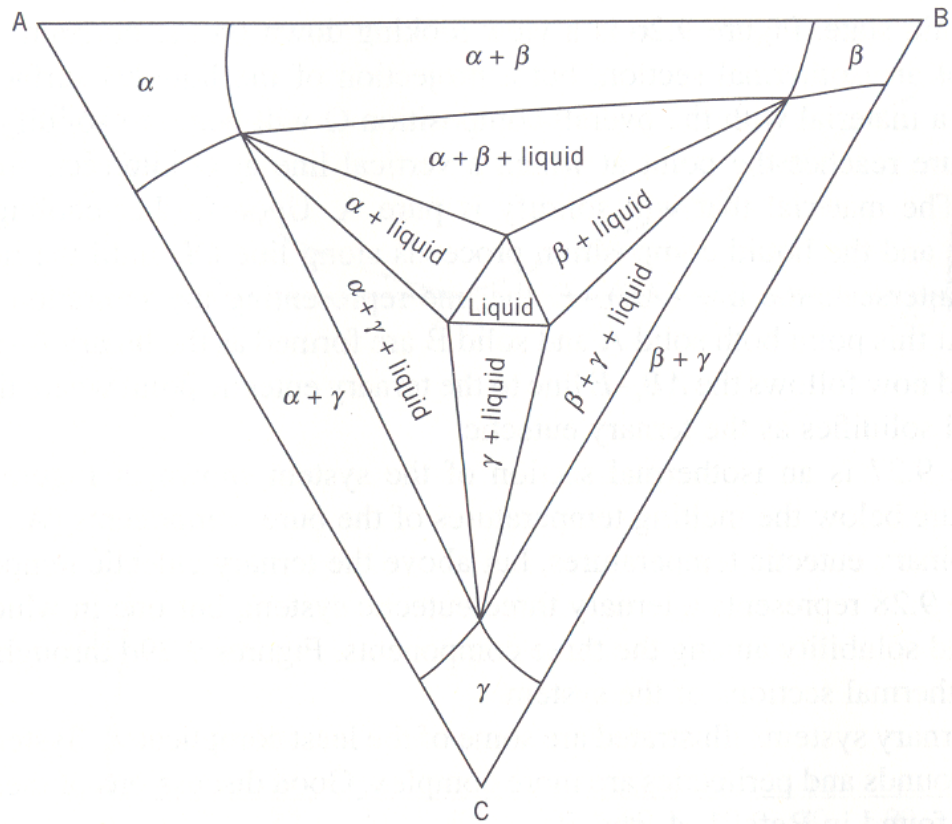

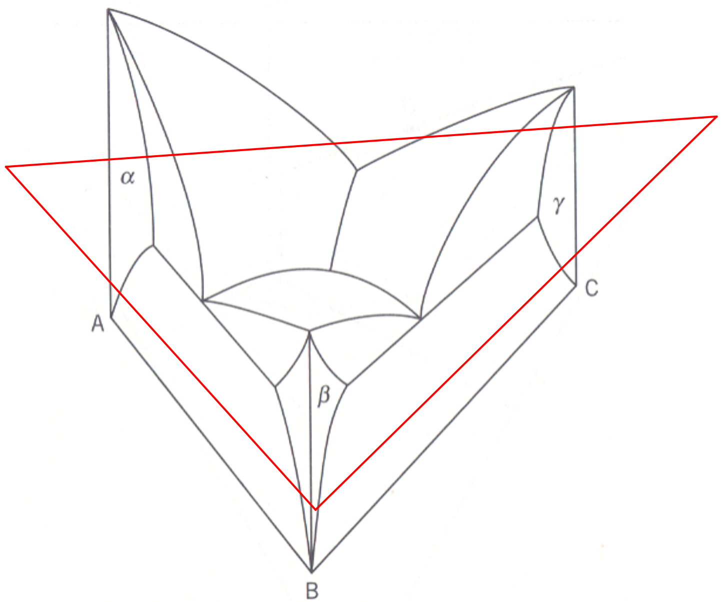

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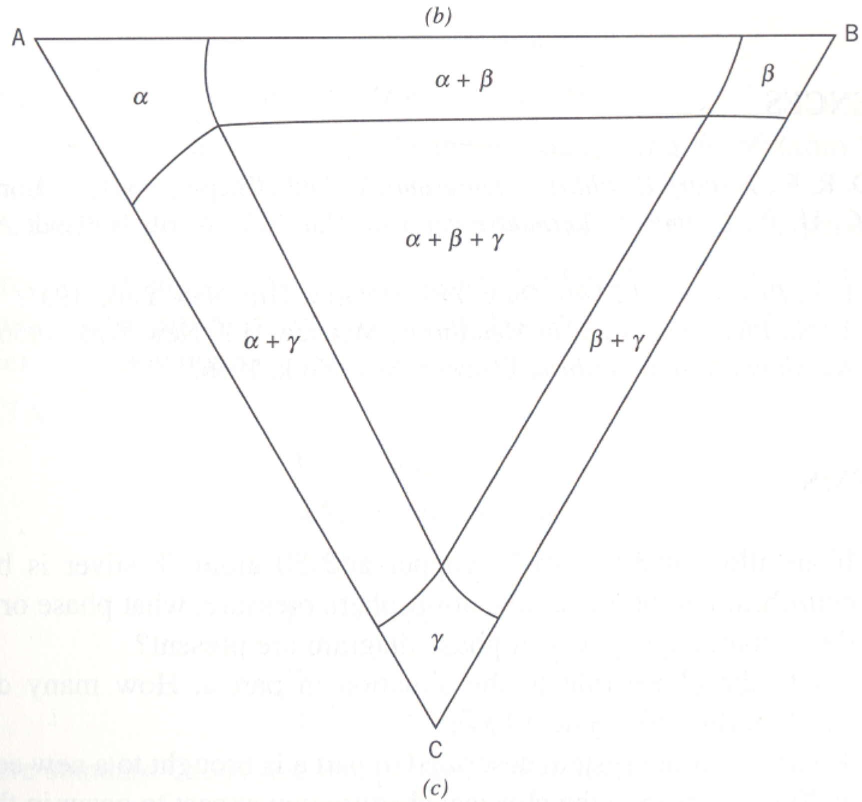

Figure 9.29 (continued)

Review of Today

- 二元相图构成的规则
- 相图测定
- 相图应用
- 二元例题
- Ternary diagrams

Homework

- Exercises in Chap 6

  P 240, 9.10, 9.15, 9,18