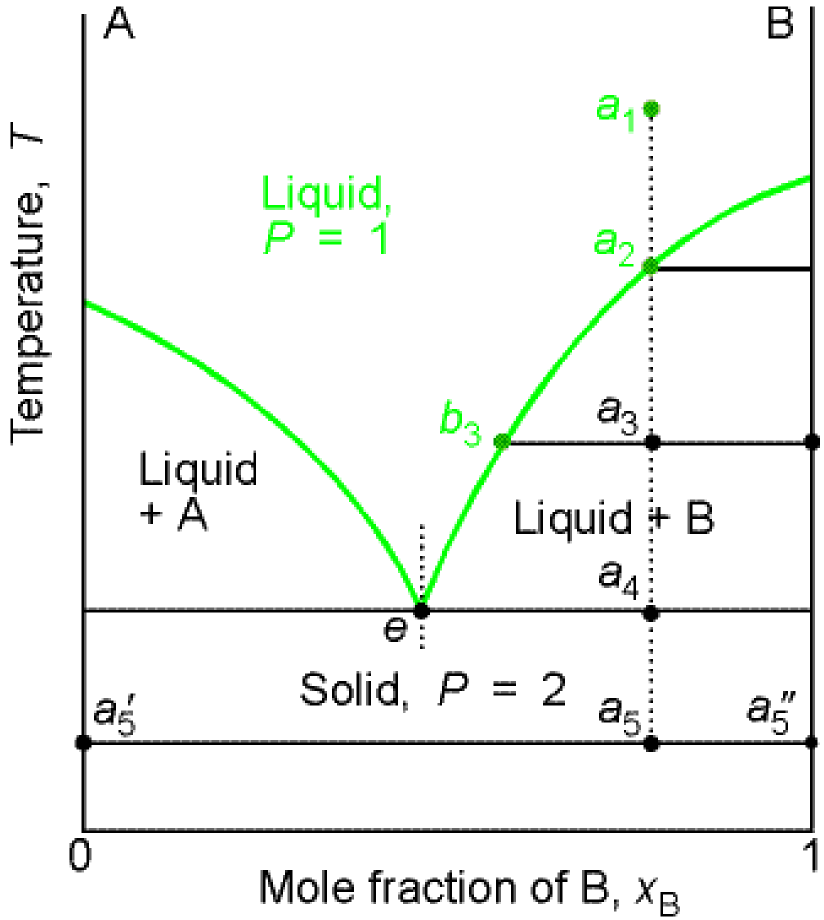
Liquid-Solid Phase Diagrams

Solid and liquid phases can be present below the boiling point (e.g., immiscible pair of metals right up to their melting points (As and Bi)



2-component liquid at temperature a_1:

(1) $a_1 \rightarrow a_2$ System enters "Liquid+B" pure solid B comes out of solution, remaining liquid richer in A

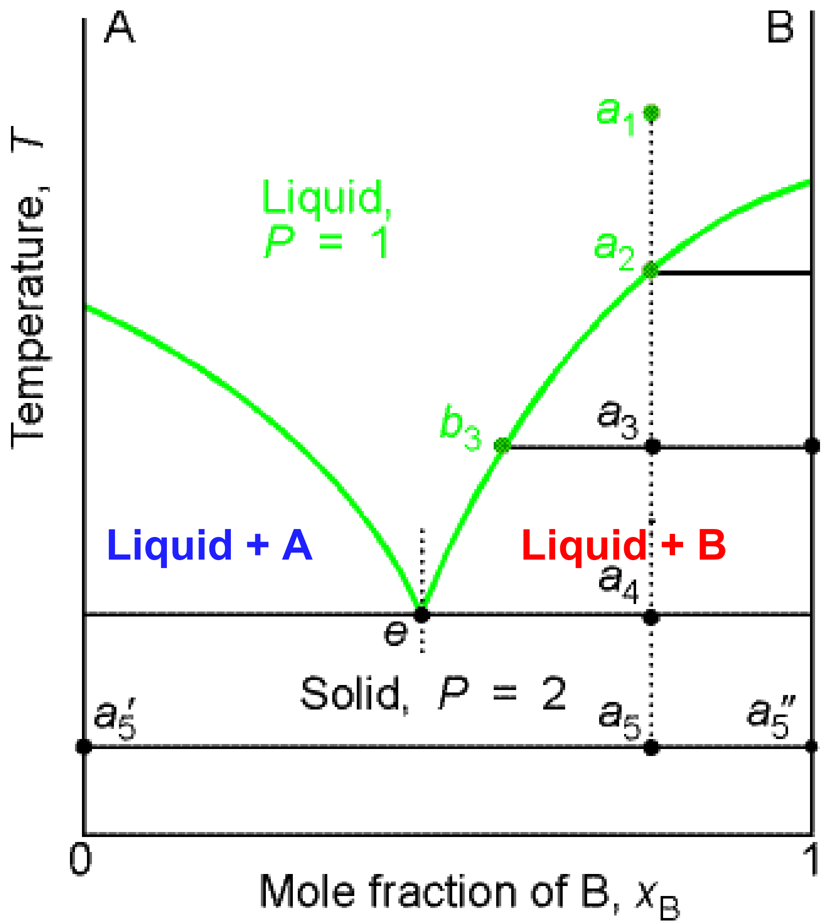
(2) $a_2 \rightarrow a_3$ More solid B forms, equal amounts from lever rule, liquid even richer in A

(3) $a_3 \rightarrow a_4$ Less liquid than at a_3, composition given by e, liquid now freezes into a two component system of A and B

Composition at e is known as the **eutectic composition** (*easily melted*), and the horizontal line at e is known as T_e, the **eutectic temperature**.

Eutectics

Liquid with **eutectic composition** freezes at a single temperature, T_e, without depositing A or B in advance of the freezing point
Solid with eutectic composition melts, without any composition change, at the lowest temperature of any mixture



Solutions to the **left of *e* deposit A as they cool**.

Solutions to the **right of *e* deposit B as they cool**.

Only the eutectic solidifies at a single temperature ($F' = 0$ when $C = 2$ and $P = 3$), no other components unloaded

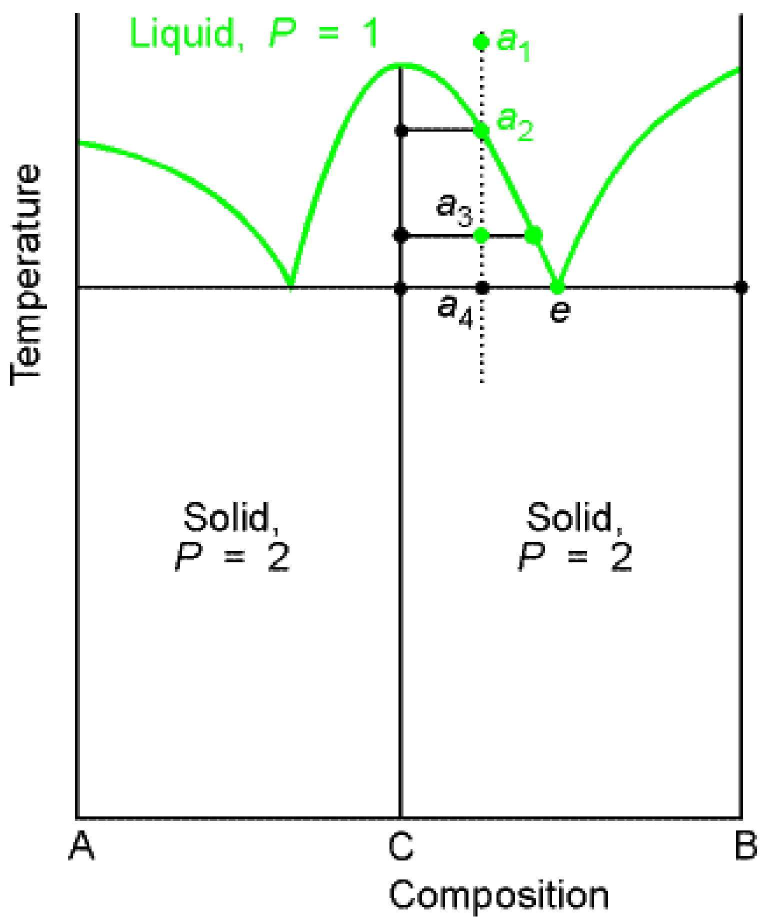
Examples:

- **Solder**, 67% tin and 33% lead, m.p. 183°C
- **23% NaCl, 77% H_2O** m.p. -21.1°C; salt added to ice on a road (isothermal) mixture melts at $T > -21.1$°C

Reacting Systems

Many binary systems react to produce different compounds - one important example is the formation of GaAs (gallium arsenide) which is very important for the **manufacturing of III/V semiconductors**:

$$\text{Ga} + \text{As} \rightleftarrows \text{GaAs}$$



System prepared with A (i.e., Ga) and excess of B (i.e., As) consists of C (i.e., GaAs) and unreacted B (i.e., As).

The binary B,C system forms a eutectic

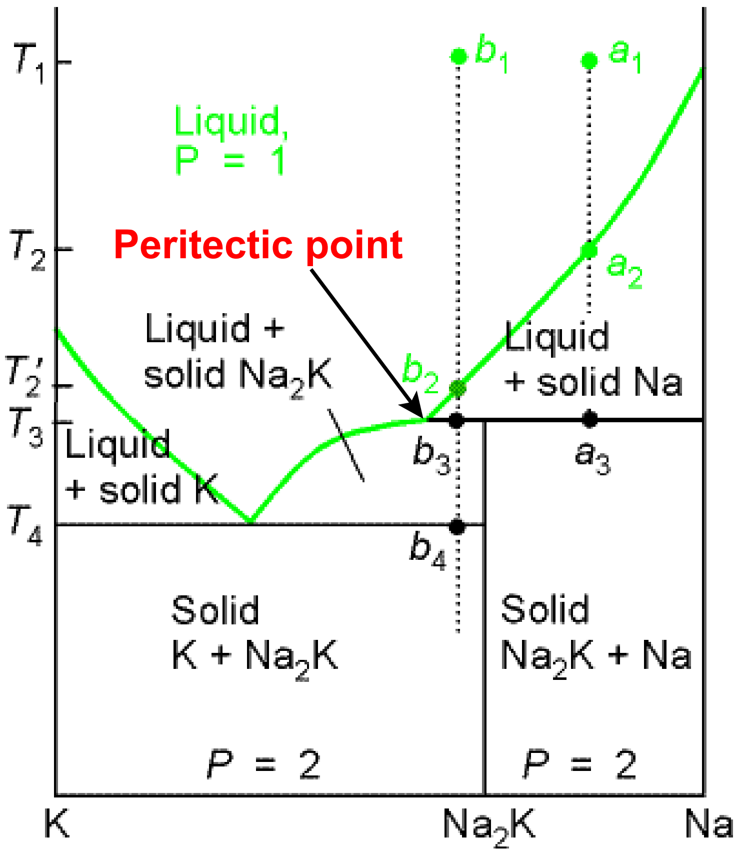
The important part of the phase diagram are the compositions of equal amounts of A and B ($x = 0.5$), pure A and pure B

Solid deposited along the cooling isopleth *"a"* is compound C

Below a_4 there are two solid phases, with some C and some B

Incongruent Melting

Sometimes component C is not stable as a liquid (e.g., alloy Na_2K)



(1) $a_1 \rightarrow a_2$ Some Na deposited, liquid richer in K

(2) $a_2 \rightarrow a_3$ Just below a_3, solid sample, with solid Na and solid Na_2K

(1) $b_1 \rightarrow b_2$ No change until Na begins to deposit at b_2

(2) $b_2 \rightarrow b_3$ Solid Na deposits, but reaction happens to make Na_2K (K atoms diffuse into solid Na)

Here, liquid Na/K in eqb. with Na_2K solid

(3) $b_3 \rightarrow b_4$ Amount of solid increases until b_4, liquid hits eutectic point, now two phase solid is formed

Incongruent melting: The temperature at which one solid phase transforms into another solid phase plus a liquid phase both of different chemical compositions than the original substance (i.e., the **peritectic temperature**, T_p).