Phase diagrams describe the melting and/or the evaporation of substances in dependence of the pressure and/or the temperature. In binary systems phase diagrams show the ranges of temperature (or pressure) and composition over which phases or mixtures of phases are stable. In phase diagrams of only one component, the pressure is plotted versus the temperature. In a two component system, the composition is plotted versus the pressure (mostly) at constant temperature or versus the temperature at constant pressure.

The Gibbs phase law $(F+P=C+2)$ describes the relation between the number of degrees of freedom ($F$; the number of variables of state that can be varied independently), the number of phases ($P$) and the number of components ($C$) that are in equilibrium with each other.

There are different kinds of binary phase diagrams. The most common ones are described below.

**System with complete range of solid solution:** (e.g. Bi-Sb). In the solid state, a solid solution exists over the whole composition range because Sb and Bi crystallize isotypic; both atoms can occupy the atomic positions in any proportion. In the area delimited between the liquid solution and the solid solution delimited respectively by the liquidus curve and by the solidus curve, the liquid and the solid coexist. In this area, the cooled down liquid and the solid being in equilibrium with each other have different compositions. There are also phase diagrams showing a thermal minimum or maximum of the solidus and liquidus curve. At this point, the solid and the liquid being in equilibrium with each other have the same composition.

**Eutectic system without partial solid solubility:** (e.g. Al-Si). Such systems show miscibility in the liquid state, but no range of solid solution. The acute minimum in the liquidus curve is called eutectic point (no degrees of freedom); it shows the lowest melting temperature of the mixture (eutectic composition). Below the line passing the eutectic point (eutectic line) the components coexist as solids in two phases and form small crystals of the pure components. A cooled down mixture of A and B reaching the liquidus curve of A impoverish of A because this component will precipitate and the composition of the melt will become richer in B. At the eutectic point the remaining solution will solidify at the given composition.

**Eutectic system with partial solid solubility:** (e.g. Cu-Ag; In-Cd). In contrast to the above mentioned system one observes a small solubility of component A in B and vice versa. Limited formation of mixed crystals occurs when the two components have different structures or when both pure components have the same structure, but the mixed crystals may not have a random composition. There are mixed crystals containing much Cu and little Ag (solid solution I) and vice versa (solid solution II). At intermediate compositions a miscibility gap is observed because there are no homogeneous mixed crystals, only a solid mixture of the solid solutions I and II. At the eutectic point no uniform mixed crystals with the same composition, but a solid consisting of the solid solution from the left and right end part of the gap will be formed.

**Binary systems with compound formation:** (e.g. Mg-Ca). The phase diagram of two components forming a congruent melting (definite melting temperature; direct change from solid to liquid of the same composition) compound can be regarded as two simple eutectic systems combined by a common y-axis. The melting point of the compound presents a maximum in the liquidus curve.
Incongruent melting compounds dissociate at the melting point into a solid and a liquid of different compositions. No maximum is observed, only a kink in the liquidus curve (peritectic point→ no degrees of freedom); (e.g. H₂O-HF-phase diagram)

**Literature:**
Anthony R. West: Basic Solid State Chemistry; second edition
Ulrich Müller: Inorganic Structural Chemistry; second edition
Holleman-Wiberg: Inorganic Chemistry; 34th edition

**Questions:**
1. Sketch an eutectic phase diagram with a partial solid solubility and explain the different areas, curves and points!
2. Sketch a binary phase diagram with the formation of an incongruent melting compound and explain the different areas, curves and points! Explain the difference between a congruent and an incongruent melting compound!