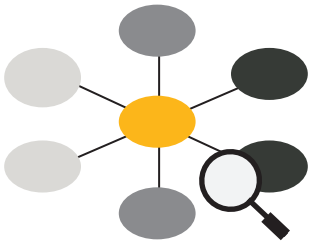
GRANTA EduPack Concept Map Answers

Phase Diagrams



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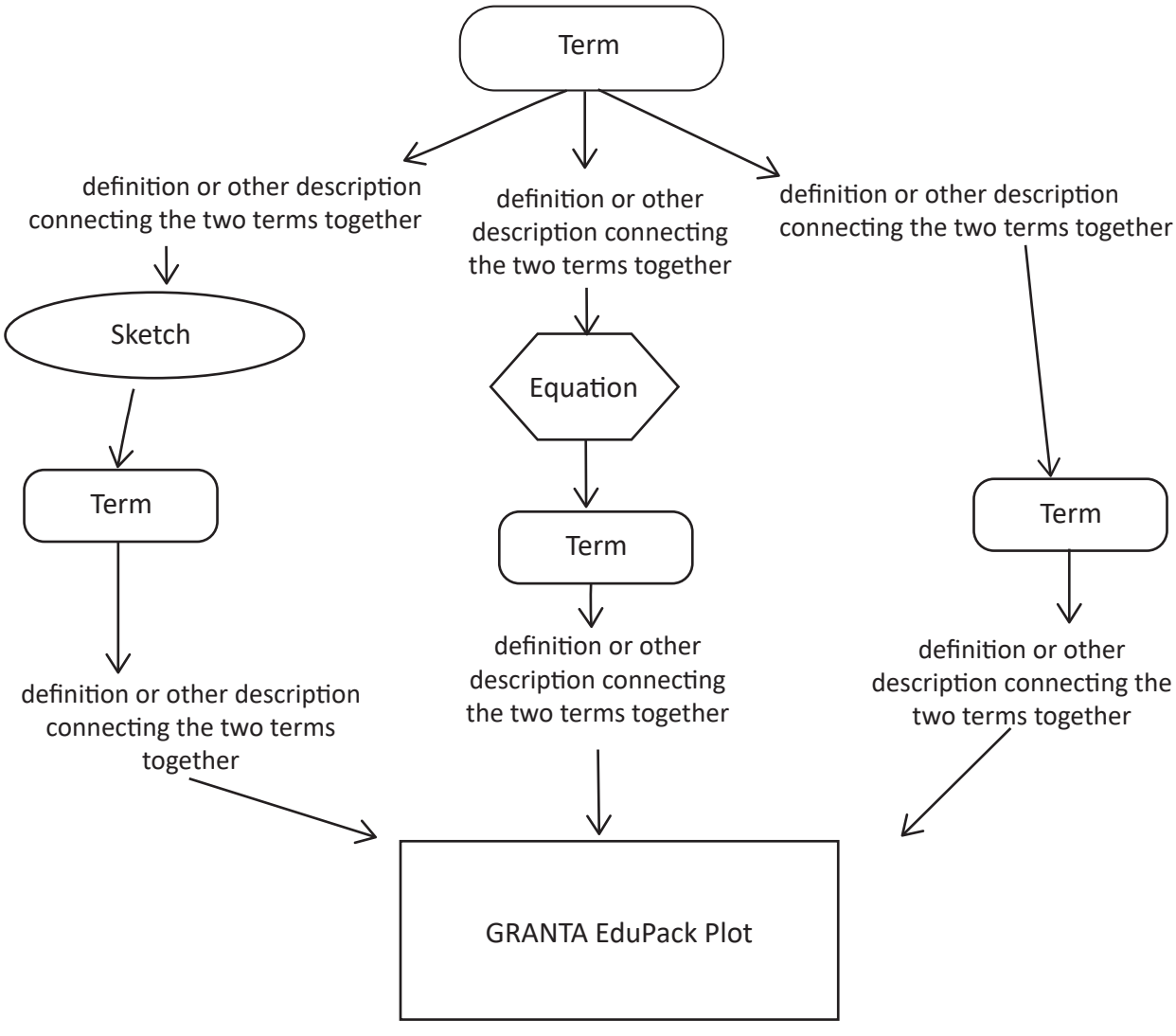
The goal of this activity is to help students understand the connections between key materials terminology. A concept map can help by giving students a way to visualize these connections. By providing a focused set of terms, definitions, sketches, equations, and plots, a map can be drawn with a specific topic area in mind. For this activity, the concept maps focus on Phase Diagrams. Lists can be adjusted based on course content. Results of student-drawn concept maps can provide insight into their understanding of these fundamental concepts, possibly highlighting areas of confusion.

Each topic set has a list of suggested list of terms, schematics, equations, or associated GRANTA EduPack plots. Students connect the items from the list together with definitions based on their personal understanding from lectures, course notes, textbooks, and more. Definitions or descriptions of how the terms connect as well as arrows showing the flow of logic used by the students are encouraged, as shown in the example below.

Example maps are included within this document. A prompts-only document can also be found in this package. Note: there is no one correct way to draw these maps. The examples are here for inspiration.



Example Use Cases:
- Solo activity with detailed instructor feedback
- In-pairs or groups to be shared and discussed in class
- Solo activity, then swap maps to provide peer review
- Solo activity drawing one map, then reversing the flow of logic and adjusting descriptions to match

References.
1. Callister, W.D., & Rethwisch, D. G. (2018). Materials science and engineering: an introduction (10th ed.). Wiley.
2. Porter, D.A., Easterling, K.E., & Sherif, M. (2009). Phase Transformations in Metals and Alloys, (Revised Reprint). CRC press.
3. Abbaschian, R., & Reed-Hill, R.E. (2008). Physical metallurgy principles. Cengage Learning.
4. GRANTA EduPack Software, Materials Science & Engineering Database, 2020

This resource is part of the Ansys Granta Phase Diagram teaching package. The goal of this package is to provide a set of resources around introducing phase diagrams in the classroom. These resources were designed to be used separately or together, depending on the needs of the class and/or curriculum. Currently, the package contains the following resources:

- PowerPoint Lecture
- Student Note Sheet
- Exercise bank
- Quiz Question bank in Word, GIFT, and Blackboard LMS format
- Three MicroProjects
- Three concept map prompts

Note: the exercises, quiz questions, MicroProjects, and concept maps all contain a "student-friendly" version for use in the classroom and a solution manual.
These resources easily integrate with the MS&E database from GRANTA EduPack and use many figures and definitions from said software. Our hope is this package, combined with GRANTA EduPack, supports teaching phase diagrams across a wide range of courses.

Topic: Phase Diagram Terminology

Terms:

- Phase Diagram
- Component
- Phase
- Isomorphous
- Binary Eutectic
- Liquidus Line
- Solidus Line
- Solubility Limit
- Solvus Line
- Eutectic Point

Sketches/GRANTA EduPack Diagrams:

- Isomorphous phase diagram
- Binary eutectic phase diagram

Phase Diagram Terminology Concept Map Example

Pure metals and/or compounds of which an alloy is composed

Information about the control of the phase structure of a particular system with respect to temperature, pressure, and composition

homogeneous portion of a system that has uniform physical and chemical characteristics

Component

Phase Diagram

Phase

Isomorphous

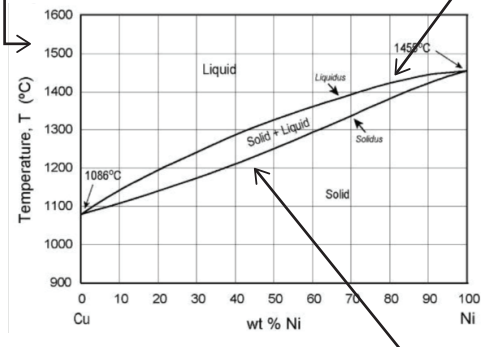
Binary Eutectic

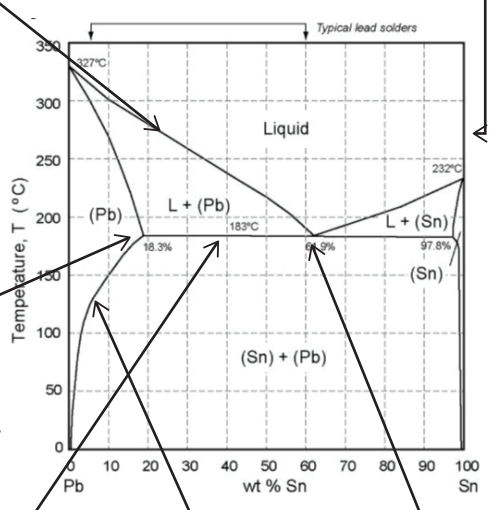
Complete liquid and solid solubility of the two components

Incomplete solid solubility of the two components leading to a eutectic reaction

Liquidus Line

Only liquid phase is present at all temperatures and compositions above this line.





Solubility Limit

Maximum concentration of solute atoms that may dissolve in the solvent to form a solid solution

Solidus Line

Only solid phase is present at all temperatures and compositions below this line.

Solvus Line

Solubility line between a single solid phase and a two solid phase region

Eutectic Point

Composition and temperature where a eutectic reaction takes place. Liquid directly transforms to two solid phases

Topic: Reaction Definitions, Equations, and Phase Diagram Appearance

Terms:

- Equilibrium Phase Transformations
- Transformation Name
    - Congruent
    - Eutectic
    - Eutectoid
    - Peritectic
    - Peritectoid

Sketches:

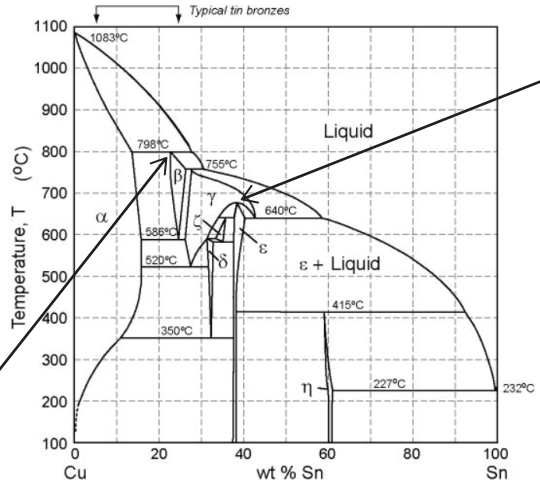
- Phase Diagram Appearance for:
    - Congruent
    - Eutectic
    - Eutectoid
    - Peritectic
    - Peritectoid

GRANTA EduPack Phase Diagram Example with labeled reaction of:

- Congruent
- Eutectic
- Eutectoid
- Peritectic
- Peritectoid

Reaction Definitions, Equations, and Phase Diagram Appearance
Concept Map Example

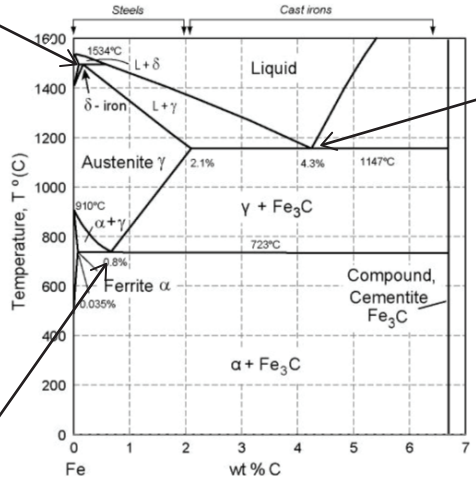
Equilibrium Phase Transformations → A change in the number and/or character of the phases that constitute the microstructure of an alloy in equilibrium



$\gamma \rightleftharpoons \varepsilon$ → Congruent → phase transformation with no compositional change

$L+\alpha \rightleftharpoons \beta$ → Peritectic → Upon cooling, a liquid and solid phase transform to a solid phase with a different composition

$L+\delta \rightleftharpoons \gamma$



$L \rightleftharpoons \gamma + Fe_3C$ → Eutectic → An isothermal transformation from a liquid to two intimately mixed solid phases

$\alpha \rightleftharpoons \beta + \gamma$ → Eutectoid → An isothermal transformation from a solid to two intimately mixed solid phases

Topic: Fe-C System

Terms:

- Steel
- Cast Iron
- Material structures formed at the eutectoid reaction
    - Pearlite
    - Bainite
    - Martensite
- Austenite
- Ferrite
- Cementite

Sketches/GRANTA EduPack Diagrams:

- Iron-Carbon Phase Diagram (7 wt%C or above)

Fe-C System Concept Map Example

A ferrous alloy with carbon content less than 2 wt%C

Steel

Cast Iron

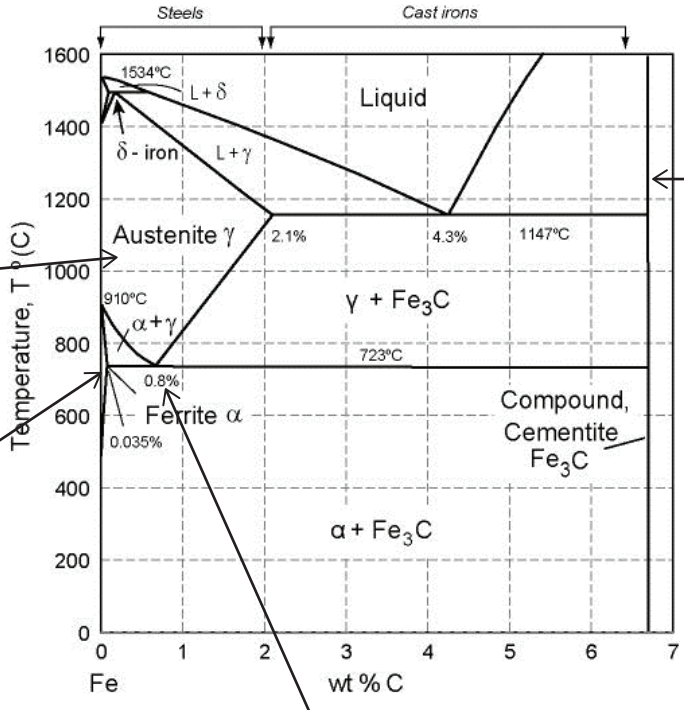
A ferrous alloy with carbon content greater than 2 wt% Carbon. Generally contains 3-4.5wt%C and 1-3 wt% Silicon

Polymorphic form of pure iron which is stable from 912°C to 1394°C. FCC Crystal Structure

Austenite

Ferrite

Room temperature stable form of pure iron. BCC Crystal Structure



Cementite

Iron-Carbon intermetallic Fe_3C Composition: 6.7 wt%C

Eutectioid Transformations

Pearlite

Eutectoid microstructure formed via a diffusion transformation Consists of alternating layers of Ferrite and Cementite

Martensite

Non-equilibrium single-phase microstructure. Formed via a diffusionless transformation

Banite

Eutectoid microstructure formed via a diffusion transformation. Consists of either needles or platelets of cementite in a matrix of ferrite (depending on cooling rate)

Document Information
This exercise unit is part of a set of teaching resources to help introduce students to materials, processes and rational selections.

Accuracy
The author(s) try hard to make sure that these resources are of a high quality. If you have any suggestions for improvements, please contact the author(s) by email. You may also write to the Ansys Granta Education Team with your suggestions at granta-education-team@ansys.com.

Ansys Granta Education Hub
For more information on Ansys GRANTA EduPack software and related teaching resources, please visit https://www.ansys.com/products/materials/granta-edupack/

Teaching Resources Website
The Teaching Resources website aims to support teaching of materials-related courses in design, engineering and science. Resources come in various formats and are aimed primarily at undergraduate education. Visit grantadesign.com/education/teachingresources/ to learn more.

There are 350+ resources on the Ansys Granta Education Hub. The resources include:

- Lecture presentations with notes
- Case studies
- Exercises with worked solutions
- MicroProjects
- Recorded webinars
- White papers
- Solution manuals
- Interactive exercises

Some of the resources are open access and students can access them. Others are only available to educators using GRANTA EduPack.

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