

[Click here to visit website](#)

MATERIAL SCIENCE

BRANCH :- MECHANICAL ENGINEERING

These Given Notes are prepared By Diplomawallah

Visit :- Diploma wallah website for more content or contact to join our WhatsApp group :- 9508550281, 78570 59075

Unit 5 – Topic 2: Identify the Given Phase Diagram and Reactions with Justification

1. What is a Phase Diagram?

A phase diagram is a graphical representation of the physical states of a substance under different conditions of temperature, pressure, and composition. In materials science and metallurgy, the most commonly used phase diagrams are binary phase diagrams, which show the relationship between two elements or components.

2. Purpose of Phase Diagrams in Engineering:

Phase diagrams help us:

- Predict what phases will be present at a given temperature and composition.
- Determine critical temperatures for phase changes (solid to liquid, solid to solid, etc.).
- Design and optimize heat treatment processes like annealing, hardening, tempering.
- Control microstructures that directly affect the material's strength, hardness, ductility, and toughness.

3. Common Types of Binary Phase Diagrams in Metallurgy:

System	Purpose / Use
• Iron–Carbon (Fe–C)	Most important for steels and cast irons.
• Copper–Zinc (Cu–Zn)	Used in manufacturing of brass, decorative parts.
• Copper–Tin (Cu–Sn)	Used for bronze, bearings, marine parts.

- **Aluminum-Silicon (Al-Si)** Common in casting and lightweight applications.
- **Lead-Tin (Pb-Sn)** Used in soldering and joining operations.

4. Basic Concepts of Phase Diagrams

Phase:

A phase is a portion of material that is uniform in composition and physical state. In metallurgy, phases can be:

- Solid (e.g., ferrite, austenite, cementite)
- Liquid
- Mixtures of solids (e.g., pearlite – a mix of ferrite and cementite)

Phase Boundaries:

Lines separating different phase regions (like liquid + solid, or solid 1 + solid 2) are called phase boundaries.

Solubility Limit:

The maximum amount of solute (e.g., carbon) that can be dissolved in solvent (e.g., iron) before forming a new phase.

5. Key Phase Transformations (Reactions) with Justification

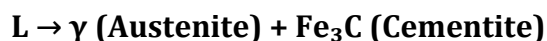
1. Eutectic Reaction

Reaction:



Occurs at a fixed temperature and composition.

Example: In Fe-C system, at 4.3% C and 1147°C:



Justification: A single liquid phase solidifies into two different solid phases. This is seen in cast iron, not mild steel.

2. Eutectoid Reaction

Reaction:



Occurs at: 0.8% C and 723°C in Fe–C diagram

Microstructure: Pearlite

Justification: A single solid phase (austenite) transforms into two different solid phases (ferrite and cementite) in lamellar form.

- **Important for heat treatment of steels (e.g., hardening, tempering).**

3. Peritectic Reaction

Reaction:



Occurs at: 0.16% C and 1495°C

Justification: A liquid phase and a solid phase combine to form a new solid phase. Seen in low-carbon steel processing.

4. Congruent Melting

- A solid melts directly into liquid without decomposition.
- Composition of solid and liquid is the same.
- Seen in some pure metals and intermediate compounds.

5. Incongruent Melting

- A solid melts into a different solid + liquid.
- This happens during peritectic reactions.
- **Example:** Seen in Fe–C system around 0.16% C.

6. Interpreting a Phase Diagram – Step by Step

- **Step 1:** Locate the given composition (e.g., 0.2% C)
- **Step 2:** Draw a horizontal line (isothermal line) at the given temperature.
- **Step 3:** Observe the phase region the point lies in (single phase, two-phase, etc.)
- **Step 4:** Use Lever Rule if in two-phase region to find phase percentages.
- **Step 5:** Note all phase transformations when cooling or heating across boundaries.

7. Examples of Phase Reactions in Fe-C for Justification

Hypo-Eutectoid Steel (~0.2% Carbon)

Structure at high temperature: Austenite

On cooling:

- Above 880°C: Fully Austenite
- Between 880–723°C: Proeutectoid Ferrite begins to form
- At 723°C: Remaining Austenite → Pearlite
- Final Structure: Ferrite + Pearlite

Justification:

- This sequence matches the eutectoid reaction path in Fe-C diagram for low carbon steel.

Hyper-Eutectoid Steel (~1.2% Carbon)

- Structure at high temp: Austenite
- On cooling:

Above 723°C: Proeutectoid Cementite forms at grain boundaries

At 723°C: Remaining Austenite → Pearlite

Final Structure: Cementite + Pearlite

Justification:

- This matches the expected path for carbon-rich steels based on the eutectoid reaction.

8. Importance of Identifying Phase Diagrams and Reactions

Benefit	Explanation
• Selection of heat treatment process temper	Decide when to harden, anneal,
• Prediction of mechanical properties (hard/brittle/ductile phases)	Based on phase fractions
• Failure analysis (e.g., excess cementite)	Understand why a component cracked

- Product design optimization
wear resistance, or flexibility

Tailor structure for strength,

9. Summary Table of Reactions in Fe-C Diagram

Type	Reaction	Occurs At	Phases Involved
Eutectic	$L \rightarrow \gamma + Fe_3C$	4.3% C, 1147°C	Liquid to two solids
Eutectoid solids	$\gamma \rightarrow \alpha + Fe_3C$	0.8% C, 723°C	Solid to two new
Peritectic solid	$L + \delta \rightarrow \gamma$	0.16% C, 1495°C	Liquid + solid \rightarrow new
Hypo-Eutectoid first	$\gamma \rightarrow \alpha + \text{Pearlite}$	<0.8% C, on cooling	Ferrite forms
Hyper-Eutectoid first	$\gamma \rightarrow Fe_3C + \text{Pearlite}$	>0.8% C, on cooling	Cementite forms

(Diploma wallah)