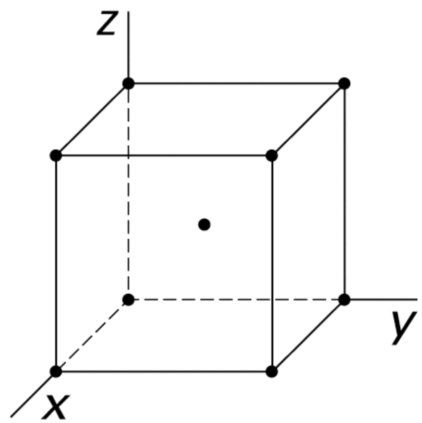
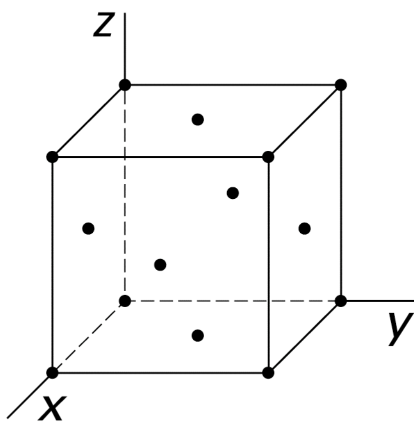
Materials Science/Structure of Matter 12-1a

Crystallography

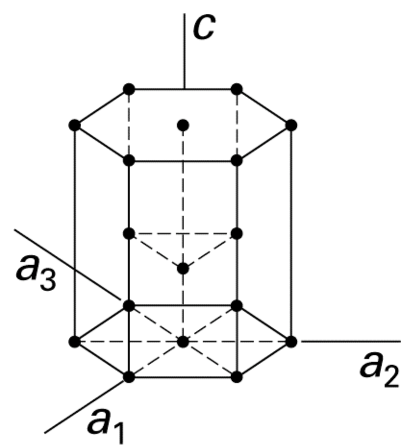
Body-Centered Cubic (BCC)



Face-Centered Cubic (FCC)



Hexagonal Close-Packed (HCP)



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Crystallography

Atoms per cell

- BCC: 2
- FCC: 4
- HCP: 6

Crystallography

Packing Factor

- BCC: 0.68
- FCC: 0.74
- HCP: 0.74

Coordination Number

- The number of the closest (touching) atoms
- FCC, HCP: 12
- BCC: 8

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Crystallography

Miller Indices

- Specify planes in crystalline lattices
- Calculated as the reciprocals of the plane intercepts

The following ARE NOT valid Miller indices:

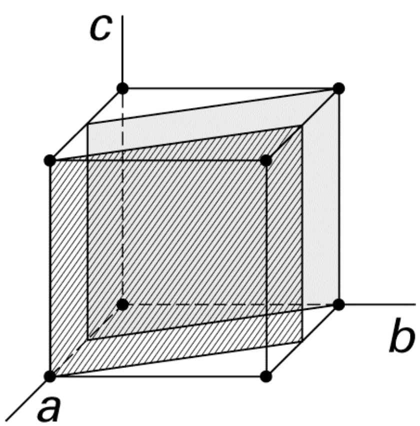
$\left(\frac{1}{4}\,\frac{1}{4}\,\frac{3}{4}\right)$ (026) (-111)

The following ARE valid Miller indices:

(113) (013) $(\bar{1}11)$

Example (FEIM):

What are the Miller indices of the series of planes shown?



The intercept on the *a* axis is 1/2, so the *a* Miller index is 2.

The intercept on the *b* axis is 1, so the *b* Miller index is 1.

The plane intercepts the *c* axis at ∞, so the *c* Miller index is 0.

The Miller indices are (210).

Atomic Bonding

Atomic Bonding

- Ionic
- Covalent
- Metallic

Example (FEIM):

Which of the following has a bond that is the least ionic in character?

(A) NaCl
(B) CH_4
(C) H_2
(D) H_2O

The NaCl is entirely ionic. In the CH_4 and H_2O, the hydrogen shares a pair of electrons with both the carbon and the oxygen in covalent bonds, but the carbon and oxygen have a larger share of the probability distribution than the hydrogen. In the H_2, the two hydrogen have equal pull on the two shared electrons, so this bond is entirely covalent and the least ionic.

Therefore, (C) is correct.

Metallurgy

Corrosion

Anode reaction (oxidation):

$$M^0 \rightarrow M^{n+} + ne^-$$

Cathode reaction (reduction):

$$\tfrac{1}{2}O_2 + 2e^- + H_2O \rightarrow 2OH^-$$

$$\tfrac{1}{2}O_2 + 2e^- + 2H_3O^+ \rightarrow 3H_2O$$

$$2e^- + 2H_3O^+ \rightarrow 2H_2O + H_2$$

Oxidation potential

- If two metals have oxidation potentials that are close, corrosion will be very slow or negligible.
- If two metals have very dissimilar oxidation potentials, corrosion will occur much faster.

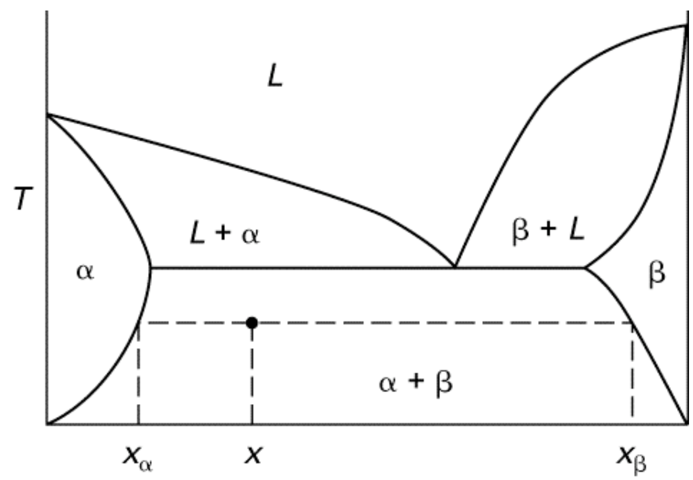
Metallurgy

Diffusion

Movement of defects through a crystal is governed by the diffusion coefficient:

$$D = D_0 e^{-Q/\overline{R}T} \qquad 42.2$$

Binary Phase Diagrams



• Show the equilibrium phase concentrations.

Binary Phase Diagrams

Table 42.3 Types of Equilibrium Reactions

reaction name	type of reaction upon cooling
eutectic	liquid $\rightarrow$ solid α + solid β
peritectic	liquid + solid α $\rightarrow$ solid β
eutectoid	solid γ $\rightarrow$ solid α + solid β
peritectoid	solid α + solid γ $\rightarrow$ solid β

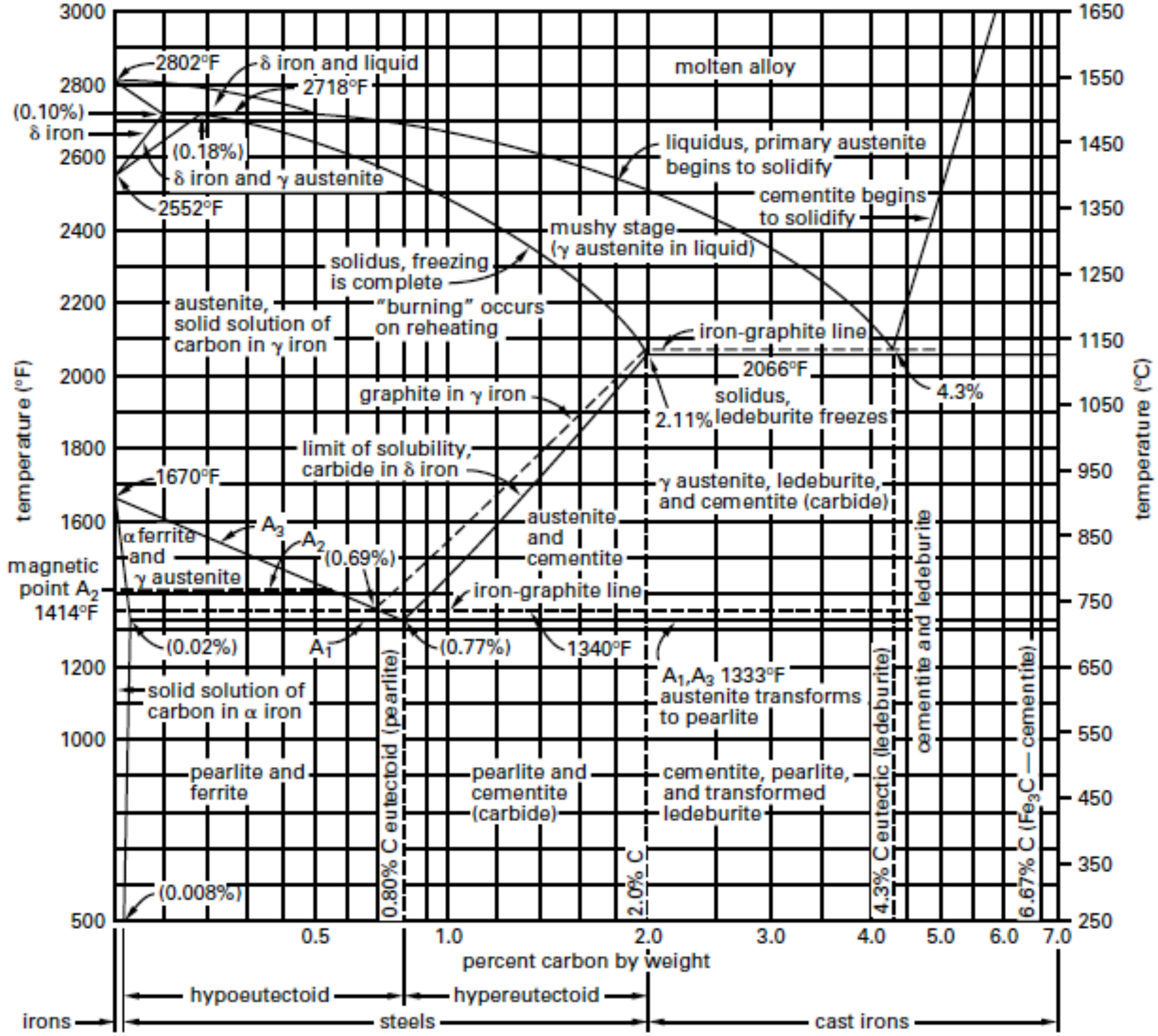
Lever Rule

$$\text{fraction solid} = \frac{x_2 - x}{x_2 - x_1} = \frac{n}{w} = 1 - \text{fraction liquid} \qquad 42.3$$

$$\text{fraction liquid} = \frac{x - x_1}{x_2 - x_1} = \frac{m}{w} = 1 - \text{fraction solid} \qquad 42.4$$

Binary Phase Diagrams

Figure 42.5 Iron-Carbon Diagram



Binary Phase Diagrams

Example (FEIM):
An alloy at 800°C is 2% carbon by weight. What are the compositions and fractions of austenite (γ) and cementite (iron carbide) in the mixture?

Follow the 800°C line to the left until it intersects the (γ) phase line; the austenite is about 1% carbon.
Follow the 800°C line to the right until it intersects the carbide line; the cementite is about 6.67% carbon.

$$\text{wt\%}_{\gamma} = \left(\frac{x_{\text{carbide}} - x}{x_{\text{carbide}} - x_{\gamma}}\right)100\% = \left(\frac{6.67-2}{6.67-1}\right)100\% = 82.4\%$$

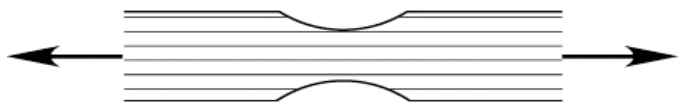
$$\text{wt\%}_{\text{carbide}} = \left(\frac{x - x_{\gamma}}{x_{\text{carbide}} - x_{\gamma}}\right)100\% = \left(\frac{2-1}{6.67-1}\right)100\% = 17.6\%$$

Thermal Processing

- If rapid changes are made to the temperature of some alloys, they will not come to the new equilibrium state and will end up with properties that are different and perhaps useful.

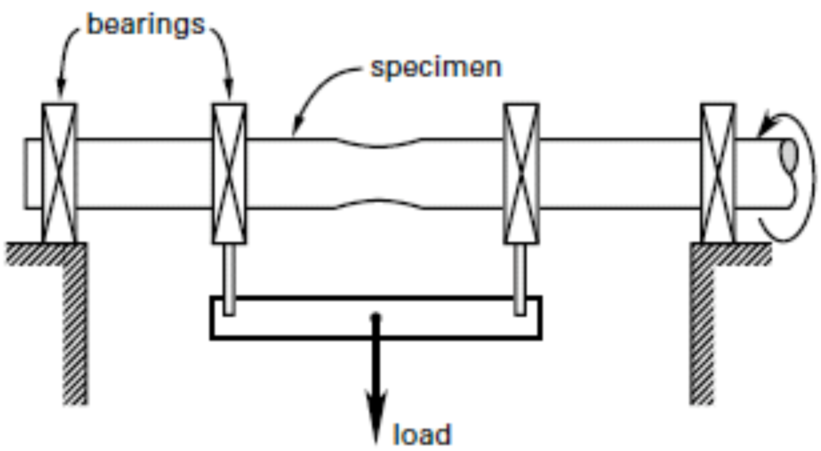
Testing Methods

- Standard Tensile Test



- Endurance Test

Figure 41.5 Rotating Beam Test



- Impact Test

Figure 41.7 Charpy Test