MSE 170 Final review part 1

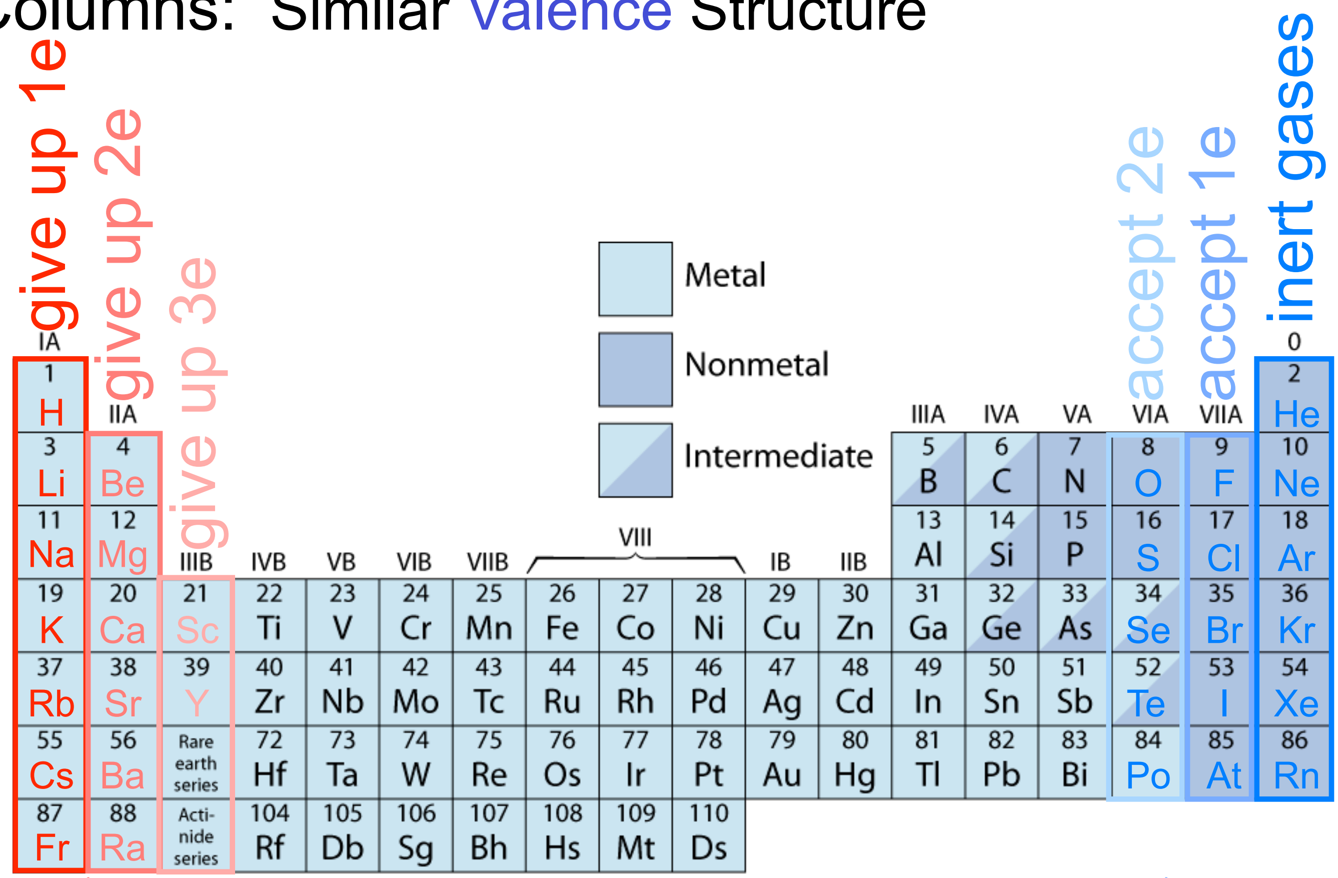
- Exam date: 12/9/2008 Tues, 8:30-10:20
- Place: Here!
- Closed book, no notes and no collaborations
- Two sheets of letter-sized paper with double-sided notes is allowed
- Exam is comprehensive: material on the exam will be taken from the text book reading, lecture notes, homework, and lab
- Bring a calculator and straight edge/triangle
- The review materials are not comprehensive, there may be questions on the exam on topics not listed here

Bonding and atomic forces

- The periodic table
- What types of bonding are there?
- How does bonding affect materials properties?

The Periodic Table

- Columns: Similar Valence Structure



Adapted from Fig. 2.6, *Callister 7e.*

Electropositive elements:
Readily donate electrons
to become + ions.

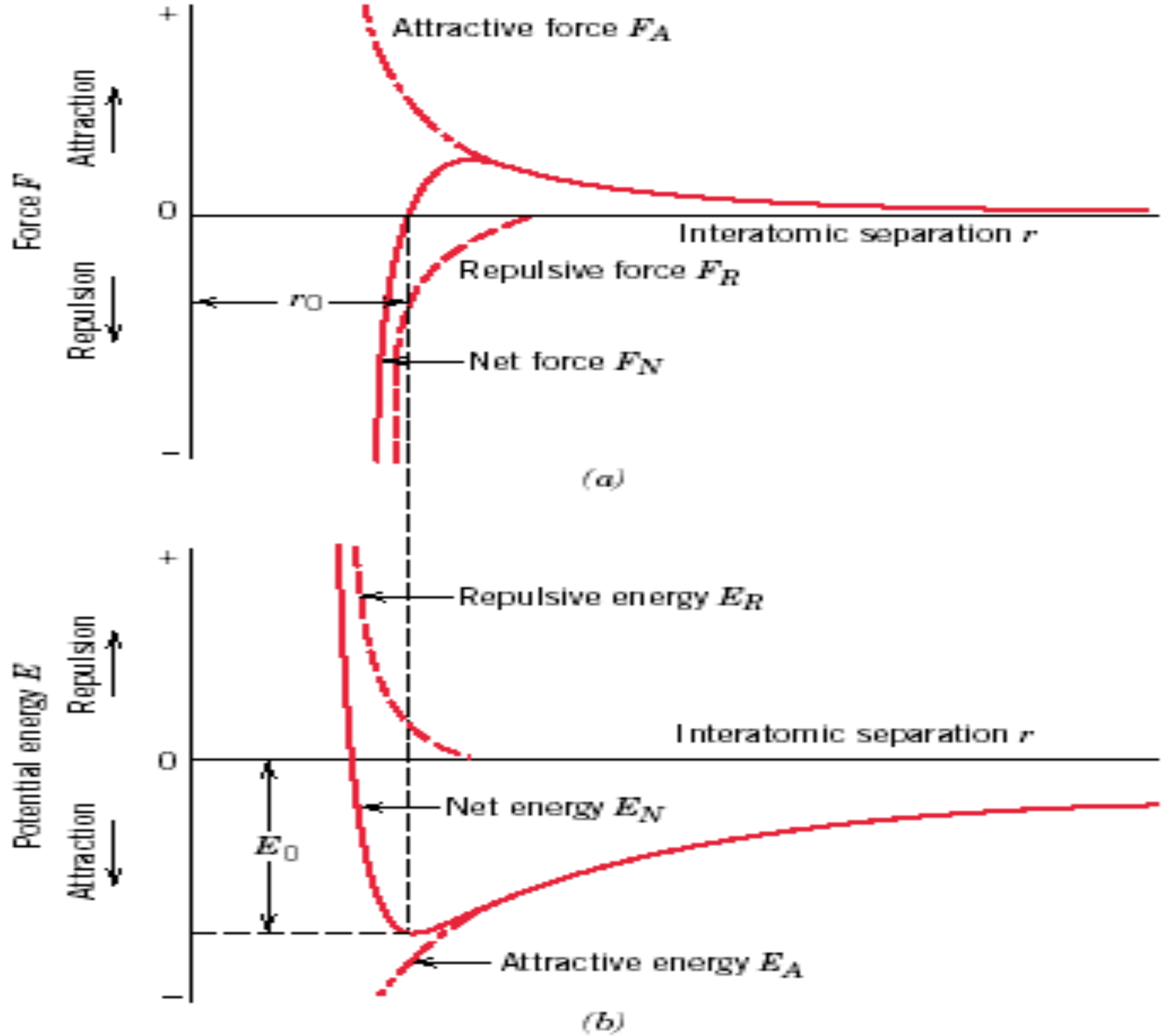
Electronegative elements:
Readily acquire electrons
to become - ions.

Bonding and atomic forces (continued)

- Atomic forces & potential vs interatomic distance

Atomic bonding in solids

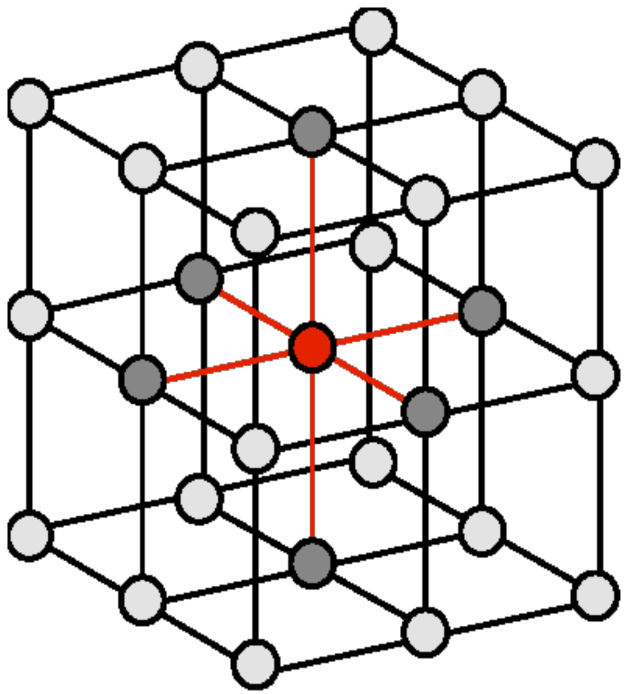
- Bonding forces and energies



Crystal structure

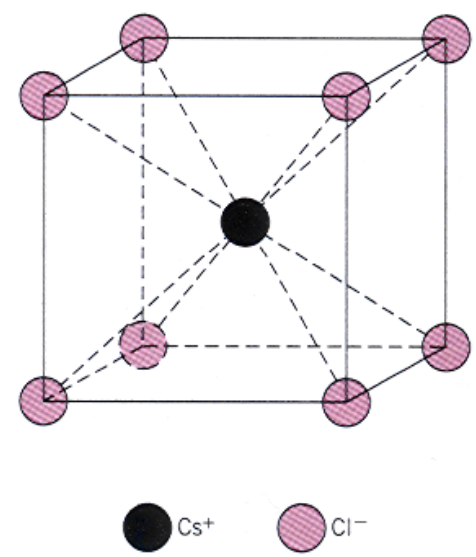
- Determine #atoms/unit cell, CN#, APF and density
- Draw and index crystallographic direction and planes
- Close-packed plane and stacking sequence
- Crystal systems

Crystal Structures



Crystal structures (*ceramics*)

- Know the types of ceramic structures and identify their unit cells
- Determine coordination number for ceramic structures based on ionic radii and charge

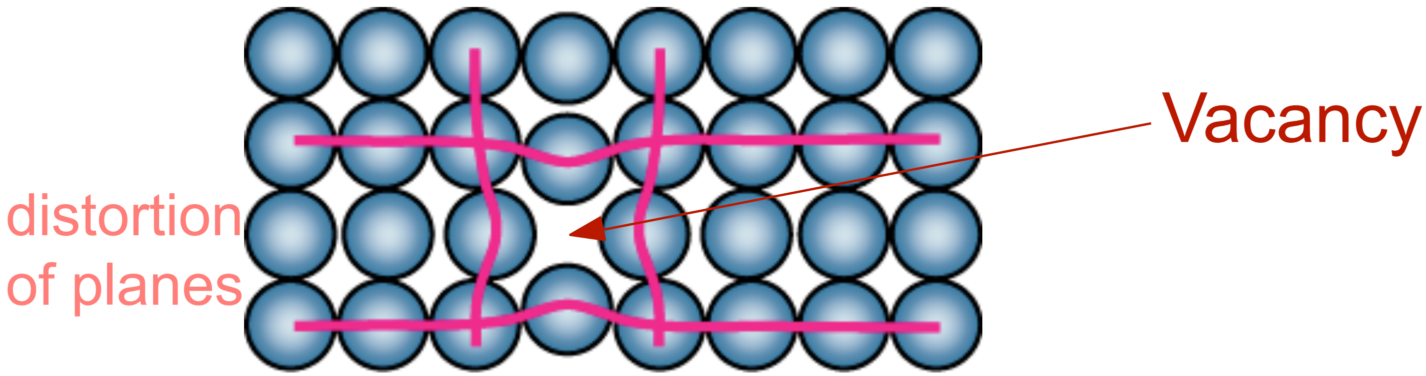


Defects

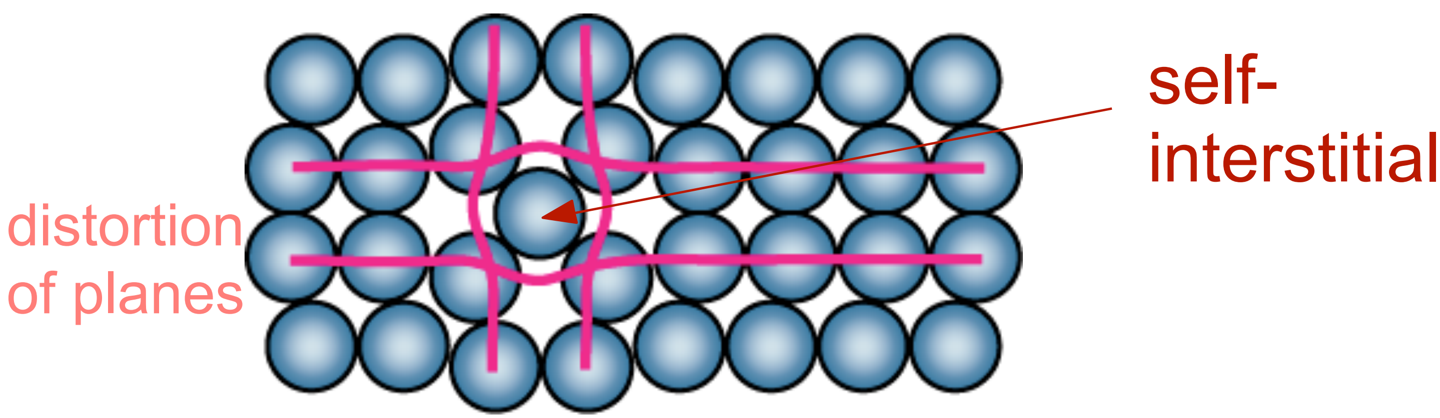
- Distinguish point, linear (dislocation 1D), interfacial(2D), volume(3D) defects
- Draw and describe edge and screw dislocations
- Burgers circuits and vectors
- Understand equilibrium of vacancies and effect of T

Point Defects

- Vacancies:
  -vacant atomic sites in a structure.



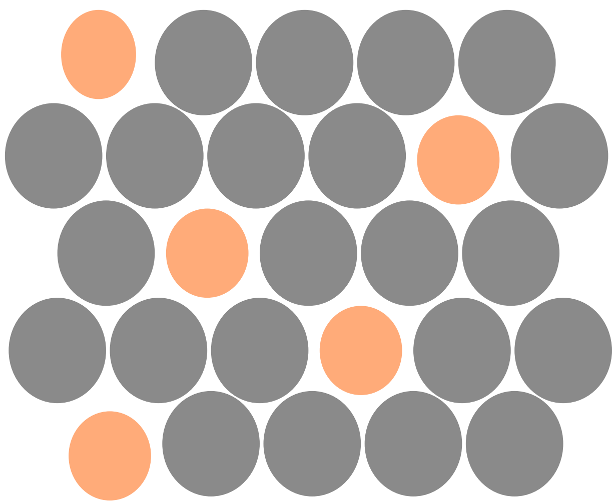
- Self-Interstitials:
  -"extra" atoms positioned between atomic sites.



Point Defects in Alloys

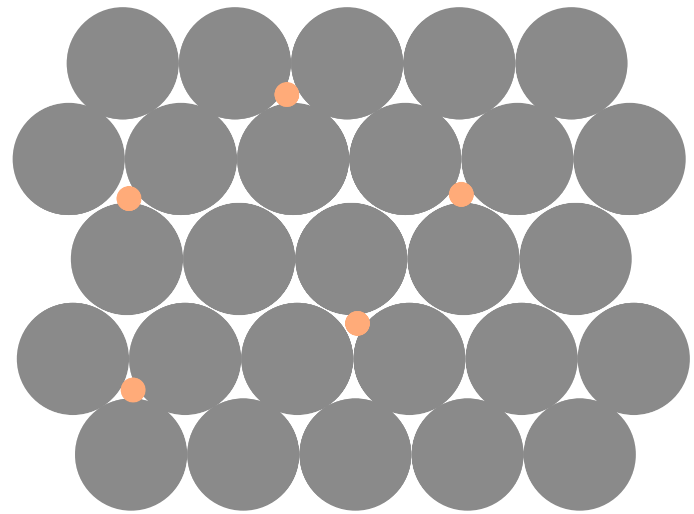
Two outcomes if impurity (B) added to host (A):

- Solid solution of B in A (i.e., random dist. of point defects)



Substitutional solid soln.
(e.g., Cu in Ni)

OR



Interstitial solid soln.
(e.g., C in Fe)

Imperfections in Solids

Edge Dislocation

- extra half-plane of atoms inserted in a crystal structure
- **b** ⊥ to dislocation line

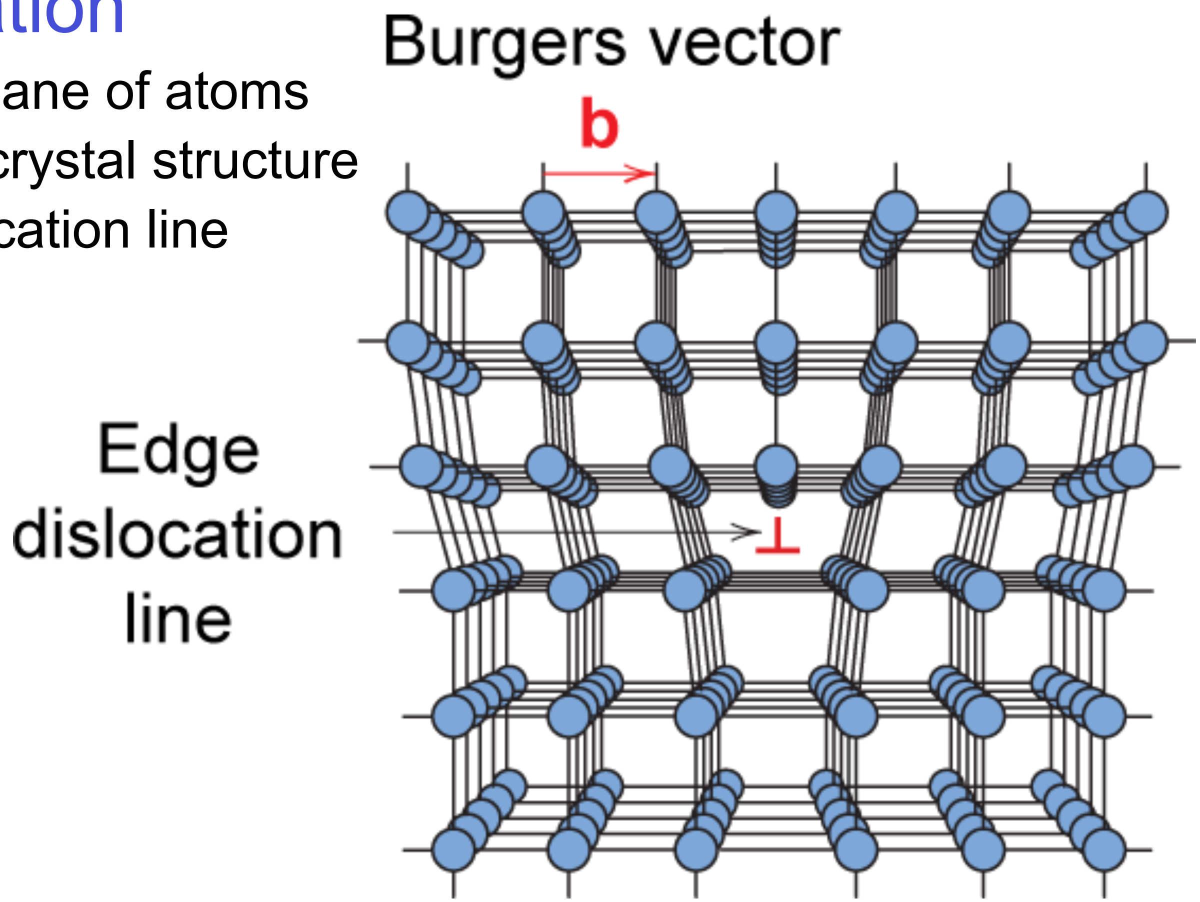


Fig. 4.3, *Callister 7e.*

Diffusion

- Mechanisms, concentration gradients, diffusion coefficient

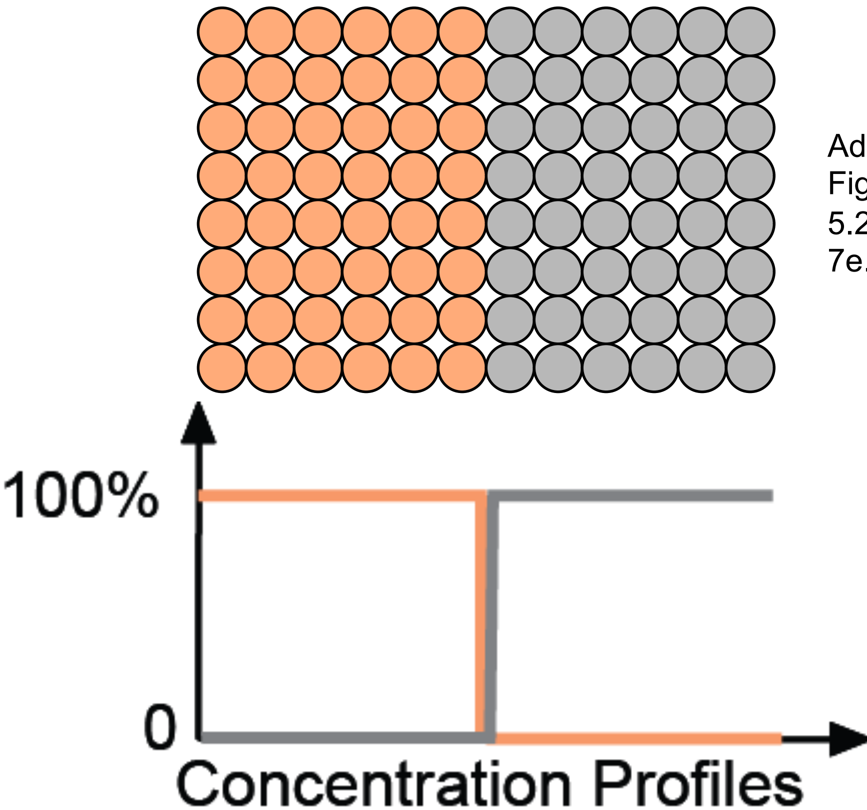
- Ficks laws

- Effects of T on diffusion coefficients

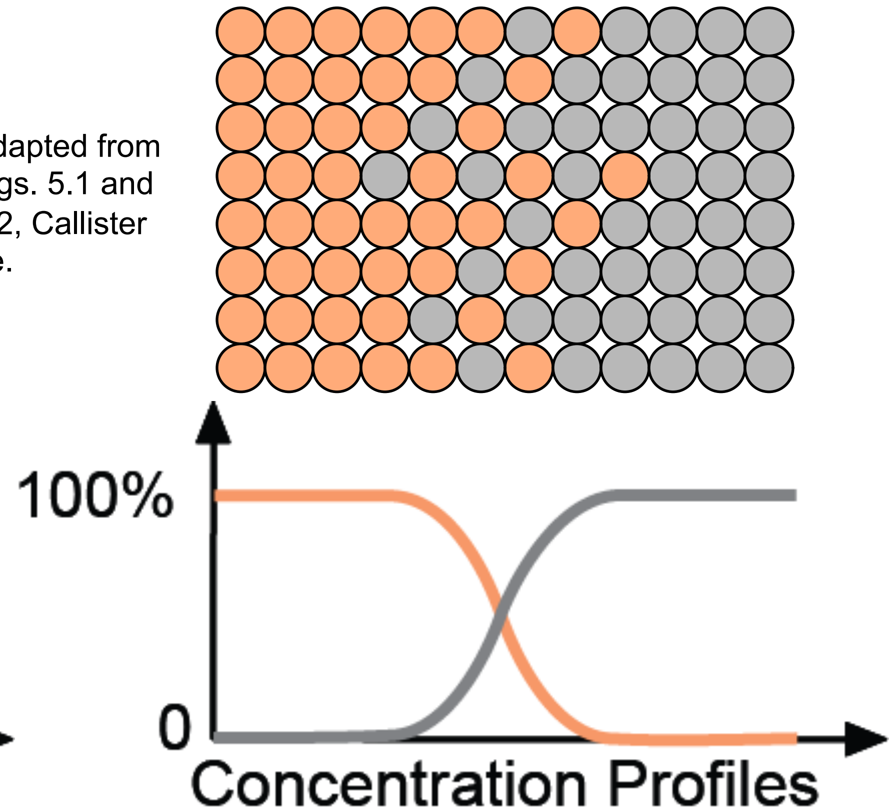
Diffusion

- Interdiffusion: In an alloy, atoms tend to migrate from regions of high conc. to regions of low conc.

Initially



After some time

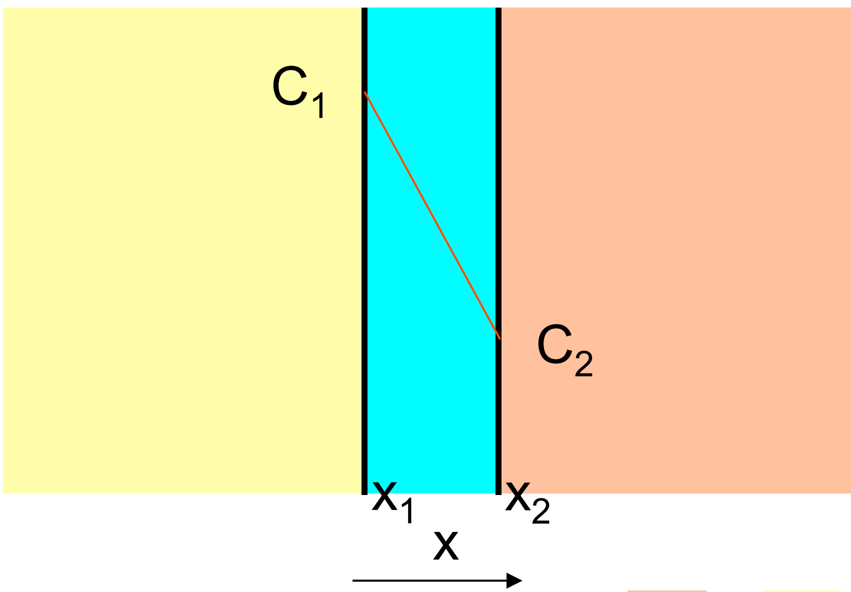


Adapted from Figs. 5.1 and 5.2, Callister 7e.

Steady-State Diffusion

Rate of diffusion independent of time

Flux proportional to concentration gradient = $\dfrac{dC}{dx}$



if linear $\dfrac{dC}{dx} \cong \dfrac{\Delta C}{\Delta x} = \dfrac{C_2 - C_1}{x_2 - x_1}$

Fick's first law of diffusion

$$\boxed{J = -D\frac{dC}{dx}}$$

D ≡ diffusion coefficient

Non-steady State Diffusion

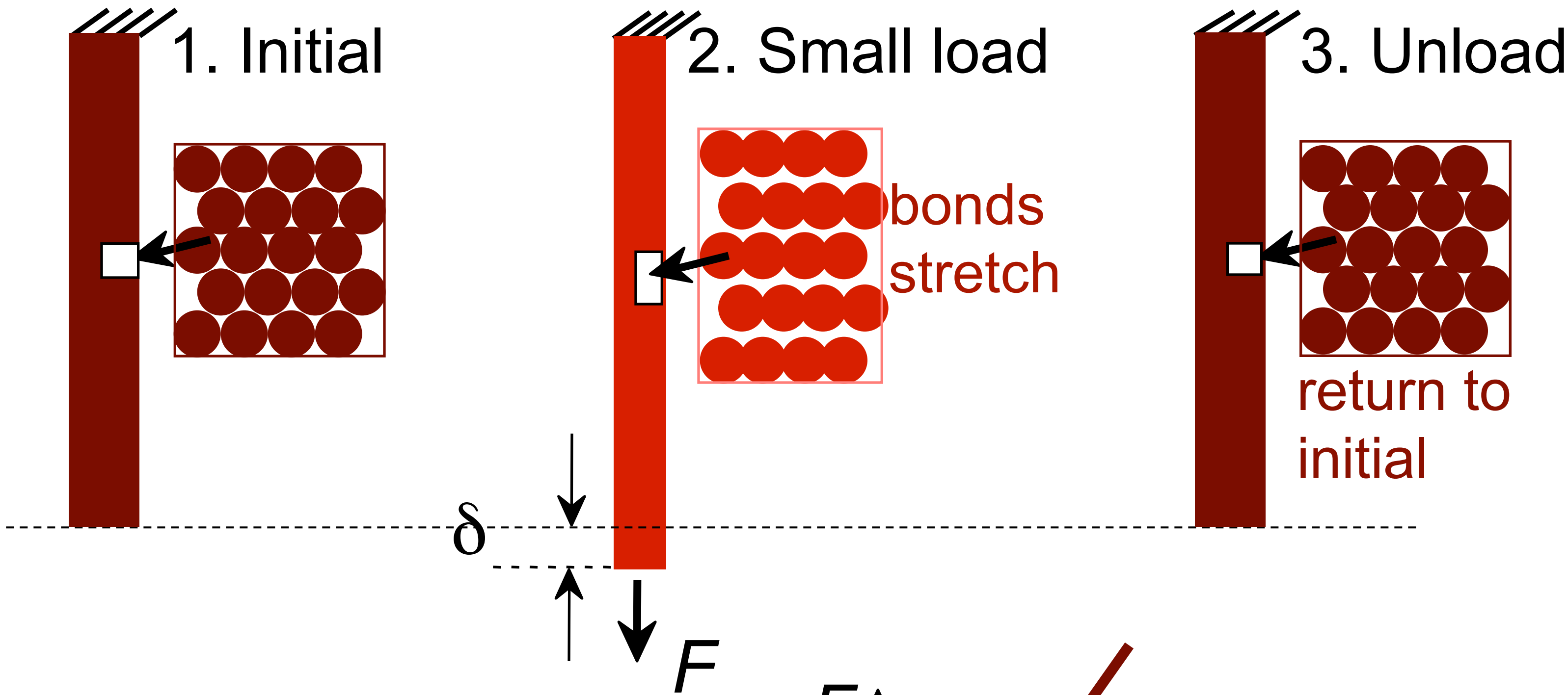
- The concentration of diffusing species is a function of both time and position $C = C(x,t)$
- In this case Fick's Second Law is used

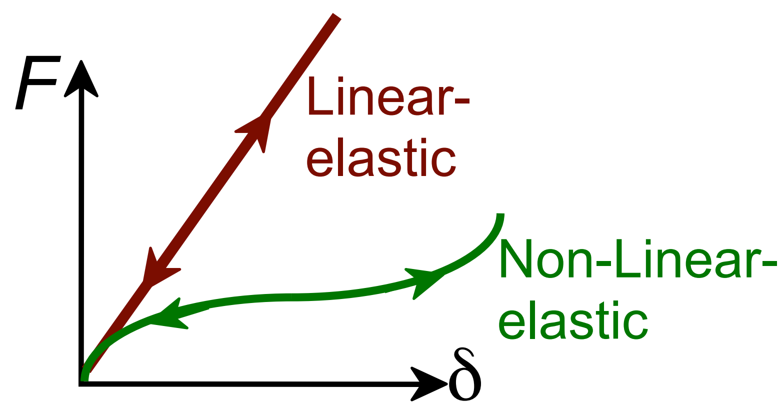
Fick's Second Law $$\boxed{\frac{\partial C}{\partial t} = D\frac{\partial^2 C}{\partial x^2}}$$

Mechanical properties

- Definition of stress, strain, elastic modulus
- Analysis of stress-strain curves
- Yield strength, tensile strength, Poisson's ratio, ductility, resilience, and toughness
- Hardness

Elastic Deformation

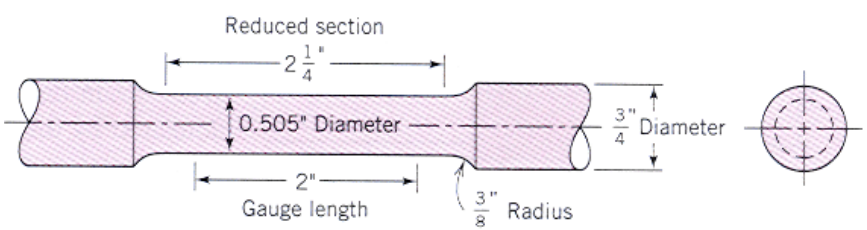


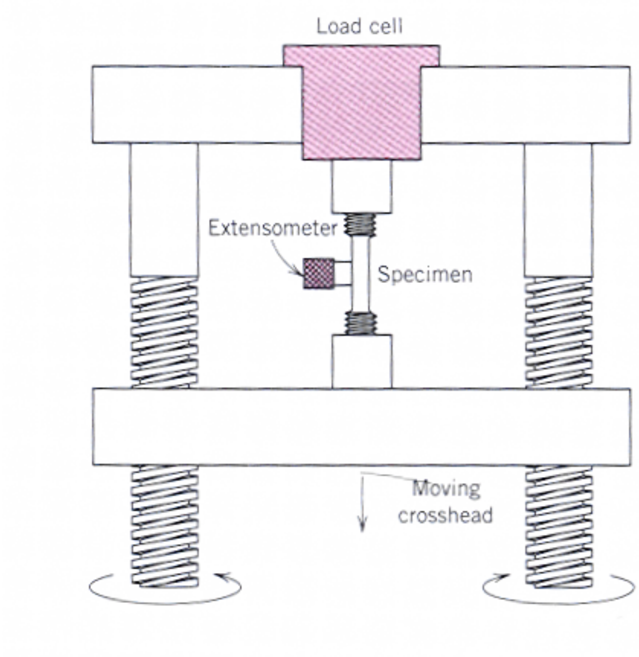


Elastic means reversible!

Concepts of stress and strain

- Tension tests
  - engineering stress $$\sigma = \frac{F}{A_0}$$
  - engineering strain $$\varepsilon = \frac{l_i - l_0}{l_0} = \frac{\Delta l}{l_0}$$





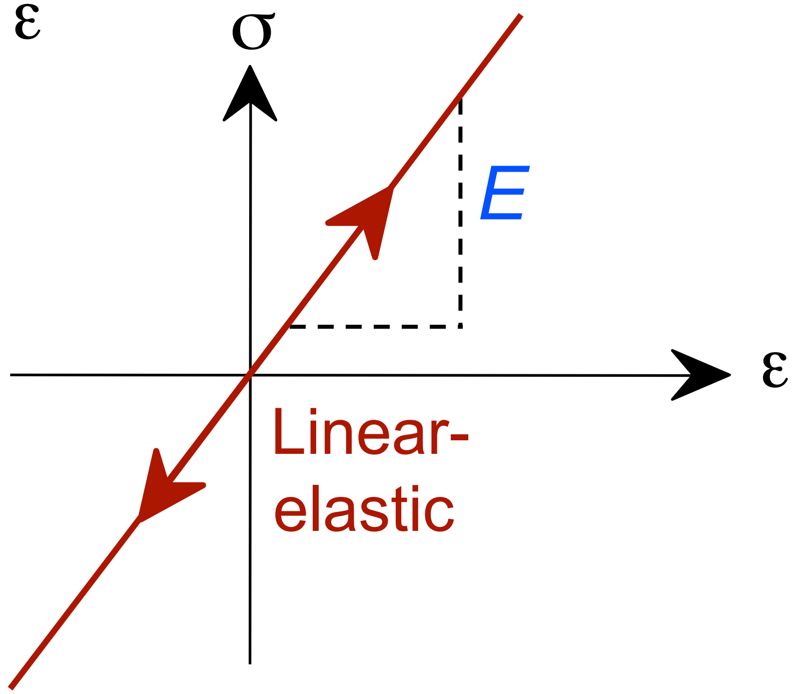
- Compression tests

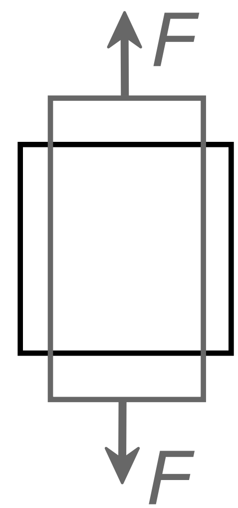
Linear Elastic Properties

- **Modulus of Elasticity, *E*:**
  (also known as Young's modulus)

- **Hooke's Law:**

$$\sigma = E\,\varepsilon$$



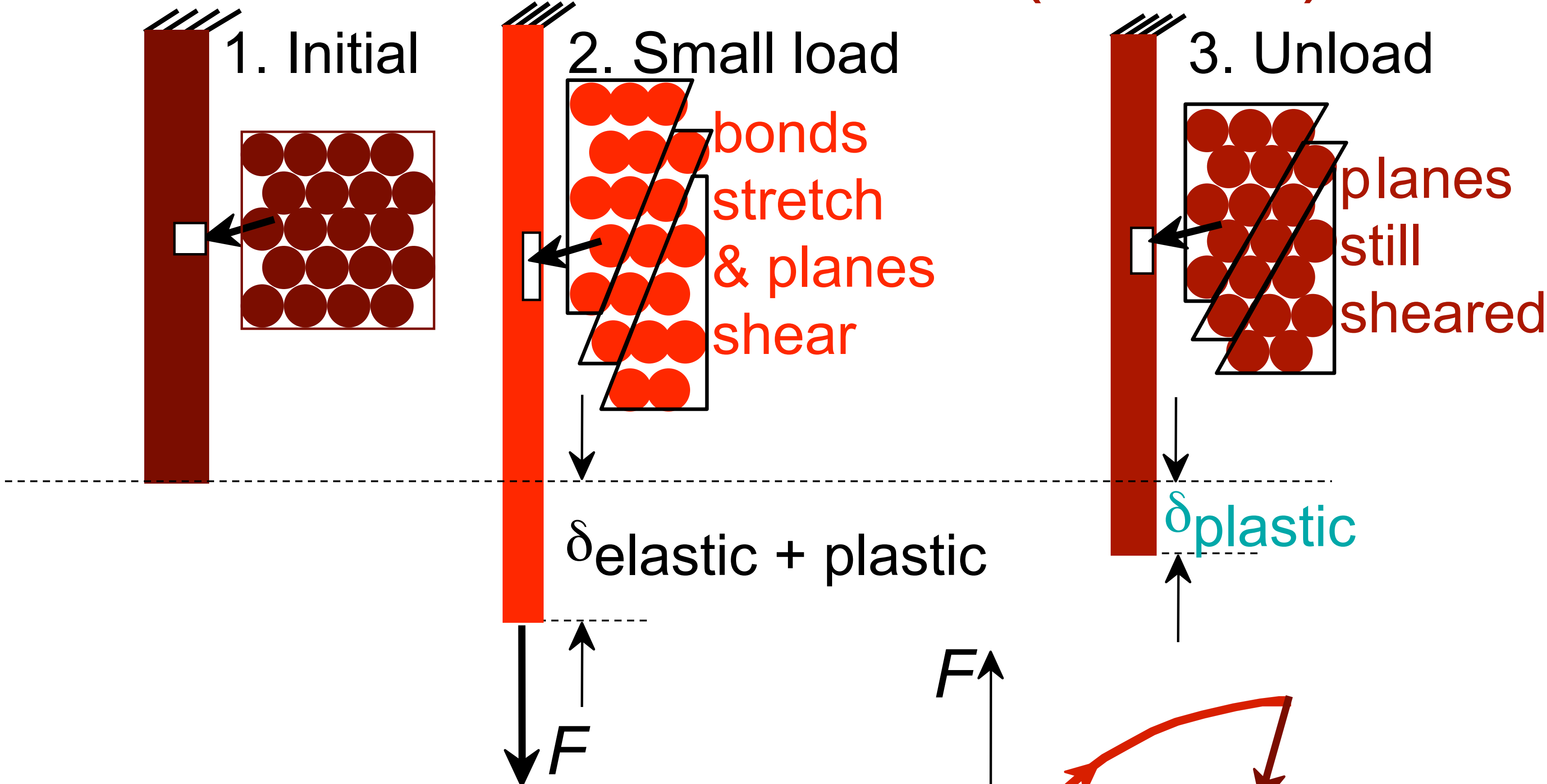


simple
tension
test

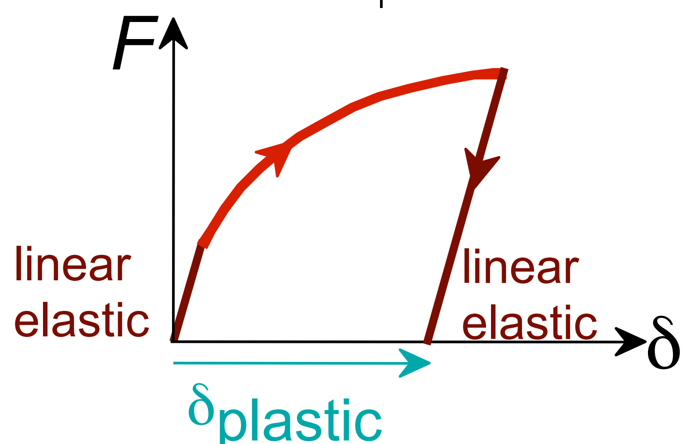
Plastic deformation

- Slip plane, direction and system, resolved shear stress
- Mechanism of plastic deformation
- Strengthening mechanisms
- Recovery, recrystallization, and grain growth

Plastic Deformation (Metals)



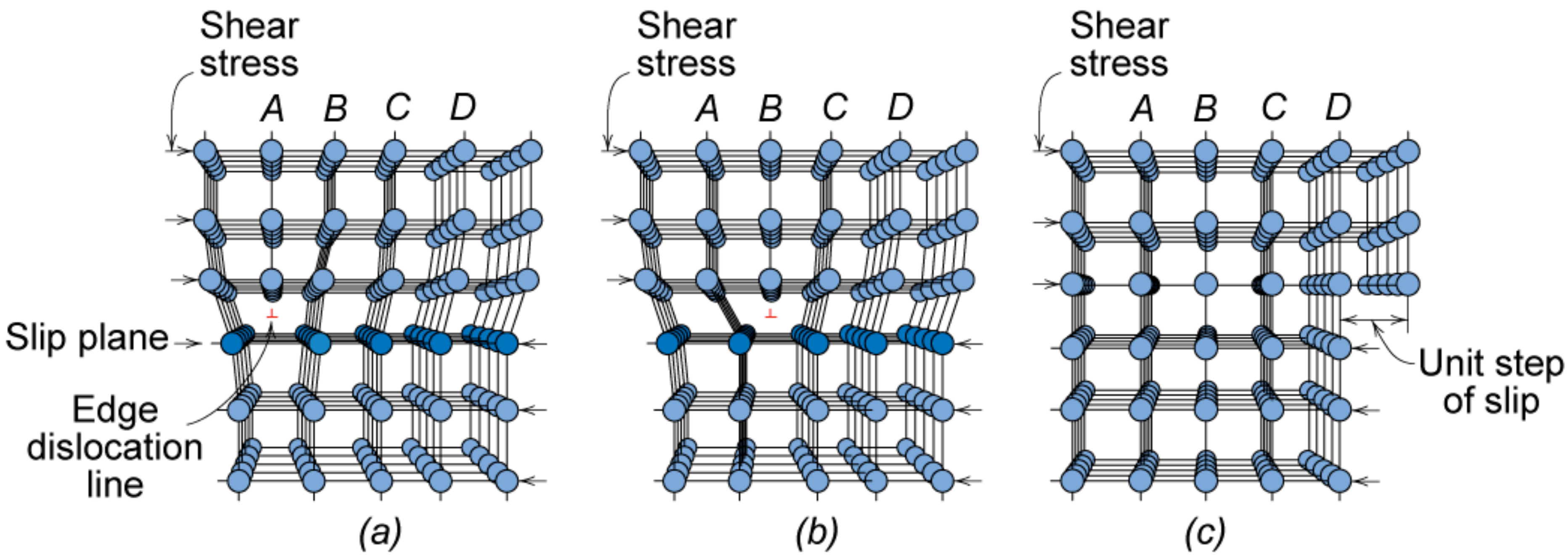
Plastic means permanent!



Dislocation Motion

Dislocations & plastic deformation

- Cubic & hexagonal metals - plastic deformation by plastic shear or slip where one plane of atoms slides over adjacent plane by defect motion (dislocations).



- If dislocations don't move, deformation doesn't occur!

Adapted from Fig. 7.1, *Callister 7e.*

Failure

- Ductile vs brittle fracture
- Stress concentrations and fracture toughness
- Creep and fatigue failure

Aside: a touch of Thermodynamics

Entalpy~ Internal Energy

$$\Delta G=\Delta H-T\Delta S$$

Gibb's free Energy

Entropy~ disorder~ probability

A transformation will occur spontaneously if ΔG is negative.