MSE 170 Midterm review

- Exam date: 11/2/2008 Mon, lecture time
- Place: Here!
- Close book, notes and no collaborations
- A sheet of letter-sized paper with double-sided notes is allowed
- 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

A few pointers

•Eat a good (light) breakfast. Bring some food if you get hungry, with less glucose your brain won't work as well.

•Take a few minutes to read the entire exam first and make sure you are clear on how many points each question is worth.

•Bring a watch! Taking 20 minutes to answer perfectly a 5 point question is still going to get you only 5 points

•Read the question carefully……Read the question carefully again! Make sure you are answering the right question. If not clear, ask! On average, 20% of the points are lost because of not reading the question carefully.

•Write clearly and explain your steps, you will be more likely to get partial credit if things go wrong at the end.

•Remember Occam's Razor: the explanation of any phenomenon should make as few assumptions as possible, eliminating those that make no difference in the observable predictions of the explanatory hypothesis or theory.

All other things being equal, the simplest solution is the best.

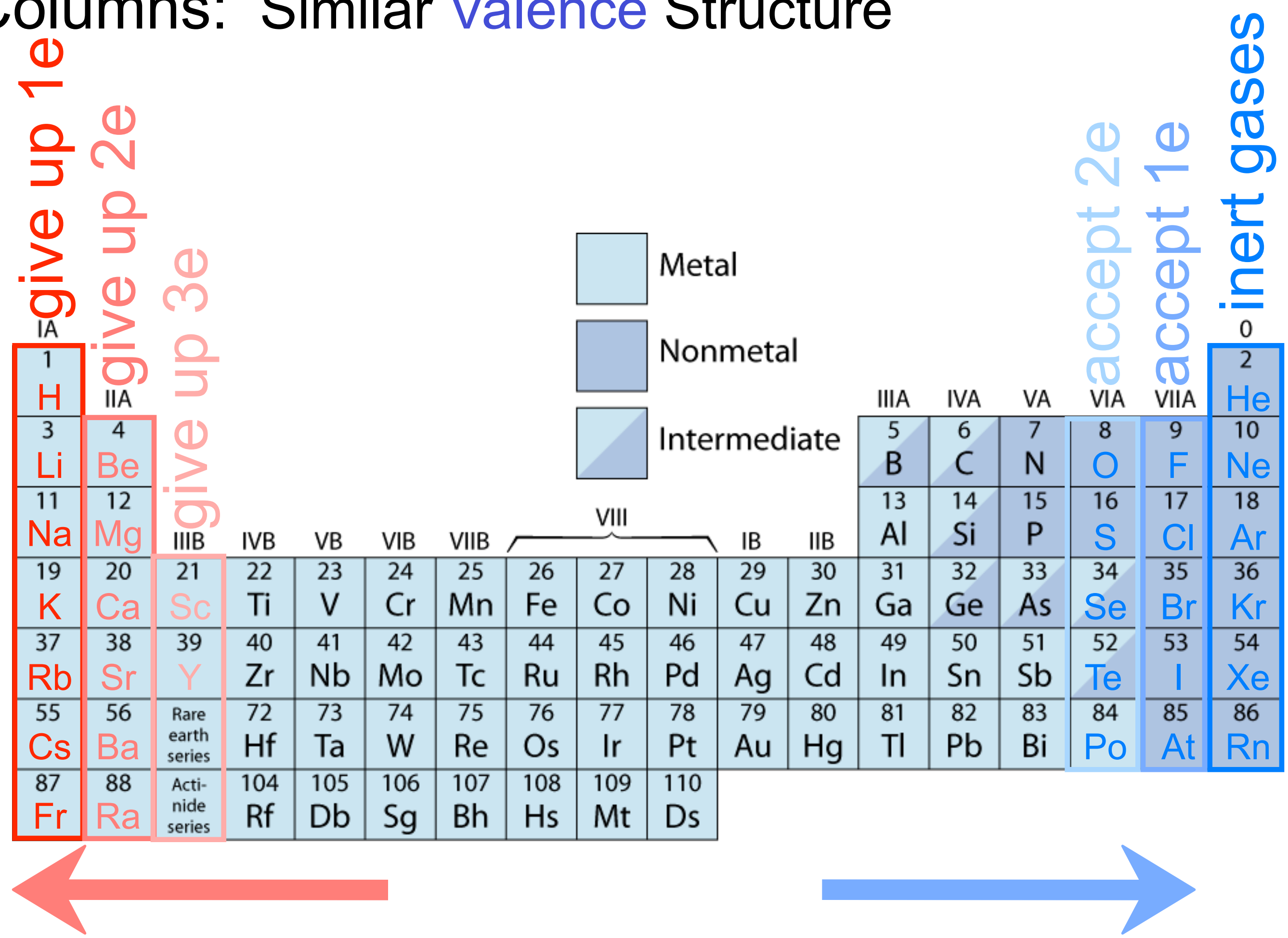
•When you are done, make sure to put your name and number and PLEASE hand in your work.

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.

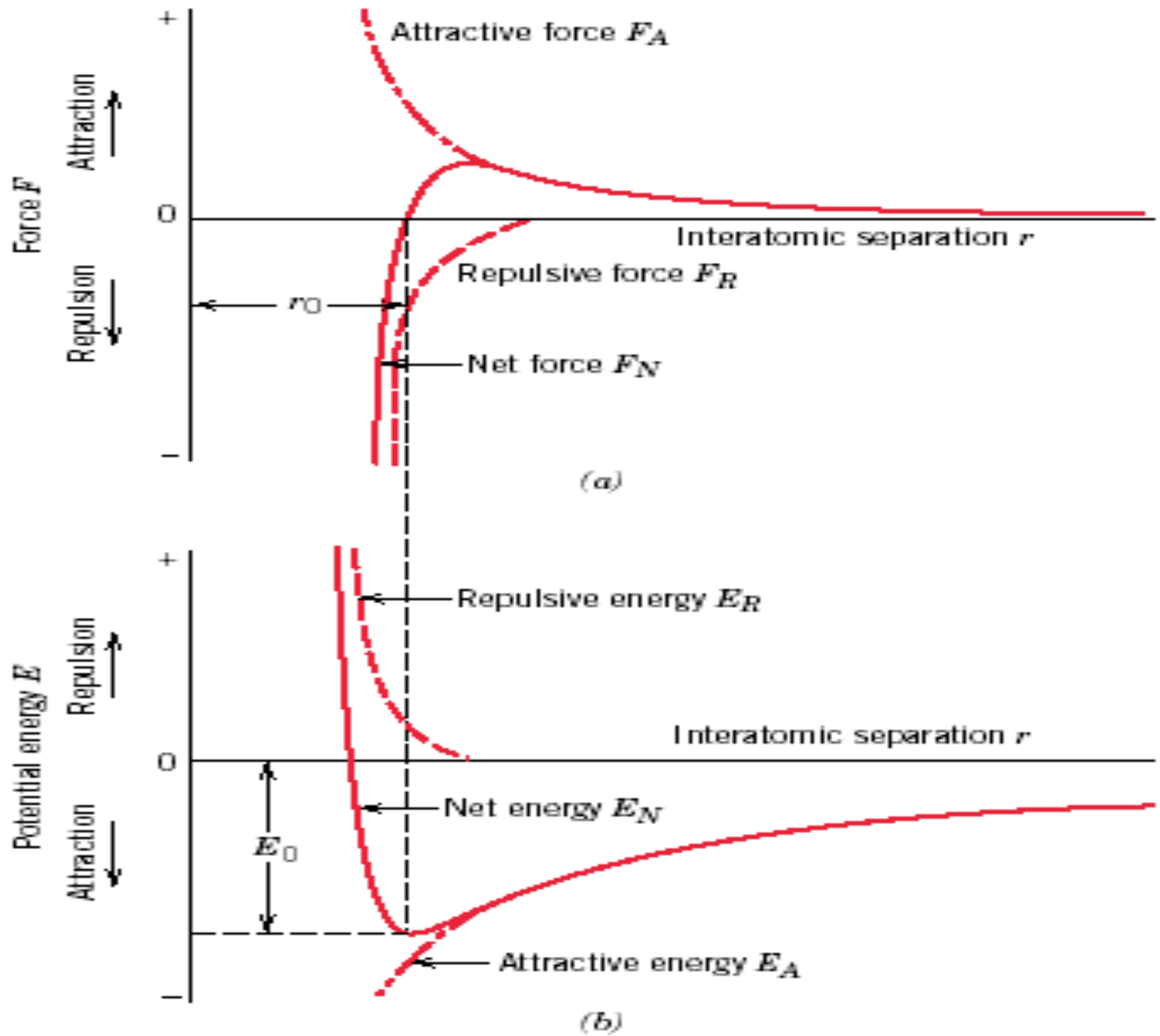
Electronegative elements: Readily acquire electrons to become - ions.

Bonding and atomic forces (continued)

- Atomic forces & potential vs interatomic distance

Atomic bonding in solids

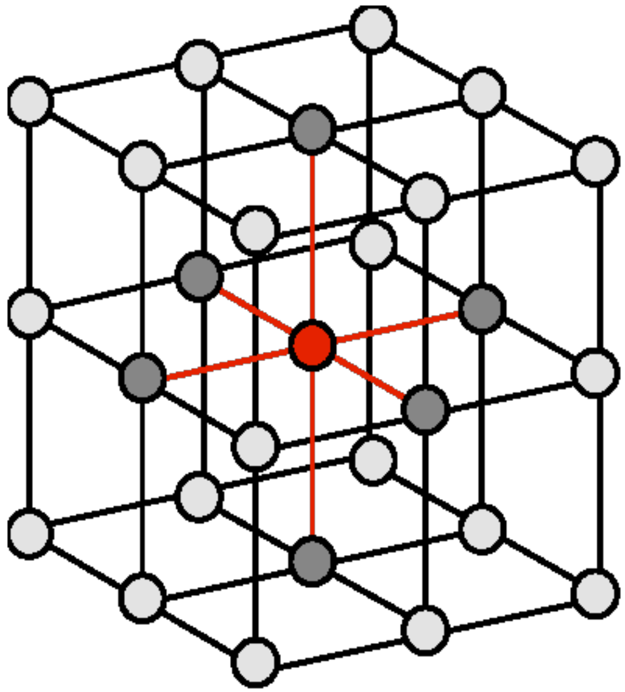
- Bonding forces and energies



Crystal structure

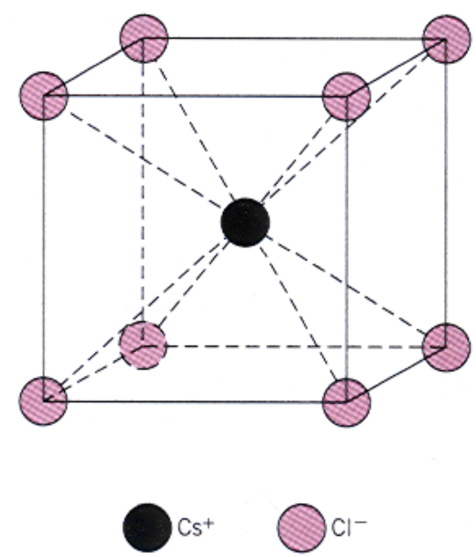
- Determine #atoms/unit cell, CN#, APF and density
- Draw and index crystallographic direction and planes
- Close-packed plane and stacking sequence
- Crystal systems

Crystal Structures

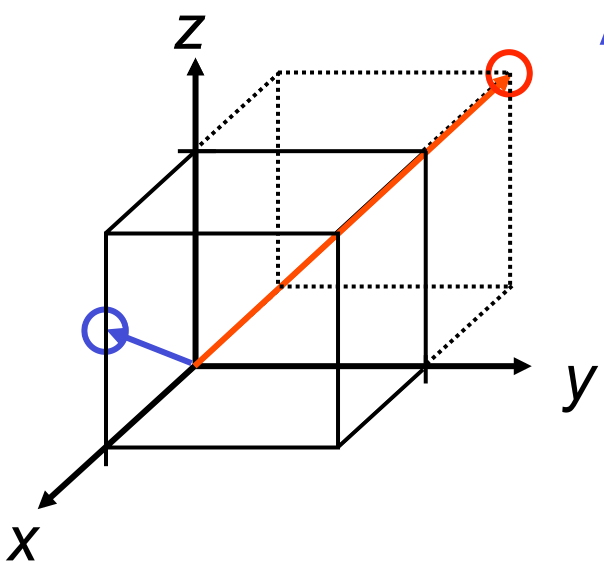


Crystal structures (*ceramics*)

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



Crystallographic Directions



Algorithm

1. Vector repositioned (if necessary) to pass through origin.
2. Read off projections in terms of unit cell dimensions *a*, *b*, and *c*
3. Adjust to smallest integer values
4. Enclose in square brackets, no commas

[*uvw*]

ex: 1, 0, ½ => 2, 0, 1 => [201]

-1, 1, 1 => [$\bar{1}$11] where overbar represents a negative index

families of directions <*uvw*>

Crystallographic Planes

- Miller Indices: Reciprocals of the (three) axial intercepts for a plane, cleared of fractions & common multiples. All parallel planes have same Miller indices.

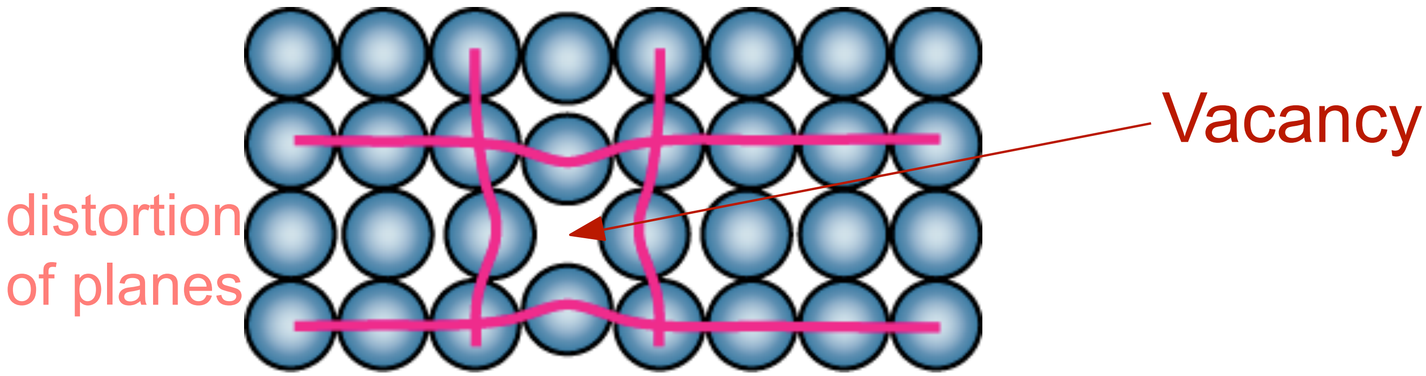
- Algorithm
  1. Read off intercepts of plane with axes in terms of *a*, *b*, *c*
  2. Take reciprocals of intercepts
  3. Reduce to smallest integer values (no always)
  4. Enclose in parentheses, no commas i.e., (*hkl*)

Defects

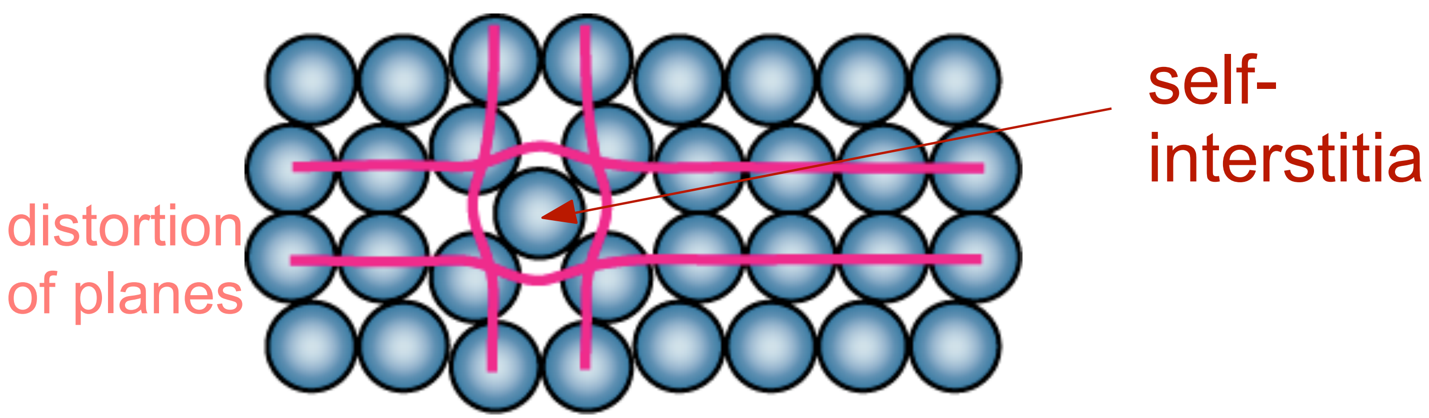
- Distinguish point, linear (dislocation 1D), interfacial(2D), volume(3D) defects
- Draw and describe edge and screw dislocations
- Burgers circuits and vectors
- Understand equilibrium of vacancies and effect of T

Point Defects

- Vacancies:
  -vacant atomic sites in a structure.



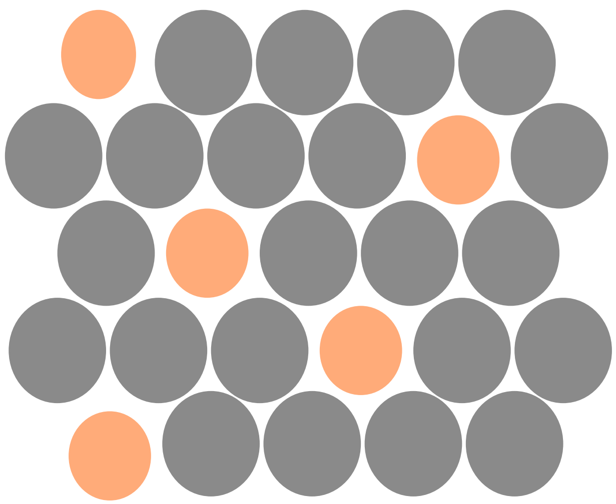
- Self-Interstitials:
  -"extra" atoms positioned between atomic sites.



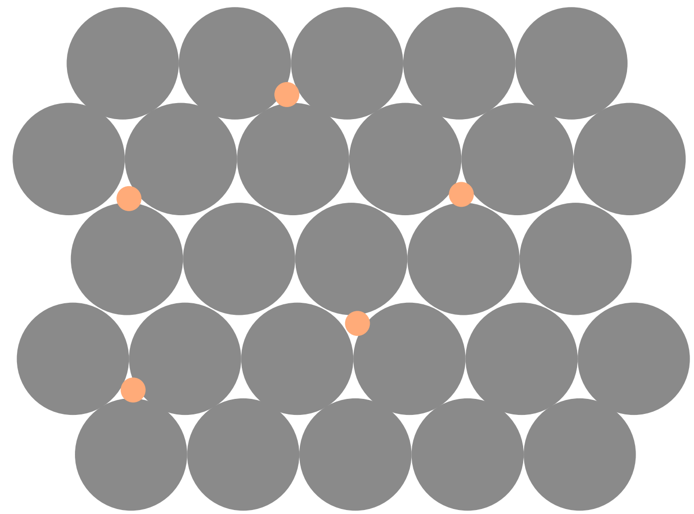
Point Defects in Alloys

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

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



OR



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

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

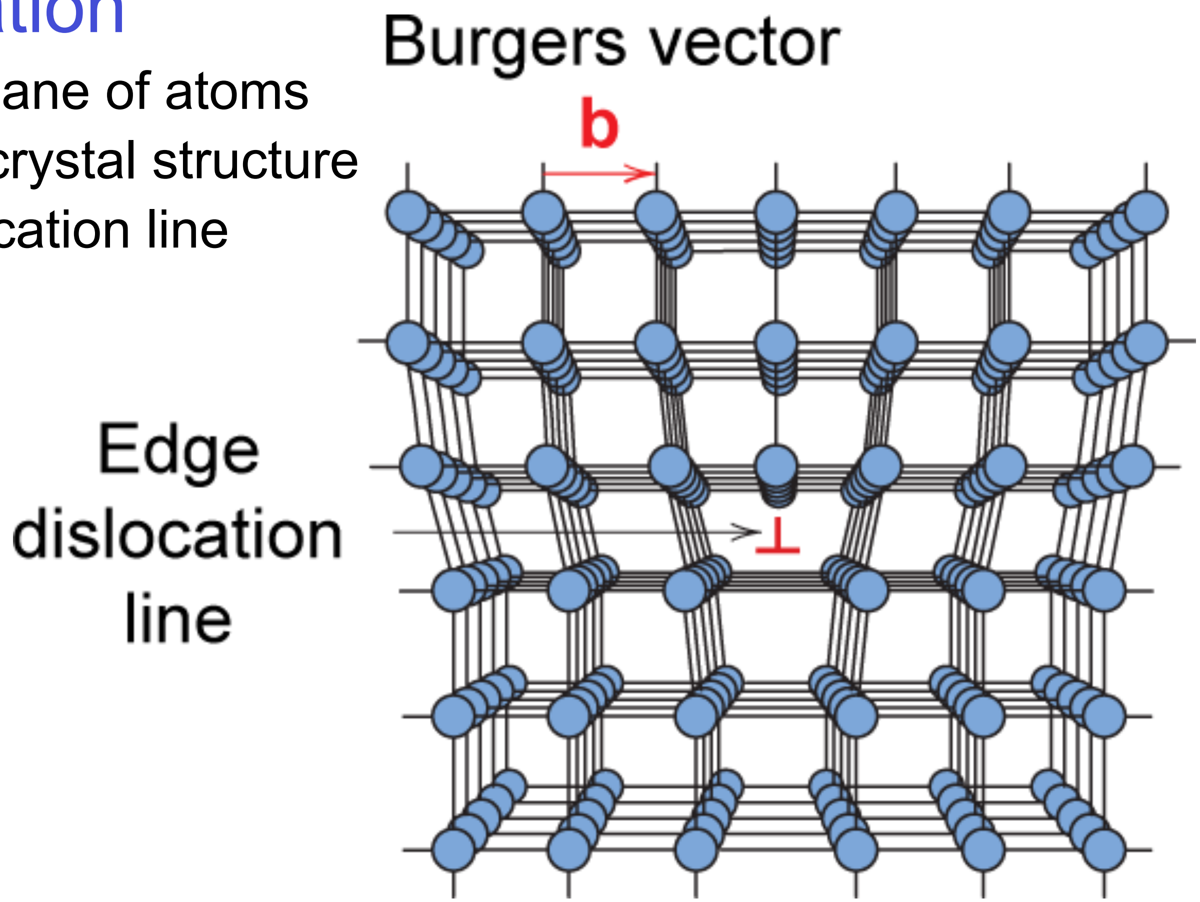


Fig. 4.3, *Callister 7e.*

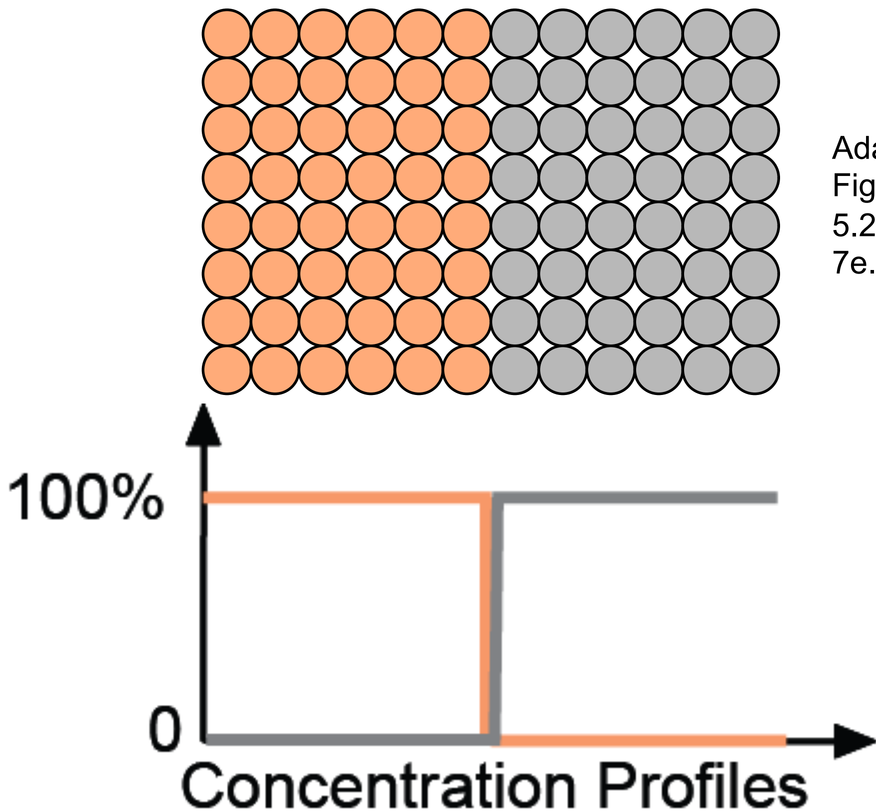
Diffusion

- Mechanisms, concentration gradients, diffusion coefficient
- Ficks laws
- Effects of T on diffusion coefficients

Diffusion

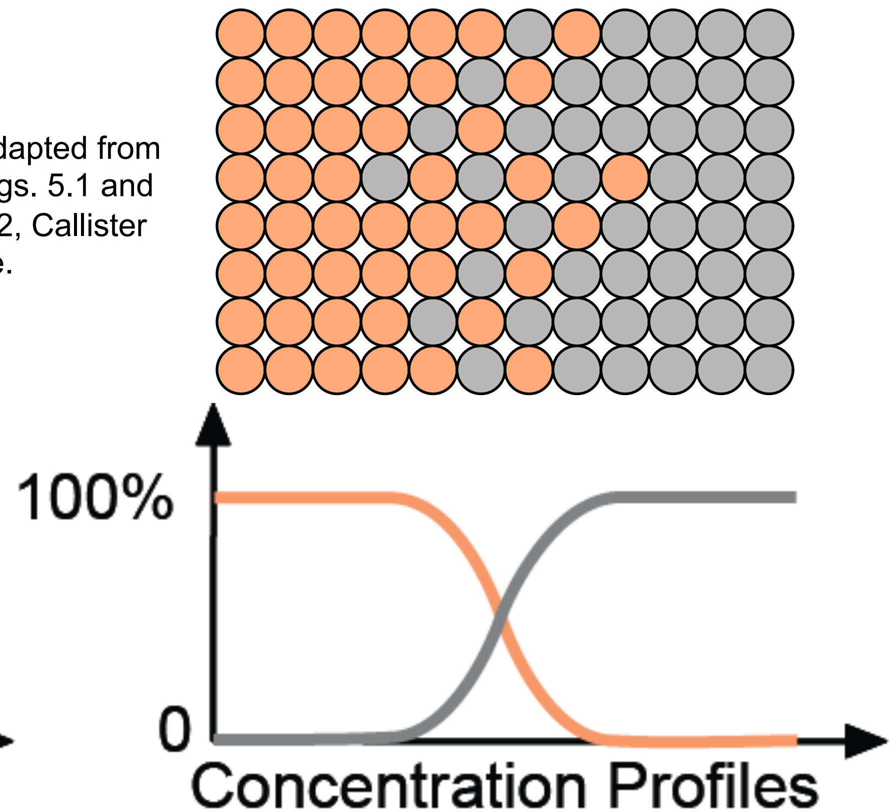
- Interdiffusion: In an alloy, atoms tend to migrate from regions of high conc. to regions of low conc.

Initially



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

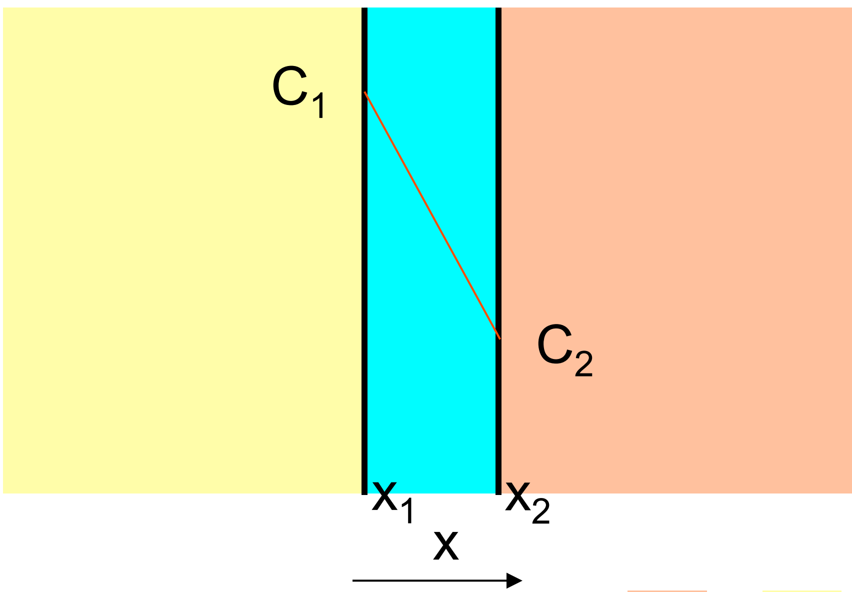
After some time



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

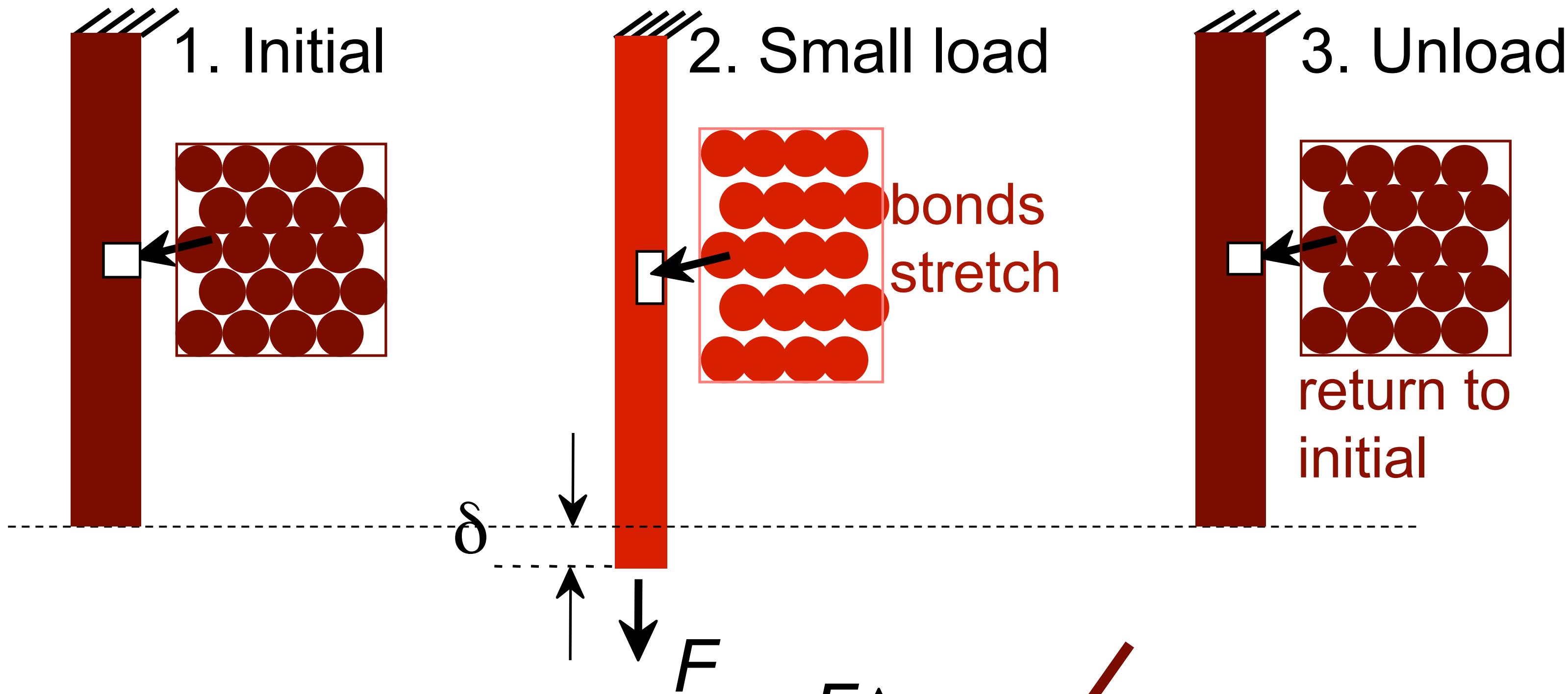
- The concentration of diffusing species is a function of both time and position $C = C(x,t)$
- In this case Fick's Second Law is used

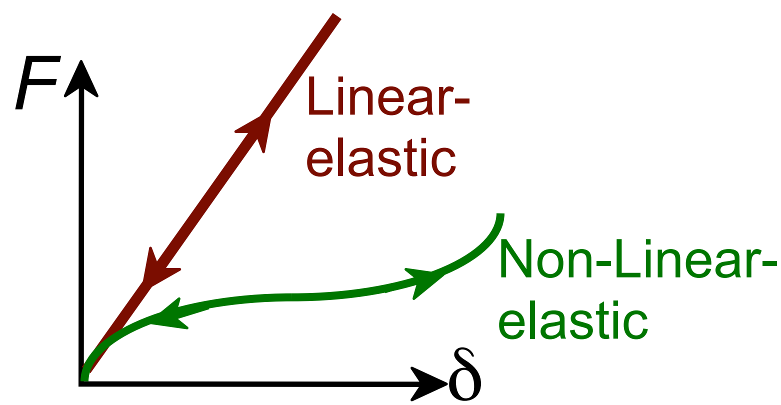
Fick's Second Law $$\boxed{\frac{\partial C}{\partial t} = D\frac{\partial^2 C}{\partial x^2}}$$

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

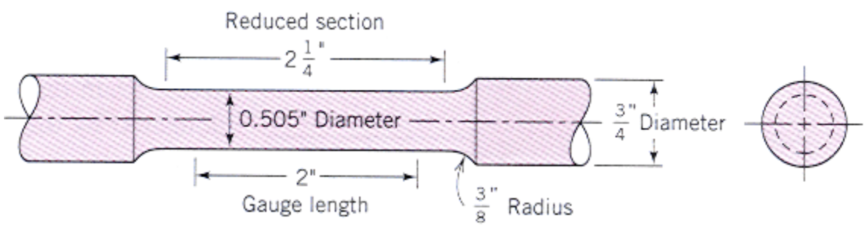


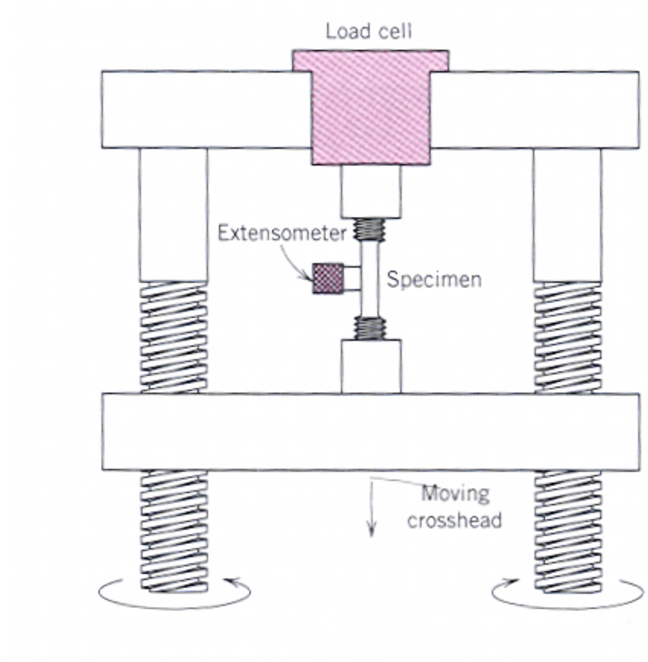


Elastic means reversible!

Concepts of stress and strain

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





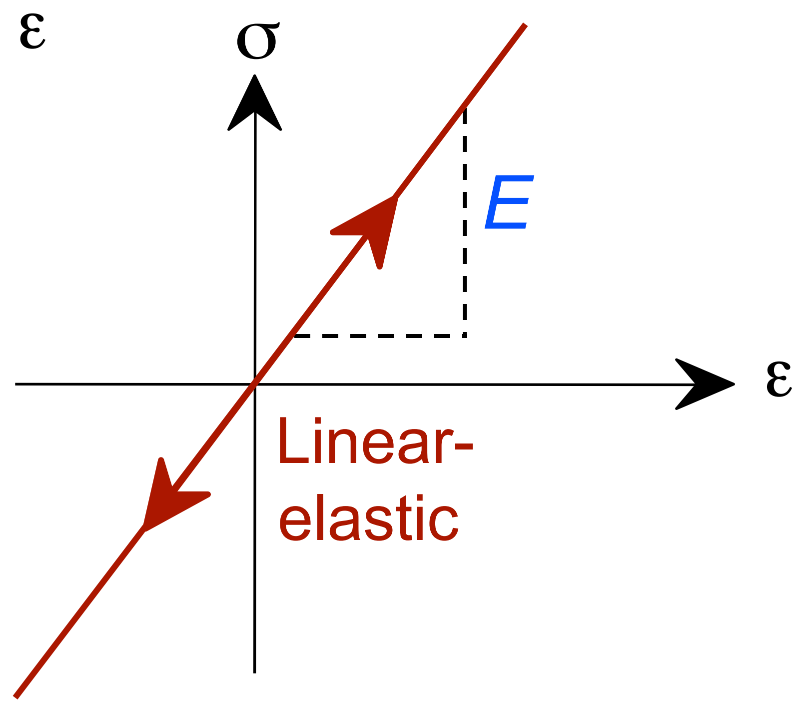
- Compression tests

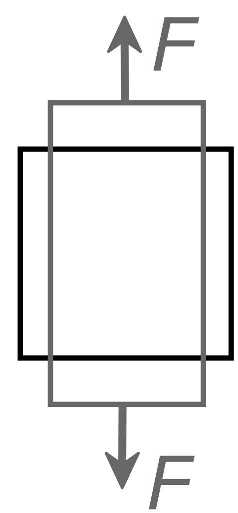
Linear Elastic Properties

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

- **Hooke's Law:**

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

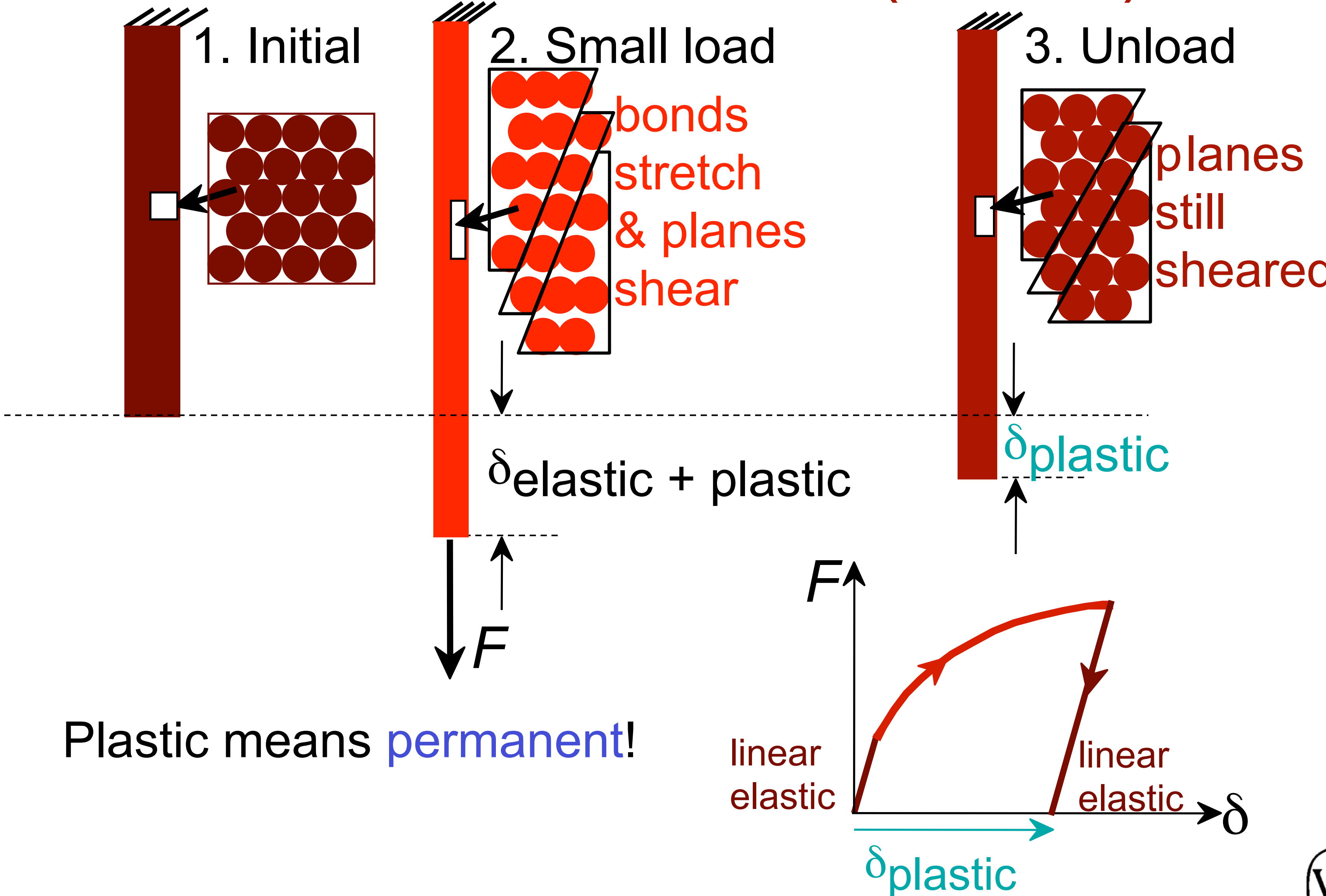




Plastic deformation

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

Plastic Deformation (Metals)

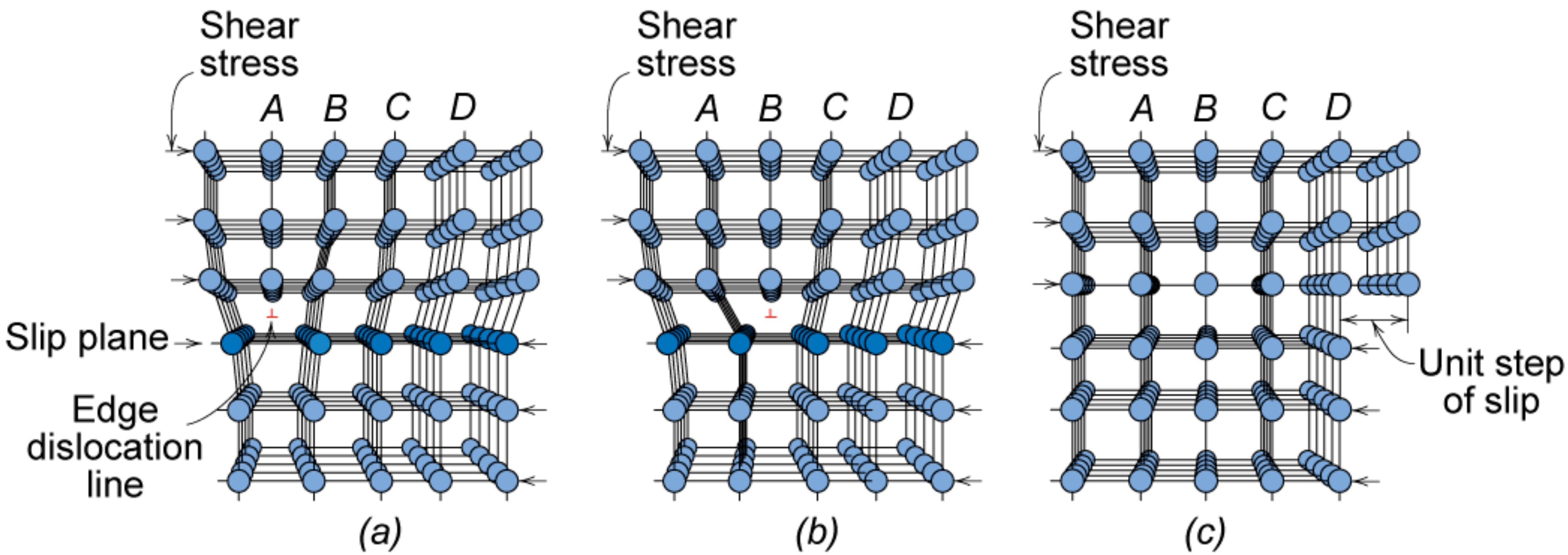


Plastic means permanent!

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.*

Remember to THINK!
and
GOOD LUCK