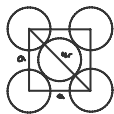


1. Question 1
a. Iron allotropy is affected by pressure in a similar way to temperature. As pressure increases a higher proportion of carbon can be forced into solution forcing the solution to become FCC, as the pressure is reduced, the interstitial carbon is forced out of solution as the structure becomes BCC.

b. For FCC, n=4
p = (nM_A) / (V_C M_A)
Where V_C = volume of a cube = a^3
p = (nM_A) / (a^3 M_A)

For a in terms of R in FCC



a^2 + a^2 = (4R)^2
a = 2*sqrt(2)*R
a^3 = 16R^3*sqrt(2)

p = (nM_A) / (16R^3*sqrt(2))
sqrt(2) = (pM_A) / (4nR^3)
R = (sqrt(2) * (4 * 63.5) / (8.94 * 6.023 * 10^23))^(1/3)
R = (sqrt(2) * (4 * 63.5) / (8.94 * 6.023 * 10^23))^(1/3)
R = 1.278 * 10^-8 cm
R = 0.128 nm

c. Atomic structure is the arrangement of subatomic particles, including protons, neutrons and electrons, that make up individual atoms.
Crystal structure is the repeating regular arrangement of atoms in a solid crystalline structure.

d. For a cubic unit cell:

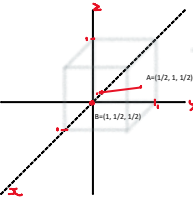


Table with 4 columns: Point, x, y, z. Rows: Point A (1/2, 1, 1/2), Point B (1, 1/2, 1/2), Resultant Vector (B-A) (1/2, -1/2, 0), Reduction (1, -1, 0).

Resultant indices [1T]

e. Sketch Planes in Unit Cell

Table for plane (012) with columns: Indices, Inverse, Intercepts. Values: Indices (0, 1, 2), Inverse (infinity, 1, 1/2), Intercepts (infinity, 1, 1/2).

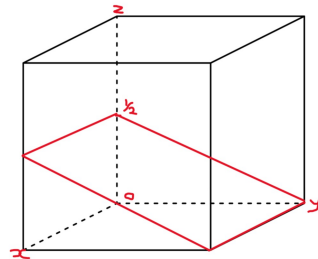


Table for plane (211) with columns: Indices, Inverse, Intercepts. Values: Indices (2, 1, 1), Inverse (1/2, 1, 1), Intercepts (1/2, 1, 1).

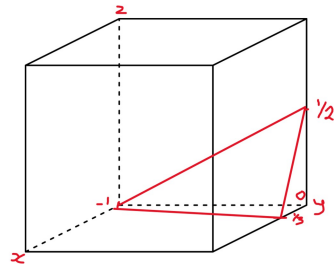
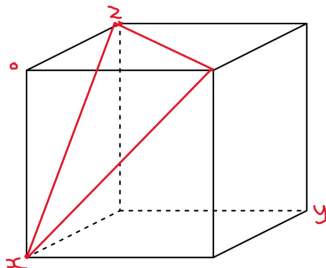


Table for plane (111) with columns: Indices, Inverse, Intercepts. Values: Indices (1, 1, 1), Inverse (1, 1, 1), Intercepts (1, 1, 1).





2. Phase Diagrams

a. 40wt% Ag 60wt% Cu at 800°C

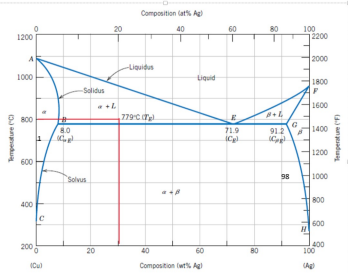


Figure 9.7 The copper-silver phase diagram. [Adapted from *Binary Alloy Phase Diagrams*, 2nd edition, Vol. 1, T. B. Massalski (Editor-in-Chief), 1990, of ASM International, Materials Park, OH.]

The alloy would contain a mixture of a phase and liquid phase in equilibrium.

b. Composition of α and Liquid Phases for 30wt% Ag 70wt% Cu at 900°C
From chart:

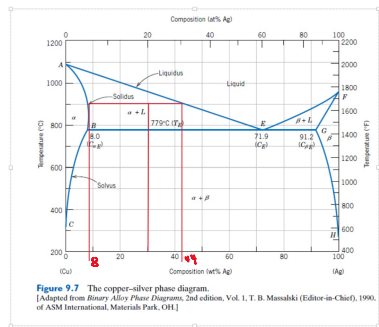


Figure 9.7 The copper-silver phase diagram. [Adapted from *Binary Alloy Phase Diagrams*, 2nd edition, Vol. 1, T. B. Massalski (Editor-in-Chief), 1990, of ASM International, Materials Park, OH.]

α = 8wt% Ag 92wt% Cu
L = 44wt% Ag 56wt% Cu

c. Fractional phase amount for α and β at 20wt% Ag 80wt% Cu at 400°C

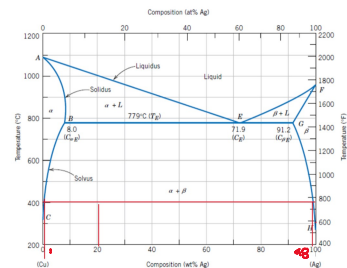


Figure 9.7 The copper-silver phase diagram. [Adapted from *Binary Alloy Phase Diagrams*, 2nd edition, Vol. 1, T. B. Massalski (Editor-in-Chief), 1990, of ASM International, Materials Park, OH.]

For Ag:

$$W_p = \frac{C_p - C_o}{C_p - C_s}$$
$$W_p = \frac{20 - 1}{91.2 - 1}$$
$$W_p = \frac{19}{90.2} = 0.20$$

$$W_s = \frac{C_p - C_o}{C_p - C_s}$$
$$W_s = \frac{91.2 - 20}{91.2 - 1}$$
$$W_s = \frac{71.2}{90.2} = 0.80$$

3. Defects

a. A Schottky defect is a anion vacancy, cation vacancy pair. The vacancies are paired which preserves the overall electroneutrality.

A Frenkel defect is characterized by a vacancy, usually a smaller cation is made vacant from a position in the lattice and forced interstitially elsewhere in the lattice. The structure remains electroneutral.

b. To calculate defect pairs:

$$N_v = N e^{\left(\frac{-E_f}{kT} \right)}$$
$$N_v = (1.58 \times 10^{23}) \cdot e^{\left(\frac{-2.6}{2 \cdot (8.62 \times 10^{-5}) \cdot (773)} \right)}$$
$$N_v = 5.32 \times 10^{14} \text{ defects m}^{-3}$$

4. Material Properties

a. Steel is suitable for car bodies due to the following material properties.

- Strength, when alloyed with elements such as manganese and vanadium a high strength to weight ratio desirable in automobiles as fuel economy in "green" cars and power to weight ratio in performance cars can be improved.
- Ductility, malleability & formability, steel can be formed and shaped in presses and dies to form complex shapes, these shapes can add structural strength allowing lighter cross sections to be used
- Hardness, resistance to dents and scratches is desirable for car manufacturers to produce vehicles with attractive, long lasting finishes.
- Abundance, iron is the 4th most abundant element in the earth's crust this increases availability to manufacturers and ultimately leads to reduced cost.
- Lifecycle, increasing environmental concerns in society have lead manufacturers to use materials that can be recycled. Recycling steel is a large portion of steel manufacture and compared with composites which are very difficult to recycle. Steel is an excellent choice.

b. 5 Considerations in the design of a lightweight car body:

- Mechanical loads, What forces will the body be subject to? Is the body structural or aesthetic? Structural materials would need to have a higher yield strength to undertake a load. Can the body be shaped in a way to distribute loads effectively in order to reduce material used and therefore weight? Is the design stress below the safe stress of the
- Wear and tear, Can the body be manufactured from a bake hardening material? Increasing formability in manufacture but having improved dent resistance when baked.
- Availability & Cost, can the material be readily sourced in the country of manufacture? Is the material available quickly? Does it have a shelf life that prevents maintaining stock?
- Corrosion resistance, is the finish aesthetically pleasing or will a paint need to be applied? If paint is to be applied, is the surface keyed for paint adherence?
- Safety, Is the body part of the crumple zone? Does the material behave predictably during failure? Does the material elongate over a high strain range or is the material brittle and fracture suddenly?