1. Determine the Miller indices of the cubic crystal plane that intersects the position coordinates (1, 1/4, 0), (1, 1, 1/2), (3/4, 1, 1/4), and all coordinate axes. (15%)

2. A sample of BCC iron was placed in an X-ray diffractometer using incoming X-rays with a wavelength λ=0.1541 nm. Diffraction from the {110} planes was obtained at 2θ=44.704°. Calculate a value for the lattice constant a of BCC iron. (Assume first order diffraction with n=1) (10%)

3. Consider the impurity diffusion on gallium into a silicon wafer. If gallium is diffused into a silicon wafer with no previous gallium in it at a temperature of 1100°C for 3h, what is the depth below the surface at which the concentration is 10^{22} atoms/m^3 if the surface concentration is 10^{24} atoms/m^3? For gallium diffusing into silicon at 1100°C. (D_{1100^oC}=7.0×10^{-17} m^2/s), $\dfrac{C_s - C_x}{C_s - C_o} = \mathrm{erf}(\dfrac{x}{2\sqrt{Dt}})$ (15%)

z	erf z
1.6	0.9763
1.7	0.9838
1.8	0.9891
1.9	0.9928
2.0	0.9953
2.2	0.9981
2.4	0.9993
2.6	0.9998
2.8	0.9999

4. Calculate the value of the diffusivity D in meters squared per second for the diffusion of carbon in γ iron (FCC) at 927°C (1700°F). Use values of D_o=2.0×10^{-5} m^2/s, Q=142 kJ/mol, and R=8.314 J/mol·K) (10%)

5. A copper-nickel alloy contains 47 *wt.*% Cu and 53 *wt.*% Ni and is at 1300°C. Use Figure 1 and answer the following: (20%)

   a. What is the weight percent of copper in the liquid and solid phases at this temperature?

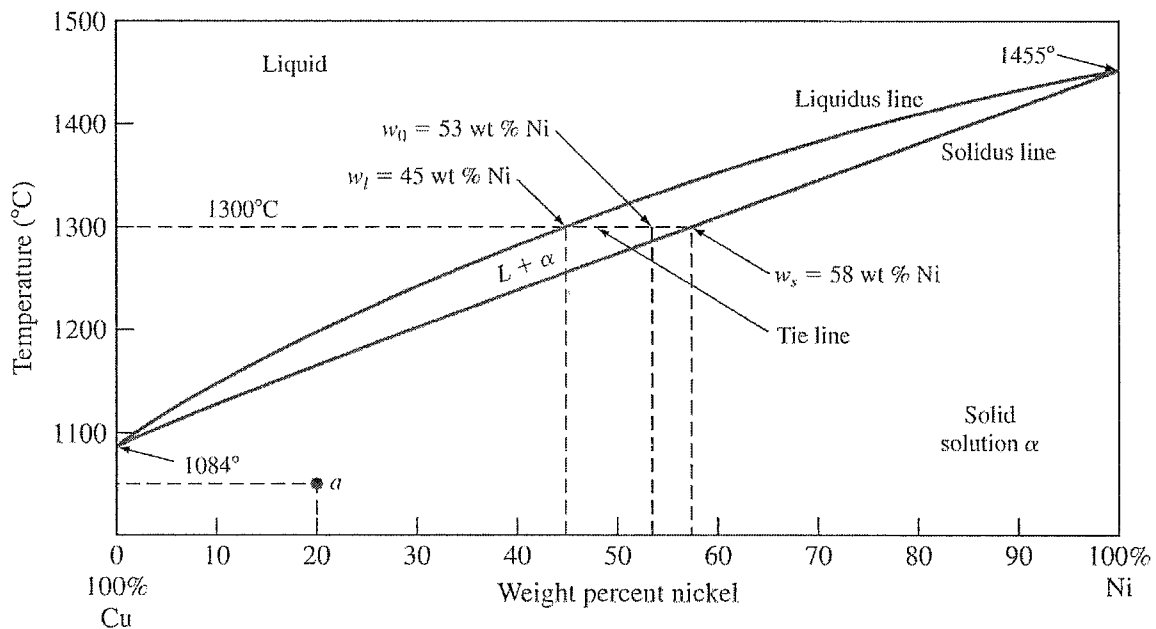   b. What weight percent of this alloy is liquid and what weight percent is solid?

Figure 1

6. Consider the titanium-nickel (Ti-Ni) phase diagram in Figure 2. This phase diagram has six points where three phases coexist. For each of these three-phase points: (30%)

a. List the coordinates of composition (weight percent) and temperature for each point.

b. Write the invariant reaction that occurs during slow cooling of the Ti-Ni alloy through each point.

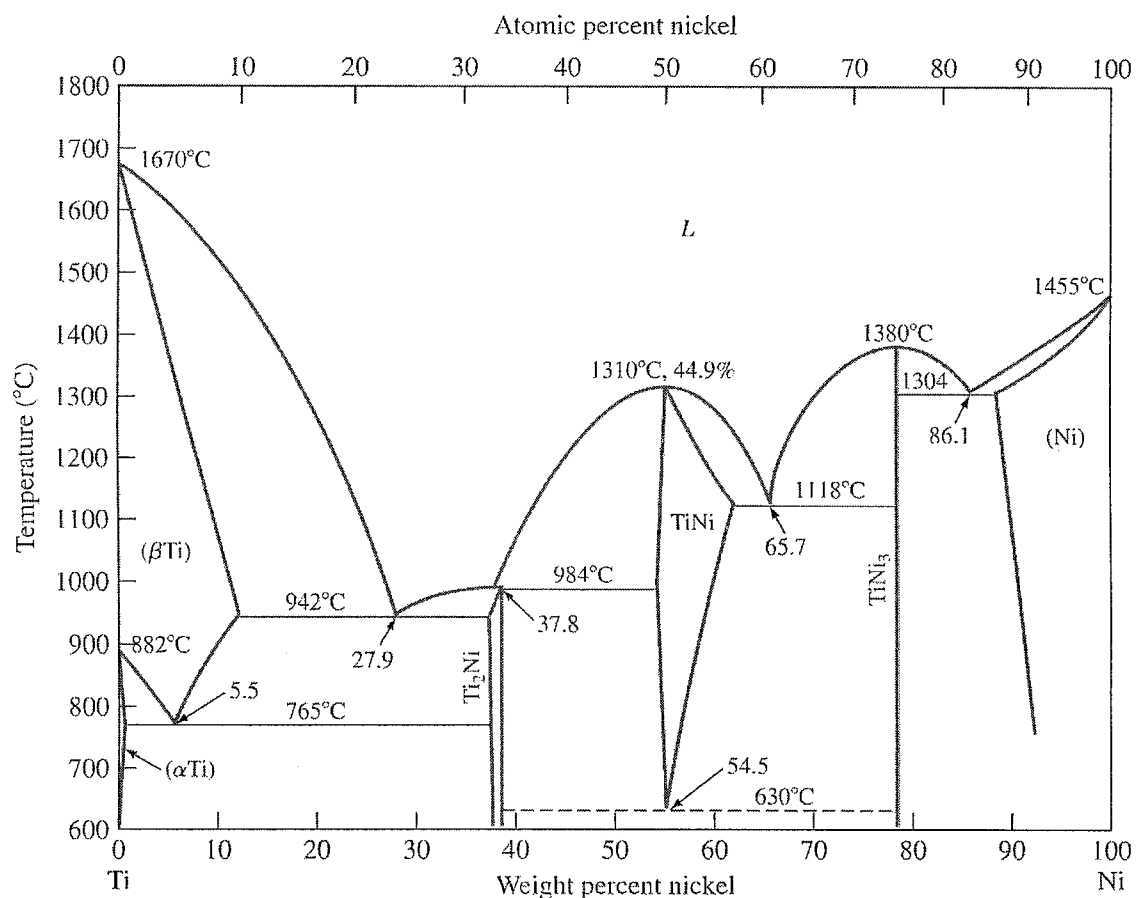c. Name the type of invariant reaction that takes place at each point.

Figure 2.