(1) A phase diagram of Ti-Ni binary system is as shown in Fig. 1. A diffusion couple made of pure Ti and pure Ni was completely welded. The couple is held at temperature 800°C for enough period of time, which means Ti-Ni interdiffusion occurs in the couple.
(a) Please schematically draw the couple by indicating each phase in it after the 800°C heat treatment (10);
(b) Please draw a plot of the variation of the composition Ni vs. weight percent of Ni across the phase diagram at 800°C with respect to the answer of question (a) (10)

(2) If a Bragg 41.31° angle is observed for first-order diffraction from the \{110\} plane of body centered cubic niobium using copper Kα1 radiation (\(\lambda = 0.1541\) nm), what is the interplanar spacing of the \{110\} planes in this metal? For niobium \(a = 0.3301\) nm. Compare the results calculating by the interplanar spacing equation and explain why they are different? (15)

(3) What type(s) of bonding would be expected for each of the following materials: rubber, solid xenon, bronze, nylon, and aluminum phosphide (AlP)? (10)

(4) An x-ray diffractometer recorder chart for an element that has either the BCC or the FCC crystal structure showed diffraction peaks at the following 2θ angles: \(40.663°, 47.314°, 69.144°,\) and \(83.448°\). (Wavelength \(\lambda\) of the incoming radiation was 0.15405 nm.)
(a) Determine the crystal structure of the element. (10)
(b) Determine the lattice constant of the element. (10)

(5) Explain how a precipitation-hardenable alloy is strengthened by heat treatment. What are the three basic heat-treatment steps to strengthen a precipitation-hardenable alloy? (10)

(6) Briefly explain the difference between hardness and hardenability. (10)

(7) Define the following terminologies: (15)
(a) Polymorphism
(b) Electronegativity
(c) Bragg's law
(d) Pauli exclusion principle
(e) Hypoeutectoid plain-carbon steels