ELEC-D8710 Principles of materials science **Intermediate Exam II**
17.4.2023

1. Figure 1 shows the Ni-Ti (Nickel-Titanium) phase diagram. With the help of the diagram, answer following questions:
a) What is the solubility of nickel to titanium at 650°C and 900°C? (1p)
b) Explain the equilibrium ($D_{Liq}=D_{solid}=\infty$) solidification (i.e. the compositions and amounts of phases as a function of temperature) from 1800°C to 600°C when the nominal composition of the alloy is Ti80Ni20 (at-%). You need to include in your answer **at least** following details. i) What is the composition of the solid phase when first solid crystals nucleate from the liquid and at what temperature this occurs? ii) What is the composition of the liquid just before it is completely solidified? iii) What phases are in equilibrium at 850°C and 750°C, what are the compositions and relative amounts of the phases at these temperatures? (5p)

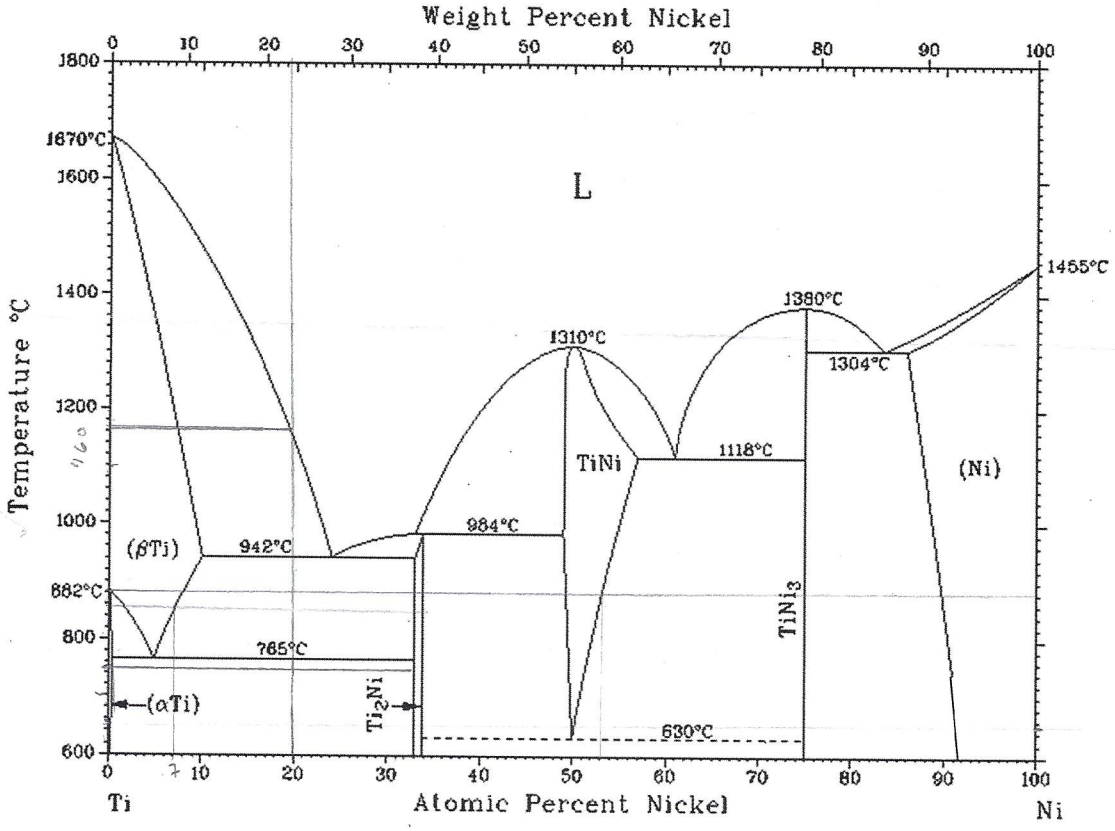

Figure 1: Ni-Ti binary phase diagram

2. Thick titanium (Ti) plate is attached against thick silicon (Si) wafer (=semi-infinite diffusion couple) at the temperature of 1200°C. Based on the phase diagram (see Fig. 2) draw the structure of the diffusion couple and the composition profiles for both components, when sufficient amount of time has elapsed so that local equilibria is achieved in all interfaces. (NB. Mark clearly the compositions of the phases at all interfaces!) In addition, explain briefly what happens if the temperature is then decreased down to 800°C (6p)

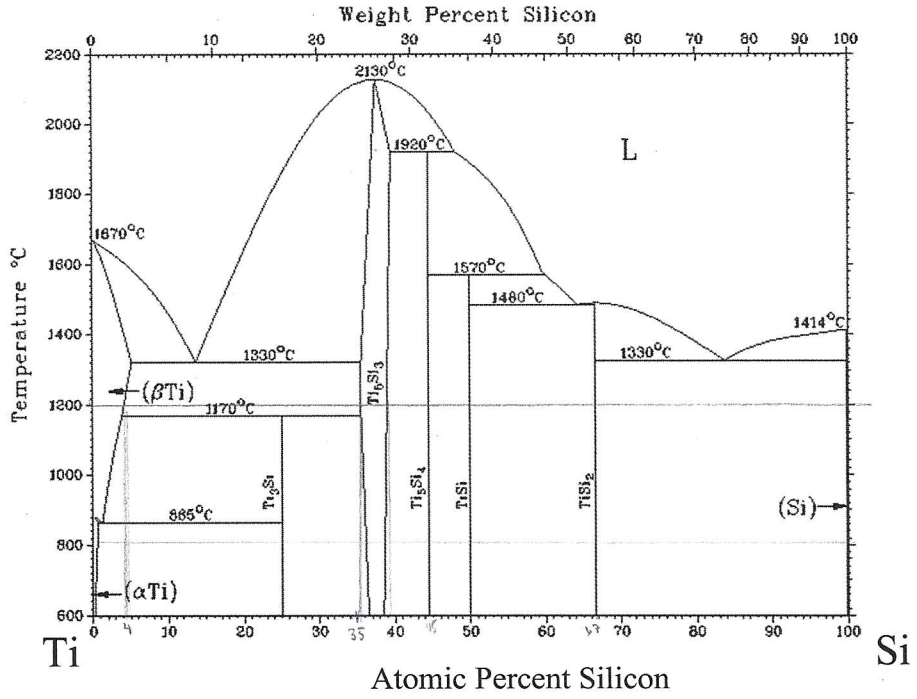

Figure 2 Ti-Si binary phase diagram [The phases in the Ti-Si system are: L(liquid), αTi, βTi, Si (diamond), Ti_3Si, Ti_5Si_3, Ti_5Si_4, TiSi and $TiSi_2$]

3. Explain briefly: i) volume diffusion mechanisms, and ii) the effect of temperature on volume (D_{vol}) and grain boundary (D_{gb}) diffusion (with the help of Figure 3 below). (3p)

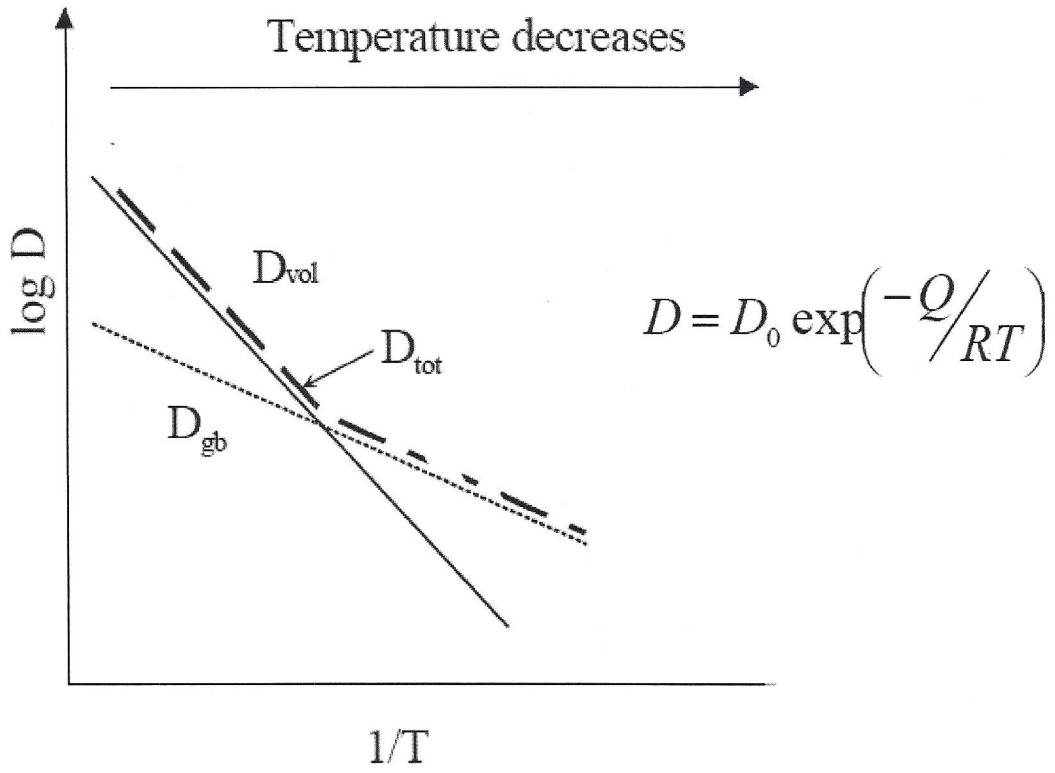

Figure 3