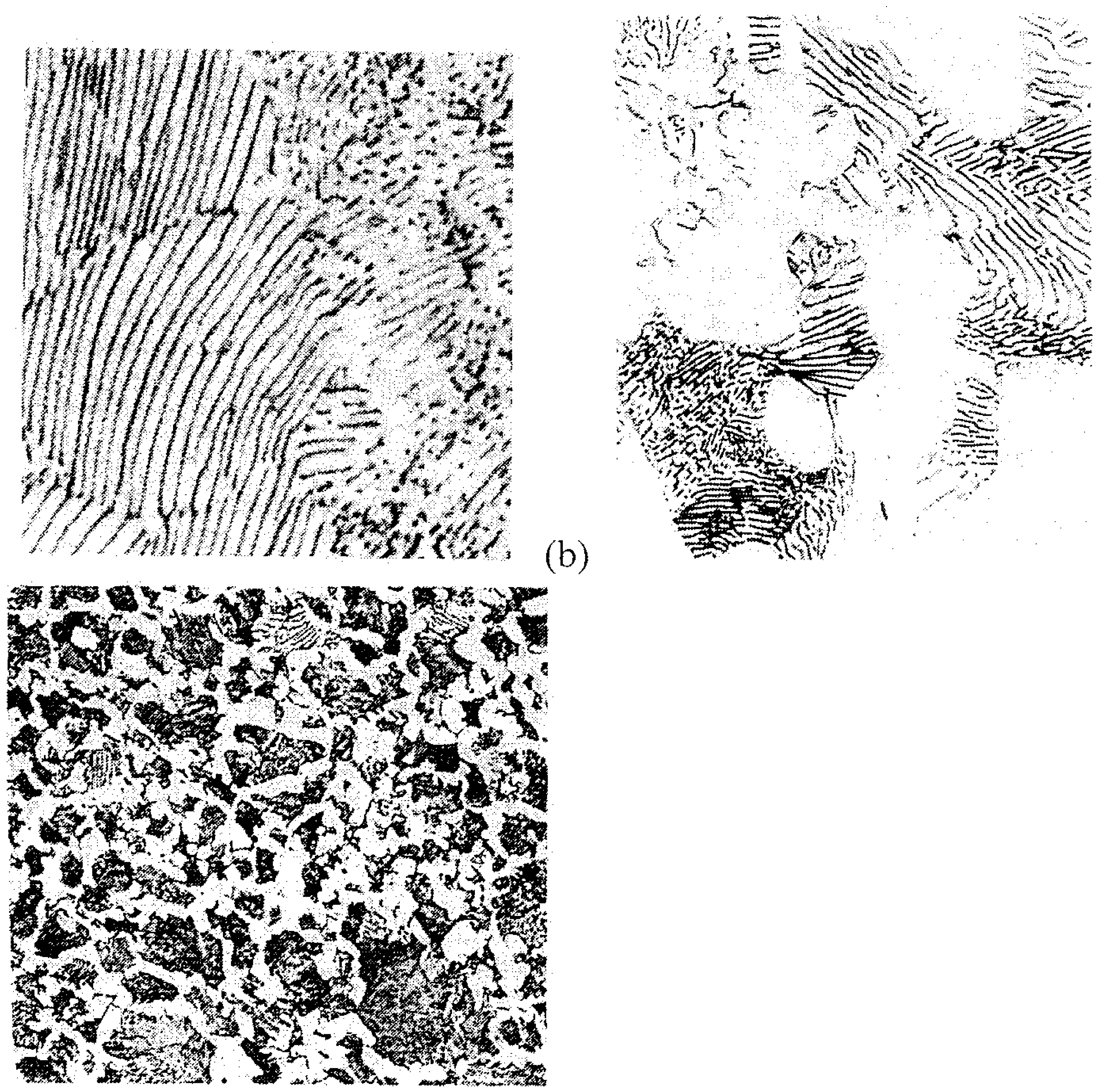
系所班組別：工程與系統科學系 甲組

考試科目（代碼）：物理冶金(2501)

1. Oh no! You dropped your steel specimens and can't remember which is which. You remember that the three steel grades are 1030, 1045, and 1080, but that's all. With nothing at your disposal but optical metallography facilities and furnaces (and the Fe-C phase diagram attached to the test), you quickly devise a scheme to save your job. Vowing to carefully label the specimens next time, you put all three in the oven to austenitize them for an hour.

Part A:

What temperatures and times are acceptable for the austenitization and why? After austenitizing you turn off the furnace and allow the specimens to cool very slowly. You obtain the following microstructures:



(a) (b) (c)

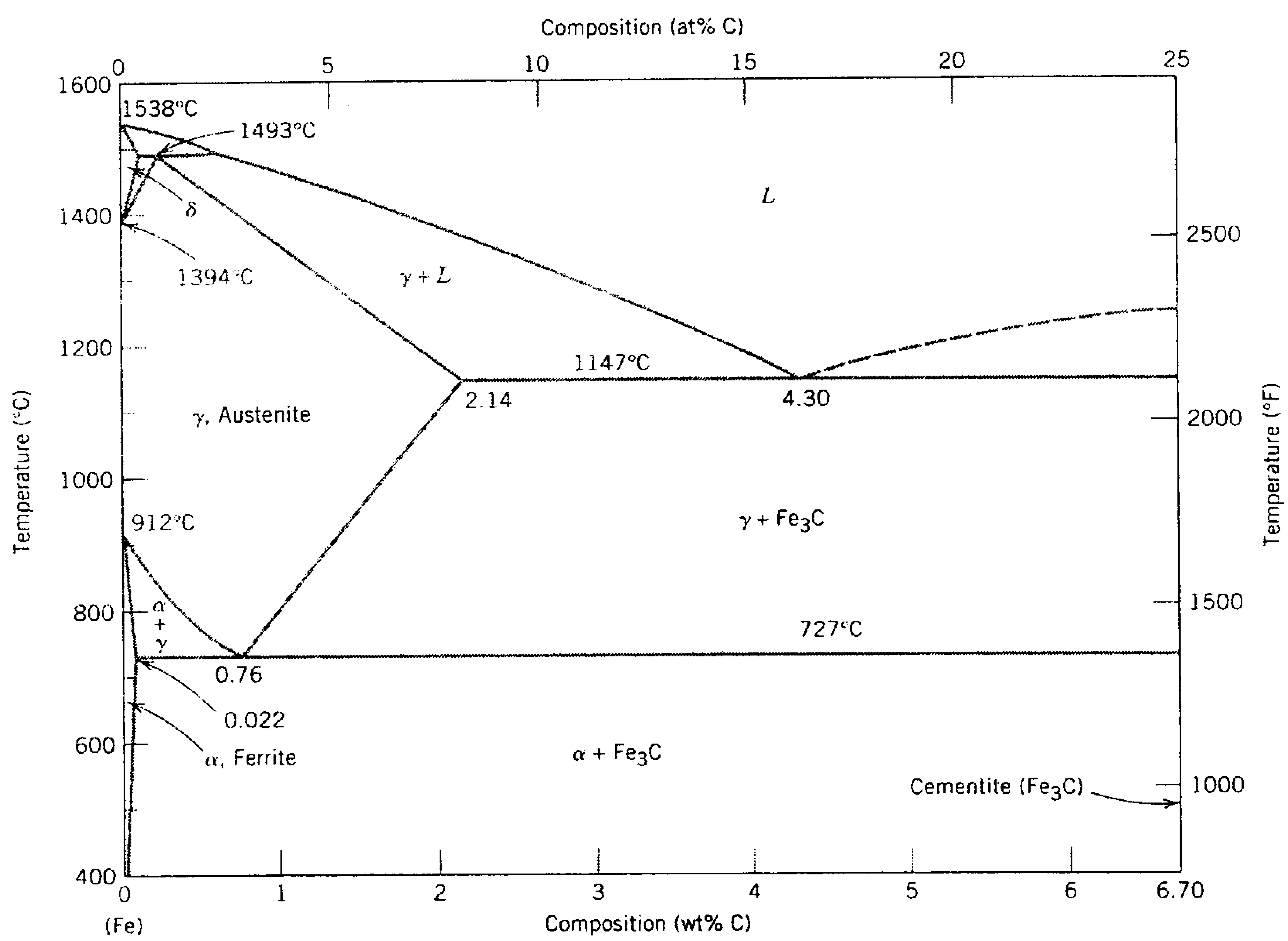


FIGURE The iron–iron carbide phase diagram. [Adapted from *Binary Alloy Phase Diagrams,* 2nd edition, Vol. 1, T. B. Massalski (Editor-in-Chief), 1990. Reprinted by permission of ASM International, Materials Park, OH.]

Part B:

Identify which steel is which on the basis of the microstructures, and write the logic of your thought process that led to your conclusions. (20%)

2. It is determined by experiment that the Kirkendall markers placed at the interface of a diffusion couple, formed by welding a thin plate of metal A to a similar plate of metal B, move with a velocity of 4.5×10^{-12} m/s toward the A component when the concentration $N_A = 0.38$ and the concentration gradient, dN_A/dx, is 2.5×10^{2} per m. The chemical diffusion coefficient $\widetilde{D}$ under these condition is 3.25×10^{-14} m^2/s. Determine the value of the intrinsic diffusivities of the two components. (20%)

3. You are working with a multi-component alloy that derives strength from three sources:
   (1) a fine grain size
   (2) solid solution strengthening from a fine interstitial
   (3) a precipitated dispersion of ~25 nm intermetallic particles

   Your specimen was just deformed past the upper yield point, so that the dislocations have broken away from their solute atmospheres.
   Describe the three major processes of structural evolution that take place in the alloy when you anneal it, and explain how these changes affect the strengthening gained from (1), (2), and (3) above. Include in your description the time laws of each process. (20%)

4. Dynamic recovery can start during plastic deformation.
   (a) When dynamic recovery occurs, how will the effective work hardening rate change? (4%)
   (b) What is the primary mechanism involved in dynamic recovery at different temperatures? (4%)
   (c) Discuss how the temperature would affect the occurrence of dynamic recovery? (6%)
   (d) Discuss how the magnitude of stacking fault energy of FCC metals would affect the occurrence of dynamic recovery? (6%)

5. (a) Derive the relation between vacancy concentration and temperature using statistical mechanics and basic thermodynamics. Remember the mixing entropy for the presence of vacancies are given as following:

$$S_m = K[(n_o + n_v)\ell_n(n_o + n_v) - n_v\ell_n n_v - n_o\ell_n n_o]$$

Where S_m = mixing entropy

國立清華大學104學年度碩士班考試入學試題

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　　*請在【答案卷】作答

n_v = the number of vacancies

n_o = the number of atoms　　　K = Boltzman's constant

(b) Vacancy supersaturation C_v/C_v^{eq} is defined as the ratio of the real vacancy concentration to the equilibrium vacancy concentration. Consider a metal is quickly quenched from a temperature T_h to a lower temperature T_l, while retaining all the vacancies from T_h. What the vacancy supersaturation would be if divacancy formation occurred at T_l ? $C_v^2/C_v = \beta/2 \times \exp(q/kT)$? (Assume the necessary thermodynamic data are known.)　　(20%)