MSE 310
Kinetics and Microstructural Evolution
2015-2016 Spring
Self Study Questions - 2

1- If 60% recrystallization of 70% cold worked iron takes 40 minutes at 600°C and 8 minutes at 650°C, how long would it take at 700°C? State your assumptions. ($X_r = 1 - \exp(-kt^n)$)

2- What is the relation between recrystallization rate and fraction recrystallized?

3- Compare the homogenous and heterogenous transformations with respect to change in the driving force during transformation.

4- Sketch the total free energy versus size curves on the same plot for homogenous nucleation at two different temperatures $T_1 > T_2$. Label the critical points.

5- If the surface energy of the grain boundary $\gamma_{\alpha\alpha}$ is equal to the surface energy of the nucleus/parent interface, $\gamma_{\alpha\beta}$, calculate the ratio $\Delta G^*(het)/\Delta G^*(hom)$ for a second phase β particle heterogenously nucleated on grain face of α. Given that,

$$\Delta G(het) = \left[\frac{4}{3}\pi r_{\alpha\beta}^3 \Delta G_B + 4\pi r_{\alpha\beta}^2 \gamma_{\alpha\beta}\right]\left[\frac{2 - 3S + S^3}{4}\right]$$

6- Consider that an iron sample with fully annealed hardness of 400 VHN is cold worked to 550 VHN. If this sample can recover to 500 VHN in 2 hours at 400°C, and to 450 VHN in 16 hours at 500°C, calculate the time necessary for recovery to 425 VHN at 600°C.

$$ln\left(\frac{P - P_{CW}}{P_a - P_{CW}}\right) = -Aexp(\frac{-Q}{RT})t$$

P_{CW}: cold worked property

P_a: annealed property

Hint: Take P in equation as hardness value

7- Sketch the TTT diagram for 95% recrystallization of

a.40% cold worked Al

b.60% cold worked Al

c.80% cold worked Al

8- Schematically skecth the energy dissipation, ΔP, versus time, t, curves that would be obtained from constant temperature thermal analysis of pure aluminum which has been

a.Cold rolled by 40% and analysed at 400°C.

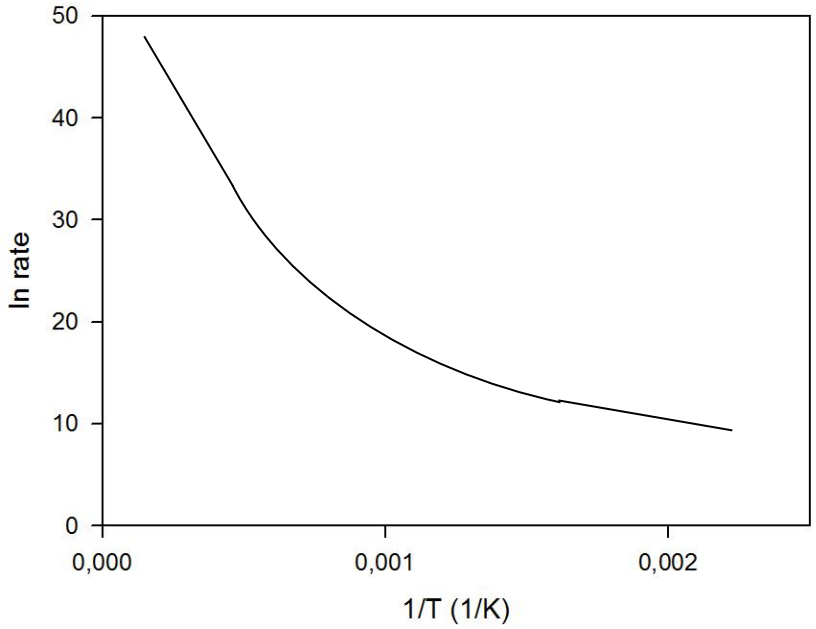
b.Cold rolled by 40% and analysed at 150°C.

c.Cold rolled by 80% and analysed at 400°C.

9- Discuss how the rate of following reactions change? Draw schematically the rate curves.

a.Two dependent processes
b.Two independent processes

10-Consider the below given kinteic data obtained experimentally for a transformation consisting of two atomic processes. Assuming that each atomic process obeys Arrhenius kinetics ($k=k_o exp(-Q/RT)$), determine the activation energy (Q) and pre-exponential constant (k_o) for each atomic process, and predict whether these processes are operating dependently or independently. Also calculate the overall rate of the transformation at 1000 K if the processes operate (a) dependently, (b) independently.



11- The recrystallization kinetics of a cold worked material was followed at 421°C and 358°C by resistivity technique. The following table shows the time taken to transform at each temperature to the fraction, Xr, indicated:

X_r	0.05	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
t(sec.)421°C	2.4	3.2	4.3	5.4	6.5	7.5	8.5	9.8	12	16
t(sec.)358°C	9.7	12	16	20	25	28	33	38	45	56

a. Plot the sigmoidal transformation curve (X_r vs. logt graph),
b. Calculate the time exponent, n, and the activation energy, Q, of this transformation,
c. Determine the time required for 25% transformation at 400°C,
d. Plot schematically recrystallization rate vs. time curve at a given temperature.

12- Specify the variables that affect recovery and recrystallization rates? Discuss their effects on the rate of those processes.

13- Questions 8.1, 8.2, 8.3 and 8.4 in Chapter 8 ‘’Nucleation’’.

14- Briefly explain why solid state transformations’ rate (i.e. austenite to pearlite trasformation) is highest at a moderate temperature. (rate is not high at higher or lower temperatures).
(Hint: Answer the question by considering the effect of mobility and driving force on nucleation)