MSE 230 **Assignment 7** **Fall 2013**

(due 10/10, 10/11)

***Problems with an * by them will not be graded, but solutions will be provided.**

1.* Callister Problem 5.6: The purification of hydrogen gas through a palladium sheet was discussed in Section 5.3. Compute the number of kilograms of hydrogen that pass per hour through a 5-mm thick sheet of palladium having an area of 0.20 m^2 at 500°C. Assume a diffusion coefficient of 1.0 x 10^{-8} m^2/s, that the concentrations at the high- and low-pressure sides of the plate are 2.4 and 0.60 kg of hydrogen per cubic meter of palladium, and that steady state conditions have been attained.

2.* Which element would you expect to diffuse through iron more rapidly, carbon or chromium? Which element would have the higher activation energy for diffusion? Please explain your answer.

3. **On the same graph**, sketch qualitatively correct plots of ln(D) vs. 1/T for i) carbon diffusing through BCC iron and ii) radioactive iron diffusing through BCC iron. Please provide reasons for any differences between the two plots (this is a follow up from problem 2).

4. The steady-state diffusion flux through a metal plate is 5.4 x 10^{-10} kg/m^2s at a temperature of 727°C (1000K) and when the concentration gradient is –350 kg/m^4. Calculate the diffusion flux at 1027°C (1300 K) for the same concentration gradient and assuming an activation energy for diffusion of 125,000 J/mol.

5.* Problem 5.15 in Callister: For a steel alloy it has been determined that a carburizing heat treatment of 10 h duration will raise the carbon concentration to 0.45 wt% at a point 2.5 mm from the surface. Estimate the time necessary to achieve the same concentration at a 5.0-mm position for an identical steel and at the same carburizing temperature.

6. The wear resistance of a steel shaft is to be improved by hardening its surface. This is to be accomplished by increasing the nitrogen content within an outer surface layer as a result of nitrogen diffusion into the steel; the nitrogen is to be supplied from an external nitrogen-rich gas at an elevated and constant temperature. The initial nitrogen content of the steel is 0.0025 wt%, whereas the surface concentration is to be maintained at 0.45 wt%. For this treatment to be effective, a nitrogen content of 0.12 wt% must be established at a position 0.45 mm below the surface. Specify an appropriate heat treatment in terms of temperature and time for a temperature between 475°C and 625°C. The preexponential and activation energy for the diffusion of nitrogen in iron are 3 x 10^{-7} m^2/s and 76,150 J/mol, respectively, over this temperature range.

7. Several samples of a ductile metal are subject to 50% cold work using a rolling mill. The samples are then given recrystallization heat treatments at temperatures ranging from 0.40 to 0.70 of T_m (the melting temperature of the metal). Sketch a qualitative plot of recrystallization time (y-axis) versus recrystallization temperature (x-axis) for the samples. Please explain your answer.