Ph.D. Qualifying Examination

Materials Science

Fall 2015

Logistics Notes:

- Time allowed: 2 hours.
- Problems count 25 points each (total=100 points).
- Exam is closed-book and closed-notes
- State your assumptions, methods, and procedures. Show your work on these exam sheets. (Add additional sheets, if needed.)
- Calculators are allowed.
- Laptops, tablets and cell phones are not allowed.

1. A high carbon content steel (e.g., 3 wt% carbon) is heated to 2000 °C and is rapidly cooled down to room temperature. It is then subjected to either 700 °C for 24 hours or 300 °C for 4 hours. (Eutectoid temperature for steel is 723 °C)

   a) Schematically explain the resulting microstructures.
   b) What are their strengthening mechanisms.

2. A structural design requires a material with the following minimum requirements: stiffness of 300 GPa and strength of 1500 MPa. What is your material of choice if: [Justify your answers]

   a) The service temperatures is1800 °C and some toughness is required.
   a) The service temperature is only 150 °C but it has to be very lightweight.

3. Consider ceramics made of ionic crystals. Stable ionic crystal structures form when the anions surrounding a cation are all in contact with that cation. Show that the minimum cation-to-anion radius ratio for a coordination number of 8 is 0.732.

4. The diffusion coefficients for carbon in nickel are: 5.5×10^{-14} m^2/s at 600ºC, and 3.9×10^{-13} m^2/s at 700ºC. Calculate the diffusion coefficient at 780ºC assuming the same diffusion mechanism operates. (Gas constant R = 8.314 J/mol-K.)