0601F: The Sintering Equation

09/23/21: Practice HW on the topic of the Sintering Equation

1.

Please review the six steps in p.2 of the notes that form the basis for the derivation of the equation that gives the time for sintering.

State what you consider to have been the most significant assumptions in the implementation of these steps in the derivation given in pages 3 and 4.

2.

The relative density of the body is related to the size of the pores and the size of the grains (or the particles).

If the pore radius is "r" and the grain size in the fully sintered body is "d", derive an expression for the relative density of the body as a function of the ratio $\frac{2r}{d}$.

Note the pore size is written as "2r", i.e. the diameter of the pore.

Hint:

•assume that there is one pore per cube (the grain is assumed to be a cube)

•Relative density = (final volume of one grain = d^3)/(d^3+volume of one pore)

Note that the relative density is less than unity in the presence of pores. At full density the pore volume goes to zero and the relative density approaches one.

Make a plot of the relative density as a ratio of (2r/d). What is the value of (2r/d) when the relative density = 0.5.

Note: the "green density" refers to the relative density of the body when made from powders, at the onset of sintering. Typical value of the green density is 0.5.

3.

The time for sintering was derived to be given by

$$t_S = \frac{1}{450}\frac{k_B T d^4}{\delta_{gb} D_{gb} \gamma_S \Omega}$$

The grain boundary diffusion coefficient for zirconia (where the diffusion of zirconium ion is rate controlling) is given in the upper data in the figure below

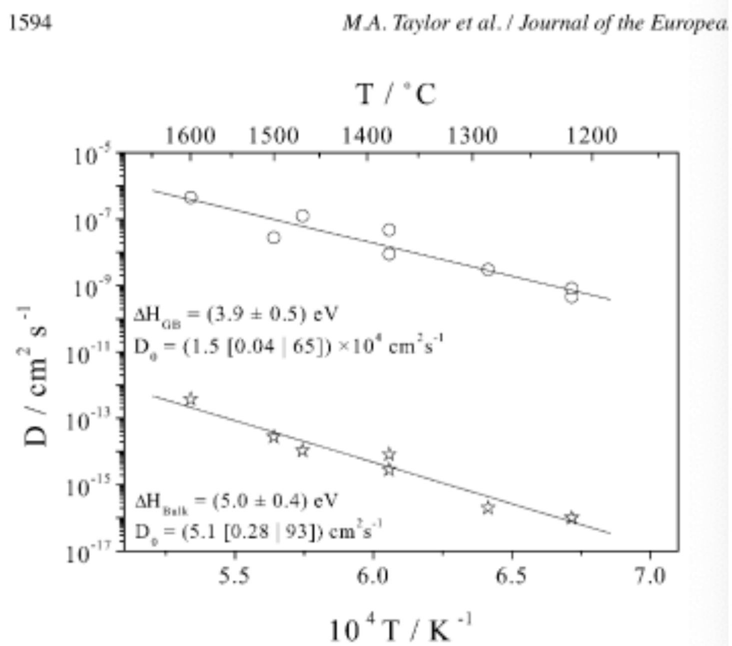

Fig. 3. Temperature dependency of ^{96}Zr tracer diffusivities. Symbols correspond to bulk diffusion (☆), and grain boundary diffusion (○), respectively.

- Assume that sintering is carried out 1t 1400 °C with a particle size of 100 nm.
- Assume that surface energy is 1 J m^{-2}.
- Assume that the width of the boundary is equal to $1.5 * \Omega^{\frac{1}{3}}$.
- Note that grain boundary diffusion coefficient is given by the upper curve, plotted with circles in the above figure.

Calculate the time required to sinter this body, as predicted by the sintering equation.