1. **Accumulate 100 points (out of 140).**

2. **If you submit more than 100 points, the grade will be calculated as a ration between “applied” and “earned”.**

Submission date: 15/06/2021

Q1(20 points)

The true stress is defined as $\sigma_t \equiv \frac{F}{A}$ in contrast to the engineering stress, which is defined as $\sigma \equiv \frac{F}{A_0}$. Please describe the true stress, at small deformation, using the engineering stress, σ, engineering elastic strain, ε, Poisson's ratio , ν, and Young's modulus, E.

(you don't necessarily need to use all the above)

Q2 (20 points)

The elastic constants of Fe are C_{11}=234 GPa; C_{12}=136 GPa and C_{44}=44 GPa.

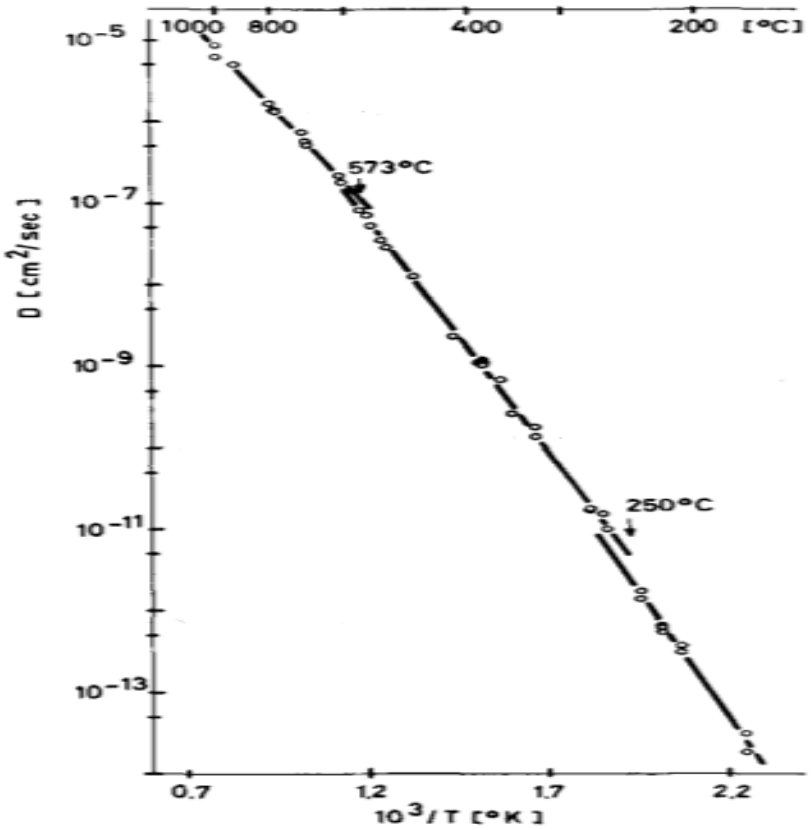
A single crystal bar of Fe, with 1 mm diameter, is subjected to a tension of 100 MPa (smaller than the yield stress) along (100) direction. Find:

a) the relative change of length (strain) along the (100) direction.

b) the diameter of the bar under the given tension.

Q3 (20 points)

Silicon oxide is used in semiconductor technology as a insulator layer in transistors. Typical thickness of the layer is 10 nm. The operating voltage is 5 V. Using the diffusion diagram below, please determine how long will the transistor operate if the layer is contaminated by Na, at room temperature?



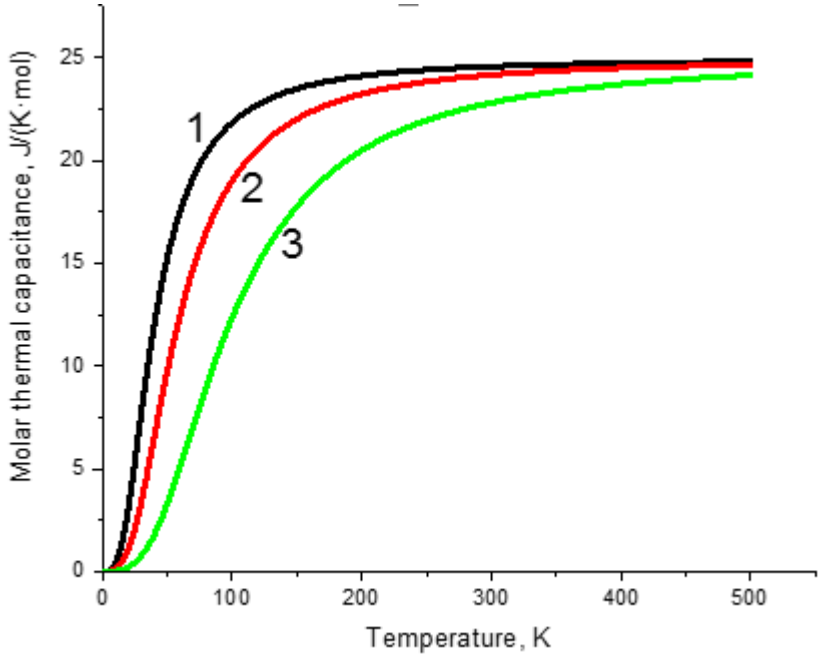
Temperature dependence of Na diffusion in SiO_2 glass

Q4 (20 points)

A palladium plate of 1 mm thick is heated to 600 ° C. The hydrogen pressure on one side of the model is equal to 0.1 atm and on the other side to 0.75 atm (syngas conditions). Under these conditions, it is assumed that the hydrogen molecules at the palladium surface are completely decomposed and the monatomic hydrogen concentration is equal to 5% of the total hydrogen gas. Assuming that all the monoatomic hydrogen is concentrated at the palladium surfaces, please calculate the hydrogen flow in the sample, if the activation energy is equal to 0.22 eV and $D_0 = 2.4 \times 10^{-7}$ [m^2 / s].

Q5 (20 points)

Please have a look at the graph of molar thermal capacitance for three different materials with similar densities. Please rank the materials in the order of increasing Young's modulus. Please give a brief explanation to your judgement.



Q6 (20 points)

Aluminum sample with a volume of 2500 cm^3 was heated by a heating element with a power of 175W for 1 hour. As a result, the sample volume increased to 2518 cm^3. Using the following data, calculate the linear thermal expansion coefficient of aluminum:

Q7 (20 points)

Please estimate the contribution of vacancies to the overall thermal expansion of Fe from room temperature to 700 ºC, if the energy for vacancy formation is 0.9 eV/atom.

Density: 7.88 g/cm^3

Linear Thermal Expansion : 1.18×10^{-5} K^{-1}

Molar Mass: 55.85 g/mol