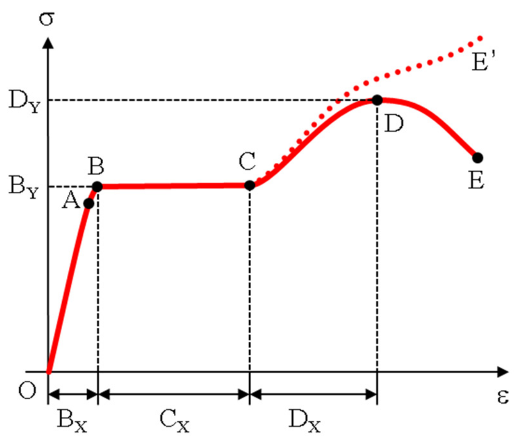
Final Exam

2017. 06. 20. 13:00~15:00, Closed Book
Instructor: Seungtae CHOI

1. (15 points) The steady-state diffusion flux through a metal plate is 5.0×10^{-10} kg/m^2·s at a temperature of 727 °C (1000 K) and when the concentration gradient is –500 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 83,100 J/mol.

2. (20 points) The following graph represents a typical stress-strain curve for mild steels obtained from tensile test.
   (a) Provide detailed explanation of the regions OB, BC, and CD, the values B_Y, D_Y, B_X, C_X, and D_X.
   (b) Explain the dashed curve (CE') with the definition of true stress and true strain, and the relationships between true stress and nominal stress, and between true strain and nominal strain.



3. (15 points) Please answer the following questions.

   (a) Provide detailed explanation on four strengthening mechanisms.
   (b) Explain the fracture criterion in linear elastic fracture mechanics.
   (c) Explain why K_C depends on the specimen thickness and thus how fracture toughness (K_{IC}) can be defined.

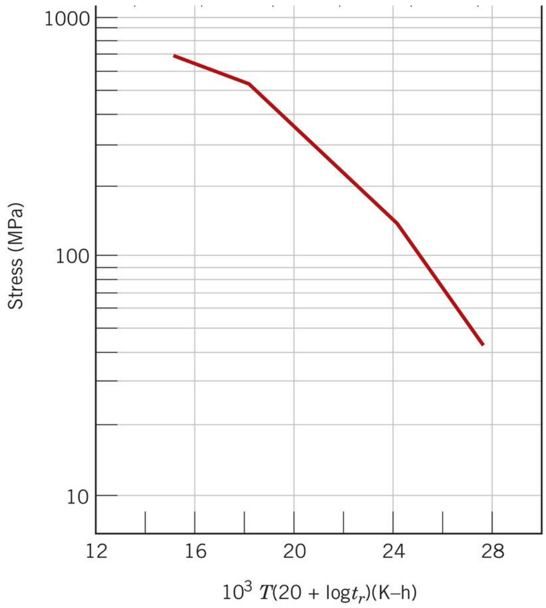
4. (20 points) Please answer the following questions.

   (a) Explain the creep behavior and stress relaxation behavior of viscoelastic polymers.
   (b) Explain the fading memory effect of polymeric materials.
   (c) Explain the glass transition temperature.
   (d) Explain the crazing phenomenon in cracking of thermoplastic polymers.

5. (15 points) Creep strain can be given in the form of Arrhenius-type equation as follows:

$$\dot{\varepsilon}_s = K_2 \sigma^n \exp\left(-\frac{Q_c}{RT}\right)$$

(a) Derive the Larson-Miller parameter relation from the above equation.
(b) Consider an S-590 alloy component that is subjected to a stress of 180 MPa. At what temperature will the rupture lifetime be 1000 h?



6. (15 points) Consider a thin-walled spherical tank of radius r and thickness t that may be used as a pressure vessel, for which a design concept, 'leak-before-break', will be used. Based on principles of fracture mechanics, allowance is made for the growth of a crack through the thickness of the vessel wall prior to the occurrence of rapid crack propagation. Thus, the crack will completely penetrate the wall without catastrophic failure, allowing for its detection by the leaking of pressurized fluid. Determing the maximum allowable pressure consistent with this leak-before-break criterion. (Hint: the critical crack length a_c (i.e., one-half the total internal crack length) is taken to be equal to the pressure vessel thickness t, and the stress intensity factor for the given geometry is given as $K_I = Y\sigma\sqrt{\pi a}$, where Y is a shape factor.)