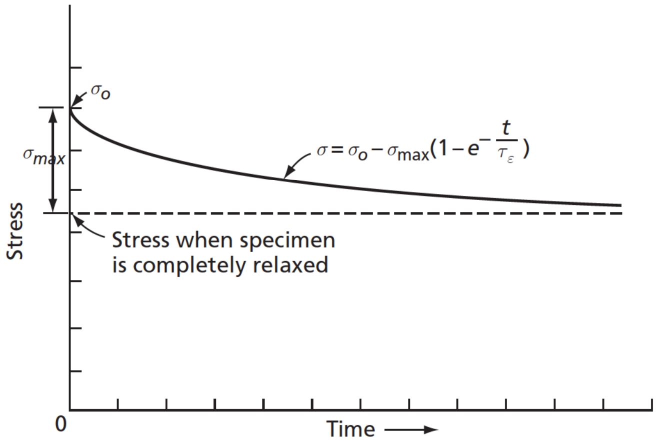

FIG. 13.12 The relaxation of the stress at constant strain

where M_U is the unrelaxed modulus and M_R is the relaxed modulus. Both of these relaxation times are related to that obtained in a torsion pendulum as follows[16]

$$\tau_R = (\tau_\sigma \tau_\varepsilon)^{1/2} \qquad \textbf{13.53}$$

This shows that τ_R, obtained in a torsion pendulum, is the geometric mean of the other two relaxation times.

PROBLEMS

13.1 For interstitial diffusion in a body-centered cubic lattice, prove that α, in the diffusion equation $D = \alpha a^2/\tau$, equals 1/24.

13.2 (a) Determine the mean time of stay of an oxygen atom in an interstitial site in niobium at 300 K. See Table 13.2 for the necessary diffusion parameters and take the lattice parameter, a, for niobium as 0.3301 nm.

(b) Do the same for a temperature of 400 K.

13.3 In a special torsion pendulum used for elastic after-effect measurements, it is not practical to measure the relaxation time if it is less than 1 minute. On this basis, determine the maximum temperature at which the apparatus should be used for determining the relaxation time of nitrogen atoms in iron. Take a = 0.28664 nm and see Table 13.2 for the diffusion equation of iron.

13.4 Compare the relaxation times, τ_σ, of vanadium and tantalum, due to the presence of oxygen atoms in solid solution, at 400 K. The lattice parameters of vanadium and tantalum are, respectively, equal to 0.3029 and 0.3303 nm.

13.5 (a) Determine the mean time of stay, τ, of a nitrogen atom in a tantalum interstitial site at 400 K.

(b) At what temperature would τ equal 1.0 second?

13.6 A torsion pendulum with a tantalum wire has a pendulum frequency, ν, of 0.82 Hz. When the logarithmic decrement, δ, is measured with this pendulum, the peak in the plot of δ versus $1/T$ occurs at 415.5 K. Show by using Eq. 13.45, with T = 415.5 K, that this peak corresponds to the presence of oxygen in the tantalum.

13.7 A torsion pendulum with a vanadium wire containing nitrogen and a period of 2.00 seconds shows a decrease in the pendulum amplitude, A, of 10 percent in 100 cycles of oscillation at 350 K. Compute:

(a) The specific damping capacity.

(b) The logarithmic decrement.

(c) Tan α, where α is the phase angle by which the strain lags the stress.

13.8 Write a computer program suitable for obtaining data to make a plot of the logarithmic decrement, δ, versus the reciprocal of the absolute temperature, $1/T$ using Eq. 13.42, in order to obtain a "bell shaped" Lorentz curve. In determining the data, vary $1/T$ from 1.4×10^{-3} to 2.1×10^{-3} in steps of 1.0×10^{-5} and assume that the pendulum frequency is 0.9 Hz and the pendulum wire is made of niobium containing nitrogen in solid solution. With the aid of this curve and Eq. 13.45, determine the relaxation time, τ_R.

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