8.33 (a) We are asked to estimate the activation energy for creep for the low carbon-nickel alloy having the steady-state creep behavior shown in Figure 8.31, using data taken at σ = 55 MPa (8000 psi) and temperatures of 427°C and 538°C. Since σ is a constant, Equation 8.20 takes the form

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

where K_2' is now a constant. (Note: the exponent n has about the same value at these two temperatures per Problem 8.32.) Taking natural logarithms of the above expression

$$\ln \dot{\varepsilon}_s = \ln K_2' - \frac{Q_c}{RT}$$

For the case in which we have creep data at two temperatures (denoted as T_1 and T_2) and their corresponding steady-state creep rates ($\dot{\varepsilon}_{s_1}$ and $\dot{\varepsilon}_{s_2}$), it is possible to set up two simultaneous equations of the form as above, with two unknowns, namely K_2' and Q_c. Solving for Q_c yields

$$Q_c = -\frac{R\left(\ln \dot{\varepsilon}_{s_1} - \ln \dot{\varepsilon}_{s_2}\right)}{\left[\frac{1}{T_1} - \frac{1}{T_2}\right]}$$

Let us choose T_1 as 427°C (700 K) and T_2 as 538°C (811 K); then from Figure 8.31, at σ = 55 MPa, $\dot{\varepsilon}_{s_1} = 10^{-7}$ h^{-1} and $\dot{\varepsilon}_{s_2} = 8 \times 10^{-6}$ h^{-1}. Substitution of these values into the above equation leads to

$$Q_c = -\frac{(8.31 \text{ J/mol-K})\left[\ln\left(10^{-7}\right) - \ln\left(8 \times 10^{-6}\right)\right]}{\left[\frac{1}{700 \text{ K}} - \frac{1}{811 \text{ K}}\right]}$$

$$= 186{,}200 \text{ J/mol}$$

(b) We are now asked to estimate $\dot{\varepsilon}_s$ at 649°C (922 K). It is first necessary to determine the value of K_2', which is accomplished using the first expression above, the value of Q_c, and one value each of $\dot{\varepsilon}_s$ and T (say $\dot{\varepsilon}_{s_1}$ and T_1). Thus,