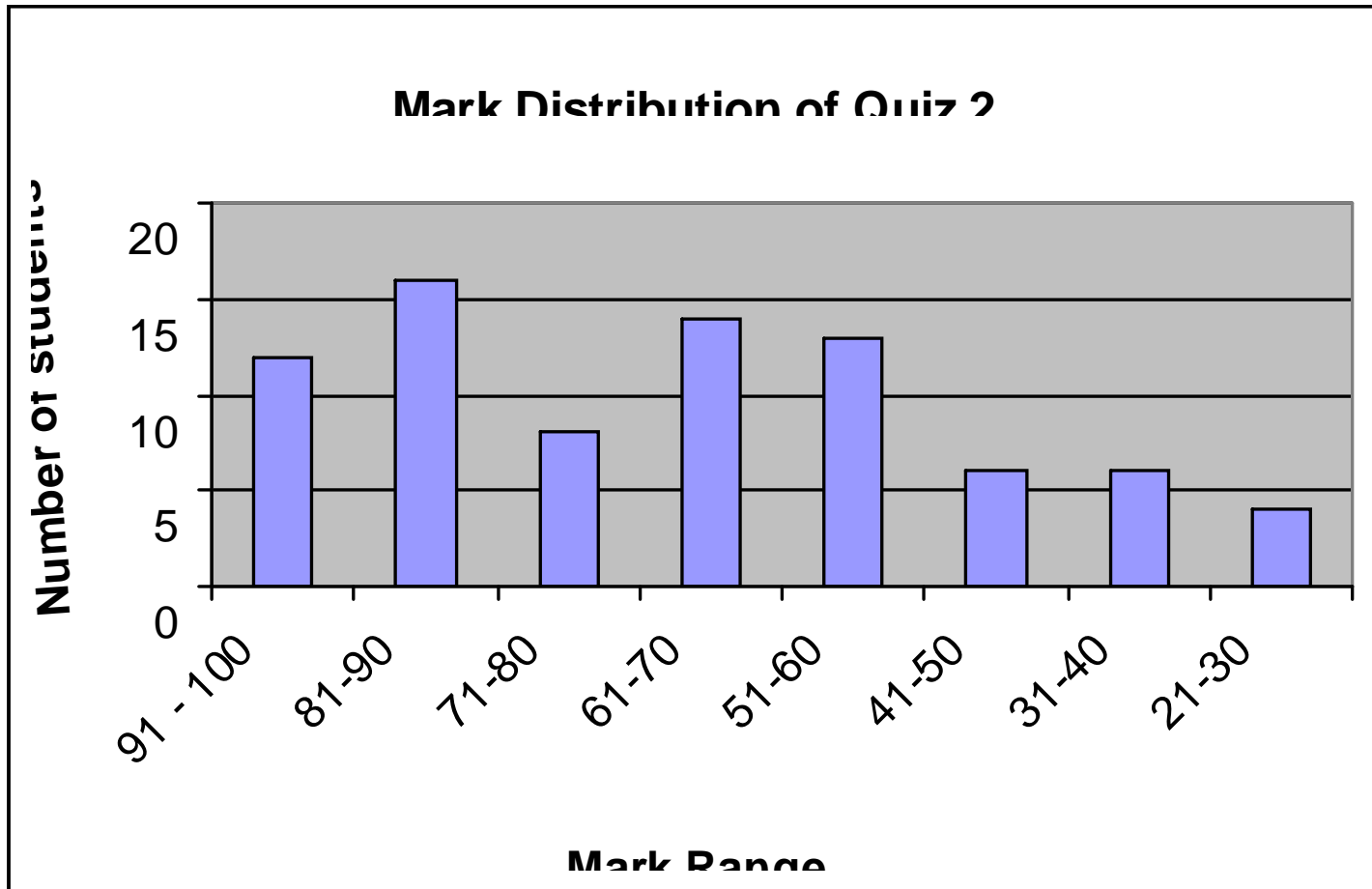


Quiz #2 Solutions

November 2, 07

Quiz #2



Average=69.0

Standard Dev=21.1

Briefly state the following properties and/or phenomena

- Young's Modulus
- Plastic deformation
- Yielding phenomenon
- Toughness
- Ductility

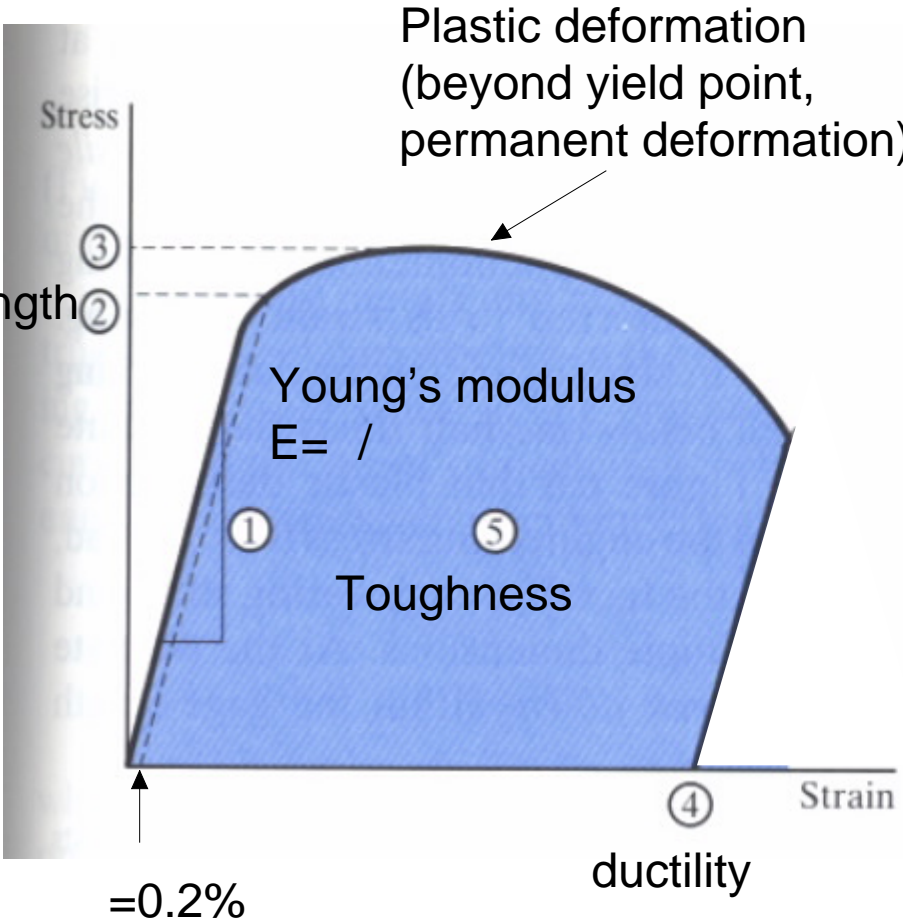


Figure 6.6 The key mechanical properties obtained from a tensile test: 1, modulus of elasticity, E ; 2, yield strength, $Y.S.$; 3, tensile strength, $T.S.$; 4, ductility, $100 \times \epsilon_{failure}$ (note that elastic recovery occurs after fracture); and 5, toughness = $\int \sigma d\epsilon$ (measured under load; hence, the dashed line is vertical).

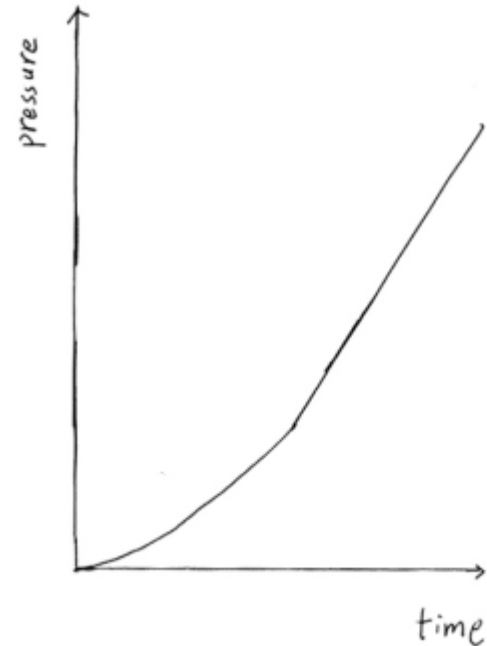
Give three examples in which diffusion is directly applicable.

- Metal alloy. Two different metals diffuse into each other.
- Water pollution by water soluble pollutant.
- Carburization.

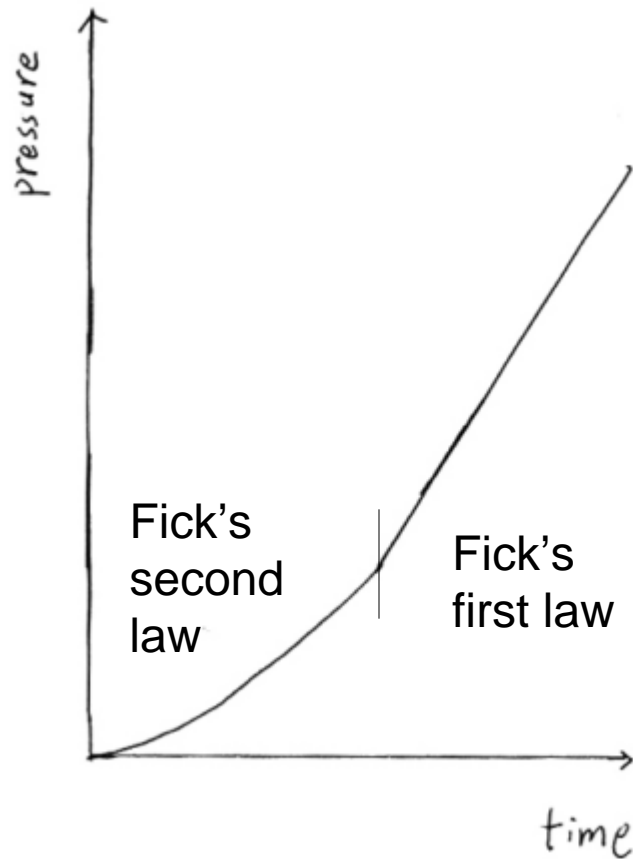
- Figure 3 shows the plot of the pressure building up as a function of time in the tem-lag apparatus. The following two equations are the Fick's first law and Fick's second law.
- (1). Please, on the pressure curve, indicate in which part the Fick's first law is applicable and in which part the Fick's second law is applicable.
- (2). What are the characteristics of these two types of diffusion phenomena?

$$J = -D \frac{dc}{dx}$$

$$\frac{dc}{dt} = D \frac{d^2c}{dx^2}$$



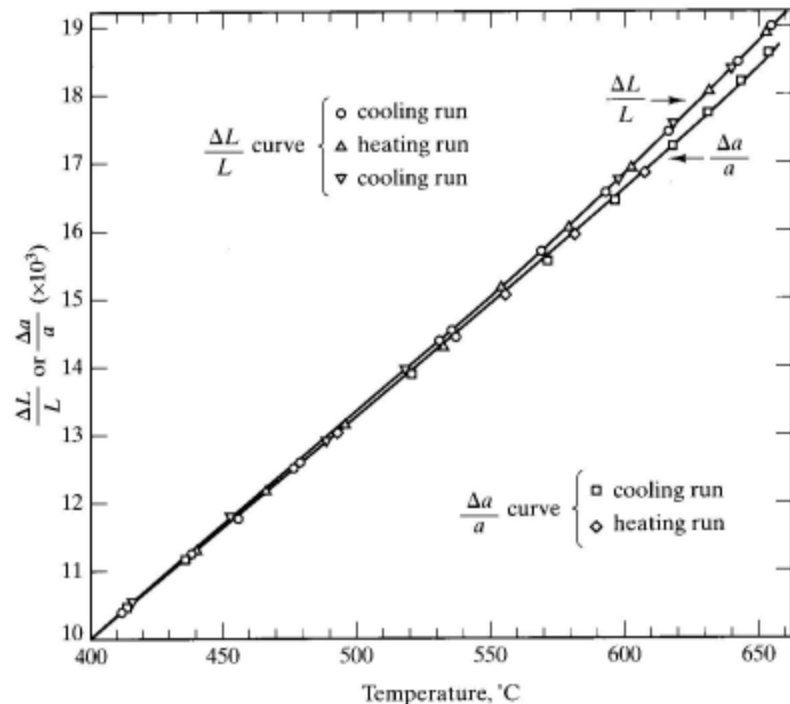
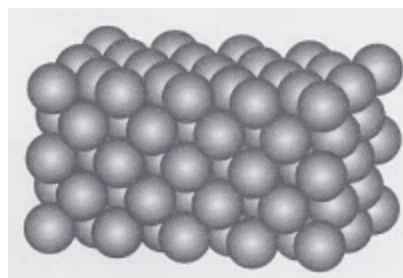
(1)



(2)

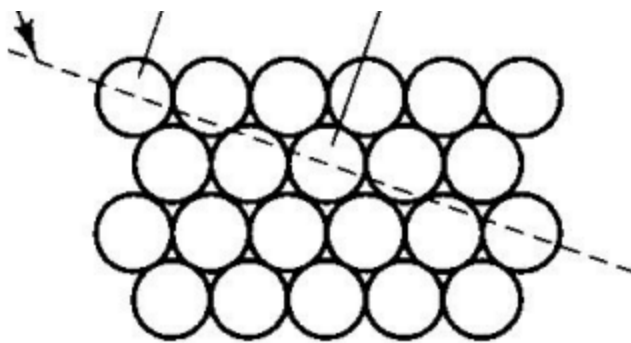
- For steady state diffusion, the concentration is only a function of x , $c=c(x)$. i.e. c is independent with time.
- For unsteady state diffusion, the concentration is a function of time and x , $c=c(t, x)$. i.e. c is dependant with time.

- Figure 4 shows the thermal expansion of a single FCC crystal. The pictures shown below are the real crystal and its FCC packing pattern. The initial dimension of the crystal is L and the dimension increment upon heating is ΔL . The initial lattice parameter of aluminum is a , and the lattice parameter increment upon heating is Δa . It is clearly seen, from Figure 4, that, in the high temperature range, the thermal expansions in actual dimension and the lattice dimension do not agree with each other.
- Please state how do you determine the L and ΔL ? (10 points)
 - Please state how do you determine a and Δa ? (10 points)
 - Please explain why the discrepancy is not seen in the low temperature range and becomes significant at higher temperature? (10 points)

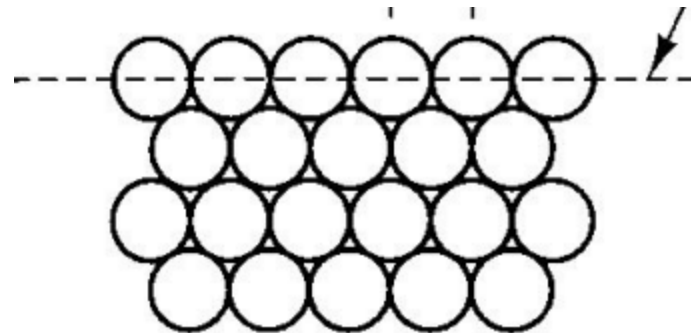


1. L and L_c can be measured by ruler or other simple
2. a and a_c can only be measured by X-ray diffraction
3. At lower temperature range, the a and L will increase in the same way (simple thermal expansion). However, at higher defects will be created, such as voids (which is not detectable under X-ray diffraction), therefore L/L_c will be higher than a/a_c .

- Plastic deformation is accompanied by slipping between crystallographic planes. Please discuss the slipping directions AB and AC and suggest which one is easier for slipping to occur? (5 points) Please give the reason. (5 points)



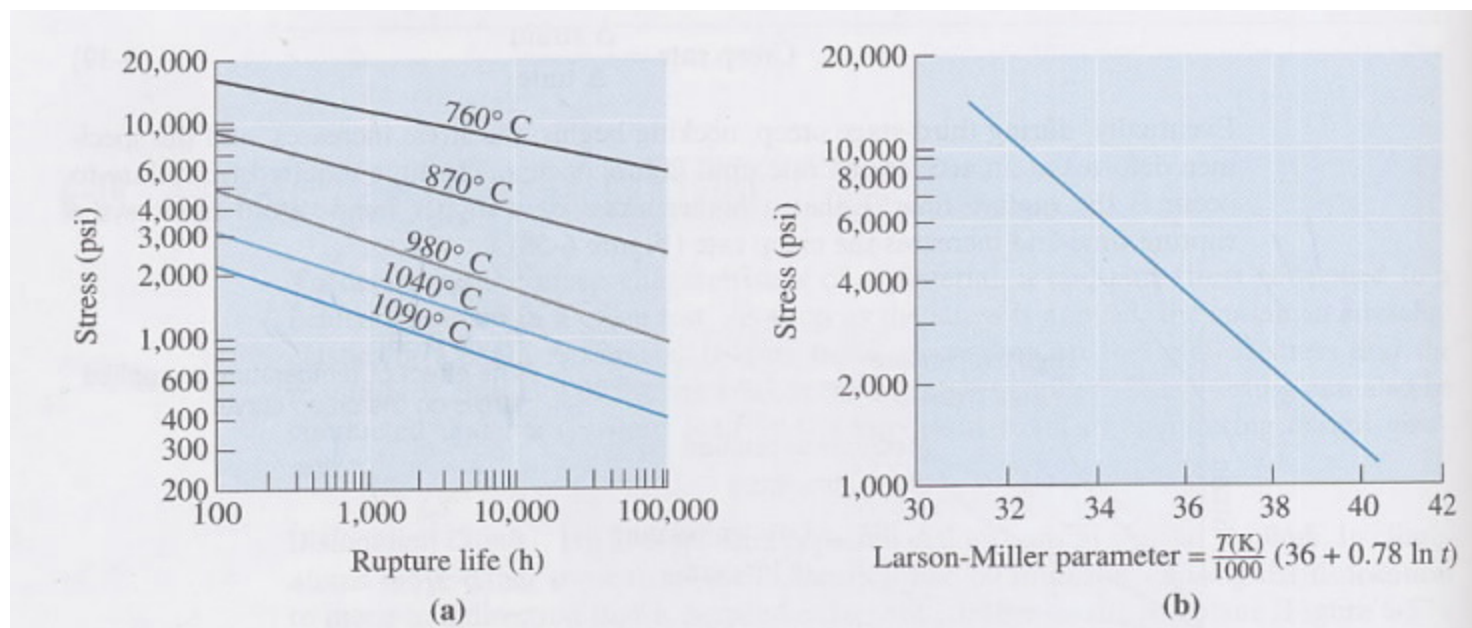
(a)



(b)

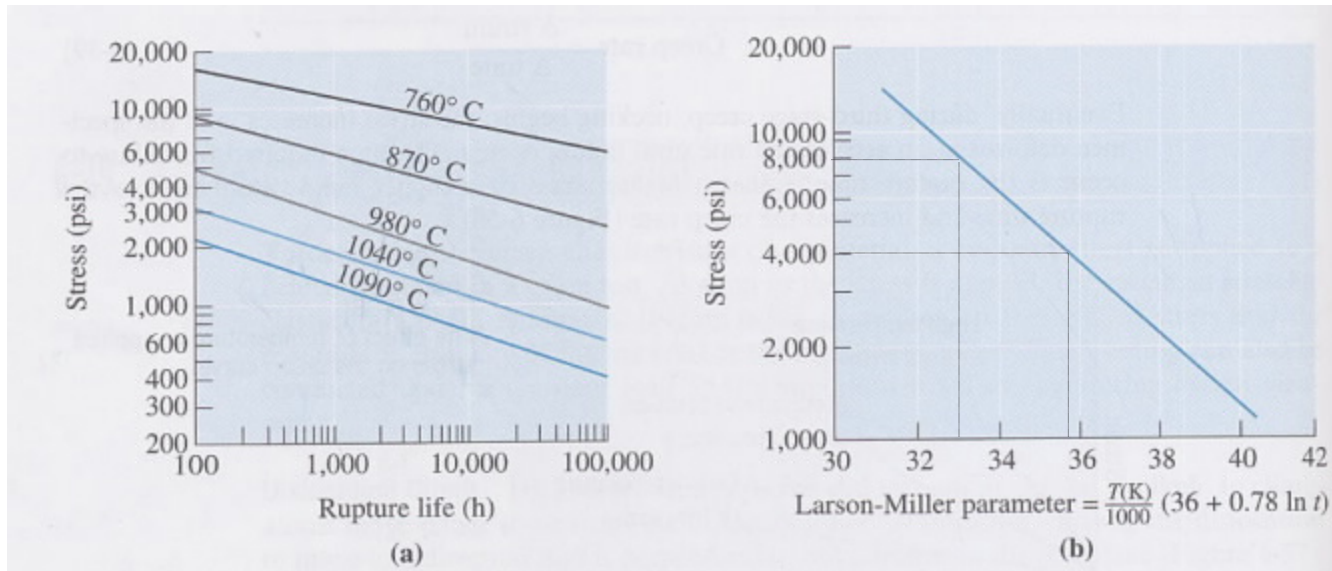
- AC is easier to slip.
- AC plane has a higher packing density so a shorter slip-distance than AB, therefore, slip-energy is lower for AC.

- Larson-Miller equation is given by In Figure 6, (a) illustrates the relationship between stress-rupture and rupture life plotted from the experimental data for limited temperatures only (the unit of t is hour).
- Please demonstrate how you can use the Larson-Miller parameter and Figure (b) to get stress-rupture curve at any temperature. For example, please generate a curve in Figure (a) at the temperature of 900 C. You don't need to show detailed calculations. You only need to demonstrate a method of how to get a stress-rupture time curve for 900 C.



From L-M equation, for 900 °C,

$$L.M = \frac{900 + 273}{1000} (36 + 0.78 \ln t) = 42 + 0.91 \ln t \quad t = e^{\frac{L.M - 42}{0.91}}$$



From figure b, we have,

=8000 psi, LM=33.1; $t = e^{\frac{33.1 - 42}{0.91}}$

=4000 psi, LM=35.7 $t = e^{\frac{35.7 - 42}{0.91}}$