MSE 2001 Quiz 23 June 2011

1. What is the *d*-spacing for a peak at $2\theta = 20°$ in an X-ray diffraction pattern for polystyrene. Assume first-order diffraction. The wavelength of the radiation is 1.54 Å.

2. A synthetic biomaterial is prepared to replace a biological membrane that selectively removes certain metabolites from the body. If the concentrations on both sides of a 0.1-cm-thick membrane are typically maintained at 0 and 8×10^{20} molecules/cm^3, and the diffusion coefficient of the metabolite through the membrane is 10^{12} m^2/s, what is the flux of metabolites through the membrane?

3. If the infinite-temperature self-diffusion coefficient for polyethylene in the melt is 1.2×10^{-11} m^2/s and the activation energy is 28 kJ/mol, what is the self-diffusion coefficient at 200 °C?

4. A polymer of average chain length 3 μm exhibits a self-diffusion coefficient of 10^{-18} m^2/s. What is the self-diffusion coefficient of the same polymer of average chain length 0.2 μm at the same temperature?

5. How long does it take to reach a carbon concentration of 0.24% at a depth of 0.01 cm beneath the surface of an iron bar when carburizing at 1000 °C? The initial concentration of the carbon in the bar is 0.2% and the surface concentration is maintained at 0.4%. The diffusion coefficient of carbon in iron at this temperature is 2.98×10^{-11} m^2/s.

$2d \sin\theta = n\lambda$, $D = D_o \exp(-Q/RT)$, $D \sim 1/L^2$, $R = 8.314$ J/K·mol, $J = -D(dC/dx)$,
$C(x,t) - C_o/(C_s - C_o) = 1 - \text{erf}(x/2\sqrt{Dt})$, $C(x,t) = (\beta/2\sqrt{\pi Dt})\exp(-x^2/4Dt)$

1. 4.43 Å
2. 8×10^{13} molecules/cm^{2}s
3. 9.7×10^{-15} m^2/s
4. 2.3×10^{-16} m^2/s
5. 104 s = 1.73 min