[pex18] Glass transition in polystyrene

Polystyrene is a petrochemical polymer that is used, for example, for the manufacture of plastic food containers. The (visco-elastic) relaxation time of liquid polystyrene is known to satisfy the Vogel-Fulcher law,

$$\tau = \tau_0 \exp\left(\frac{B}{T - T_0}\right),\,$$

with $T_0 = 50^{\circ}$ C, $B = 710^{\circ}$ C, and τ_0 to be determined.

(a) In an experiment performed on an effective time scale, $\tau_{exp}^{(1)} = 1000s$ (a good quarter of an hour), a glass transition is observed at $T_g^{(1)} = 101.4^{\circ}$ C. Find τ_0 . (b) What glass transition temperature $T_g^{(2)}$ is to be expected if an experiment on the much longer

(b) What gates transformed the presence $\tau_g^{(2)}$ time scale of $\tau_{exp}^{(2)} = 10^5$ s (roughly one day) is carried out? (c) Plot $\ln(\tau_0/\tau)$ versus 1/T as a solid curve. Mark the two experimental relaxation times as

horizontal dashed lines and the two glass transition temperatures as vertical dashed lines.

(d) Show that in order to observe a glass transition as low as $T_q^{(3)} = 75^{\circ}$ C, the experimental time scale would have to be of the order of a human life time.

[adapted from Jones 2002]

Solution: