

Soft Matter exercise, Chapter 1: Introduction

1. Viscosity

The viscosity of acetone (3×10^{-4} Pa.s) is lower than that of water (10^{-3} Pa.s). Why is this the case?

2. Non-Newtonian fluids

Give some examples of non-Newtonian fluids. In what sense is this flow behavior favorable/unfavorable in processing and storage of these fluids? What does this behavior tell us about the composition of these fluids?

3. Temperature dependence of the viscosity of poly(styrene)

The variation of the viscosity with temperature of poly(styrene) follows the Vogel-Fulcher law with $B = 710$ K and $T_0 = 50^\circ\text{C}$.

- Plot η/η_0 as a function of temperature for $80^\circ\text{C} < T < 150^\circ\text{C}$. By what factor, F_1 , does η vary between $T = 80^\circ\text{C}$ and $T = 100^\circ\text{C}$? And by what factor, F_2 , does η vary between $T = 120^\circ\text{C}$ and $T = 140^\circ\text{C}$? Are the two calculated factors, F_1 and F_2 , similar? If yes, why? If not, why not?
- You are asked to define the temperature at which poly(styrene) is extruded into bars. What factors do you have to consider? What would be the processing temperature and based on what considerations did you make your decision?

4. Temperature dependence of the viscosity for glass-forming liquids

The configurational re-arrangement is the rate limiting step in the flow of poly(styrene) at $T = 101.4^\circ\text{C}$ and the experimental time scale $\tau_{\text{exp}} = 1000$ s. The relaxation time follows the Vogel-Fulcher law with $B = 710$ K and $T_0 = 50^\circ\text{C}$.

- What is T_g if the experimental time scale is 10 s? What is it if the experimental time scale is 100 s and what is it if the experimental time scale is 10^6 s?
- (i) On what time scale do you have to conduct the experiment if T_g must be 50°C above T_0 ?
(ii) On what time scale do you have to conduct the experiment if T_g must be 10°C above T_0 ?

5. Glass transition

From 0 K to 152 K the heat capacity C_p^g of a particular glass is essentially the same as that of the crystalline phase, C_p^c . At around 160 K, a glass transition temperature is measured and the heat capacity of the glass rises above the heat capacity of the crystal. At 162 K $\Delta C_p = C_p^g - C_p^c = 180 \text{ J K}^{-1} \text{ mol}^{-1}$. From 162 K to the melting temperature of the crystalline phase $\Delta C_p \propto T^{-1}$, where T is the temperature.

- Draw a qualitative graph of C_p , the enthalpy, H , and the entropy, S , as a function of T .
- Why is the heat capacity of a glass higher than that of a crystal?
- Why is the entropy of a glass different to that of a crystal?
- How does T_g change with the rate at which the glass is quenched from the melt?

6. Elasticity

Rubber bands are made from amorphous polymers. If a rubber band with an unstretched cross section of 0.4 mm^2 is loaded with 10 N , its length will increase by 50% . Calculate its Young's modulus. Assume that the total volume of the rubber band remains constant.