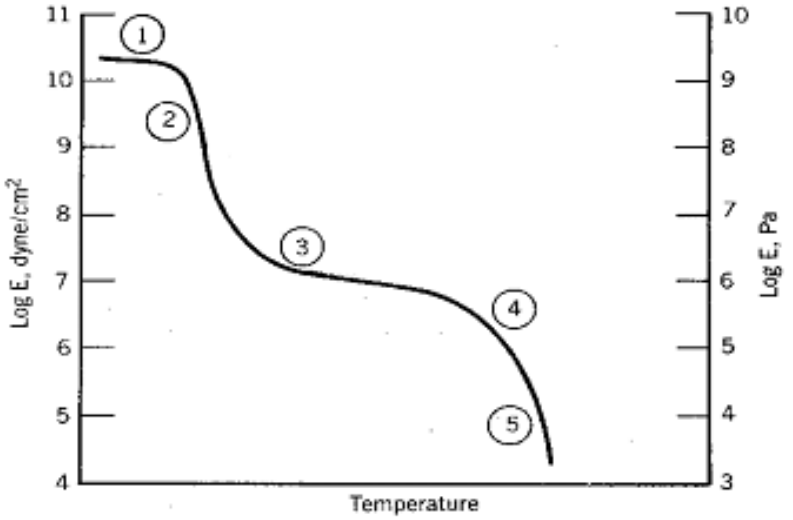
Polymer Physics Exam #3 2008. 12. 10

Name_____

1. (a) Name the five regions of viscoelastic behavior. And illustrate the viscoelastic behavior for crystalline polymers and cross-linked polymers and explain the reasons of the difference. (5)



(b) Name and give one-sentence definition of each of the three theories of the glass transition. (5)

(c) Describe the important advantages and disadvantages of the three theories of the glass transition. (10)

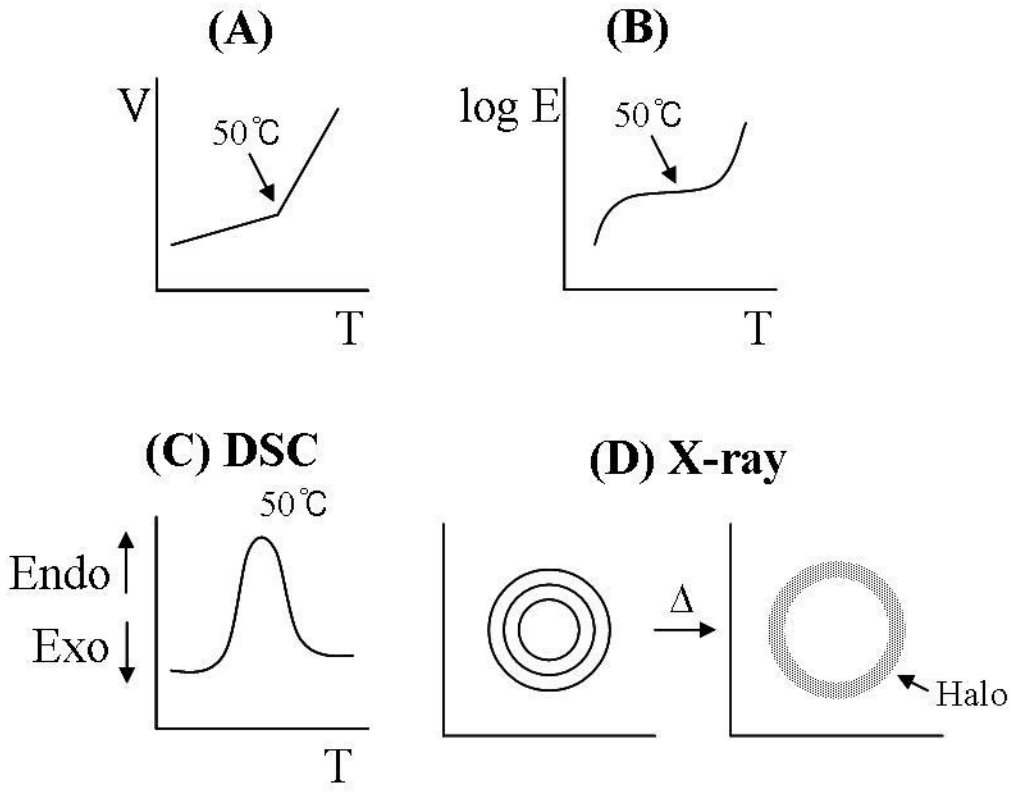
2. Suppose a free volume of a polymer is

$$f = -\frac{B}{15\ln((T - T_n)/T_n)}$$ (B: Doolittle constant)

Free volume of a new polymer is 0.0373 at glass transition temperature. If this polymer has a glass transition temperature of 0℃ and a viscosity of 7.88×10^{13} Pa·s at glass transition temperature, what will its viscosity be at 40℃? (Suppose B of this polymer is 1.5) (20)

3. A new polymer was found to soften at 50℃. Several experiments were performed to determine if the softening was a glass transition or a melting point. (Figure 1)
   (a) In interpreting the results for each experiment separately, was it a glass transition? a melting transition? cannot be determined for sure? (10)
   (b) What is your reasoning for each decision? (10)

Fig.1 Experiment data of transitions.

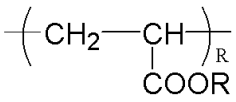


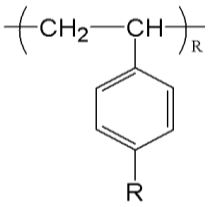
4. You are the engineer in charge of a polystyrene drinking cup manufacturing unit. Normally you process the material at 160℃, where the viscosity is $1.5x10^3$ poises at Z_w (critical entanglement chain length) =800. Today, your polystyrene has Z_w=950. What changes in processing temperature will bring the viscosity down to $1.5x10^3$ poises again? What temperatures is needed to increase in the cases of polyisobutylene and poly(ethyl methacrylate), if the viscosities at the certain Z_w are same. (20)

5. Which polymer in each of the following pairs would you expect to exhibit the higher glass transition temperature? Explain your choice in each case. (10)

(a) syndiotactic polymer – atactic polymer

(b)



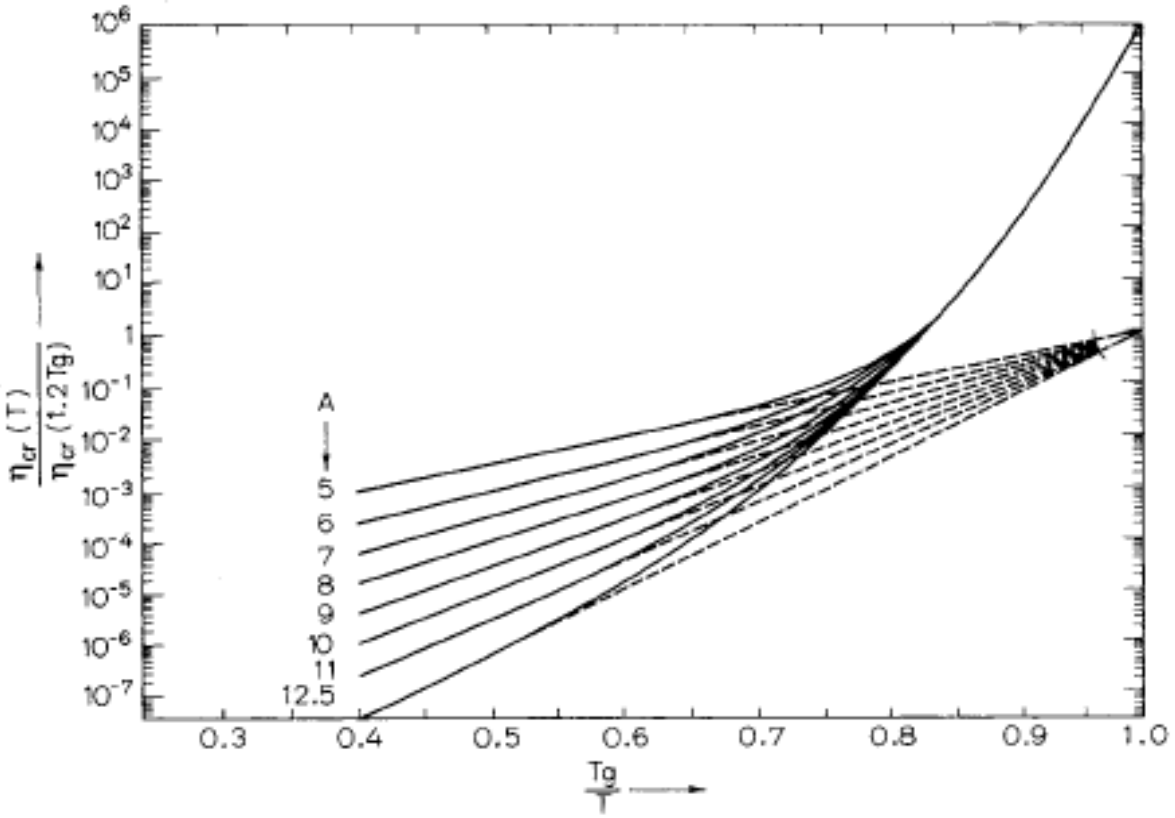


6. (a) Draw stress-time and strain-time curve of relaxation behavior when polymer follow Maxwell and Kelvin model, respectively. Which model describes relaxation behavior better? (10)

(b) A new polymer follows Kelvin model. Its glass transition temperature is 5℃, where it has a viscosity of 1 x 10^{11} Pa·s. The quantity η obeys the WLF equation. When we conduct an experiment at 25℃ to know creep behavior, how long it will take to reach the 50% of the total expected creep? (E = 5 x 10^{7} Pa at 25℃) (20)

7. Based on an equation about the Weissenberg effect, explain the Weissenberg effect. (20) (The reason why Newtonian fluid doesn't show Weissenberg effect should be included.)

8. (Challenge) Next graph is a master curves for $\eta_{cr}(T)$. At 12℃, polybutadiene has K_H = 2.02x10^{-10}, K_L = 9.40x10^{-4}, E_η = 26kJ/mol, $\log\eta_{cr}(1.2T_g)$ = 3.8Ns/m^2 and T_g = 171K. Calculate degree of polymerization of this polymer. (20)



9. (Bonus) You attended the polymer physics class during this semester. What did you learn from this lecture? And express your opinion why we have to learn the polymer physics. (10)

Supporting Information

Table 1. WLF parameters

Polymer	C_1'	C_2'	T_g(K)
Polystyrene	14.5	50.4	373
Polybutadiene	17.6	65.5	335