Properties of Polymers Homework #3 Due on 10 June 2010

Questions from the Textbook

Do problems 2, 3, 4, 14, and 21 of Chapter 8 on pp421-422 of the textbook.
Do problems 1 and 11 of Chapter 9 on pp495-496 of the textbook.
Do problems 11, 13, and 15 of Chapter 10 on pp550-552 of the textbook.
Do problems 5, 7, 8, and 10 of Chapter 11 on pp611-612 of the textbook.

Questions from the exams taken earlier

1. In mechanical models that consist of spring and dashpot;
   (a) Show that a Maxwell model cannot describe creep behavior correctly.
   (b) Show that a Kelvin model cannot describe stress relaxation behavior correctly.
   (c) The problems of the models of (a) and (b) results from the fact that they have *single* ____________ or ____________ time, which is unrealistic.

2. In the construction of 'master curve' using the time-temperature superposition principle;
   (a) Vertical shift can be ignored. Why?
   (b) For horizontal shift, does the result at a temperature higher than reference temperature shift to a shorter or longer time frame? Why?

3. (a) When a strip of rubber is stretched rapidly, it gets warm. Explain why.
   (b) Using Deborah number, show that every material is viscoelastic.
   (c) Why does the equation of state theory for rubber elasticity predict the behavior of rubber only to a certain extension ratio?

4. Suppose that you are a scientist working for a company. Your company need a plastic material that will be used at 150 °C. You are given a piece of plastic sample from a supplier, who claims that the polymer 'melts' at 200 °C.
   (a) How would you know if it is made of an amorphous or a semicrystalline polymer? Suggest two methods to distinguish.
   (b) Your lab assistant reports that the polymer 'softens' at 100 °C, how would you know whether it is T_g or T_m? Suggest two methods to distinguish.
   (c) How would you explain the difference between T_g and T_m to the president of your company? Suppose that your president has never taken a college-level science or engineering course, and is a friend of the supplier.

5. How are (i) the stress-strain rate behavior of shear flow, (ii) normal stress difference upon shear flow, and (iii) the stress-strain rate behavior of elongational flow, respectively, of polymer fluids different from those of Newtonian fluids?

6. When a polymer is said to be "hard," its Rockwell hardness, R, or Shore hardness, S, is large. Using analogy, fill the blanks.
   (a) When a polymer is said to be "strong," ____________________ or ________________ is large.
   (b) When a polymer is said to be "stiff," ____________________ or ________________ is large.
   (c) When a polymer is said to be "tough," ____________________ or ________________ is

large.

(d) When a polymer is said to be “incompressible,” ________________ or ______________ is large.

(e) When a polymer is said to be “heat resistant”, ______________, ______________, or ______________ is large.

(f) When a polymer is said to be “ductile,” it is able to __________________________.

(g) When a polymer is said to be “tough,” it is able to ___________________________.

7. Using the creep curve given below (Note that the strain is given in %);
   (a) Construct the 1-day isochronous stress-strain curve.
   (b) Estimate the Young’s modulus after 1 year (~ 3 x 10^7 s) upon the stress of 20 MPa.
   (c) For the polymer rod with the dimensions of 10 mm x 10 mm x 100 mm, what would be the cross-sectional area after 1 year upon the stress of 20 MPa along the 100 mm direction? Use the Poisson’s ratio of 0.4.

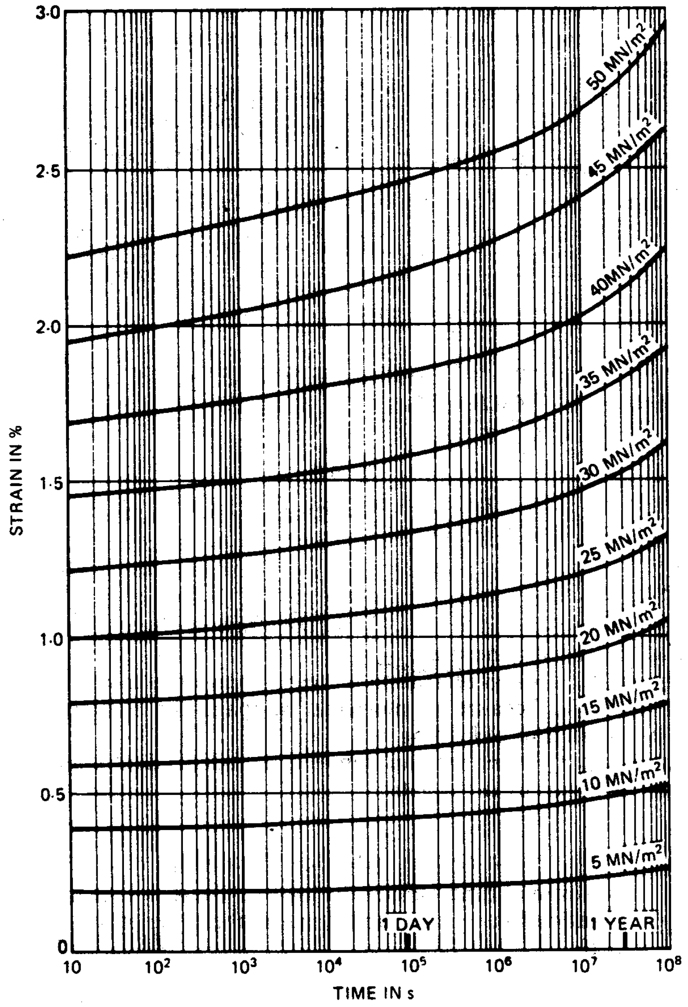

Figure 9.9. Curves for creep in tension of a commercial polysulphone (Polyethersulphone 300P–ICI) at 20°C. (From ICI Technical Service Note PES 101, reproduced by permission of ICI Plastics Division)