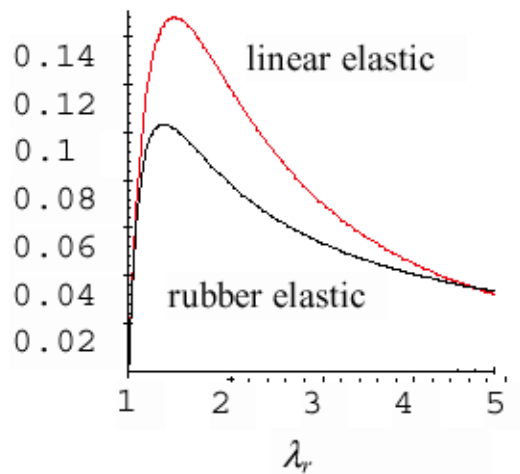


### 3.064 Quiz 10/10/03

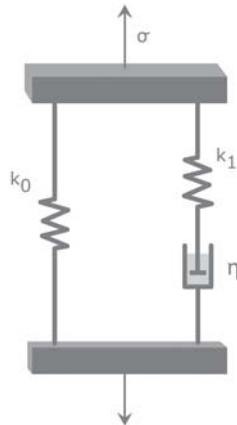
#### Sample questions

1. What is the "glass transition temperature" of a polymer? How can it be measured? What molecular characteristics determine its value? Illustrate by giving the chemical structure and T<sub>g</sub> for polyethylene, polyvinyl chloride and polystyrene.
2. What is the "glass transition temperature" of a polymer? How can it be measured? What molecular characteristics determine its value? Illustrate by giving the chemical structure and T<sub>g</sub> for polyethylene, polypropylene and polystyrene.
3. Draw the chemical formulas for polydimethyl siloxane, polyethylene, polypropylene, polyvinyl chloride, polymethyl methacrylate, polystyrene, polytetrafluoroethylene, polycarbonate, and polyethylene terephthalate.
4. For each of the previous polymers, give the approximate glass transition temperature, the percent crystallinity, and some principal market applications.
5. Describe the role of polarity and topology on glass transition temperature.
6. Draw plots of modulus versus temperature for various polymers: amorphous, crystalline, crosslinked, non-crosslinked. Explain why the plots have the shape they do.
7. Why is Teflon so good as a non-stick surface? How do they get it to stick to the pan?
8. Explain what a spherulite is, and describe the effect of spherulite size on polymer mechanical properties.
9. Explain how the molecular weight distribution of a polymer can be measured by size exclusion chromatography. Sketch the form of the raw data obtained from this instrument, and state how the number and weight average molecular weight can be obtained from the data.
10. Explain the effect of molecular weight on tensile strength and viscosity. Give an example of an application of an ultra-high molecular weight polymer.

11. Define the Hermann's orientation function, and explain how it can be determined experimentally. Derive its value for uniaxial, transverse, and random orientation.
12. Outline some methods for obtaining ultra-high orientation in polymers (e.g. Kevlar, Spectra).
13. Define the following elastic constants: Poisson's ratio, tensile modulus and compliance, and shear modulus and compliance. Give approximate values for the Poisson's ratio and tensile modulus of both glassy and rubbery polymers.
14. Why does rubber have to be crosslinked to be useful (usually)? How is this done (show the chemistry).
15. Only cis-1,4 polymerization of butadiene produces a good elastomer. What are some other possibilities, and why do they not make good rubbers? How do we get the form we want?
16. Outline the concepts involved in the kinetic theory of rubber elasticity.
17. Give the relation for strain energy in a rubber as a function of the extension ratios, and from this develop equations governing the extension ratio and the applied load for uniaxial tension, equal biaxial tension, and unequal biaxial tension.
18. Develop an expression for the radius of a spherical rubber balloon as a function of the internal pressure.
19. Consider two spherical rubber balloons, initially identical. One is inflated to  $\lambda_r = 2$ , the other to  $\lambda_r = 3$ . What happens when the balloons are connected at their necks so that air can flow from one to the other? (Just a qualitative description, based on the "rubber elastic" curve below.)



20. Give the relation for strain energy in a rubber as a function of the extension ratios, and from this develop equations governing the extension ratio and the engineering stress for uniaxial tension.
21. Draw plots of modulus versus temperature for various polymers: amorphous, crystalline, crosslinked, non-crosslinked. Explain why the plots have the shape they do. For the three-element spring-dashpot model below:



- (a) Sketch the relaxation and compliance functions  $G_{rel}(t)$  and  $J_{crp}(t)$  conceptually, without recourse to equations.
- (b) Develop the differential equation for the model, and solve it for relaxation  $G_{rel}(t)$ .
- (c) Derive (or at least set up) the expression for the complex modulus of the model.
22. Explain the significance of the terms "complex modulus," "storage modulus," "loss modulus."
23. What is the rationale for claiming that the presence of a low-temperature loss peak is a necessary and sufficient condition for good room-temperature impact strength?