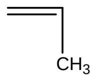
Properties of Polymers **Exam #3** **10 June 2010**

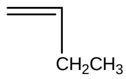
Total of 100 points. Each question is worth of 5 points, unless otherwise noted.

1. For a polymer sample with M_w of 500000, the plateau shear modulus, G_N^0, was determined as 1.0 MPa at 27 °C.
   (a) Estimate the Young's modulus of this polymer sample at the glassy state.
   (b) What would be the plateau shear modulus, when the molecular weight is doubled up?
   (c) What would be the slope of log η – log M_w plot of this polymer sample when it is melted? Explain your answer with a calculation.
   [You may need this: R = 8.3 x 10^7 dyn cm/mol K]

2. Choose one in the bracket, and explain why using "free volume."



propylene



butylene

   (a) The glass transition temperature of polybutylene is [lower, higher] than that of polypropylene.
   (b) As the molecular weight of a polymer increases, glass transition temperature [increases, decreases] up to a certain molecular weight.
   (c) As the crosslinking density of a network polymer increases, glass transition temperature [increases, decreases].

3. You observed that zero-shear viscosity of polystyrene (T_g = 100 °C) decreases by 5% by raising the temperature from 200 °C to 210 °C.
   (a) What would be the % change in zero-shear viscosity, when the temperature is raised from 210 °C to 230 °C?
   (b) What would be the % change in zero-shear viscosity, when the temperature is raised from 150 °C to 160 °C?

4. Answer the following questions briefly in your own words.
   (a) Why is rubber called an 'entropy spring?'
   (b) What is the 'Kauzmann paradox,' and how is the paradox resolved?
   (c) What is the 'two-thirds rule,' and why is it observed for polymers?

5. Fill the blanks. No need to explain. [Each right answer counts 3 points.]
   The reason why fracture stress of polymers is much lower than (a)________________, which is about one-tenth of its modulus, is the existence of flaw like crack, inclusion, or notch.
   In front of a crack, there are two factors that lead to brittle fracture, (b)________________ and (c)________________. In front of a sharp crack (b) makes the stress very high, but the stress is cut-off by (d)________________, which let the material in front of a crack undergo plastic deformation. This is the reason why measured (e)________________ is much higher than that expected based on the (f)________________ created by crack propagation.
   However, the plastic deformation in front of a crack is restricted by (c), which is the result of triaxial stress state in front of a crack and let the material yield at a higher stress than its inherent (d). If the effective (d) is higher than its (g)________________, the polymer

fractures in a brittle manner. At surface or edge of a fracture test specimen, the stress state is in (h)__________________ condition, and a larger volume of material yields. At inside of a specimen, (c) cut the (i)___________________ to about one-third of that at surface. This is the reason for (j)___________________ transition when specimen thickness varies.

6. The drawing below shows yield and crazing criteria of polymers.
   (a) Is this polymer ductile or brittle upon uniaxial tension? Explain your answer using a drawing.
   (b) Is this polymer ductile or brittle upon biaxial compression? Explain your answer using a drawing.
   (c) Show how the drawing changes when the strain rate increases.