Name:_____.

Midterm Exam 2

CM 4650 Polymer Rheology

31 March 2009

Note:
Please be neat.
Please write on one side of the paper only.

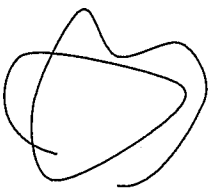
1. (10 points) For the tensor given below, what is the magnitude of the tensor?

$$\underline{\underline{\dot{\gamma}}} = \begin{pmatrix} 0 & 6x_2 & 0 \\ 6x_2 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}_{123}$$

2. (20 points) What material behavior is well predicted by the power-law generalized Newtonian fluid model? What material behavior is not well predicted by this model?

3. (20 points) For a linear polymer of low molecular weight (molecular weight is below the critical molecular weight for entanglement M_c), if we double the molecular weight, does the zero shear viscosity η_0 double? Why or why not?

$M=M_1<M_c$



$M=2M_1$

4. (20 points) What is the prediction of the Carreau-Yasuda generalized Newtonian fluid model for elongational viscosity $\bar{\eta}$? Show how you arrive at your answer. Hint: if $\dot{\gamma}$ is in your answer, you are not done.

5. (30 points) A power-law, generalized Newtonian fluid is confined between two long, wide parallel plates as shown below. The top plate is drawn steadily to the left and moves with a velocity V. The bottom plate is stationary. The pressure at $x_1=0$ is p_0, which is higher than the pressure at $x_1=L$, p_L. The flow is steady. Answer the questions below. Show your calculations and use the coordinate system shown in the figure. This flow configuration is common in extruders.

   a. What is the differential equation in terms of stress and pressure that we need to solve on the way to the velocity field? Simplify as much as possible (will still contain a stress term).
   b. Solve for $p(x_1)$.
   c. Solve for $\tau_{21}(x_2)$; your answer will contain an integration constant.
   d. What is the magnitude of the rate of deformation tensor $\underline{\underline{\dot{\gamma}}}$ for this flow? Does it depend on position in the flow?
   e. What are the two boundary conditions on velocity for this flow?
   f. BONUS: (10 points) Solve for the velocity field.