Polymer Processing, Quiz 1 Make-up

1.) a) Plot viscosity versus rate of strain for a polymer melt on a log-log plot.
b) Explain how one point in this plot could be obtained from a simple shear flow measurement in parallel plate geometry where you measure the *force*, F_x, on the top plate with normal in the y direction and the *strain*, γ_{xy}, on the top plate for a fixed time. (show equations)
c) If you wanted to compare viscosities of different molecular weights, which point in this plot would you use?
d) Explain why you would not use a point at high strain rate.
e) Plot the typical behavior of melt viscosity versus molecular weight for polymers.
f) Give two functions that describe the two behaviors observed.
g) How is the entanglement molecular weight determined from this plot?

2.) a) Consider a polymer that has the following molecular weight distribution:

Fraction	0.25	0.25	0.25	0.20	0.05
g/mole	1,000	5,000	20,000	50,000	100,000

If the entanglement molecular weight is 10,000 g/mole convert this distribution to an effective fractional contribution to the melt viscosity by using the functions of problem 1) f) and the fraction given above. (The two functions are equal at 10,000 g/mole and have a value of 5,000 Poise.)
b) From your calculation, which fraction contributes most to flow?

3) In a dynamic measurement of viscosity the top plate in problem 1) b) oscillates following the function,

$$\gamma_{xy} = \gamma_{xy,0}\cos(\omega t)$$

where t is time and ω is the frequency.
a) Calculate the rate of strain.
b) Calculate the shear stress for a Newtonian Fluid.
c) Is the shear stress in-phase or out-of-phase with the applied shear strain?
d) Calculate the shear stress for a Hookean Solid.
e) Is the Hookean shear stress in-phase or out-of-phase with the applied shear strain?
f) For a fluid such as a polymer melt the shear stress follows a function,

$$\tau_{xy} = \tau_{xy,0}\cos(\omega t + \delta)$$

where δ is the phase-shift or phase angle. Explain this behavior in your own words.