Kuppa Homework (Based on the Kuppa Notes)

1.) Stress and strain are tensors.

a) Use differential tensor notation to describe compressive stress, tensile stress, bending stress, shear stress, hydrostatic stress.

b) What is biaxial stress? How is this related to compressive stress?

c) Use differential tensor notation to describe compressive strain, tensile strain, bending strain, shear strain, hydrostatic strain.

d) Define the tensile modulus, the shear modulus and the compressibility.

e) How do true stress and true strain differ from engineering stress and engineering strain?

2) Polymers are viscoelastic materials.

a) Define a viscous material using Newton's law for flow. Is airplane glue (polystyrene and toluene) a purely viscous material?

b) Define an elastic material using Hooke's Law. Is a rubber band an elastic material?

c) How is it determined if a material is brittle or ductile? Is Jello® a brittle or a ductile material? Is Jello® elastic, viscous or plastic?

d) Polymers have been classified as thermoplastics, thermosets, and elastomers. Give two examples of each of these categories of polymers.

e) Polymerization has been classified as addition and condensation by Kuppa. An alternative classification is chain growth or step growth. Explain the difference and give exclusive examples of these four classifications of polymers.

3) Polymers are described by distributions in properties while metals and ceramics have a single value.

a) Define the number average, weight average and z-average molecular weights. How do these relate to the moments of the molecular weight distribution? (e.g. the second moment of the distribution of molecular weight is $M_2 = \sum_i n_i M_i^2 \Big/ \sum_i n_i$. How can the polydispersity index be described by moments?

b) What is an atactic polymer in terms of diads, triads and pentads?

c) Elastomers are a polymer melt with the chains linked together in a network. Chains can be linked together chemically, with crystallinity or with glassy phases. Give an example of each of these types of elastomers.

d) Many of the polymers we encounter on a day to day basis are semi-crystalline. Describe the semicrystalline morphology and give four examples of semi-crystalline polymers with the chemical structure of the monomers and the polymer.

e) The space shuttle Challenger exploded on takeoff in January 1986.

"Disintegration of the entire vehicle began after an O-ring seal in its right solid rocket booster (SRB) failed at liftoff. The O-ring failure caused a breach in the SRB joint it sealed, allowing pressurized hot gas from within the solid rocket motor to reach the outside and impinge upon the adjacent SRB attachment hardware and external fuel tank. This led to the separation of the right-hand SRB's aft attachment and the structural failure of the external tank. Aerodynamic forces promptly broke up the orbiter."

The morning of take-off the temperature was close to freezing. Explain how this low temperature could effect a rubber o-ring to cause this disaster. Use a plot of elastic modulus versus temperature and a plot of elastic modulus versus frequency (rockets vibrate at high frequency) in your explanation.