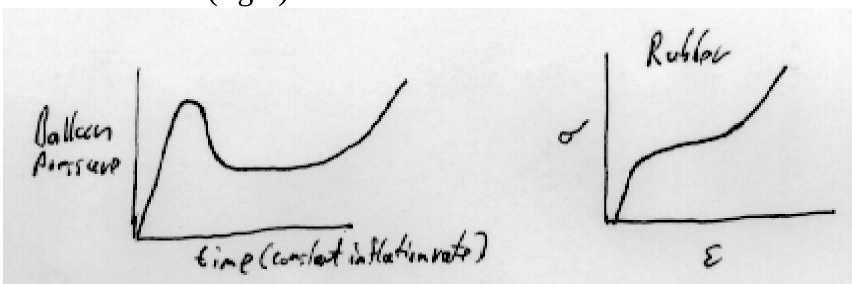
# 020516 Quiz 8 Properties

1) When a rubber balloon is inflated the air pressure (lung power) required is higher initially, reaches a maximum and then lowers after the balloon begins to inflate to reach a plateau pressure. This can be demonstrated by connecting two balloons through a valve, one barely inflated and one inflated about half full. If the valve is opened the smaller balloon will deflate!. The pressure in the balloon is given by F/A where the area increases as the balloon inflates which leads to a diminishing pressure. The stress on the rubber follows the curve shown above (right).




a) **Argue** for or against the opinion that, "this behavior is due to the rubber chains straightening under stress." **Explain** your answer and use equations where appropriate.

b) **Would** it be easier or more difficult to blow up balloons on a very hot day (50°C) versus a normal day (25°C). **Explain** (give equations and calculate the ratio of stress).

c) When you use an eraser you subject a rubber to shear stress.
**Does** a similar plateau in stress occur when you use an eraser? **Explain** and give equations.

d) **Would** it be easier or more difficult to use an eraser on a very hot day (50°) versus a normal day (25°C)? **Explain** and calculate the ratio.

e) **What** is the first normal stress difference and would it have a value for the balloon and/or the eraser?

f) **What** is a Mooney-Rivlin Plot? **What** type of deformation is it appropriate for?

2)

a) **What** is the basic assumption required to calculate the stress optical law, $\frac{\Delta n}{(\sigma_{zz} - \sigma_{xx})} = C_{opt}$?

b) **Give** an equation for the orientation function, $S_{or}$, and explain its meaning.

d) **Describe** the basic features of the Rouse model. **What** molecular weight dependence does it predict for viscosity?

c) For an elastomer subjected to 0.5 MPa of stress at 25°C and at 50°C **what** is the ratio of Δn for the two cases? **List** your assumptions.

**Answers: 020516 Quiz 8 Properties**

1)

a) $\sigma_{zz} = v_c kT\left(\lambda^2 - 1/\lambda\right)$ completely describes the curve on the right hand side. When this is combined with the increase in area during inflation, the curve to the left is described. The behavior is not related to chain orientation.

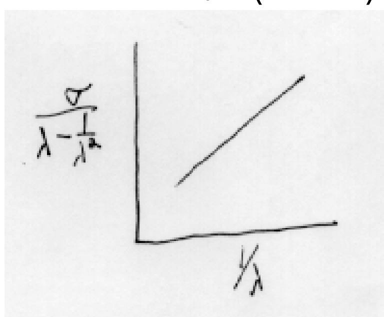
b) Harder, by a factor of about 1.1 (ratio of absolute temperatures).

c) No. $G = kTv_c$ so there is Hookean behavior in shear.

d) It should be harder by the same ratio, 1.1.

e) $\Psi_1 = \left(\sigma_{zz} - \sigma_{xx}\right)$ It has a value for the eraser but not for the balloon.

f) Based on the Mooney-Rivlin equation, $\sigma_{zz} = v_c kT\left(\lambda^2 - 1/\lambda\right)$,




2)

a) Stress and birefringence are both based on segmental orientation.

b) $S_{or} = \dfrac{3\left\langle \cos^2\theta_z \right\rangle - 1}{2}$. This reflects the orientation of a group of objects with a value of 1 for perfect orientation and a value of 0 for random orientation.

d) The Rouse model is a bead and spring model where the polymer is considered as composed of sub chains that are modeled as viscous elements (beads) and elastic elements (springs). The elastic response is given by rubber elasticity theory and the viscous response is given by Stokes Law. The viscosity is the molecular weight, N, times the viscosity of a single segment. for a melt.

c) 1.1 same as above.

Segmental basis; affine deformation; Gaussian chain; Rouse chain model; Stokes law; Rubber elasticity.