Advanced Transport Phenomena 1

ChE 862 **February 22, 2019** **Spring 2019**

Due: March 1, 2019

Poiseuille flow between parallel planes with thermal energy production by viscous dissipation, the fluid is 85% glycerol. This is an extension of the Gavis-Laurence problem that appears in the text on page 104.

As we saw in class, the viscosity of an aqueous solution of glycerol is very sensitive to temperature. Consequently, in cases where significant heating by viscous dissipation is possible, the temperature dependence of μ must be taken into account. Suppose we have a pressure-driven flow of 85% glycerol between two parallel plates. The lower plate is located at y=0 and the upper plate at $y=b$ (where b=1 cm) and both plates are maintained for all time at 20 °C. Assume that the viscosity of 85% glycerol can be represented as

$$\mu = aT + b$$

where a=-5.25 and b=215.5 such that μ(25°C)=84.25 cp. This straight-line approximation is problematic, for if T attains 41.04 °C the viscosity will be zero. Clearly this is unphysical and we can only use this linear function of temperature if the range of T is limited! Under steady conditions, the governing ordinary differential equations are

$$\frac{dp}{dx} = \frac{d}{dy}\left[\mu(T)\frac{dv_x}{dy}\right] \text{ and}$$

$$\frac{d^2T}{dy^2} = -\frac{\mu(T)}{k}\left(\frac{dv_x}{dy}\right)^2 .$$

Let's assume that we are interested in pressure gradients ranging from -3000 to -7000 dynes/cm^2 per cm. We want to know the maximum temperature attained in the 85% glycerol over this range of dp/dx; present your results in a graph showing T_{max} as a function of dp/dx. In two separate figures show 1) the velocity distribution and 2) the temperature distribution for the case where dp/dx=-5000 dynes/cm^2 per cm.