84.

<u>Problem 18.39 (RHK)</u>

Liquid mercury (viscosity, $\eta = 1.55\times10^{-3}$ N s m^{-2}) *flows through a horizontal pipe of internal radius* 1.88 cm *and length* 1.26 m. *The volume flux is* 5.35×10^{-2} L min^{-1}. *We have to show* (a) *that the flow is laminar;* (b) *calculate the pressure between the two ends of the pipe.*

<u>Solution:</u>

(a)

In order to find whether the flow is laminar we will calculate the Reynolds number

$$R = \frac{\rho D v}{\eta}.$$

Internal radius of the pipe is 1.88 cm and the volume flux is

$$5.35\times10^{-2}\ \text{L min}^{-1} = \frac{5.35\times10^{-2}\times10^{-3}}{60}\ \text{m}^3\ \text{s}^{-1}$$

$$= 8.92\times10^{-7}\ \text{m}^3\ \text{s}^{-1}.$$

Speed of flow of mercury in the pipe

$$v = \frac{8.92\times10^{-7}}{\pi\times\left(1.88\times10^{-2}\right)^2}\ \text{m s}^{-1} = 8.03\times10^{-4}\ \text{m s}^{-1}.$$

Reynolds number for this speed of flow is

$$R = \frac{13.6\times10^{3}\times3.76\times10^{-2}\times8.03\times10^{-4}}{1.55\times10^{-3}} = 264.9.$$

As this is less than 2000, flow is laminar.

(b)

Volume flux through a pipe of length L and radius r is

$$\frac{dV}{dt} = \frac{\pi r^4 \Delta p}{8\eta L}.$$

Difference in pressure between the two ends of the pipe is

$$\Delta p = \frac{8\eta L}{\pi r^4}\frac{dV}{dt} = \frac{8\times1.55\times10^{-3}\times1.26\times8.92\times10^{-7}}{\pi\left(1.88\times10^{-2}\right)^4}$$

$$= 35.5\ \text{mPa}.$$