278.

Problem 27.18 (RHK)

Assume that each conducting ball in problem **277** *is losing charge at the rate of* $1.20\ \text{nC s}^{-1}$. *We have to calculate the instantaneous relative speed with which the two balls approach each other initially.*

Solution:

We have shown in problem 277 that the equilibrium separation of the two balls is given by the relation

$$x = \left(\frac{q^2 L}{2\pi\varepsilon_0 mg} \right)^{1/3} .$$

Therefore,

$$\frac{dx}{dt} = \left(\frac{L}{2\pi\varepsilon_0 mg} \right)^{1/3} \times \left(\frac{2}{3} \times q^{-1/3} \times \frac{dq}{dt} \right) = \left(\frac{Lq^2}{2\pi\varepsilon_0 mg} \right)^{1/3} \times \left(\frac{2}{3q} \frac{dq}{dt} \right)$$

$$= \frac{2x}{3q} \frac{dq}{dt}.$$

We use the data that initially

$x = 4.70$ cm, $q = 22.8 \times 10^{-9}$ C, and

$\dfrac{dq}{dt} = 1.20 \times 10^{-9}$ C s^{-1}.

Therefore, initially the two balls will approach other with relative speed

$$\left(\frac{dx}{dt}\right)_{initial} = \frac{2 \times 4.70 \times 1.20 \times 10^{-9}}{3 \times 22.8 \times 10^{-9}} \text{ cm s}^{-1} = 1.65 \text{ mm s}^{-1}.$$