In Millikan's oil drop experiment, what is the terminal speed of an uncharged drop of radius $2.0 \times 10^{-5} m$ and density $1.2 \times 10^{3}\ kg\,m^{-3}$. Take the viscosity of air at the temperature of the experiment to be $1.8 \times 10^{-5}\ Pa\,s$. How much is the viscous force on the drop at that speed ? Neglect buoyancy of the drop due to air.

Ans) Terminal speed $= 5.8\,cm/s$

Viscous force $= 3.9 \times 10^{-10} N$

Radius of the given uncharged drop, $r = 2.0 \times 10^{-5} m$

Density of the uncharged drop,

$\rho = 1.2 \times 10^{-3} kg\,m^{-3}$

Viscosity of air,

$\eta = 1.8 \times 10^{-5} Pa\,s$

Density of air (ρ_0) can be taken as zero in order to neglect buoyancy of air.

Acceleration due to gravity,

$g = 9.8\,m/s^2$

Terminal velocity (v) is given by the relation:

$$V = 2r^2 \times (\rho - \rho_0)g/9\eta$$

$$= 2 \times (2 \times 10^{-5})^2 (1.2 \times 10^3 - 0) \times 9.8/(9 \times 1.8 \times 10^{-5})$$

$$= 5.8 \times 10^{-2} m/s$$

$$= 5.8\, cm\, s^{-1}$$

Hence, the terminal speed of the drop is $5.8\, cm\, s^{-1}$.

The viscous force on the drop is given by:

$$F = 6\pi\eta rv$$

$$\therefore F = 6 \times 3.14 \times 1.8 \times 10^{-5} \times 2 \times 10^{-5} \times 5.8 \times 10^{-2}$$

$$= 3.9 \times 10^{-10} N$$

Hence, the viscous force on the drop is $3.9 \times 10^{-10} N$.