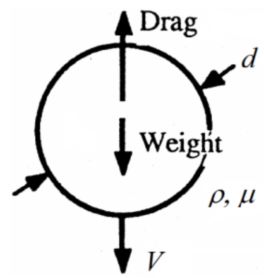
AME

Fluids-ID

Quiz 12. Small water droplets ($\gamma$ = 9800 N/m$^3$) of $d$ = 0.06 μm (6 × 10$^{-8}$ m) diameter fall through air. The drops reached to a terminal falling velocity $V$ and the drag force $D$ acting on the droplet is in balance with its weight $W = \gamma \forall$, where the volume $\forall = \pi d^3/6$. The drag force is known that $D = 3\pi d V \mu$ if the flow Reynolds number is small such that $Re << 1$. (a) Find the falling velocity $V$ if the air is under standard sea-level condition ($\rho$ = 1.23 kg/m$^3$ and $\mu$ = 1.789 × 10$^{-5}$ N·s/m$^2$) and (b) calculate the $Re$ and justify the validity of the use of the low $Re$ drag equation. Note that the buoyancy force acting on the droplet is negligibly small and the drops do not evaporate.




**Solution:**

(a) Since $D = W$,

$$3\pi d V \mu = \gamma \forall$$

or

$$3\pi d V \mu = \gamma \left(\frac{\pi d^3}{6}\right) \qquad \text{(+5 points)}$$

Solve for $V$:

$$V = \frac{\gamma d^2}{18\mu} = \frac{\left(9800\ \frac{\text{N}}{\text{m}^3}\right)(6 \times 10^{-8}\ \text{m})^2}{18\left(1.789 \times 10^{-5}\ \frac{\text{N}\cdot\text{s}}{\text{m}^2}\right)} = 1.10 \times 10^{-7}\ \text{m/s} \qquad \text{(+3 points)}$$

(b) Reynolds number:

$$Re = \frac{\rho V d}{\mu} = \frac{\left(1.23\ \frac{\text{kg}}{\text{m}^3}\right)\left(1.10 \times 10^{-7}\ \frac{\text{m}}{s}\right)(6 \times 10^{-8}\ \text{m})}{\left(1.789 \times 10^{-5}\ \frac{\text{N}\cdot\text{s}}{\text{m}^2}\right)} = 4.54 \times 10^{-10} \ll 1 \qquad \text{(+2 points)}$$