The JET$ Challenge

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Challenge 67 — The Salad Dressing Challenge

Problem:

Stokes law governs the settling of particles in fluids is given by the equation

$$V = a^2 \cdot g \cdot (\rho_s - \rho) / (18 \cdot \mu)$$

where V = settling velocity in m / s
a = radius of particles (m)
g = 9.81 m/s^2 (earth gravity)
μ = absolute viscosity (N-sec/m^2)
ρ_s = density of particles (kg/m^3)
ρ = fluid density (kg/m^3)

If you shake up homemade vinegar and oil salad dressing, the bubbles of oil will eventually rise to float on the surface of the vinegar because they are lighter. The density of oil and vinegar are 885 kg/m^3 and 1049 kg/m^3 respectively. The absolute viscosity of vinegar is 0.001222 N-sec/m^2.

What is the minimum diameter oil bubble in mm that will rise to the top from the bottom of a 10 cm bottle in 2 minutes?

Solution:

$v = 8.333 \times 10^{-4}$ m/s

a =

g= 9.81 m/s^3

$\mu = 0.001222$ (N-sec/m^2)

$\rho = 855$ kg/m^3

$\rho_s = 1{,}049$ kg/m^3

$$v = \frac{D}{T} = \frac{.1\ m}{120\ sec} = 8.333 \times 10^{-4}\ m/s$$

$$x m = 10\ cm \times \frac{1\ m}{100\ cm} = .1\ m$$

$$x sec = 2\ min \times \frac{60\ sec}{1\ min} = 120 sec$$

$$v = \frac{a^3 \cdot g(\rho_s - \rho)}{18\mu}$$

$$8.333 \times 10^{-4} = \frac{a^2(9.81)(1{,}047 - 885)}{0.021996}$$

$$a^2 = 1.1323 \times 10^{-6}$$

$$a = 1.06 \times 10^{-4} \times 2 = 0.21\overline{3}\ mm$$