Viscosity Activity Worksheet

1. Describe the fluid you are working with using every day descriptive vocabulary. (For example: “I am looking at honey. It is yellow(ish) and clear(ish). It is pretty thick and moves slowly. It feels sticky.”)

2. Calculate the density of the fluid using these steps:
   - Weigh the empty graduated cylinder. Record its mass in grams.
     \[ M_{\text{cylinder}} = \square \text{ g} \]
   - Fill the cylinder with fluid, and record the volume in \( \text{cm}^3 \). Note: \( 1 \text{ cm}^3 = 1 \text{ ml} \).
     \[ V_{\text{fluid}} = \square \text{ cm}^3 \]
   - Weigh the full graduated cylinder. Subtract the mass of the empty graduated cylinder and record the mass of the fluid.
     \[ M_{\text{fluid}} = \square \text{ g} \]
   - The density of the fluid is the mass over the volume. Calculate the density of the fluid.
     \[ \rho_f = \frac{\text{Mass of Fluid}[g]}{\text{Volume of Fluid}[\text{cm}^3]} \]
     \[ \rho_f = \square \text{ g/cm}^3 \]
3. **Measure the density of the sphere using these steps:**
   - Measure the radius of the sphere. Record as \( r \) [cm].
     \[
     r_s = \underline{\quad} \text{[cm]}
     \]
   - Calculate the volume of the sphere. Either use the equation:
     \[
     V_{ol_s} = \frac{4}{3}\pi r^3
     \]
     or place the sphere in a graduated cylinder filled with water and record its displacement.
     \[
     V_{ol_s} = \underline{\quad} \text{[cm}^3]\]
   - Weigh the sphere. Record its mass.
     \[
     M_s = \underline{\quad} \text{[g]}
     \]
   - Calculate the density of the sphere by dividing its mass by its volume.
     \[
     \rho_s = \frac{\text{Mass of Sphere}[g]}{\text{Volume of Sphere}[cm^3]}
     \]
     \[
     \rho_s = \underline{\quad} \text{[g/cm}^3]\]

4. **Measure the terminal velocity of the sphere falling through the fluid using these steps:**
   - With your stopwatch ready, drop the ball into the fluid.
     If the fluid is not very viscous, the ball will fall through it very fast, *so be ready!*
     If the fluid is thick enough, then the ball will reach a constant speed.
     This is the **terminal velocity**, the point at which the drag on the sphere by the fluid is equal to the force of gravity.
   - Measure how fast the ball falls a distance. Record the distance, and the time.
     \[
     \text{distance} = \underline{\quad} \text{[cm]}
     \]
     \[
     \text{time} = \underline{\quad} \text{[s]}
     \]
   - Calculate the velocity, which is the distance divided by the time.
     \[
     V_s = \underline{\quad} \text{[cm/s]}
     \]
5. Using this equation, derived from Stokes’ law, calculate the viscosity of your fluid.
Gravity is 981 cm/s². Be very careful to show your units and how they cancel out.
Your final answer should be in units of [g/(cm s)].

\[ \mu = \frac{2 \tau^2 g (\rho_s - \rho_f)}{9 V_s} \]

\[ \mu = \underline{\ \ \ \ \ \ \ \ } [g/(cm \ s)] \]

6. Viscosities are usually recorded in [Pa s]. To convert from [g/(cm s)] to [Pa s], simply divide by 10:

\[ 1 [Pa \ s] = 1 \left[ \frac{kg}{m \ s} \right] = 1 \left[ \frac{1000 g}{100 \ cm \ s} \right] = 10 \left[ \frac{g}{cm \ s} \right] \]

\[ \mu = \underline{\ \ \ \ \ \ \ \ } [Pa \ s] \]

7. Using the internet, look up the viscosities of some common household fluids.
Be sure to include units. Do any of the answers surprise you?

<table>
<thead>
<tr>
<th>Fluid</th>
<th>Viscosity</th>
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<tbody>
<tr>
<td>Example: blood</td>
<td>3 x 10^-3 to 4 x 10^-3 [Pa s]</td>
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</tbody>
</table>

Note: In searching the internet, you may find viscosities in a variety of units. Some may be in Poise [P] or Centipoise [cP]. 1 [cP] = .001 [Pa s]. The viscosity of water is 1 [cP]. Other fluids may have viscosity in Stokes [St], which is the ratio of the viscosity to the density of the fluid. To convert from Stokes, multiply it by the fluid’s density, or find another source! Hint: Search for “dynamic viscosity.”