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.
     \[ M_{\text{cylinder}} = \boxed{\text{[g]}} \]
   - Fill the cylinder with fluid, and record the volume in cm\(^3\). Note: 1 cm\(^3\)=1 ml.
     \[ V_{\text{fluid}} = \boxed{\text{[cm}^3]\text{]} \]
   - Weigh the full graduated cylinder. Subtract the mass of the empty graduated cylinder and record the mass of the fluid.
     \[ M_{\text{fluid}} = \boxed{\text{[g]}} \]
   - The density of the fluid is the mass over the volume. Calculate the density of the fluid.
     \[ \rho_f = \frac{\text{Mass of Fluid [g]}}{\text{Volume of Fluid [cm}^3]\text{]} \]
     \[ \rho_f = \boxed{\text{[g/cm}^3]\text{]} \]
3. **Measure the density of the sphere using these steps:**
   - Measure the radius of the sphere. Record as r [cm].
     \[ r_s = \text{__________ [cm]} \]
   - 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.
     \[ V_{ol_s} = \text{__________ [cm}^3\text{]} \]
   - Weigh the sphere. Record its mass.
     \[ M_s = \text{__________ [g]} \]
   - Calculate the density of the sphere by dividing its mass by its volume.
     \[ \rho_s = \frac{\text{Mass of Sphere [g]}}{\text{Volume of Sphere [cm}^3\text{]}} \]
     \[ \rho_s = \text{__________ [g/cm}^3\text{]} \]

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.
     distance = _________ [cm]
     time = _________ [s]
   - Calculate the velocity, which is the distance divided by the time.
     \[ V_s = \text{__________ [cm/s]} \]
5.

6. **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 \([g/(cm\ s)]\).

   \[
   \mu = \frac{4r^2g_0(p_s - p_f)}{9\nu}
   \]

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

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

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

   \[\mu = \text{________} \text{[Pa s]}\]

8. **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>
</tr>
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<tbody>
<tr>
<td>Example: blood</td>
<td>3 x 10⁻³ to 4 x 10⁻³ [Pa s]</td>
</tr>
</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.”*