Viscosity Activity Worksheet Answers

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.”)

   Answers to questions 1-6 will vary, depending on the fluids and equipment used.

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

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

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

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

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

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

\[\mu = \text{[Pa S]}\]

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>
<th>Fluid</th>
<th>Viscosity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example: blood</td>
<td>3 x 10^-3 to 4 x10^-3 [Pa S]</td>
<td>castor oil</td>
<td>0.25 to 0.5</td>
</tr>
<tr>
<td>SAE 30 motor oil</td>
<td>0.25 to 0.5 [Pa S]</td>
<td>ketchup</td>
<td>50 to 70 [Pa S]</td>
</tr>
<tr>
<td>maple syrup</td>
<td>0.15 to 0.2 [Pa S]</td>
<td>shortening or lard</td>
<td>1,000 to 2,000 [Pa S]</td>
</tr>
<tr>
<td>milk</td>
<td>2 x 10^-3 to 5 x10^-3 [Pa S]</td>
<td>honey</td>
<td>2 to 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]=0.001 [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.”