**Archimedes’ Principle**

**Purpose:** Use Archimedes’ Principle to determine the specific gravity of various fluids.

**Materials:** metal samples, various fluids, balance.

**Discussion:** ARCHIMEDES’ PRINCIPLE states that when an object is immersed in a fluid, it is acted upon by an upward buoyant force that is EQUAL to the weight of the fluid displaced. \( F_B = mg \) where “ \( m \)” is the mass of the fluid displaced by the object.

Archimedes’ Principle applies to objects immersed in ANY fluid, liquid or gas. Helium filled balloons rise because the buoyant force is greater than the gravitational force. Boats float for the same reason. Rocks sink when thrown into water, because the buoyant force is not enough to overcome gravity.

\[ F_A = \text{applied force of the balance (m}_A\text{g) needed for equilibrium} \]

\[ F_B = \text{buoyant force} \]

\[ F_g = mg \]

\[ m = \text{mass of object in air} \]

\[ m_A = \text{apparent mass submerged} \]

\[ m - m_A = \text{mass of fluid displaced} \]

The **specific gravity** (SG) of a fluid is found as the ratio of the density of the fluid to that of water:

\[ SG = \frac{\rho_{\text{fluid}}}{\rho_{\text{water}}} = \frac{\frac{\text{mass}_{\text{fluid}}}{V}}{\frac{\text{mass}_{\text{water}}}{V}} = \frac{\text{mass}_{\text{fluid}}}{\text{mass}_{\text{water}}} \]

Using Archimedes principle, see above, the mass of the fluid displaced is \( m - m_A \), so:

\[ SG = \frac{\text{mass} - \text{mass}_{\text{fluid}}}{\text{mass} - \text{mass}_{\text{water}}} \]

mass = mass in air

mass\text{fluid} = \text{apparent mass when submerged in the test fluid}

mass\text{water} = \text{apparent mass when submerged in water}
**Procedure:** complete a data table to include the following:
1. Record the mass, \( m_i \) of the hanger apparatus (pan replacement)
2. Record the mass, \( m \) of the sample metal.
3. Record the apparent mass, \( m_A \) of the metal sample while submerged in the three liquids. Make sure the object is completely submerged.
4. Repeat steps 2 and 3 using the other metal samples.
5. Complete the table below.

\[ m_i = \text{____________________} \text{(mass of the hanger apparatus only)} \]

<table>
<thead>
<tr>
<th>Metal sample mass(g)</th>
<th>fluid</th>
<th>water</th>
<th>oil</th>
<th>AF</th>
<th>water</th>
<th>oil</th>
<th>AF</th>
</tr>
</thead>
<tbody>
<tr>
<td>( m_A ) (g)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( F_B ) (N)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Results:** The average specific gravity of oil and anti-freeze. Compare your values to the known values of 1.10 for anti-freeze and .92 for vegetable oil.

**Supplemental Questions:** (write the questions and show all work)

1. If a wooden block is thrown into water and it floats half submerged, what is its density? (show your work)

2. By what % is the mass of the copper sample affected by the atmosphere given the density of air at 1.3kg/m\(^3\). (hint: find the buoyant force using Archimedes Principle.)

3. Determine the density of an unknown gas used to fill a 2.0g balloon to a volume of 4.0L if the balloon floats at equilibrium in air.