Surface Tension- Worksheet

A-Surface tension phenomenon

1. After watching the video, explain how can insects walk on the surface of the water?

2. Using the glass beaker, water and paper clip in front of you, can you make the paper clip float on water?

3. With a water dropper place drops of water on a penny. How many drops of water can you put on the penny before the water flows off?

4. Compare between the interior molecules in a liquid and the molecules at its surface from the following aspects:

    a. Which of the molecules have more neighbors?
    b. The net force on the molecules.
    c. Which are more stable?

5. From you evaluation above, how will the surface of a liquid look like?

6. Can you define the Surface tension?

B-Surface tension using the capillary rise

Place the capillary tubes in front of you in the water beaker. Observe the water rise in the tube.

1. Is the water level in the tube (higher than – lower than – the same as) the liquid level in the beaker?

2. What are the forces that are pulling up the liquid level in the tube?

3. Why does the rise in the liquid's level in the tube stop a certain height?

4. Distinguish between the characteristics of the different tubes in front of you. Place the tubes in liquids (water and oil) observe the rise of the liquids in them. From your observation, what are the factors the affect the height of the liquid in a tube?

5. Use the different capillary glass tubes and liquid water to deduce a relation between the height of the water level in the tube above water surface, h, and the radius of the tube, r.

6. Measure the values of h and r for each tube and tabulate your data.

7. The surface tension of a liquid is defined as $\gamma = \frac{h \rho g r}{2}$, where h is the liquid level, ρ the density of the liquid, g is the acceleration due to gravity and r the radius of the tube. Using the data you obtained from the above step, measure the surface tension of water.

C-Surface tension by the break-away method

An alternative way to measure the surface tension is the break-away method. Attach a ring to a hanging dynamometer. Place a beaker filled with a liquid on an adjustable height table. Raise the table level until the ring touches the liquid surface. Now lower the table beneath the beaker until the ring breaks away from the surface.

1. Measure the force needed to pull the ring away from the surface?

2. Using the different rings and liquids(water and oil) try to deduce the factors that affect the break-away force?

3. Record the break-away force of the different rings in the two water beakers. The surface tension of a liquid is given by: $\gamma = F/2L$, where F is the break-away force and L is the circumference of the ring. From this relation, calculate the surface tension of the different liquids in front of you.

4. Compare the surface tension of the different liquids and comment on your results.

5. When washing our cloths we add detergents to the water to better remove stains. How do detergents affect the surface tension of water? Can you explain the use of detergents in cleaning?

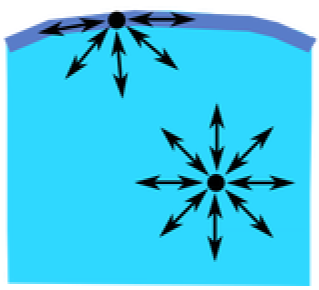
6. How does an umbrella protect us from rain?

Surface Tension

Surface tension is a phenomenon in which the surface of a liquid, where the liquid is in contact with gas, acts like a thin elastic sheet. This term is typically used only when the liquid surface is in contact with gas (such as the air). If the surface is between two liquids (such as water and oil), it is called "interface tension."

Causes of Surface Tension

Various intermolecular forces, such as Van der Waals forces, draw the liquid particles together. Along the surface, the particles are pulled toward the rest of the liquid, as shown in the figure below.



Surface tension (denoted with the Greek variable *gamma*) is defined as the ratio of the surface force *F* to the length *d* along which the force acts:

$$\gamma = F / d$$

Units of Surface Tension

Surface tension is measured in SI units of N/m (newton per meter), although the more common unit is the cgs unit dyn/cm (dyne per centimeter).

In order to consider the thermodynamics of the situation, it is sometimes useful to consider it in terms of work per unit area. The SI unit in that case is the J/m^2 (joules per meter squared). The cgs unit is erg/cm^2.

These forces bind the surface particles together. Though this binding is weak - it's pretty easy to break the surface of a liquid after all - it does manifest in many ways.

Examples of Surface Tension

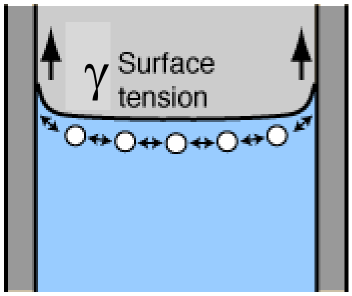
Drops of water. When using a water dropper, the water does not flow in a continuous stream, but rather in a series of drops. The shape of the drops is caused by the surface tension of the water. The only reason the drop of water isn't completely spherical is because of the force of gravity pulling down on it. In the absence of gravity, the drop would minimize the surface area in order to minimize tension, which would result in a perfectly spherical shape.

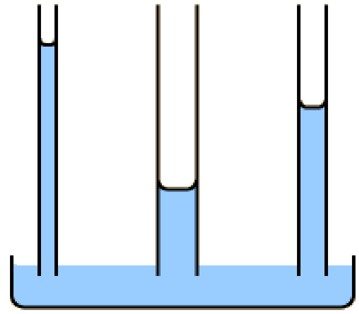
Insects walking on water. Several insects are able to walk on water, such as the water strider. Their legs are formed to distribute their weight, causing the surface of the liquid to become depressed, minimizing the potential energy to create a balance of forces so that the strider can move across the surface of the water without breaking through the surface. This is similar in concept to wearing snow shoes to walk across deep snowdrifts without your feet sinking.

Needle (or paper clip) floating on water. Even though the density of these objects is greater than water, the surface tension along the depression is enough to counteract the force of gravity pulling down on the metal object.

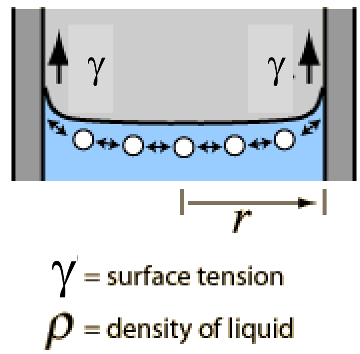
Capillary Action

Capillary action is the result of adhesion and surface tension. Adhesion of water to the walls of a vessel will cause an upward force on the liquid at the edges and result in a meniscus which turns upward. The surface tension acts to hold the surface intact, so instead of just the edges moving upward, the whole liquid surface is dragged upward. This phenomena is shown in figure below.



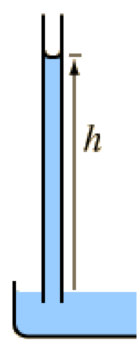


Capillary Action



Capillary action occurs when the adhesion to the walls is stronger than the cohesive forces between the liquid molecules. The height to which capillary action will take water in a uniform circular tube is limited by surface tension. Acting around the circumference, the upward force is given by:

$$F_{upward} = 2\pi r\ \gamma$$



The height *h* to which capillary action will lift water depends upon the weight of water which the surface tension will lift:

$$2\pi r\ \gamma = \ \rho g(h\pi r^2)$$

The height to which the liquid can be lifted is given by:

$$h = \frac{2\gamma}{\rho r g}$$