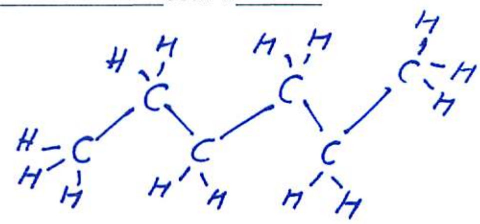
*AP Chem Liquid Mini-Lab* *Name:* Sarah *Seat #*______

*Viscosity, Surface Tension, Capillary Action, etc!*

**Station 1: Drops of Liquid on a Penny**



Liquids tested: Water( $H_2O$ ) and Hexane ( $C_6H_{14}$ )

Procedure: Go to a balance and find a glass specimen dish. Put a dry piece of paper towel at the bottom of the dish, and a dry penny on top of that. Put the dish/penny/paper on the balance and zero the balance. Use the dropper to add water or hexane, a drop at a time, to see how much liquid can fit on the penny before rolling over the side. Watch out for liquid "sneaking" over the sides! Add drops slowly enough that you can write down the mass that fit on the penny (before the liquid went over the sides). Do two trials for each liquid. Dry the penny between each trial, and start with a dry paper towel each time.

Mass of water that fit on the penny Trial 1________ Trial 2__________ Avg:_________ ← $H_2O$ ~~drop~~ mass should have been higher!

Mass of hexane that fit on the penny Trial 1________ Trial 2__________ Avg:_________

The higher the surface tension of the liquid, the more liquid fits on the penny before going over the sides. Explain why. (Hint: if the liquid resists going over the sides, it will be somewhat spherical (or hemi-spherical) on top of the penny. How does a sphere compare to other geometries, in terms of surface area to volume ratio?)

Quantitatively, surface tension is the energy required to increase a liquids surface area (energy per unit area increase). If the molecules are strongly attracted to each other (if cohesive forces are strong), more force will be required to spread the molecules out and increase the surface area. A sphere has the lowest possible surface area to volume ratio, so liquids with particularly strong cohesion will "ball up" into a sphere (or hemisphere, on the top of the penny); they require a large force to increase their surface area (they have a high viscosity!) and the force of gravity is (up to a point...) not strong enough to pull the sphere of liquid over the side, and increase its surface area.

Which liquid had more surface tension: Water or hexane? water!

Explain why this liquid would be expected to have higher surface tension, in terms of its structure/formula/types of bonds/type of Intermolecular Force (IMF).

$H_2O$ is very polar - due to O-H bonds...; $H_2O$ molecules are strongly attracted to each other by hydrogen bonding.

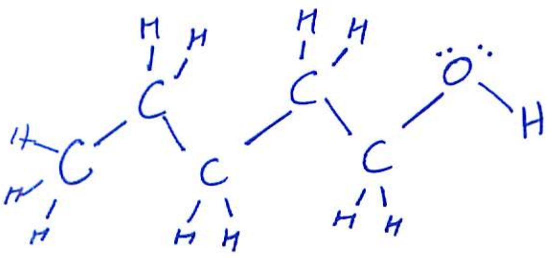
hexane is nonpolar (due to the low ΔEN between C and H and symmetry) so has only London Dispersion Forces for its IMF.

$H_2O$ has stronger IMF than hexane / $H_2O$ molecules have more cohesion to each other than hexanes, so $H_2O$ has a higher surface tension than hexane.

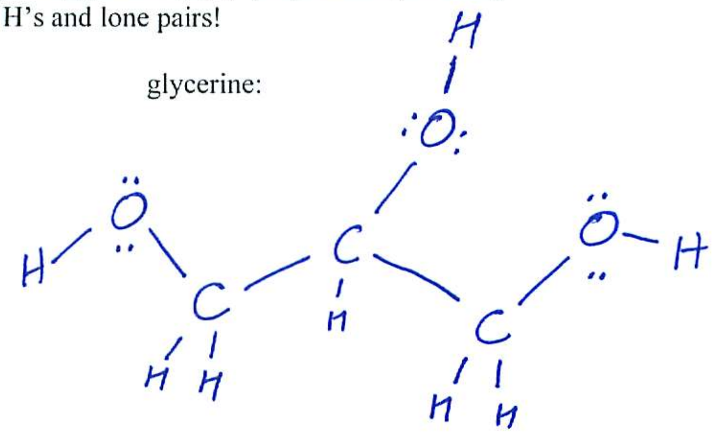
**Station 2: Air bubbles traveling through a liquid**

Liquids tested: n-pentanol (1-pentanol; 88 amu) and glycerine (1,2,3 propanetriol; 92 amu).
Draw the structure of each liquid, including all H's and lone pairs!

n-pentanol (1-pentanol)



glycerine:



Procedure part (a) : Find the two tubes marked ("X" and "Y"). These should be at room temperature and should be stoppered. Turn each tube upside down and observe as the bubble rises to the top.

Observations: The bubble rose much more slowly in tube X

For the liquid that required more time for the bubble to rise to the top, does this liquid have a higher or lower viscosity than the other liquid? higher

Identify Tubes "X" and "Y" (which glycerine, and which is pentanol?)

X = glycerine Y = pentanol

Explain your choice / How did you know which was which?

The molecules are similar sizes, so have similar strengths of London Forces. But glycerine has 3 polar OH groups per 3 carbons (the hydrocarbon part of each molecule is nonpolar), and pentanol has only one polar O-H group per 5 carbons. So glycerine has stronger cohesive forces than pentanol since it is more polar, which means glycerine will be more viscous.

Procedure part (b): Now that you have identified substances X and Y, Find the test tube containing warm glycerine (in a warm water bath). Invert this tube and observe as the air bubble rises to the top.

Which has higher viscosity: the cold glycerine or the warm glycerine? Cold glycerine

In general, does the viscosity of a liquid increase or decrease as temperature increases? it decreases.

Explain why this would be the case:

As temp increases, the molecules have more kinetic energy, and are more capable of overcoming their intermolecular attractive forces.

**Station 3: Capillary Action**

Liquids tested: pentane( $C_5H_{12}$ ) and water( $H_2O$ )

Procedure: Put a piece of thin glass tubing into the sample of pentane and into the sample of water. Hold the tubing perpendicular to the liquid surface, and measure the distance traveled up the tube by the liquid.

Pentane: 6, 6.5, 6 mm 7, 10 Water 10, 9.3, mm 18, 10, 20 ← my trials last yr? or maybe the class data?

Which liquid exhibits "stronger" capillary action? $H_2O$

Why would this liquid be expected to have stronger capillary action?

Explain in terms of structure/formula/types of bonds/type of IMF.

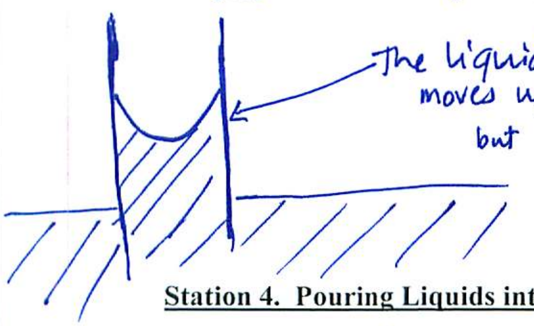
$H_2O$ is very polar (due to O-H bonds having a ΔEN of 1.4); $H_2O$ molecules are strongly attracted to each other by hydrogen bonding so have strong cohesive forces.

pentane is nonpolar so can only do London dispersion forces; it has weaker cohesive forces than $H_2O$.

($H_2O$ also has strong attractive forces to the glass; it adheres to the glass well.)

Capillary action is caused by a combination of cohesive and adhesive forces. Explain!

To "climb up" the glass tube, the liquid must overcome the down word pull / force of gravity.



The liquid adheres to the glass (adhesion / adhesive forces) so moves up to increase contact with the glass. but cohesion causes more molecules (like those in the middle of the tube, not near the glass) to come with the ones that are adhering to the glass; they are pulled up by the attractive forces ~~of the~~ / attraction to the molecules in contact with the glass.

**Station 4. Pouring Liquids into a Test Tube!!!**

Liquids: Water( $H_2O$ ) and pentane ( $C_5H_{12}$ )

Procedure: Pour the water from the beaker into the test tube. Pour the pentane from the beaker to the other test tube. Pour each liquid back into its beaker to get ready for the next group.

Which liquid was easier to pour without spilling? $H_2O$

Which liquid had stronger cohesive forces? $H_2O$

**Station 5: Air bubbles traveling through a liquid:**

Liquids: Hydrocarbons (specifically, alkanes) from roughly $C_8H_{18}$ to $C_{18}H_{38}$

Procedure: Arrange the "tube device" so that the lightest colored liquids are on the left, and the darker colored liquids are on the right. This way, the shortest chain hydrocarbons will be on your left, and chain length will increase as you go right. Carefully flip the set of hydrocarbon tubes and observe the time required for the air bubble to travel to the top of the tube.

As the chain length/number of carbons/molar mass increased,

Did the time required for the bubble to reach the top increase or decrease? increased

Did the viscosity of the liquids increase or decrease? increased

Does the intermolecular force strength increase or decrease? increased ***

Should the vapor pressure (at a given temp) increase or decrease? decrease

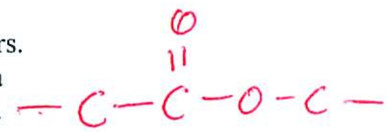
Should the normal boiling point increase or decrease? increase

*** explain why the IMF strength should increase/decrease as the chain length increases!
Explain in terms of structure/formula/types of bonds/type of IMF.

All the liquids were hydrocarbons ($C_xH_y$),
so all are nonpolar, and have only London Dispersion Forces (LDF)
As the chain length / size of the molecule increases,
the LDF strength increases, due to increased surface area/
increased surface contact possible between molecules.
(They have similar "polarizabilities" since they contain the same types of atoms).
as LDF strength increases, cohesion and viscosity increase as well.

**Station 6: Putting a small amount of water onto different solid surfaces:**

Liquid: Water
Solid surfaces: Glass, parafilm, paper, waxed paper
Glass is amorphous silicon dioxide; $SiO_2$.
Parafilm contains paraffin; Paraffin (or paraffins) usually refers to solid hydrocarbons with around 20 to 40 carbons. (esters can be present too.)
Paper is essentially cellulose, which is a polymer made from glucose ($C_6H_{12}O_6$) monomers.
Waxed Paper is coated in wax (!). Waxes are generally long chain esters with the formula $CH_3(CH_2)_xCOO(CH_2)_yCH_3$; the total number of carbons is often in the 40s or 50s.



Procedure: Use the plastic squirt bottle to put about 1 mL of water onto each of the solid surfaces.

Observations: Observe the interaction of the water with the solid – does it spread out on the solid or "ball up"?

Water on glass: $H_2O$ doesn't ball up much, and ~~soaks into the paper~~ spreads out somewhat onto the glass.

Water on parafilm: $H_2O$ balls up on surface

Water on paper: $H_2O$ doesn't ball up much, and it soaks into the paper

Water on wax (waxed paper): $H_2O$ balls up (does not soak in)

Which two solid surfaces caused the water to "ball up" the most. parafilm, wax (waxed paper)
Did water have relatively strong or weak adhesive forces with these solids?

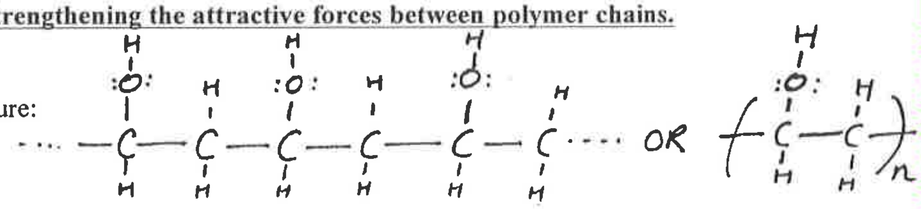
weak

Explain why water should have relatively strong/weak adhesive forces with these two solids:

$H_2O$ is very polar. wax and parafilm are very nonpolar.
parafilm contains long hydrocarbon chains; hydrocarbons are nonpolar.
waxes are generally esters, which means they contain 2 oxygens (and therefore, polar C–O and C=O bonds)
but they also contain very long hydrocarbon chains,
so overall they will act nonpolar; they will not be strongly attracted to $H_2O$.

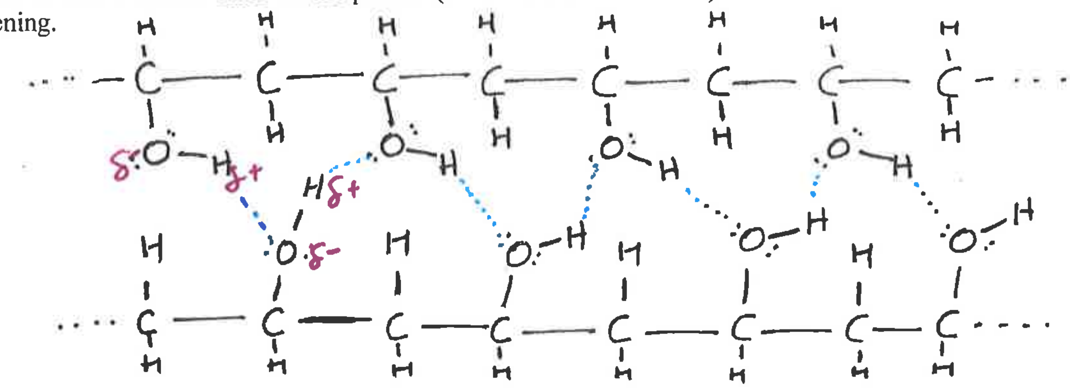
**Station 7: Weakly crosslinking a polymer by strengthening the attractive forces between polymer chains.**
(aka "making slime!")

Polyvinyl alcohol (PVA) has the following structure:




Materials: beaker containing 20 mL of the 5% $PVA_{(aq)}$ solution
flask containing 10 mL of the 4% borax solution + blue food coloring
stirring rod

a. Observe the solution of polyvinyl alcohol (the PVA is dissolved into water). clear, colorless, more viscous than $H_2O$
b. Explain why this polymer is so highly soluble into water: It has lots of very polar OH groups, so it can H-bond w/ $H_2O$.
c. Two strands of polyvinyl alcohol are shown below.
Put at least 2 δ+ symbols and at least 2 δ - symbols on the appropriate atoms on the picture below.
d. What type of intermolecular force occurs between the δ+ atoms of the top chain and the δ- atoms of the bottom chain, and vice versa? Hydrogen bonds / H-bonding
e. Draw at least 6 dashed lines on the picture (between attracted atoms) to illustrate where this attractive force is happening.



Borax Cleaner contains $Na_2B_4O_7 \cdot 10\ H_2O$ (sodium tetraborate decahydrate). Boron compounds can dissolve in water and react to form a variety of "borates", including $BO_3^{-3}$, $B_2O_5^{-4}$, $B_4O_7^{-2}$, and $B(OH)_4^{-1}$
When a solution of borax is added to a solution of polyvinyl alcohol (PVA), the borate ions increase the attractive forces between the polymer chains.

Procedure: Pour the blue borax solution into the PVA solution. Stir and observe:
f. Observation: viscosity increases dramatically! It becomes a "lump" of semi-~~fluid~~ solid

g. Two more chains of PVA are shown below. Using $B(OH)_4^{-1}$ as the formula for borate, draw at least ~~three~~ borate ions in between the polymer chains, and use dashed lines (at least 8) to show how the borate ion is attracted to the atoms in the polymer. (To show the borate ion, you can just draw a circle and label it as $B(OH)_4^{-1}$) ⟶ $B(OH)_4^{-1}$

h. What is name of the attractive force (IMF) that occurs between the borate ions and the atoms in the polymer?
Ion - Dipole!