Liquids

1. Are liquids closer in physical properties to solids or gases? Why?

   Liquids are more similar to solids. There are many intermolecular forces experienced by solids and liquids and very few by gases.

2. Characteristics of liquids

   a. Surface Tension – The resistance to increase surface area.

      i. How do the intermolecular interactions affect this characteristic?

         An increase in interactions leads to an increase in surface tension.

   b. Capillary Action – The spontaneous rising of a liquid in a narrow tube.

      i. What forces are responsible for this characteristic?

         1. Adhesive – Interactions of molecule with the container.

         2. Cohesive – Interactions between molecules with each other.

      ii. How do intermolecular interactions affect these forces?

         Increased interactions between molecules increases cohesiven interactions.

         Increased interactions between the molecule and container

increases adhesive interactions.

c. Viscosity – Resistance to flow.

   i. How do intermolecular forces affect this property?

      Increased interactions → increased cohesive forces → increased viscosity

d. Vapor Pressure – Pressure above a liquid/solid due to evaporation.

   i. How do intermolecular forces affect this property?

      Increased interactions → decreased vapor pressure

   ii. How does temperature affect this property?

      Increased temperature → increased vapor pressure.

3. In each of the following groups of substances, pick the one that has the given property

   a. Highest boiling point: HBr, Kr, Cl_2

      The stronger the interactions the higher the boiling point.
      Kr and Cl_2 are nonpolar – this means that they only experience LDFs.
      HBr is a polar molecule, which means that it experiences LDF *and* dipole-dipole interactions. These forces are stronger.

   b. Highest freezing point: H_2O, NaCl, HF

      The stronger the interactions the higher the freezing point.
      H_2O and HF are both polar molecules that would experience LDF and

hydrogen bonding intermolecular forces. NaCl, however, is an ionic compound. Thus it would experience, much stringer, ionic interactions.

c. Lowest Vapor Pressure: Cl_2, Br_2, I_2

The stronger the interactions the lower the vapor pressure. All of these compounds are nonpolar – meaning they experience only LDF interactions. Remember, the strength of the LDF very much depends on the size of the particle. Because I_2 is the largest molecule, it would have the greatest LDF.

d. Lowest freezing point: N_2, CO, CO_2

The weaker the interactions the lower the freezing point. CO is a polar molecule and CO_2 and N_2 are nonpolar. Nonpolar substances experience the weakest forces. Because N_2 is smaller, it would experience the smallest LDF and, therefore, have the lowest freezing point.

e. Greatest viscosity: H_2S, HF, H_2O_2

The greater the intermolecular forces the greater the viscosity. H_2S experiences dipole-dipole interactions and LDFs. Both HF and H_2O_2 experience H-bonding and LDFs. Because H_2O_2 has two areas for H-bonding it has the stringer intermolecular forces.

f. Greatest heat of vaporization: CH_3OCH_3, CH_3CH_2OH, $CH_3CH_2CH_3$

The greatest heat of vaporization would be associated with the compound that has the greatest intermolecular forces. CH_3CH_2OH is the only to experience H-bonding, thus it would have the highest

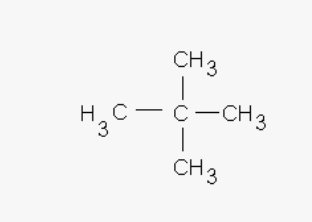
heat of vaporization.

g. Smallest enthalpy of fusion: I_2, CsBr, CaO

Both CsBr and CaO are ionic compounds and I_2 is a non-polar compound. The enthalpy of fusion is amount of heat required to melt a substance (s→l). The smallest enthalpy of fusion would be associated with the weakest intermolecular forces. Because I_2 is non-polar it would only experience LDFs – the weakest intermolecular force and would therefore have the smallest ΔH_{fusion}.

4. Rationalize the difference in boiling point for:

$CH_3CH_2CH_2CH_2CH_3$
(36.2°C)



(9.5°C)

More surface area leads to more effective LDFs. Additionally, long molecules have the potential for tangling.

5. Which of the following substance would have a boiling point closest to argon?

Cl_2, HCl, F_2, NaF, or HF

Argon is non-polar and therefore has only LDF forces. That means we are looking for non-polar compounds from the list – only F_2 and Cl_2 fit the bill. Remember that LDFs are very much dependent upon the size/mass of the compound – so we need to determine whether Cl_2 or F_2 has a mass that is closer to Ar. The molar mass of Ar is 39 g/mol. F_2 has a molar mass = 38 g/mol. These two would therefore have relatively similar LDFs and thus the closest boiling points.

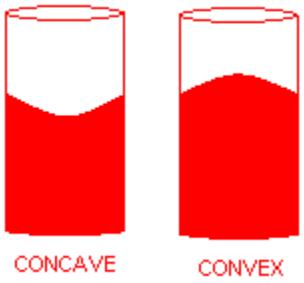
6. Match the following boiling points with the correct structure; -42.1°C, -23°C and 78.5°C

   a. CH_3CH_2OH 78.5°C (strongest forces – H-bonding)

   b. CH_3OCH_3 -23°C (dipole-dipole interactions)

   c. $CH_3CH_2CH_3$ -42.1°C (Weakest forces – LDFs)

7. Why does water create a concave meniscus and mercury a convex meniscus?



Water's adhesive forces are greater than its cohesive forces.

Mercury's cohesive forces are greater than its adhesive forces.

8. Why does water form into beads on a waxed car?

Surface tension is used to minimize surface area. A bead, or sphere, is the shape with the lowest possible surface area.