

## General Chemistry II Challenge Problem: Intermolecular Forces

A common physical property of a liquid is the normal boiling point, BP. It is useful in identifying an unknown liquid. More importantly the magnitude of the BP is related to the intermolecular forces in the liquid. Consider each of the following series of substances.

A.  $\text{CH}_4$ ,  $\text{CH}_3\text{Cl}$ ,  $\text{CH}_2\text{Cl}_2$ ,  $\text{CHCl}_3$ ,  $\text{CCl}_4$ .

B.  $\text{CH}_3\text{CO}_2\text{H}$ ,  $\text{CH}_3\text{CH}_2\text{OH}$ ,  $\text{CH}_3\text{CO}_2\text{CH}_3$ ,  $\text{CH}_3\text{COCH}_3$ ,  $\text{CH}_3\text{CH}_2\text{CH}_3$ ,  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$

For each of the series:

1. Using the VSEPR approach draw the molecular structure for the compounds. Indicate if the molecule is polar or non-polar.
2. Indicate the intermolecular forces for the compounds in the liquid state.
3. Look up the normal boiling points of the substances using your textbook, CRC Handbook, Merck Index, or another printed reference source or an electronic source such as that of the National institutes for Standards and Technology (NIST) at <http://webbook.nist.gov>.
4. Prepare a graph of boiling point (in K) vs. molecular weight (molar mass).
5. Discuss whether your graphs indicate that there is a regular relationship between molecular weight and boiling point, why these two quantities might be related and why there are differences between the series of substances. Your discussion should include the structures of all the compounds and make reference to the predominant intermolecular forces present in the substances in each series and their relative strengths.
6. Discuss any anomalous results, that is, exceptions to an otherwise smooth trend in the graph.
7. Based on the data you gathered is molecular weight by itself a good predictor of boiling point? Why or why not?