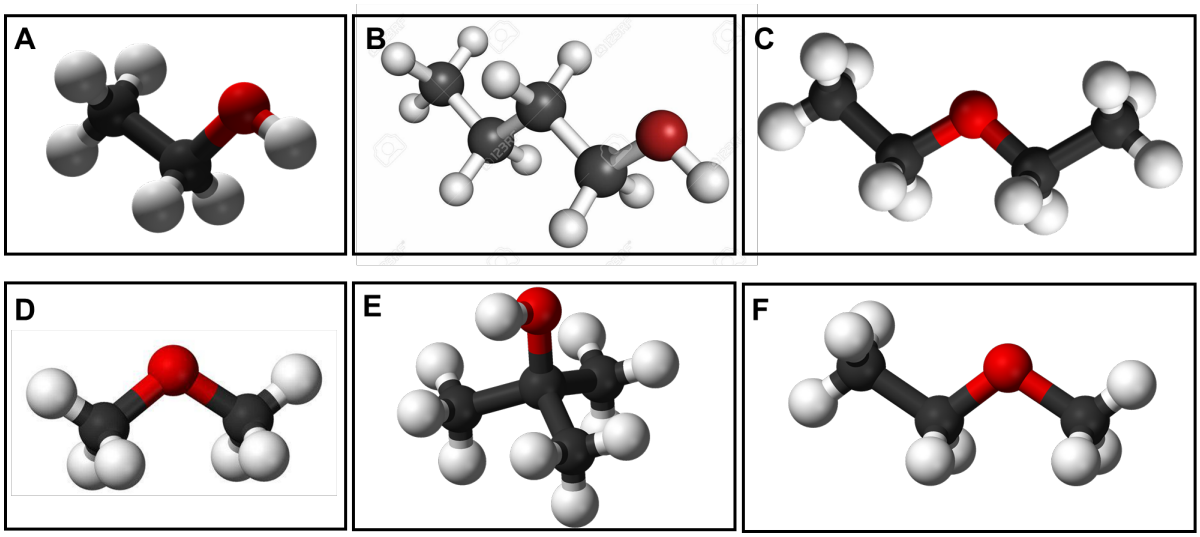
CHEM 1032 – KEY

Intermolecular Forces

In lecture last week we learned about intermolecular forces and how they affect compounds. The presence of stronger or weaker IMF has huge implications on how a compound behaves, especially in phase transformations! Using the material we learned in lecture and your previous knowledge, work with your group to match the molecule with the correct boiling point:

Molecules:

C O H



The slightly different image of B is not significant for the worksheet

Boiling Points:

BP (ºC)
118
82
78
35
7.4
-24

First things first, determine the formula for each molecule and calculate the molar mass of each compound.

	Formula	Molar Mass (g/mol)
A	C_2H_6O	46
B	$C_4H_{10}O$	74
C	$C_4H_{10}O$	74
D	C_2H_6O	46
E	$C_4H_{10}O$	74
F	C_3H_8O	60

If molar mass were the only factor affecting phase transitions, then how would you match up the molecules to boiling point?

BP (°C)	Molecule
118	
82	
78	
35	F
7.4	
-24	

B, C, E

A, D

Can you fully assign the boiling points? Why or why not? Explain why the above assignments are potentially not correct. What else might need to be taken into account?

Using molar mass I cannot completely assign BPs because a few molecules have the same molar mass. We haven't taken IMF into account.

List the four different types of intermolecular forces (IMF) in order of strength and what types of charges are present for each.

① Dispersion — temporary partial
② Dipole-Dipole — permanent partial
③ Hydrogen Bonding — permanent partial
④ Ion-Dipole — permanent full

Based on the molecules, which forces should we consider when assigning boiling points of our molecules?

There are no mixtures, so only ①②③

When first identifying the order of boiling point, let's consider if the molecules only had dispersion forces. What would the order be if there was no dipole-dipole or hydrogen boding? When considering dispersion forces, do not forget to consider the size and shape of the electron cloud.

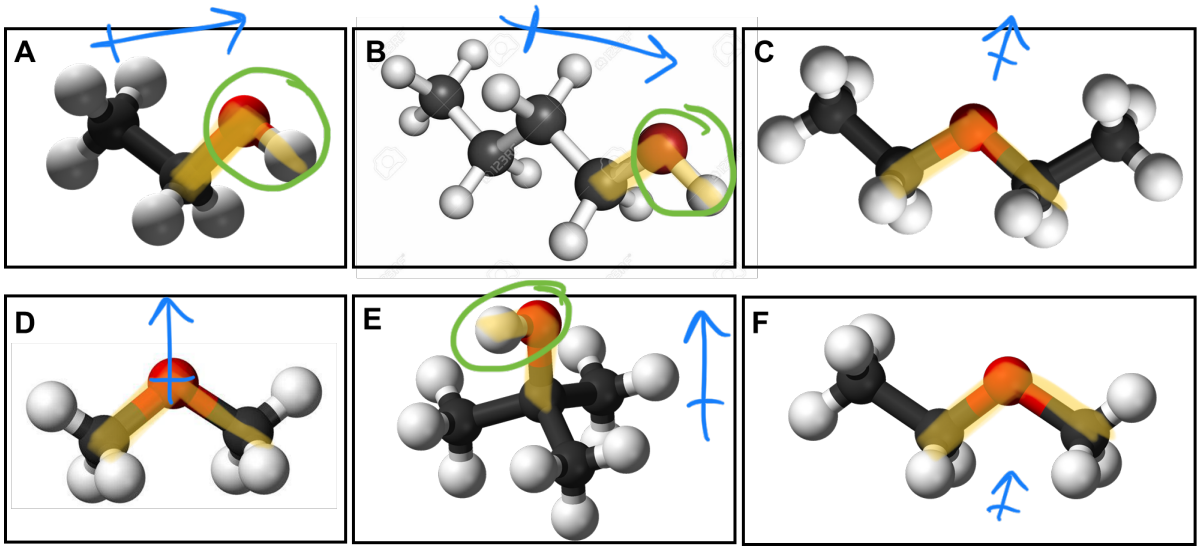
BP (°C)	Molecule
118	
82	
78	E
35	F
7.4	
-24	

B, C same mass, linear

E ← same mass as B, C, but smaller cloud

A, D same mass, linear

Now, highlight all of the polar bonds in the molecule and identify if the molecule is polar. If it is polar, draw the dipole arrow and indicate the δ+ and δ- regions.



Do any of the molecules have bonds which could result in hydrogen bonding? Circle them.

A, B, E all have OH groups ... so H-bonding.

Remember, when a molecule has a stronger force it also has the weaker forces too. For each molecule list all of the IMF present:

A Dispersion Dipole-Dipole H-bonding	B Dispersion Dipole-Dipole H-bonding	C Dispersion Dipole-Dipole
D Dispersion Dipole-Dipole	E Dispersion Dipole-Dipole H-bonding	F Dispersion Dipole-Dipole

Based on the assignments above, break the molecules into two groups:

	Molecules
Higher BPs	A, B, E
Lower BPs	C, D, F

Now that we've broken them into two groups let's decide the order within the groups. Consider the "**Higher BPs**" group. Using the order based on dispersion, put this group in order of boiling point.

	Molecule
Highest	B
Middle	E
Lowest	A

For the molecules with "**Lower BPs**" complete the same analysis, the molecule with the strongest dispersion force, would have the highest BP.

	Molecule
Highest	C
Middle	F
Lowest	D

Now using your two lists and assign a boiling point to each molecule:

BP (ºC)	Molecule
118	B
82	E
78	A
35	C
7.4	F
-24	D

Does your final list match the list that was solely based on molar mass? Why or why not?

No, the molar mass did not take into account IMF, and how that would affect boiling point. Strong IMF in low molar mass compounds induce higher BPs than high molar mass compounds with weak IMF.