CH101 Fall 2018
Discussion #6
Chapter 6

Your name: _____ TF's name:_____ Discussion Day/Time: _____

Things you should know when you leave Discussion today:

- Equilibrium Vapor pressure. Mahaffy, 2e sections 6.2
- Specific heat capacity (c (J/(g·K)) Mahaffy, 2e sections 6.2
  - Heat during temperature change: q=m×c×ΔT;
  - Heat during phase change: q = n ×ΔH
  - Enthalpy change of vaporization $\Delta_{vap}H$
  - Mahaffy, 2e exercises 6.1, 6.2, 6.3, 6.4
- Intermolecular forces (IMF) and molecular geometry. Mahaffy, 2e sections 6.3
- Memorize Mahaffy, 2e Figure 6.28 page 181

1. The normal boiling point of ammonia is −33 ˚C, of hydrogen chloride is −85 ˚C, of methane is −162 ˚C and of nitrogen is −196 ˚C. Assume that at −210 ˚C all four of these substances are liquids at 1 bar pressure. Which substance has the **smallest vapor pressure** at −210 ˚C and why?

   a. Define vapor pressure**:**

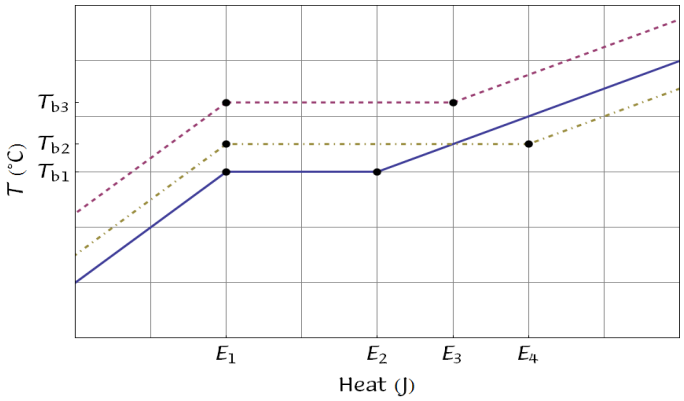
2. At room temperature, the vapor pressure of liquid acetone is 31kPa, bromine is 28.7 kPa, hexane is 20.2 kPa. Which of these liquids has the highest normal boiling point?

3. The figure shows the heating of three liquids to their corresponding boiling point, then subsequent heating until each liquid has been completely converted to gas, and finally heating of the gas.

   a. *Define enthalpy of vaporization* ΔH_{vap}:

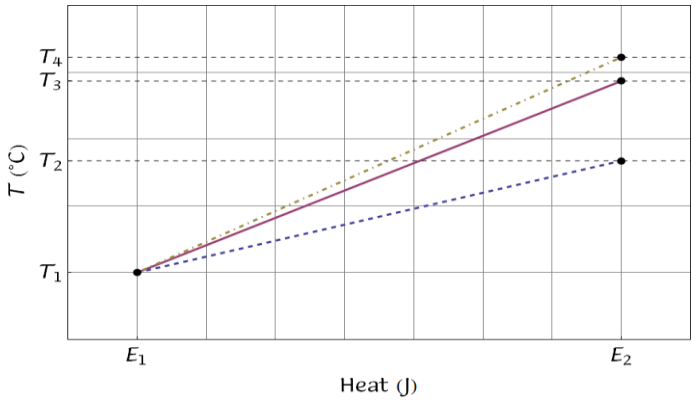
   b. The boiling point of the substance with the highest enthalpy of vaporization is: (Circle your answer)

   T_{b1} T_{b2} T_b



4. The figure shows the heating equal masses of three substances, each initially at temperature T_1. The same amount of energy, $\Delta E = E_2 - E_1$, is added to each substance. The substance with the highest heat capacity is the one whose final temperature is: (Circle your answer)

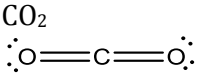
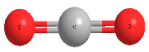
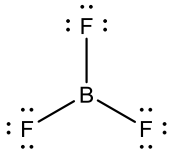
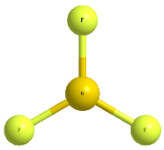
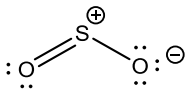
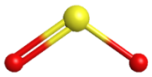
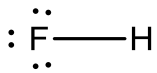
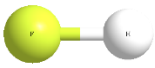
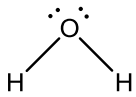
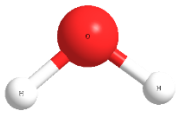
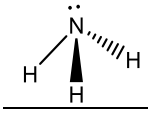
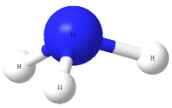
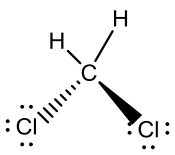
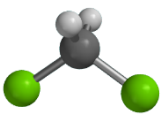
   T_2 T_3 T_4



5. What is necessary to have a polar covalent bond?

6. What are necessary conditions for a molecule to be a polar molecule?

7. Add to the pictures the bond dipoles and fill in the table for the **center** atom.

Molecule	3-D Drawing (Draw arrows indicating any polar bonds)	# of atoms bonded to the center atom	# of lone pairs on the center atom	# of atoms and # of lone pairs attached to the center atom	What is the geometry? Net dipole? (Polar or Non-polar)	At home: List all IMFs
CO_2 						
BF_3 						
SO_2 						
HF 						
H_2O 						
NH_3 						
CH_2Cl_2 						

Useful table to memorize:

Steric Number	Electron Geometry	# of bond pairs (# of atoms bonded to the center atom)	# of lone pairs	Molecular Geometry
2	Linear (<180°)	2	0	Linear
3	Trigonal Planar (<120°)	3	0	Trigonal Planar
3	Trigonal Planar	2	1	Bent
4	Tetrahedral (<109.5°)	4	0	Tetrahedral
4	Tetrahedral	3	1	Trigonal Pyramidal
4	Tetrahedral	2	2	Bent

8. Let's assume that each molecule is bouncing around in an imaginary cube. This cube represents the space a molecule occupies. Given that 1 mol of gas occupies 24 liters at room temperature (24 L/mol for any gas) and the density of liquid water is 1g/cm^3. *Hint: Find the size of the side of the cube for the gas and for the liquid assume one mole.*
   a. Find the distance between liquid molecules (in cm):

   b. Find the distance between molecules in the air (in cm):

   c. How much farther, on average, from one another are particles in a gas than particles in a liquid. *Hint: Look for the ratio of air distance/liquid distance.*

   d. If the density of matter in outer space is one atom of hydrogen per 1cm^3. Find the distance between atoms in space:

   e. How much farther, on average, from one another are particles in space than particles in an air. *Hint: Look for the ratio of space distance /air distance.*

9. If it takes 60.0 s for a kettle to heat 1.00 kg of water, (heat capacity of water is 4.18 J/(g·K)), from 25.0°C to 100.0°C, how long (in "sec") would it take for the same kettle to heat 0.500 kg of ethanol, (heat capacity of ethanol is 2.44 J/(g·K)), through the same temperature range?

10. Student A heats a 0.25 L sample of water (d = 1 g/mL) from 25°C to the boiling point of water. Student B uses a sample of carbon tetrachloride with twice the mass of the sample of student A and heats it from 50.°C to the boiling point of carbon tetrachloride (75°C). Assuming that neither solution begins to boil, and the ratio, of the energy required by student A to the energy required by student B, $E_A/E_B=7$. What is the heat capacity of carbon tetrachloride?

11. While boiling water to cook pasta, you notice a vapor bubble form that is 1.00 cm in radius. Assuming that 1 mol of gas at 100.°C occupies 30.6 L of space; calculate how many water molecules are contained in the bubble.

12. One mole of a water vapor at 100°C occupies 30,000 cm^3. Estimate the distance between the water molecules in the vapor.

13. SCI/109 has the approximate dimensions: 10 m x 5 m x 30 m, assuming that air is completely N_2, if all of the air in SCI/109 were liquefied, what is a volume of the liquid air would be in gallons? Additional information: $d(N_{2(l)})$=0.8 g/mL, 1.00 mol of any ideal gas occupies 24.4L .

14. If 42. kJ of energy is add to 1.0 kg of water (C = 4.184 J/(g·K)), initially at 25°C
    a. What is the final temperature of the water (in K)?

    b. The same amount of energy was added to 2.0 kg of an unknown substance and its temperature increased by 6.0°C. What is the specific heat of the unknown substance (in J/(g·K))?

15. A sample of ethanol (CH_3CH_2OH) is maintained at a temperature of 352. K (the boiling point of ethanol) until the entire sample evaporates. It was found that the evaporation of the sample required 78.0 kJ of energy. Determine the volume of the sample of ethanol that was used. Useful information: ΔH_{vap}=39.0kJ/mol, density=0.800 g/mL

In preparation for next week Mahaffy, 2e sections 6.3**:**

1. Define what are the intermolecular forces:

    a. Name all intermolecular forces:

    b. Which intermolecular force exist in all the molecules?

        i. What are the factors that will make that force greater?

    c. Which intermolecular force exists only in polar molecules?

        i. What are the factors that will make that force greater?

    d. Defined hydrogen bond IMF :

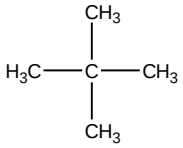
        i. What are necessary conditions to have the IMF hydrogen bonding?

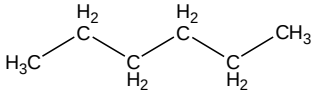
2. IMFs have relative strengths as follows for the molecules of comparable size:
   Hydrogen Bonds > Dipole-Dipole > Induced Dipole – Induced Dipole (dispersion force).
   Which intermolecular forces will become much more significant in larger molecules?

3. Which IMF is least significant around the boiling point?

4. Circle the compound that has the higher boiling point explain why.

a.

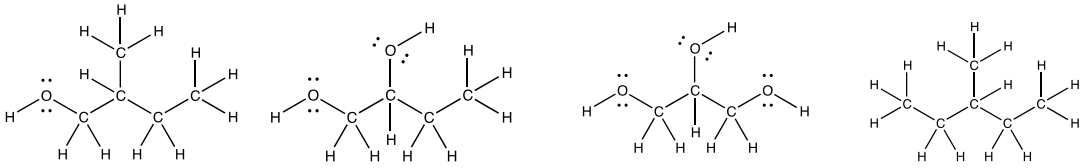




b. CH_2F_2 CH_3OH

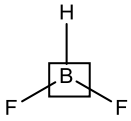
c. NH_3 NF_3

5. Using number labels 1, 2, 3 and 4, rank the following molecules in order of lowest (label 1) to highest (label 4) boiling point. Give your reasons why.

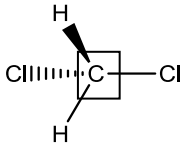


6. Indicate the molecule's geometry about the boxed atom:
   i. Indicate all the polar bonds molecule has.
   ii. Indicate if molecule has a dipole moment. (Draw arrows indicating direction of the dipole moment.)
   iii. (at home) List all intermolecular forces between two of those molecules.

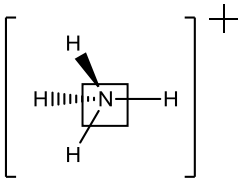
a. BF_2H



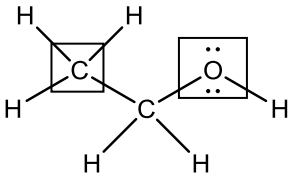
b. CH_2Cl_2



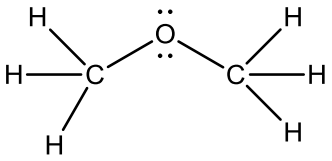
c. NH_4^+



d. CH_3CH_2OH



e. CH_3OCH_3



Numerical Answers

1. NH_3
2. Hexane
3.
   a. amount of energy needed to transfer one mol of the liquid into 1 mol of the gas at given pressure
   b. T_{b2}
4. T_2
7. Table to the right:
8.
   a. 3×10^{-8} cm
   b. 3×10^{-7} cm
   c. 10 times farther apart
   d. 1 cm
   e. 3.3×10^{6} farther apart
9. 17.5 seconds
10. 0.90 J/g·K
11. 8.24×10^{19} water molecules
12. 4×10^{-7} cm/atom
13. 600 gallons
14.
   a. 308 K
   b. 3.5 J/g·K
15. 115 mL EtOH

Molecule	# of atoms bonded to the center atom	# of lone pairs on the center atom	# of atoms and # of lone pairs attached to the center atom	What is the geometry? Net dipole? (Polar or Non-polar)	List all IMFs
CO_2	2	0	2	linear, NP	LDF
BF_3	3	0	3	trigonal planar, NP	induced dipole
SO_2	2	1	3	bent. P	LDF, dipole
HF	1	3	4	linear, P	LDF, dipole, hydrogen bonding
H_2O	2	2	4	bent, P	LDF, dipole, hydrogen bonding
NH_3	3	1	4	trigonal pyramidal, P	LDF, dipole, hydrogen bonding
CH_2Cl_2	4	0	4	Tetrahedral polar	LDF, dipole, induced dipole

*LDF , induced dipole, dispersion are the same thing.

In preparation for next week:

4. C_6H_{14} , CH_3OH, NH_3
5. 2,3,4,1

Exam 1 Answers:

1.
   a. $Al(PO_4)$
   b. Barium Permanganate
   c. 143
   d. ^{14}C
2.
   a. C−S
   b. C≡N
   c. C−H
   d. C−S
3.
   a. 1.91581
   b. 6.02482×10^{23} 1/mol
   c. 6.02214×10^{23} 1/mol
4. 4.4 g of carbon dioxide, CO_2 :largest ; 72 u of water, H_2O: smallest
5. 2.76×10^{-8}cm or 2.75×10^{-8}cm
6. 3.2×10^{15}kg
7. As
   a. 650 cm^{-1}
   b. 8.847×10^{13}1/s; 3389nm
8.
   a. $C_2H_4{}^{35}Cl^+$; $C_2H_2{}^{37}Cl^+$
   b. 146 -- $\frac{1}{8}$
      144 -- $\frac{1}{8}+\frac{3}{8}=\frac{4}{8}$
      142 -- $\frac{3}{8}$
9. 9.23g
10. 0.600mol
11. 0.4
12. 176,000 g/mol
13. 1.6mol
14. 51.838%