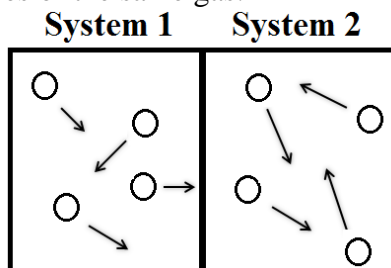
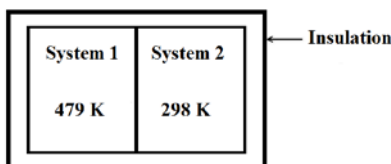


Lecture 15
Thermodynamics I
Worksheet

- 1) Use the Boltzmann distribution curves from the fourth slide in the lecture to relate temperature to the motions of particles.
- 2) Arrows were used to represent the relative velocities of the particles in the following two pure samples of the same gas.

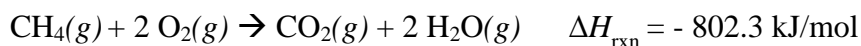


- a. Is System #2 at a higher or lower temperature than System #1? Justify your answer.
 - b. Will kinetic energy be transferred from one of these systems to the other? Justify your answer in terms of molecular collisions.
- 3) Consider the following two systems, which are housed in rigid containers that are in thermal contact with one another.



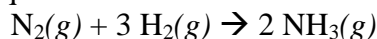
- a. If the insulation of the outside of the two systems prevents any energy from flowing into the surroundings, will the energy lost by System #1 be greater than, less than or equal to the energy gained by System #2.
 - b. Identify the type of energy that is transferred from System #1 into System #2. Justify your answer.
- 4) A gas contracts from 4.26 L to 1.89 L in a cylinder under a constant external pressure of 1.10 atm.
 - a. Calculate the work associated with this contraction in joules.
 - b. Was this process endothermic or exothermic? Justify your answer.
 - 5) 1354 J of heat are absorbed by a balloon from the surroundings, which causes the gas inside the balloon to expand from 2.31 L to 3.98 L under a constant external pressure of 1.07 atm.
 - a. Calculate the change in the internal energy of the balloon.
 - b. Was this process endothermic or exothermic? Justify your answer.
 - c. Was energy conserved during this process? Justify your answer in terms of the magnitudes of the energy changes that occurred.

- 6) Using only the information given in the thermochemical equation below, make a comparison between the sum of the bond enthalpies of the reactants and the sum of the bond enthalpies of the products. Explain why one value is greater than the other.

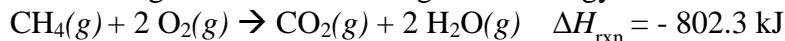


- 7) The following questions pertain to the bonds between the carbon atoms in C_2H_6 and C_2H_4 .
- Draw visual representations that show the relative differences in bond lengths between the carbon atoms in C_2H_6 and C_2H_4 .
 - Which carbon-carbon bond contains the least amount of potential energy? Justify your answer.
 - Which carbon-carbon bond requires the greatest input of energy in order to be broken? Justify your answer.
- 8) Determine the enthalpy change, ΔH_{rxn} , that occurs when two gaseous oxygen atoms combine to form a gaseous oxygen molecule ($2 \text{O}(g) \rightarrow \text{O}_2(g)$) using the table of average bond energies.

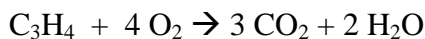
- 9) Use the chemical equation below and the table of average bond energies to answer the following questions.



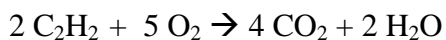
- Draw Lewis structures for all three species represented in the reaction above.
 - Calculate the enthalpy change, ΔH_{rxn} , that occurs in the reaction.
 - Draw a symbolic representation that demonstrated the flow of energy between the system and the surroundings.
 - Is the process endothermic or exothermic?
- 10) Use the thermochemical equation for the combustion of methane and the table of average bond energies to find the average bond energy in a C – H bond.



- 11) Use the chemical equation and the table of average bond energies to answer the following questions.



- Draw Lewis structures for all four species represented in the reaction above.
 - Calculate the enthalpy change, ΔH_{rxn} , that occurs in this reaction.
- 12) Use the chemical equation and the table of average bond energies to answer the following questions.



- Draw Lewis structures for all four species represented in the reaction above.
- Calculate the enthalpy change, ΔH_{rxn} , that occurs in this reaction.

Bond	Average Bond Enthalpies
O – C	351 kJ/mol
O = C	799 kJ/mol
O – O	142 kJ/mol
O = O	499 kJ/mol
C – C	348 kJ/mol
C = C	612 kJ/mol
C ≡ C	960 kJ/mol
H – H	436 kJ/mol
H – C	412 kJ/mol
H – O	467 kJ/mol
N – N	193 kJ/mol
N = N	418 kJ/mol
N ≡ N	941 kJ/mol
N – H	393 kJ/mol