CH301 Worksheet 12

1. Consider the molecules below and determine the total number of motional modes, as well as the number of translational, rotational and vibrational modes, respectively.

a. CH_4
b. H_2O
c. HCN
d. HCl
e. SF_6

2. Complete the table below by filling in the energy associated with each cell (express in terms or R or k):

	CH_3F	SCN^-	SF_6	BH_2^-
translational for 10 molecules				
rotational for 5 moles				
vibrational for 2 molecules				
non-vibrational for 6 moles				
total E for 2 moles				

3. When calculating positional entropy using the equation S = k ln W, how does the calculated value of S compare to the actual, experimental value of S. (Hint: consider what W describes and whether that description is accurate)

4. Complete the following table by filling the positional entropy associated with each cell (express in terms of R or k and a ln function):

	CH_3F	Cl_2	HCl	BH_2F
0.5 moles				
3 moles				
4 molecules				
2 molecules				

5. Assuming you have equal amounts of each, rank the following species from greatest to least internal entropy: BrCl, BrI, FI, Cl_2, FCl.

6. Calculate the pressure-volume work for the following systems. Indicate whether it is work done on or by the system. (Hint: 1 Joule is equal to 1 kPa·L and you may need to do unit conversions)

a. A piston pushes against a pressure of 1 Pascal while expanding from an initial volume of 10 liters to a final volume of 1010 liters.

b. A piston with surface area of 45 cm^2 is pushed 9 mm inward against a pressure of 1 atmosphere.

$45\ cm^2 \cdot 9\ mm = 0.0405\ L$
1 atm = 101.325 kPa

c. A balloon with an internal pressure of 100 atm and a volume of 3 liters is placed in a vacuum where it expands to a volume of 1500 liters.

7. A piston expands isothermally against a vacuum. Which of the following values for the system are equal to zero? (circle or underline the values which are equal to zero.)
q ΔV ΔP w ΔH ΔT ΔE Δn

8. Heat (q) and work (w) are path functions, which are different from state functions in that their value is dependent on how a system gets from one configuration to another. What is a famous example of this fact?

9. Consider the 1st law of thermodynamics. Complete the partial equation below and state the 1st law in your own words.
$\Delta E_{universe}$

10. Calculate ΔE for the following systems
a. 3681 J of work done on a system which releases 1057 kJ of heat to its surroundings

b. A system absorbs 3.289 kJ of heat while doing 7.123 kJ of work on its surroundings.

c. You eat an entire bag of Cheetos™, a Twix™ and drink 64 oz of Mountain Dew™ all while playing WoW™ for 15 hours straight. In total, you consume 1,400 Calories, release 5,400 kJ of heat, do 100 kJ worth of work, and feel terrible. What is the change in your internal energy.

11. Consider the 2nd law of thermodynamics. Complete the partial inequality below and state the 2nd law in your own words.
$\Delta S_{universe}$

12. Calculate $\Delta S_{surroundings}$ for the reactions below based on the provided data.
a. $H_2(g) + ½\ O_2(g) \rightarrow H_2O(g)$ $\Delta H_{rxn} = -241.82\ kJ\cdot mol^{-1}$ $T_{surr} = 25\ °C$

b. $½\ N_2(g) + ½\ O_2(g) \rightarrow NO(g)$ $\Delta H_{rxn} = 90.00\ kJ\cdot mol^{-1}$ $T_{surr} = -80\ °C$

c. $C(g) + O_2(g) \rightarrow CO_2(g)$ $\Delta H_{rxn} = -393.50\ kJ\cdot mol^{-1}$ $T_{surr} = 400\ °C$

13. Complete the partial equations below.
$\Delta G_{sys} =$
$\Delta S_{univ} =$

14. Use the table provided to determine whether the species listed below are stable or unstable under standard conditions:

	$\Delta G°_{rxn}$ ($kcal\cdot mol^{-1}$)
$NH_3(g) \rightarrow 1/2\ N_2(g) + 3/2\ H_2(g)$	3.976
$C_{graphite}(s) + 1/2\ O_2(g) \rightarrow CO(g)$	-32.81

$C_8H_{18}(g) \rightarrow 8\ C_{graphite}(s) + 9\ H_2(g)$	-4.14
$2\ C_{graphite}(s) + 3\ H_2(g) \rightarrow C_2H_6(g)$	-7.86

a. $NH_3(g)$
b. $CO(g)$
c. $C_8H_{18}(g)$
d. $C_2H_6(g)$

15. Write the formation reaction for each of the following species.
a. $O_3(g)$

b. $SF_6(g)$

c. HCN(s)

16. Calculate the temperature at which the following phase transitions occur based on the provided data
a. Vaporization of methanol, ΔH_{vap} = 35.3 $kJ\cdot mol^{-1}$, ΔS_{vap} = 104.5 $J\cdot mol^{-1}\cdot K^{-1}$

b. Condensation of butane, ΔH_{con} = -21.0 $kJ\cdot mol^{-1}$, ΔS_{con} = -77.0 $J\cdot mol^{-1}\cdot K^{-1}$

c. Vaporization of phosphine, ΔH_{vap} = 14.6 $kJ\cdot mol^{-1}$, ΔS_{vap} = 78.9 $J\cdot mol^{-1}\cdot K^{-1}$

17. A certain reaction (the system) is endothermic by 45.68 $kJ\cdot mol^{-1}$ and its entropy increases by 172.3 $J\cdot mol^{-1}\cdot K^{-1}$. Calculate $\Delta S_{universe}$ if the surroundings are at a constant temperature of 0 °C. Can the reaction occur at this temperature? If not, should we raise or lower the temperature to make it spontaneous.

18. Calculate ΔG° for the reactions below using the provided data. Assume 298 K is standard temperature for your calculations.

	ΔH°_f ($kJ\cdot mol^{-1}$)	ΔS°_m ($J\cdot mol^{-1}\cdot K^{-1}$)
$Ag^+(aq)$	105.6	72.68
AgCl(s)	-127.1	96.2
$C_{graphite}(s)$		5.740
CH3OH(l)	-238.7	126.8
$Cl^-(aq)$	-167.2	56.5
$H_2(g)$		130.6
$O_2(g)$		205.0

a. $Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$

b. $C_{graphite}(s) + 1/2\ O_2(g) + 2\ H_2(g) \rightarrow$ CH3OH(l)

19. A giant chunk of diamond weighing 10 g is heated to 500 °C and is then transferred to a insulated container holding 100 g of water at 10 °C. What temperature will the water and diamond be at once the system has equilibrated? (Hint: the specific heat capacity of diamond is 0.5091 $J \cdot g^{-1} \cdot K^{-1}$ and that of water is 4.184 $J \cdot g^{-1} \cdot K^{-1}$)

20. When using a bomb calorimeter, the experimenter measures the change in temperature of the __________ using a __________. Heat released by the reaction being studied is presumed to be _______ by the heat sink, which is typically composed of _____, as well as the apparatus itself. If a reaction is endothermic, the measured changed in temperature will be _______ because the heat _______ by the system must come from the surroundings.