CH 301 Exam 4 Review Session - Discussion Questions
Adapted from McCord gchem additional content spring 2022

State Function / Path Function
Is temperature, T, a state function? Give an example of a state function.

System vs. Surroundings
Draw out two diagrams of system and surroundings
Give an example of negative q and an example of positive q.

Work
Suppose a gas compresses by 185 mL against a pressure of 0.400 atm. How much work is done on the system due to this compression? Report your answer in units of Joules.

Heat
Which of the following materials would you expect to experience the greatest temperature change if 1 gram of each metal were exposed to the same amount of thermal energy? Explain your answer.
Aluminum 0.89 J/g °C
Lead 0.129 J/g °C°
Steel 0.466 J/g °C

Internal Energy
A system lost 11.9 J of heat, yet it was found that its internal energy increased by 85.5 J. Calculate w. Was work done on the system or did the system do work?

Endothermic / Exothermic
Which types of phase changes are endothermic? Which types of phase changes are exothermic? Give an example of a common chemical process that is exothermic.

Coffee Cup Calorimetry
When 0.113 g of liquid benzene, C6H6, burns in excess oxygen in a calibrated constant pressure calorimeter the temperature of the calorimeter rises by 8.60°C and carbon dioxide gas and liquid water are formed.
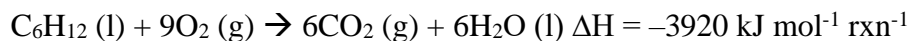Given that the heat capacity of the calorimeter is 551 J/°C, how might one calculate the amount of energy that flowed from the system to the surroundings?

Bomb Calorimetry
1.14 g of liquid octane (C8H18) is combusted in a bomb calorimeter surrounded by 1 L of water. The combustion produces carbon dioxide gas and liquid water. The initial temperature of the water and calorimeter hardware is 25°C. The final temperature of the water and calorimeter hardware is 33°C. The heat capacity of the calorimeter (not including the water!) is 456 J/°C. Determine the heat flow into the surroundings (water + calorimeter). Recall that the density of water is 1 g/mL.
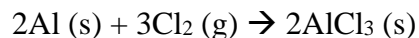
Enthalpy
Here is a thermochemical equation for the combustion of cyclohexane at room temperature:

$$C_6H_{12} \text{ (l)} + 9O_2 \text{ (g)} \rightarrow 6CO_2 \text{ (g)} + 6H_2O \text{ (l)} \; \Delta H = -3920 \text{ kJ mol}^{-1} \text{ rxn}^{-1}$$

What would happen to the value of the enthalpy if you reversed the chemical process (switched reactants and products)? What would happen to the value of the enthalpy if you reduced each of the stoichiometric coefficients by a factor of 3?

Hess's Law
Show how you would manipulate the listed thermochemical equations to get the desired reaction for the synthesis of anhydrous aluminum chloride, which is written:

$$2Al\ (s) + 3Cl_2\ (g) \rightarrow 2AlCl_3\ (s)$$

$2Al\ (s) + 6HCl\ (aq) \rightarrow 2AlCl_3\ (aq) + 3H_2\ (g)$	$\Delta H_1 = -149\ kJ\ mol^{-1}\ rxn^{-1}$
$HCl\ (g) \rightarrow HCl\ (aq)$	$\Delta H_2 = -74\ kJ\ mol^{-1}\ rxn^{-1}$
$H_2\ (g) + Cl_2\ (g) \rightarrow 2HCl\ (g)$	$\Delta H_3 = -185\ kJ\ mol^{-1}\ rxn^{-1}$
$AlCl_3\ (s) \rightarrow AlCl_3\ (aq)\ \Delta$	$\Delta H_4 = -323\ kJ\ mol^{-1}\ rxn^{-1}$

Entropy
Write three equations for the change in entropy of a system when it experiences a change in temperature, a change in volume and or a change in phase. Define each of the variables and give the units for each.

Which compound would you expect to have the lowest absolute entropy of the given pairs? Explain your choice.

a. Br_2 (l) or Br_2 (g)?

b. C (s) graphite or C (s) diamond?

c. Fe_2O_3 (s) or Fe_3O_4 (s)?

d. NH_3 (g) or NH_3 (aq)?

Gibbs Free Energy

The change in the Gibb's free energy, ΔG, is actually derived from the change in entropy of the universe. What is the equation relating the change in Gibb's free energy for a process and the change in enthalpy and entropy for the same process? Define the variables and provide units for each.

What is the sign of ΔG for a spontaneous process? For a non-spontaneous process?

What are the four possible combinations of ΔH and ΔS and what kind of change do they lead to – always spontaneous, always non-spontaneous or temperature dependent?

Calculate the ΔG_{rxn} of the following reaction using the given standard free energy of formation data:

$6CO_2$ (g) + $6H_2O$ (l) → $C_6H_{12}O_6$ (s) + $6O_2$ (6)
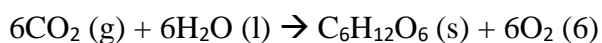
$\Delta Gf°$ CO_2 (g) = –394.36 kJ/mol
$\Delta Gf°$ H_2O (l) = –237 kJ/mol
$\Delta Gf°$ $C_6H_{12}O_6$ (s) = –910 kJ/mol

The condensation of CH_3OH gas to CH_3OH liquid is spontaneous when ΔG is negative. Using the data below, predict at what temperature is this process first spontaneous at 1 bar.

S° CH3OH (g) = 240 J/K mol $\Delta Hf°$ CH3OH (g) = –201 kJ/mol
S° CH3OH (l) = 127 J/K mol $\Delta Hf°$ CH3OH (l) = –239 kJ/mol