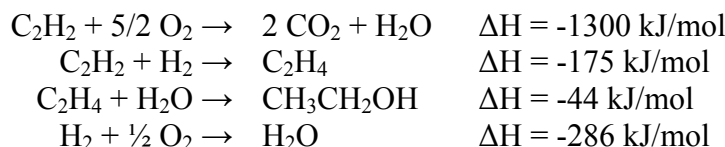


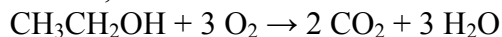
## Fall 2007 CH301 Worksheet 12--Thermodynamics

- A small (74 g) serving of French fries is burned in a bomb calorimeter containing 3 L of water. The temperature of the water increases by 82°C. The calorimeter has a heat capacity of 200 J/°C, the density of water is 1 g/mL, and the heat capacity of water is 4.18 J/g°C. How much heat is evolved per gram of french fries?
- The same calorimeter as in number 1 is used to measure the enthalpy of dissolving 2.5 mol of potassium chloride (KCl) in water. If the enthalpy of the process is  $\Delta H = +15$  kJ/mol and the initial temperature of the water is 298 K, what is the final temperature of the water?

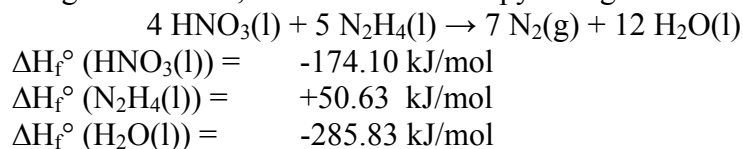
3. Given



Find  $\Delta H$  for the combustion of ethanol,



4. Given the following information, calculate the enthalpy change for the reaction



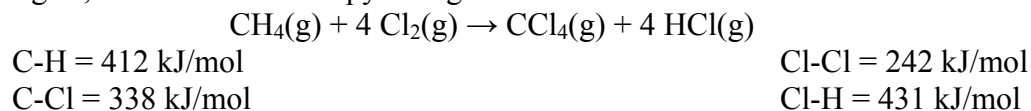
5. Calculate the free energy change of the same reaction at 298 K, given



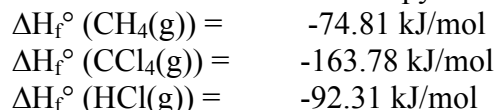
5. Calculate the enthalpy change for the combustion of ethanol using bond energies.



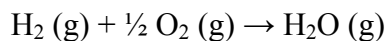
6. Using bond energies, calculate the enthalpy change for the reaction



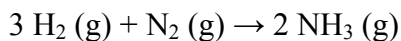
7. Use enthalpies of formation to find the enthalpy change for the same reaction.



8. Find the approximate work done for the following reaction at 400 K.



9. For the reaction



how many moles of hydrogen gas must be reacted for the work to be 8 kJ at 300 K?

10. A reaction occurs in a beaker. You touch the beaker and it feels cold. What is the sign of  $\Delta H$  for the reaction? What can you say about the sign of  $\Delta S$ ?

11. A reaction happens in a balloon, and in the end, the volume of the balloon has doubled. What is the sign of work for the reaction?

12. Give the sign of the entropy change of the system for the following processes:

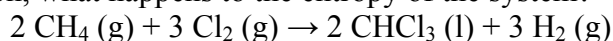
a. Dr. Laude pours hot water in a tub of liquid  $\text{N}_2$  and makes a thundercloud.

b. Water freezes.

c. Two cars are in a head-on collision.

d. Sugar is dissolved in a drink.

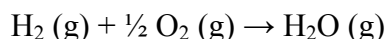
13. For the following reaction, what happens to the entropy of the system?



14. The reaction above happens. What can you say about its enthalpy change?

15. From your knowledge of the temperature dependence of (a) water boiling and (b) water freezing, predict the sign of  $\Delta H$  and  $\Delta S$ .

16. The reaction



is exothermic. Is its spontaneity temperature-dependent? In what way?

17. For each of the following combinations of enthalpy and entropy change, tell whether it occurs *always*, *never*, *at high temperature*, or *at low temperature*.

a.  $\Delta H < 0$ ,  $\Delta S < 0$

c.  $\Delta H > 0$ ,  $\Delta S < 0$

b.  $\Delta H < 0$ ,  $\Delta S > 0$

d.  $\Delta H > 0$ ,  $\Delta S > 0$

18. Explain why, although water has three vibrational degrees of freedom, carbon dioxide must have four. (Hint: both molecules have 9 total degrees of freedom)

19. What is the total motional (i.e. due to the motion of the atoms in the molecule) contribution to the energy of methanol,  $\text{CH}_3\text{OH}$ ? Express your answer as a multiple of  $RT$ .

20. How many translational, rotational, and vibrational degrees of freedom does ammonia have?

