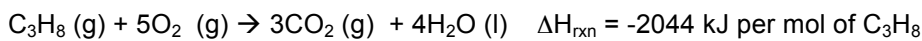


**Part A: Chem 1A Review: Enthalpy**

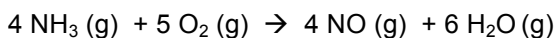
1. Identify each process as endothermic or exothermic and indicate the sign of  $\Delta H_{\text{sys}}$ . The underlined word is the system.

- a) sweat evaporating from skin
  
- b) water freezing in a freezer
  
- c) wood burning in a fire
  
- d) gasoline burning within the cylinder of an automobile

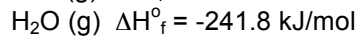
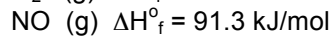
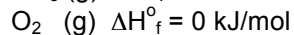
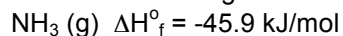
2. A gas tank in a home barbeque contains 13.2 kg of propane,  $\text{C}_3\text{H}_8$ . Calculate the heat in kJ for the complete combustion of propane within the tank.



3. Use the standard enthalpies of formation to determine  $\Delta H_{\text{rxn}}^\circ$  for the reaction below.



Given the following:



**Part B: Spontaneous and Non-Spontaneous Processes**

4. Use your intuition and identify each process as spontaneous or non-spontaneous.
- a) A smell diffusing into a room:
  
  - b) Iron rusting:
  
  - c) Mixing carbon dioxide and water to give gasoline.
  
  - d) Dissolving AgCl (s) in water.
  
  - e) Dissolving NaCl (s) in water.
5. A few more... Use your intuition and identify each process as spontaneous or non-spontaneous.
- a) Dissolution of  $\text{NH}_4\text{Cl}$  in water
  
  - b) Melting of ice above  $0^\circ\text{C}$
  
  - c) Evaporation of liquid water to steam above  $100^\circ\text{C}$ .
  
  - d) All of the above processes absorb heat (require heat) but they are spontaneous. What drives these processes? What makes them spontaneous then if the enthalpy change is unfavorable?

**Part C: Entropy and the 2<sup>nd</sup> Law of Thermodynamics**

6. Identify each process as increasing entropy or decreasing entropy. Predict the sign of  $\Delta S$ .

a) the boiling of water

b)  $I_2(g) \rightarrow I_2(s)$

c)  $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

d) Sublimation of solid carbon dioxide (dry ice).

e)  $C_2H_4(g) + H_2(g) \rightarrow C_2H_6(g)$

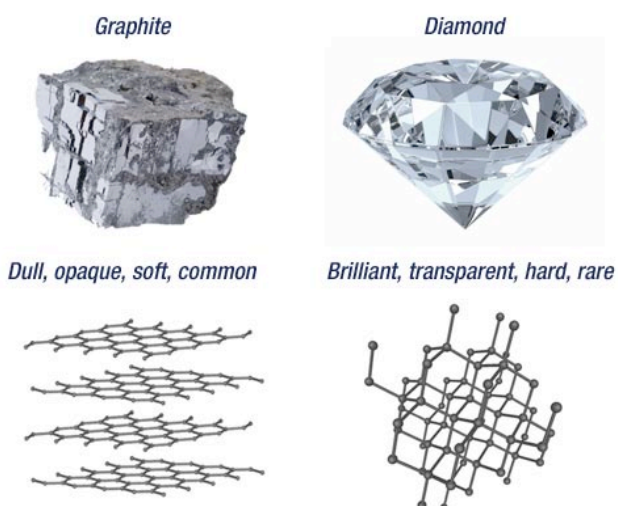
**Part D: Calculating Changes in Entropy using Standard Molar Entropies (3<sup>rd</sup> Law of Thermodynamics)**

6. Conceptual Practice:

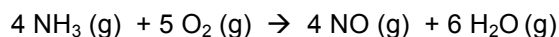
Carbon can exist in several forms called allotropes. Diamond is solid carbon with atoms that are constrained by chemical bonds in a highly restricted 3-dimensional crystal structure (see picture below). Graphite is another form of carbon but the atoms are bond together in sheets and the sheets have freedom to move or slip past each other (which is why graphite is used as a lubricant).

Given this information, which would you expect to have the highest standard molar entropy?

**Graphite vs Diamond**



7. For problem 3) you calculated the  $\Delta H^{\circ}_{\text{rxn}}$  for the reaction below. Now calculate the  $\Delta S^{\circ}$  given standard  $S^{\circ}$  values below.



$$\text{NH}_3 (\text{g}) \quad S^{\circ} = 192.8 \text{ J/molK}$$

$$\text{O}_2 (\text{g}) \quad S^{\circ} = 205.2 \text{ J/molK}$$

$$\text{NO} (\text{g}) \quad S^{\circ} = 210.8 \text{ J/molK}$$

$$\text{H}_2\text{O} (\text{g}) \quad S^{\circ} = 188.8 \text{ J/molK}$$

8. Using the equation below, calculate  $\Delta S_{\text{univ}}$  to determine if the reaction is spontaneous at  $T = 298\text{K}$ .

$$\Delta S_{\text{univ}} = \Delta S_{\text{sys}} - \Delta H_{\text{sys}}/T$$