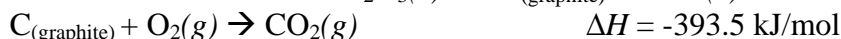
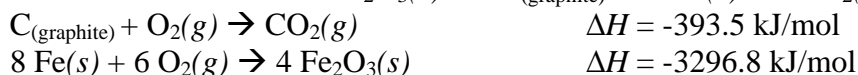


Lecture 16  
Thermodynamics II  
Worksheet

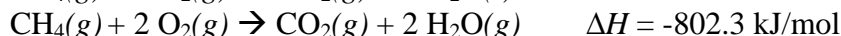
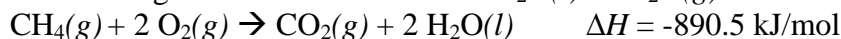
- 1) A 85.2 g copper bar was heated to 221.32 °C and placed in a coffee cup calorimeter containing 425.0 mL of water at 22.55 °C. The final temperature of the water was recorded to be 26.15 °C.
- How much heat was gained by the water?
  - How much heat was lost by the copper?
  - What is the specific heat of copper?
  - Was energy conserved in the process? Justify your answer.
- 2) A 100.0 mL sample of 0.76 M HCl at 23.0 °C was mixed with 100.0 mL of 0.76 M NaOH at 23.0 °C in a coffee cup calorimeter and the following reaction occurred.
- $$\text{H}^+ (\text{aq}) + \text{OH}^- (\text{aq}) \rightarrow \text{H}_2\text{O} (\text{l})$$
- The temperature of the solution increased and a maximum temperature of 28.2 °C was recorder. Assume that no heat was lost to the surroundings, the volumes were additive, the specific heat capacity of the solution was 4.184 J/gK, and the density of the solution was 1.00 g/mL.
- Calculate the enthalpy change,  $\Delta H_{\text{rxn}}$ , for the formation of 1.0 mol H<sub>2</sub>O in this reaction.
  - Is the reaction endothermic or exothermic?
  - Was energy conserved in the process? Justify your answer.
- 3) A coffee cup calorimeter contains 100.0 mL of 1.50 M Ba(NO<sub>3</sub>)<sub>2</sub> at 25.0 °C. A student pours 100.0 mL of 1.50 M Na<sub>2</sub>SO<sub>4</sub> at 25.0 °C into the calorimeter. A precipitate forms and the temperature rises to 29.7 °C. Assume that no heat was lost to the surroundings, the volumes were additive, the specific heat capacity of the solution was 4.184 J/gK, and the density of the solution was 1.00 g/mL.
- This reaction could be represented as a complete ionic or a net ionic equation. Write the balanced chemical equation that should be used in association with the  $\Delta H_{\text{rxn}}$  value for this reaction. Justify your choice.
  - Find the amount of heat that was lost or gained by the solution in the calorimeter.
  - Find the heat of reaction,  $\Delta H_{\text{rxn}}$ .
  - Is the reaction endothermic or exothermic?
- 4) An experiment was conducted in order to determine the enthalpy change that occurs when 1.0 mole of ice at 0 °C melts and becomes 1.0 mole of water at 0 °C. The enthalpy change associated with this process is referred to as the heat of fusion,  $\Delta H_{\text{fus}}$ , of ice. In the experiment, a 9.68 g sample of ice at 0 °C was added to a coffee cup calorimeter containing 278.25 mL of distilled water. The temperature of the water was 22.485 °C before the ice was added. The lowest temperature that was recorded after the ice had melted was 19.050 °C.
- Find the amount of heat lost or gained by the water in the calorimeter.

- In this experiment, the ice melted and then the temperature of the water produced by the ice increased from 0°C to 19.050°C. Calculate the amount of heat absorbed by the melted ice ( $q_{\text{melted ice}}$ ) as its temperature increased from 0.000°C to 19.050°C.
- Calculate the amount of heat that was gained by the ice during the melting process ( $q_{\text{melting}}$ ). (Hint:  $q_{\text{temp gain}} + q_{\text{melting}} = -q_w$ )
- Calculate the heat of fusion of ice,  $\Delta H_{\text{fus}}$ .
- Is the reaction endothermic or exothermic?
- Energy was transferred from one system to another during this experiment. Identify the two interacting systems and outline the direction of energy flow.
- Was energy conserved in the process? Justify your answer.

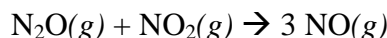
- 5) Determine the value of the enthalpy change,  $\Delta H_{\text{rxn}}$ , for the following reaction using the information below.



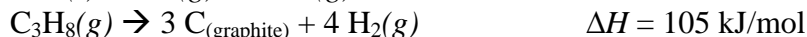
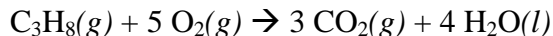
- 6) Determine the value of the enthalpy change,  $\Delta H_{\text{vap}}$ , for the evaporation of one mole of water using the information below.



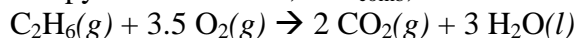
- 7) Determine the value of the enthalpy change,  $\Delta H_{\text{rxn}}$ , for the following reaction using the information below.



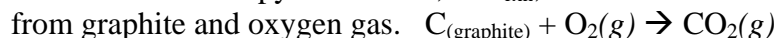
- 8) Determine the value of the enthalpy change,  $\Delta H_{\text{rxn}}$ , for the following reaction using the information below.



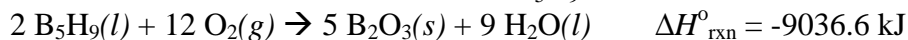
- 9) Using standard enthalpy of formation values from the appendix in your textbook, calculate the enthalpy of combustion,  $\Delta H_{\text{comb}}^\circ$ , of one mole of ethane at 25°C.



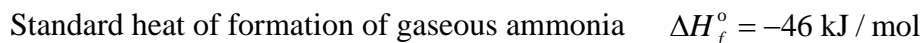
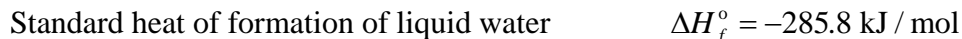
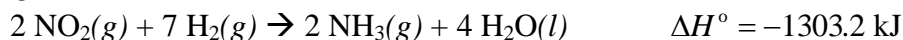
- 10) Using standard enthalpy of formation values from the appendix in your textbook, calculate the enthalpy of reaction,  $\Delta H_{\text{rxn}}^\circ$ , for the formation of carbon dioxide from graphite and oxygen gas.



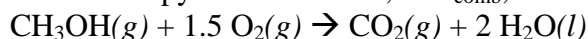
- 11) The standard heat of formation of  $B_2O_3(s)$  is  $-1263.6$  kJ/mol and the standard heat of formation of liquid water is  $-285.8$  kJ/mol. Use the information below to find the standard heat of formation for one mole of  $B_5H_9$ .



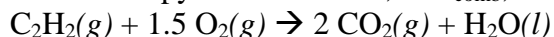
- 12) Use the following information to find the standard heat of formation for one mole of  $NO_2(g)$ .



- 13) Using standard enthalpy of formation values from the appendix in your textbook, calculate the enthalpy of combustion,  $\Delta H_{\text{comb}}^{\circ}$ , for one mole of methanol at  $25^{\circ}\text{C}$ .



- 14) Using standard enthalpy of formation values from the appendix in your textbook, calculate the enthalpy of combustion,  $\Delta H_{\text{comb}}^{\circ}$ , for one mole of  $C_2H_2$  at  $25^{\circ}\text{C}$ .

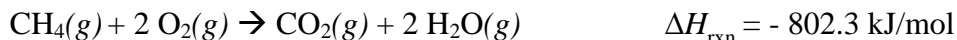


- 15) Humans started using elemental copper about 6000 years ago and started using elemental tin about 3800 years ago. Use the heat of formation values for copper (II) oxide and tin (IV) oxide to help explain why humans were able to use elemental copper before they were able to use elemental tin.

- 16) Write the balanced chemical equation that outlines the reaction used to determine the enthalpy of formation for one mole of water.

- 17) Write the balanced chemical equation that outlines the reaction used to determine the enthalpy of formation for one mole of  $H_2CO(g)$ .

- 18) How much heat is released when 24.8 g of  $CH_4(g)$  is burned in excess oxygen gas to produce carbon dioxide and water?



- 19) How much heat is released or absorbed when 45.8 g of hydrogen gas reacts with excess nitrogen gas according to the chemical equation below?

