Chapter 6 Study Questions

1. Draw an energy diagram for an exothermic reaction where $\Delta H = -20$ kJ.

2. Classify each of the following processes as endothermic or exothermic. In each case, indicate which has greater heat content (enthalpy), reactants or products.
   a) combustion of natural gas
   b) condensation of water vapor
   c) splitting of carbon dioxide into carbon and oxygen
   d) solidification of melted wax
   e) formation of sodium chloride (NaCl) from it elements
   f) evaporation of alcohol

3. Propane gas, C_3H_8, is a common fuel for camp stoves.
   a) What is $\Delta H_f°$ for propane? (Use $\Delta H_f°$ Table.)
   b) Write a balanced <u>thermochemical</u> equation for the formation of propane from its elements.
   c) Is this reaction endothermic or exothermic?
   d) How many moles of H_2 are needed to produce 1090 kJ according to the equation in b)?
   e) How much heat is produced during the formation of 30.1 g of propane?
   f) Write a balanced chemical equation for the complete combustion of propane.
   g) Find ΔH for the reaction in f) using $\Delta H_f°$ Table and Hess' Law.

4. For each of the reactions below, calculate ΔH and indicate whether the reaction is endothermic or exothermic. (Use $\Delta H_f°$ Table as needed.)
   a) $2\ NO(g) + O_2(g) \rightarrow 2\ NO_2(g)$
   b) $6\ PbO(s) + O_2(g) \rightarrow 2\ Pb_3O_4(s)$

5. A coffee cup calorimeter is used to calculate the heat change when NH_4Cl is dissolved in water. Use the data table below to calculate the heat change when 1.00 mole of NH_4Cl is dissolved in water. (Assume that the heat change for the solution is the same as that of water alone and that you can ignore the mass of solid in the water, so use only the mass of water and the specific heat of water, 4.18 J/g °C, in calculating the heat change.)
   Mass of NH_4Cl = 5.03 g
   Mass of water in the coffee cup = 60.0 g
   Initial temperature of the water = 24.78 °C
   Final temperature of the water = 19.23 °C
   Is this process endothermic or exothermic?

6. To change the temperature of a particular calorimeter and the water it contains by one degree Celsius requires 6485 Joules. The complete combustion of 1.40 g of ethylene gas, C_2H_4, in the calorimeter causes a temperature rise of 10.7 degrees. Find the heat of combustion per mole of ethylene.

7. Calculate ΔH for the reaction: $N_2H_4(l) + O_2(g) \rightarrow N_2(g) + 2\ H_2O(l)$
given the following data:

$2\ NH_3(g) + 3\ N_2O(g) \rightarrow 4\ N_2(g) + 3\ H_2O(l)$	ΔH = −1010 kJ
$N_2O(g) + 3\ H_2(g) \rightarrow N_2H_4(l) + H_2O(l)$	ΔH = −317 kJ
$2\ NH_3(g) + ½\ O_2(g) \rightarrow N_2H_4(l) + H_2O(l)$	ΔH = −143 kJ
$H_2(g) + ½\ O_2(g) \rightarrow H_2O(l)$	ΔH = −286 kJ

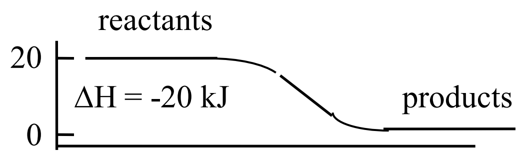
Summary of Chapter 6: Thermochemistry

heat content = enthalpy
change in heat content (ΔH)
heat content diagrams
endothermic, exothermic
change in heat content associated with physical and chemical changes
calorimetry: calculation of heat change from temperature change
joules, calories
specific heat
ΔH_{fus} & ΔH_{vap}
$\Delta H_f°$, definition & use of table to find heat changes of chemical reactions
complete combustion
thermochemical equations
ΔH/mole conversions
Hess' Law

Honors Chemistry

Answers to Chapter 6 Study Questions

1.



2. a) exothermic, reactants b) exothermic, reactants c) endothermic, products
   d) exothermic, reactants e) exothermic, reactants f) endothermic, products

3. a) $\Delta H_f°(C_3H_8) = -103.8$ kJ/mol

   b) $3\,C(s) + 4\,H_2(g) \rightarrow C_3H_8(g) \qquad \Delta H = -103.8$ kJ

   c) exothermic

   d) $1090\text{ kJ} \times \dfrac{4\,mol\,H_2}{103.8\,kJ} = 42.0\text{ moles } H_2$

   e) $30.1\text{ g } C_3H_8 \times \dfrac{1\,mol\,C_3H_8}{44.0\,g\,C_3H_8} \times \dfrac{103.8\,kJ}{1\,mol\,C_3H_8} = 71.0\text{ kJ}$

   f) $C_3H_8(g) + 5\,O_2(g) \rightarrow 3\,CO_2(g) + 4\,H_2O(l)$

   g) $\Delta H(\text{reaction}) = 3\,\Delta H_f°(CO_2) + 4\,\Delta H_f°(H_2O) - \Delta H_f°(C_3H_8)$
   $= 3\,(-393.5\text{ kJ}) + 4\,(-285.8\text{ kJ}) - (-103.8\text{ kJ})$
   $= -1180 + (-1143) + 103.8 = -2220\text{ kJ}$

4. a) from the $\Delta H_f°$ Table:
   (i) $\frac{1}{2}N_2(g) + \frac{1}{2}O_2(g) \rightarrow NO(g) \qquad \Delta H = +90.4$ kJ
   (ii) $\frac{1}{2}N_2(g) + O_2(g) \rightarrow NO_2(g) \qquad \Delta H = +33.9$ kJ;

   $-2 \times (i) = \quad 2\,NO(g) \rightarrow N_2(g) + O_2(g) \qquad \Delta H = -2(90.4) = -180.8$ kJ
   $2 \times (ii) = \quad N_2(g) + 2\,O_2(g) \rightarrow 2\,NO_2(g) \qquad \Delta H = 2(33.9) = 67.8$ kJ;

   overall reaction = $2\,NO(g) + O_2(g) \rightarrow 2\,NO_2(g) \qquad \Delta H = -180.8 + 67.8 = -113.0$ kJ
   Exothermic

   b) (i) $Pb(s) + 0.5\,O_2(g) \rightarrow PbO(s) \qquad \Delta H = -217.9$ kJ
   (ii) $3\,Pb(s) + 2\,O_2(g) \rightarrow Pb_3O_4(s) \qquad \Delta H = -734.7$ kJ; therefore:

   $2 \times (ii) = 6\,Pb(s) + 4\,O_2(g) \rightarrow 2\,Pb_3O_4(s) \qquad \Delta H = 2(-734.7) = -1469$ kJ
   $-6 \times (i) = 6\,PbO(s) \rightarrow 6\,Pb(s) + 3\,O_2(g) \qquad \Delta H = -6(-217.9) = +1307$ kJ

   overall reaction = $6\,PbO(s) + O_2(g) \rightarrow 2\,Pb_3O_4(s) \qquad \Delta H = -1469 + 1307 = -162$ kJ
   Exothermic

5. Q (J) = specific heat (J/g °C) x mass (g) x ΔT (°C); ΔT = 19.23 – 24.78 = –5.55 °C

Q = 4.18 J/g °C x 60.0 g x –5.55 °C = 1390 J

$$1 \text{ mole } NH_4Cl \times \frac{1390\ J}{5.03\ g\ NH_4Cl} \times \frac{53.5\ g\ NH_4Cl}{1\ mol\ NH_4Cl} = 14{,}800 \text{ J} = 14.8 \text{ kJ/mole}$$

Endothermic

6. Q = 6485 J/°C x 10.7°C = 69,400 J = 69.4 kJ

$$1 \text{ mole } C_2H_4 \times \frac{28.0\ g\ C_2H_4}{1\ mol\ C_2H_4} \times \frac{69.4\ kJ}{1.40\ g\ C_2H_4} = 1390 \text{ kJ} = 1.39 \times 10^3 \text{ kJ}$$

7.

$2\ NH_3(g) + 3\ N_2O(g) \rightarrow 4\ N_2(g) + 3\ H_2O(l)$	ΔH = –1010 kJ
$3\ N_2H_4(l) + 3\ H_2O(l) \rightarrow 3\ N_2O(g) + 9\ H_2(g)$	ΔH = 3(+317) kJ
$N_2H_4(l) + H_2O(l) \rightarrow 2\ NH_3(g) + \frac{1}{2}\ O_2(g)$	ΔH = +143 kJ
$9\ H_2(g) + 4\frac{1}{2}\ O_2(g) \rightarrow 9\ H_2O(l)$	ΔH = 9(–286) kJ
$4\ N_2H_4(l) + 4\ O_2(g) \rightarrow 4\ N_2(g) + 8\ H_2O(l)$	ΔH = –2490 kJ

for the reaction, $N_2H_4(l) + O_2(g) \rightarrow N_2(g) + 2\ H_2O(l)$, ΔH = (–2490)/4 = –623 kJ