Thermodynamics Worksheet #4

1. What is the specific heat of a substance that has a mass of 25.0 g and requires 525.0 kJ to raise its temperature by 15.0°C?

2. Suppose 100.0 g of $H_2O_{(s)}$ absorbs 1255.0 J of heat. What is the corresponding temperature change? The specific heat of $H_2O_{(s)}$ is 2.1 J/g.°C.

3. How many joules of heat energy are required to raise the temperature of 100.0 g of aluminum by 120.0°C? The specific heat of aluminum is 0.900 J/g.°C.

4. Calculate the amount of heat evolved when 15.0 g of $Ca(OH)_2$ forms from the reaction of $CaO_{(s)} + H_2O_{(l)}$.
   $CaO_{(s)} + H_2O_{(l)} \rightarrow Ca(OH)_{2(s)}$ $\Delta H = -65.2$ kJ

5. Calculate the amount of heat produced when 52.4 g of methane, CH_4, burns in an excess of air, according to the following equation.
   $CH_{4(g)} + 2\ O_{2(g)} \rightarrow CO_{2(g)} + 2\ H_2O_{(l)}$ $\Delta H = -890.2$ kJ

6. What is the enthalpy change for the formation of hydrazine, $N_2H_{4(l)}$, from its elements?
   $N_{2(g)} + 2\ H_{2(g)} \rightarrow N_2H_{4(l)}$
   Use the following reactions and enthalpy changes:
   $N_2H_{4(l)} + O_{2(g)} \rightarrow N_{2(g)} + 2\ H_2O_{(l)}$ $\Delta H = -622.2$ kJ
   $H_{2(g)} + ½\ O_{2(g)} \rightarrow H_2O_{(l)}$ $\Delta H = -285.8$ kJ

7. Barium oxide reacts with sulfuric acid as follows:
   $BaO_{(s)} + H_2SO_{4(aq)} \rightarrow BaSO_{4(s)} + H_2O_{(l)}$
   Calculate the change in enthalpy of the reaction from these data:
   $SO_{3(g)} + H_2O_{(l)} \rightarrow H_2SO_{4(l)}$ $\Delta H_f^o = -78.2$ kJ
   $BaO_{(s)} + SO_{3(g)} \rightarrow BaSO_{4(s)}$ $\Delta H_f^o = -213.4$ kJ

8. The following equation shows the combustion of ethane.
   $2\ C_2H_{6(g)} + 7\ O_{2(g)} \rightarrow 4\ CO_{2(g)} + 6\ H_2O_{(g)}$
   Use Hess's Law to calculate the enthalpy change for combustion of ethane, C_2H_6, from the following data.

   $C_2H_{4(g)} + 3\ O_{2(g)} \rightarrow 2\ CO_{2(g)} + 2\ H_2O_{(g)}$ $\Delta H = -1323$ kJ/mol C_2H_4
   $C_2H_{4(g)} + H_{2(g)} \rightarrow C_2H_{6(g)}$ $\Delta H = -137$ kJ/mol
   $H_{2(g)} + ½\ O_{2(g)} \rightarrow H_2O_{(g)}$ $\Delta H_f^o = -242$ kJ/mol

9. Using the table below, calculate ΔG_{rxn} for each of the following reactions. Decide whether the reaction would occur spontaneously or not. Hint: Calculate ΔH_{rxn} and ΔS_{rxn} first. Assume a temperature of 25°C.

   a. $PbBr_{2(s)} + Cl_{2(g)} \rightarrow PbCl_{2(s)} + Br_{2(l)}$
   b. $H_2O_{(l)} \rightarrow H_2O_{(g)}$
   c. $2\ C_2H_{6(g)} + 7\ O_{2(g)} \rightarrow 4\ CO_{2(g)} + 6\ H_2O_{(l)}$
   d. $Cu_2S_{(s)} + S_{(s)} \rightarrow 2\ CuS_{(s)}$
   e. $CuS_{(s)} + 2\ O_{2(g)} \rightarrow CuSO_{4(s)}$

Substance	ΔH_f^o (kJ/mol)	S^o (J/mol.K)
$Br_{2(l)}$	0	152.231
$C_2H_{6(g)}$	-84.68	229.60
$CO_{2(g)}$	-393.509	213.74
$Cl_{2(g)}$	0	223.066
$Cu_2S_{(s)}$	-79.5	120.9
$CuS_{(s)}$	-53.1	66.5
$CuSO_{4(s)}$	-771.36	109
$H_2O_{(l)}$	-285.830	69.91
$H_2O_{(g)}$	-241.818	188.825
$O_{2(g)}$	0	205.138
$PbBr_{2(s)}$	-278.7	161.5
$PbCl_{2(s)}$	-359.41	136.0
$S_{(s)}$	0	31.80