CH301 Fall 2008 Worksheet 12

1. Assume we want to use a bomb calorimeter to determine the specific heat capacity of an unknown liquid. We use 3 L of the unkown liquid and perform a known reaction that releases 400 kJ of heat. We measure an initial and final temperature of 25 ºC and 28.7 ºC, respectively. If the heat capacity of the calorimeter is 85 $J \cdot K^{-1}$, and the density of the liquid is 2.34 $g \cdot mL^{-1}$, what is the specific heat capacity of the unknown liquid?

2. Lets say we filled the calorimeter above with 3 L of water and performed the same known reaction above. We measured a final temperature of 57.56 ºC, but forgot to measure the inital temperature. Considering the density and specific heat capacity of water are 1 $g \cdot mL^{-1}$ and 4.184 $J \cdot g^{-1} \cdot K^{-1}$, could we calculate what the initial temperature must have been? If so, what was the initial temperature?

3. Given the following data:

$P_4(s) + 6Cl_2(g) \leftrightarrow 4PCl_3(g)$ $\Delta H = -1{,}225.6\ kJ \cdot mol^{-1}$
$P_4(s) + 5O_2(g) \leftrightarrow P_4O_{10}(s)$ $\Delta H = -2{,}967.3\ kJ \cdot mol^{-1}$
$PCl_3(g) + Cl_2(g) \leftrightarrow PCl_5(g)$ $\Delta H = -84.2\ kJ \cdot mol^{-1}$
$PCl_3(g) + 1/2O_2(g) \leftrightarrow Cl_3PO(g)$ $\Delta H = -285.7\ kJ \cdot mol^{-1}$

calculate ΔH for the reaction

$P_4O_{10}(s) + 6PCl_5(g) \leftrightarrow 10Cl_3PO(g)$

4. Given the following data:

$2O_3(g) \leftrightarrow 3O_2(g)$ $\Delta H = -427\ kJ \cdot mol^{-1}$
$O_2(g) \leftrightarrow 2O(g)$ $\Delta H = 495\ kJ \cdot mol^{-1}$
$NO(g) + O_3(g) \leftrightarrow NO_2(g) + O_2(g)$ $\Delta H = -199\ kJ \cdot mol^{-1}$

calculate ΔH for the reaction

$NO(g) + O(g) \leftrightarrow NO_2(g)$

5. Hyrdoiodic acid (HI) and sodium hydroxide (NaOH) are a strong acid and strong base respectively. Calculate the change in enthalpy for their neutralization reaction:

$HI(g) + NaOH(s) \rightarrow NaI(s)$ and $H_2O(l)$

Consult Appendix 2 in your ebook for standard enthalpy of formation values.

6. Calculate the change in enthalpy for the reaction of hydroxylamine and hydrogen peroxide to form ammonia, water and ozone.

$2NH_2OH(s)2 + H_2O_2(aq) \rightarrow 2NH_3(aq) + H_2O(l) + O_3(g)$

Consult Appendix 2 in your ebook for standard enthalpy of formation values.

7. Using bond enthalpies, approximate the change in enthalpy for the reaction in question 6 above. Would the reaction be more or less endothermic with every species in the gas phase? Consult tables 6.7 and 6.8 in your ebook for mean bond enthalpies

8. Calculate the change in standard molar entropy for the reaction in question 6 above. Consult Appendix 2 in your ebook for standard molar entropy values. Assume that hydroxyalmine has a standard molar entropy of 0. Also, discuss whether we are overestimating or underestimating the change in standard molar entropy for the reaction .

9. Based on the values of ΔH_{rxn} and ΔS_{rxn} calculated in question 6 and question 8, how would the reactions spontaneity be effected by temperature? Explain your answer.

10. Based on the values of ΔH_{rxn} and ΔS_{rxn} calculated in question 6 and question 8, at what temperature would the reaction switch from being non-spontaneous to spontaneous. In other words, what would T be if $\Delta G_{rxn} = 0$. Considering your answer to number 8, are we overestimating or underestimating the temperature at which the reaction switches from non-spontaneous to spontaneous?

11. In the list of elements below, mark (circle, underline, etc.) all of the elements that are not shown in their standard state.

$C_{diamond}(s)$ Ca(s) $B_2(s)$ Na(s) Fe(s) Hg(s)
$Br_2(l)$ Mo(s) H(g) He(g) Xe(g) $Rb_2(s)$
Cd(l) As(s) $N_2(l)$ $O_2(l)$ $Si_{60}(s)$ $F_2(g)$

12. Write the standard formation reactions for the following chemical species

$NH_3(g)$

$Fe_2O_3(s)$

$O_2(l)$

$O_3(g)$

$NH_2OH(s)$

13. State in your own words the first law of thermodynamics. What are some of the consequences of the first law?

14. What is a state function? List all of the state functions you can.

15. If we were harnessing a combustion reaction that produces lots of gaseous products to do work (like in a car's engine), how would lowering the temperature effect the amount of work we could do?

Consider the following molecules for questions 16-20: O_3, N_2, CH_4, SF_6

16. Which has the fewest rotational modes? how many? why?

17. Which has most vibrational modes? how many? why?

18. Do any have more or less than 3 translational modes? why?

19. Which has the most total modes? how many? why?

20. Which has 9 vibrational modes?