

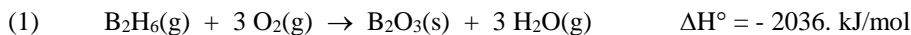
CHM 3400 – Problem Set 3

Due date: Wednesday, February 5th.

Do all of the following problems. Show your work.

“Scientists do not believe; they check.” – John Cornforth

1) Using only the data given below, find the value for ΔH°_f for diborane, $B_2H_6(g)$, at 298. K.



2) One mole of argon gas ($C_{p,m} = 20.79 \text{ J/mol}\cdot\text{K}$) at an initial temperature $T_i = 450.0 \text{ K}$ is expanded adiabatically and irreversibly against an unknown constant external pressure. The value for work for the process is $w = - 1098. \text{ J}$. Based on this information find the final temperature of the gas. You may assume that argon is an ideal gas.

3) Gasoline consists of a mixture of hydrocarbons and other compounds. One of these hydrocarbons is n-decane ($C_{10}H_{22}(\ell)$).

a) Give the correctly balanced combustion reaction for n-decane.

b) The enthalpy of combustion for n-decane is $\Delta H^\circ_{\text{comb}}(C_{10}H_{22}(\ell)) = - 6777.9 \text{ kJ/mol}$. Based on this information, find the numerical value for $\Delta H^\circ_f(C_{10}H_{22}(\ell))$, the enthalpy of formation for n-decane. Note that $\Delta H^\circ_f(CO_2(g)) = - 393.51 \text{ kJ/mol}$, $\Delta H^\circ_f(H_2O(\ell)) = - 285.83 \text{ kJ/mol}$.

4) Consider the following gas phase chemical reaction



a) Using the table of average bond enthalpies in Handout 2, estimate the value for ΔH_{rxn} for reaction 4.1

b) Using the thermochemical data in the table below (given at $T = 25.0 \text{ }^\circ\text{C}$), find the value for $\Delta H^\circ_{\text{rxn}}$ for reaction 4.1

c) Which value for reaction enthalpy is better? Why?

d) Using the thermochemical data in the table below, find the value for $\Delta S^\circ_{\text{rxn}}$ for reaction 4.1

e) Using your values for $\Delta H^\circ_{\text{rxn}}$ and $\Delta S^\circ_{\text{rxn}}$ for reaction 4.1, find the values for $\Delta S^\circ_{\text{sys}}$, $\Delta S^\circ_{\text{surr}}$, and $\Delta S^\circ_{\text{univ}}$ when one mole of reaction 4.1 is carried out under standard conditions and $T = 25.0 \text{ }^\circ\text{C}$.

f) Will reaction 4.1 occur spontaneously at standard conditions and $T = 25.0 \text{ }^\circ\text{C}$? Why or why not?

Substance	ΔH°_f (kJ/mol)	S° (J/mol·K)	ΔG°_f (kJ/mol)	$C_{p,m}$ (J/mol·K)
$C_2H_4(g)$	52.26	219.56	68.15	43.56
$C_2H_6(g)$	- 84.68	229.60	- 32.82	52.63
$NH_3(g)$	- 46.11	192.45	- 16.45	35.06
$N_2(g)$	0.0	205.2	0.0	29.12

5) 60.00 g of $H_2O(\ell)$ ($M = 18.02 \text{ g/mol}$) at $T = 40.00 \text{ }^\circ\text{C}$ is added to 40.00 g of $H_2O(\ell)$ at $T = 20.00 \text{ }^\circ\text{C}$ in an insulated container.

a) What is T_f , the final temperature of the water when equilibrium is reached? Note that the constant pressure molar heat capacity for water is $C_{p,m} = 75.29 \text{ J/mol}\cdot\text{K}$, and is constant over the temperature range of the problem.

b) What is ΔS for the above process? (HINT: Since entropy is a state function, you can find the change in entropy separately for the 60.00 g of water and the 40.00 g of water, and then combine the results to obtain ΔS .)