

Chemistry 2720 Fall 2001 Assignment 6

Due: Tuesday, Oct. 30, 9:25 a.m.

- (a) Based on thermodynamic considerations alone, can liquid boron trichloride be made by reacting diborane ($\text{B}_2\text{H}_6(\text{g})$) with chlorine gas if the pressures of the two reactants are both 0.5 bar and the pressure of hydrogen gas is 0.03 bar at 25°C ? [5 marks]
 - (b) What if the reaction was run at -10°C instead of 25°C ? Assume that $\Delta\bar{H}^\circ$ and $\Delta\bar{S}^\circ$ are independent of temperature. [5 marks]
2. The standard free energy of formation of cyclohexane ($\text{C}_6\text{H}_{12}(\text{l})$) in the old atm-based convention is 26.7 kJ/mol. Calculate the standard free energy of formation of cyclohexane corresponding to the new standard pressure of 1 bar. [5 marks]
3. There are two ways to extract energy from a fuel to do work. The first is to burn it and to use the heat to operate a heat engine. The second is to use it as the energy source in an isothermal free energy machine. Batteries and fuel cells are examples of the latter class of devices. A fuel cell works somewhat like a battery in that it generates electricity, but the overall reaction which produces the electrical work is the oxidation of a fuel such as hydrogen or methane by oxygen.
 - (a) What is the maximum electrical work per mole of methane which can be performed by a methane fuel cell operating at 25°C if the pressure of methane is regulated at 0.7 bar and oxygen and carbon dioxide are held at their atmospheric partial pressures of 0.2 and 0.0003 bar, respectively? Assume that pure water is produced. [5 marks]
 - (b) In a real fuel cell, the water produced enters a highly concentrated solution of potassium hydroxide or another similar base. Does this affect the electrical work which can be produced? Explain briefly. [4 marks]
 - (c) At higher altitudes, the partial pressure of oxygen drops off. Does the fuel cell generate more or less electrical work per mole of methane at higher altitudes? Explain briefly. [2 marks]
 - (d) Would it be possible to obtain as much work by burning methane in a heat engine under any conditions? Explain briefly, and discuss the environmental implications. [8 marks]

Note: Keep your answer under one page. Marks may be deducted if you drift off topic. You can include sample calculations if you think it will help make your point. Both theoretical and practical considerations can be included in your discussion.