

CHEM 3410: Physical Chemistry I — Fall 2009

Homework 5

Due in Class: Wednesday, October 14, 2009

1. Calculate ΔG for the isothermal expansion of 2.50 mol of an ideal gas at 350 K from an initial pressure of 10.5 bar to a final pressure of 0.500 bar.
2. In a fuel cell, natural gases such as methane undergo the same redox reaction as in the combustion process to produce gaseous carbon dioxide and liquid water and generate electricity. Using standard thermochemical data, calculate the maximum electrical work that can be obtained from 1 mole of methane at 25°C .
3. Calculate ΔS_{mix} and ΔG_{mix} for:
 - (a) the formation of a quantity of air containing 1 mole of gas by mixing nitrogen and oxygen at 298.15 K. Air may be taken to be 80% nitrogen and 20% oxygen;
 - (b) mixing 2 mol of H₂ with 1 mol of O₂ at 25°C under conditions where no chemical reaction occurs.
4. Given below are thermodynamic data for the transformation of DNA from double-stranded to single-stranded (denaturation) and the transformation of a synthetic polypeptide, poly(benzyl L-glutamate), from an ordered helix structure to a disordered random coil - each in the stated solvent and temperature conditions.
 - (a) What is the free energy for denaturation of DNA at 37°C ? Will DNA denaturation occur spontaneously at this temperature?
 - (b) If the enthalpy and entropy changes of denaturation vary only weakly with temperature, can we cause this denaturation reaction to become spontaneous by raising the temperature? How do you know?
 - (c) Consider now the helix to coil transition given below for poly(benzyl L-glutamate). Is this transition spontaneous at 39°C ?
 - (d) Does increasing the temperature favor the helix-to-coil transition in poly(benzyl L-glutamate)?
 - (e) Assuming the enthalpy and entropy changes for the helix-to-coil transition are approximately constant over a significant temperature range, at what temperature would the helix and coil forms of the polypeptide be in equilibrium?

Transition	ΔH°	ΔS°
DNA double-strand to single-strand in 1 M NaCl at 37°C , 1 atm	35 kJ/mole base pairs	88 J/(mole base pairs K)
Poly(benzyl L-glutamate) helix-to-disordered coil in ethylene dichloride/dichloroacetic acid solvent at 39C, 1 atm	-4.0 kJ/mole amide bonds	-12 J/(mole amide bonds K)