North Carolina State University Homework #5
Name _____ Section _____ Physical Chemistry 331
Due: December 5, 2003

1. A. Calculate the thermodynamic efficiency of a steam turbine that operates at 550 K if the exhaust temperature is 300 K. An engineer proposes to increase the operating temperature to 600 K. B. What is the increase in thermodynamic efficiency? C. What is the increase in radiative losses?

2. Calculate the O_2 bond length if the rotational line spacing detected by a light scattering experiment is 5.8 cm^{-1}. Keep in mind that a rotational light scattering experiment has twice the line spacing of a pure microwave spectrum.

3. The catabolism (break-down) of glucose is an important source of energy for all cells. It begins with the following transformation which is the first step of the glycolytic pathway:

Glucose → Glucose-6-Phosphate

Theoretically, the cell could phosphorylate glucose directly with inorganic phosphate (Pi) like so:

Glucose + Pi → Glucose-6-Phosphate + H_2O ΔG^o = + 3.3 kcal/mol

a) Calculate the equilibrium constant for this reaction (include correct units).

b) Is it favorable under standard conditions? Why or why not?

c) In a typical cell, glucose and phosphate are maintained at 4.8 mM each. (1 mM = 10^{-3} M) What would be the equilibrium concentration of Glucose-6-Phosphate if the cells used the reaction as written above to make it?

d) Does this direct phosphorylation of glucose represent a reasonable route for the catabolism of glucose? Explain briefly.

The cell actually accomplishes the phosphorylation of glucose by coupling it to the hydrolysis of ATP in a reaction catalyzed by the enzyme hexokinase:

ATP + H_2O → ADP + Pi ΔG^o = -7.3 kcal/mol

e) Write a balanced equation for the coupled reactions showing the ΔG^o for the net reaction.

f) Calculate the K_{eq} for the net reaction.

g) The concentration of Glucose-6-Phosphate typically found in cells is 250 mM. If the [ATP] were 3.38 mM and the [ADP] were 1.32 mM, what concentration of glucose would be necessary to yield the observed Glucose-6-Phosphate concentration if the reactions are coupled?

4. The following kinetic data were collected for an enzyme-catalyzed reaction. Determine V_{max} and K_m for this system. (5 points)

Measurement	[S] M	v0 µmol/min
1	1.0 X 10-5	15.6
2	5.0 X 10-5	34.6
3	1.0 X 10-4	41.0
4	5.0 X 10-4	47.9
5	6.0 X 10-2	49.8
6	5.0 X 10-1	50.0
7	8.0 X 10-1	50.0