Chemistry 1B S'99, Exam II RJ Saykally Name _____ 1

1. (5 points each) Consider the following chemical reaction as a source of abundant clean energy for the world:

$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(\ell) \qquad \Delta H^\circ = -286\text{kJ/mole}, \quad \Delta G^\circ = -237\text{kJ/mole}$$

A. Calculate the maximum possible efficiency for using this reaction in an internal combustion engine operating between temperatures of 3000K and 1000K with a compression ratio of 7.

B. Calculate the maximum work available per cycle from this engine.

C. Calculate the maximum electrical work obtainable from a H_2/O_2 fuel cell operating at $P_{H_2} = 10$ atm, $P_{O_2} = 2$ atm, and T = 1000K.

D. Calculate the maximum voltage obtainable from the fuel cell above.

E. Calculate the energy equivalent (in kJ/kg) of this fuel cell.

F. Calculate the equilibrium constant for the H_2/O_2 reaction at 25°C.

G. Calculate the maximum total work obtainable from this reaction under standard conditions (hint: use ideal gas approximation).

H. Calculate the efficiency of a H_2/O_2 fuel cell operating under standard conditions.

I. In this fuel cell, _____ is being oxidized at the _____,

_____ is being reduced at the _____,

and the _____ is the positive electrode.

2. (5+5+5+5+10 points)

A. The total world energy consumption is _____, of which _____ % is chemical energy, _____ % is nuclear energy, _____ % is used for transportation, and which is increasing by _____ % per year.

B. Write a balanced equation for the alpha emission by $^{155}_{70}Yb$.

C. Calculate the energy equivalent (kJ/kg) for the fusion of deuterium (2.0141079u) to make $^{4}_{2}He$ (4.002033u).

D. Complete and balance the following equation for reactions taking place in acidic solution.

$$MnO_4^-(aq) + H_2S(aq) \rightarrow Mn^{2+}(aq) + SO_4^{2-}(aq)$$

E. Diagram the following galvanic cell, indicating the direction of flow of electrons in the external circuit and the motion of ions in the salt bridge.

$$Ni(s)|Ni^{2+}(aq) \,||\, HCl(aq)|H_2(g)|Pt(s)$$

Write a balanced equation for the overall reaction in this cell.

3. (5+5+5+5+5 points) Benzene's enthalpy of vaporization is 30.8 kJ mol^{-1} at its normal boiling point, 80.1°C. Calculate q, w, ΔE, ΔS_{sys}, and ΔG when 1.00 mol of benzene is vaporized reversibly at 78°C and 1 atm. Assume that the vapor is an ideal gas and neglect the volume of liquid benzene relative to that of its vapor.

$\Delta E =$

$q =$

$w =$

$\Delta S_{sys} =$

$\Delta G =$