2.83 and 2.813 Exergy Homeworks March 2,

1. Calculate the entropy change for a reversible heat engine, and

2. Calculate the entropy loss for a reversible heat engine.

Answer: Consider the process in two stages; 1) you transfer heat in, and 2) You transfer heat and work out. Use the result from Carnot to Show that the change in entropy is zero. This leads to the result that The exergy lost is also zero.

$$\Delta S = S_2 - S_1 = \frac{1}{T_o}\left[\left(E_2 - E_1\right) - (B_2 - B_1)\right] = \frac{Q_L}{T_L} - \frac{Q_H}{T_H}$$

$$B_{lost} = Q_H - Q_L + T_o \Delta S - W$$

3. Show that maximum amount of work that can be obtained from a system in reference to the environment at standard conditions, T_o, P_o *is*

$$B = (H - T_o S) - (H - T_o S)_o$$

Answer: this system is almost identical to the one done in class. The problem is just “reversed” be sure to keep track of signs.

4. Calculate the maximum work one can obtain from oxidizing H2

$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)}$ ΔB = + 457 kJ, or 114 MJ/kg hydrogen

5. Calculate the minimum work required to obtain H2 from water.

Reverse the above reaction but start with liquid water, ΔB = -474kJ, or 119 MJ/kg of hydrogen

6. Calculate the minimum work to reduce iron using hydrogen, use

3Fe2O3 + H2 = 2 Fe3O4 + H2O (1)
Fe3O4 + H2 = 3 FeO + H2O
FeO + H2 = Fe + H2O

Now assume the H2 comes from the electrolysis of water and add this too.

7. What is the minimum work required for photosynthesis?

$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$

8. What is the maximum work one could obtain from auto-respiration?

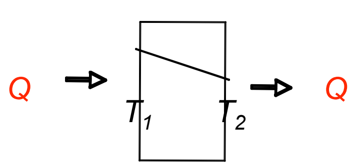
$$6CO_2 + 6H_2O \leftarrow C_6H_{12}O_6 + 6O_2$$

9. What is the maximum work one could obtain from burning the following fuels with oxygen: octane? methane? methanol? hydrogen? How much CO_2 is generated for each?

Calculated Exergy and Reported Heating Values

Chemical	Calculated Max Exergy MJ/kg*	CO_2 generated gCO_2/MJ	Fuel	Heat of Combustion MJ/kg	Ref
Carbon	33	112	Coal anthracite	18-29 30-33	Smil BCCA
Octane	46	68	Gasoline	46-47	Smil
Methane	49	56	Nat. gas	33-37 38-50	Smil Web
Oil	42	75	Fuel oil	42-44	Smil
Hydrogen	114	0		114	Smil
Methanol	21	64			

10. Calculate the exergy lost due to steady state heat transfer as shown below.



The exergy in is: $B_1 = Q(1-T_0/T_1)$

The exergy out of the law is: $B_2 = Q(1-T_0/T_2)$

The exergy lost is: $\Delta B = T_0Q(1/T_2 - 1/T_1)$