ChE-304 Problem Set 3

Week 3

Problem 1

A change in entropy for an ideal gas system undergoing a change in entropy where both, T, V and P can be calculated with:

$$\Delta S = n\left(C_p \ln\left(\frac{T_2}{T_1}\right) - R\ln\left(\frac{P_2}{P_1}\right)\right)$$

or

$$\Delta S = n\left(C_V \ln\left(\frac{T_2}{T_1}\right) + R\ln\left(\frac{V_2}{V_1}\right)\right)$$

Prove that these expressions hold for a single change where both T, V and P are changing starting from the definition of ΔS: $\Delta S = \int \frac{dQ_{rev}}{T}$

Problem 2

A community (average T=27°C) has an enormous underground reservoir of high-pressure (inert) gas. The reservoir has the following properties:

T= 237 °C
P = 9.95 atm
V= 10^6 m^3
Depth = 2000 m below the surface
Cp = 36 J/(mol K)
Mw= 0.03 kg/mol

Assume that the gas is ideal.

What is the maximum amount of work that the community could extract out of the gas?

Problem 3

When you heat your house with fuel oil ("mazout") you produce gases in a continuous process in the burner that are around 1400 °C (1673 K). These gases are ultimately cooled to around 100°C in order to heat a home at a temperature that is generally constant at around 20°C (and no work is produced in the process). This is not efficient because a tremendous amount of work/exergy is wasted by not exploiting this temperature difference. Can you calculate the maximum amount of work that is lost as a fraction of the heat used to heat the house?

The gases can be considered ideal and they are always at a pressure of 1 atm (101'325 Pa).

The Cp can be assumed to be independent of temperature and equal to:

Cp= 30 J/(mol K) (assumed to be constant with T°)

Problem 4

Can you plot the efficiencies of the Otto, Diesel and Brayton cycles as a function of compression ratios? For the Diesel cycle, also consider different expansion ratios. Based on this can you rate the different engines if they were to use the same compression ratio?