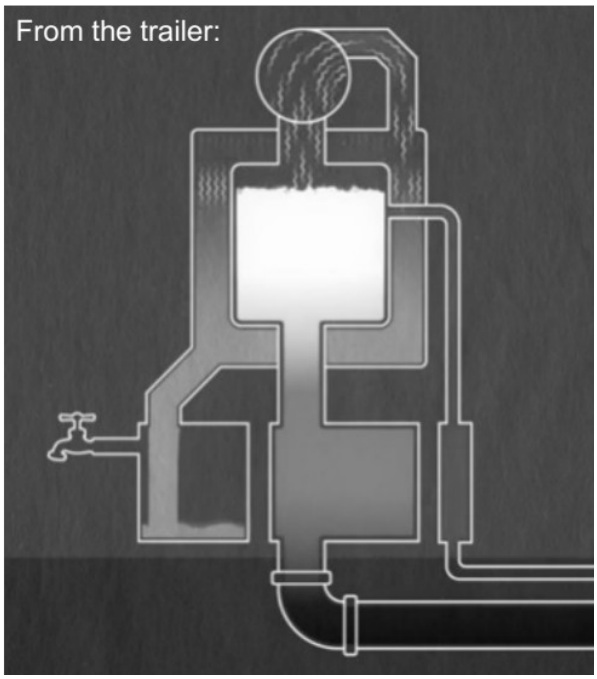
ChE-304 Problem Set 5

Week 5

Problem 1

After watching the video introducing the Slingshot water purification technology, you might have realized that this is just a purification system based on boiling water, compressing it and condensing the (now pure) steam.



List all material and work streams and draw the system, following the example of Figure 2.4A. Also list **all** the specifications. As we will see later in the course, it is often convenient to split liquid heating, gas heating and phase change into 3 separate units.

We know (from watching the whole movie) that the system uses 1KW electricity to treat 1000 L/day.

Note: the cooling and condensing of the compressed steam is used to heat up the boiling water but we will worry about that later…. For now, list the streams independently.

Problem 2

Calculate the properties (T, P and $\dot{V}_{steam}$) of the slingshot steam after compression using 1 kW of electricity for 1000 L per day of liquid water. Assume that the compression is adiabatic and that 100% of the electrical work ends up as mechanical compression work. You can also assume that steam acts like an ideal gas.

Cp (steam) = 1.97 kJ/ (kg K)

Cv (steam) = 1.5 kJ/ (kg K)

Problem 3

Can you calculate the entropy of 1 mol of a liquid mixture of X and a salt at 120°C and 0.7 MPa where the molar fraction of salt is: $x_{salt}=0.05$? You can assume an ideal solution.

Parameters:

$R=8.314\,J\,K^{-1}\,mol^{-1}$
$S_{salt}=100\,J/(K\,mol)$ Molar entropy for the salt at 120°C and 0.7 MPa
S_X^0 = 188.84 $J\,K^{-1}\,mol^{-1}$ (Standard entropy of gaseous X at 25°C and 0.1 MPa)

Cp equation:

$C_P(T)=A_X+B_X T+C_X T^2+D_X T^3+\frac{E_X}{T^2}$, where $T=temperature\in K$

Cp equation coefficients, for X in the vapor phase:
A = 30 $J\,K^{-1}\,mol^{-1}$ B = 0 $J\,K^{-2}\,mol^{-1}$ C = 0 $J\,K^{-3}\,mol^{-1}$
D = 0 $J\,K^{-4}\,mol^{-1}$ E = 82'000 $J\,K\,mol^{-1}$

$\Delta H_{vap}^{100\,°C}$= 40.6 kJ/mol (Enthalpy of vaporization, X at 100°C)
T_C=¿ 647 K P_C=¿22 MPa (Critical temperature, pressure of X)
$P_{sat,X\,120°C}=0.2\,MPa$ (Saturation pressure for X at 120°C)