Practice Problems **21-1:** A gas (assume constant specific heat) is compressed in a closed system from 1.00 atm and 40 °C to  
 11.39 atm in an isothermal process. For this gas cp = 523 J/kg-k, cv = 315 J/kg-k, and  
 R=208 J/kg-K. The quantity of gas in this process is 0.13 kg. Calculate:

a) Work required [J]

b) Heat transfer required [J]

c) Entropy produced [J/K]

d) Does this process violate the second law of thermodynamics?

**21-2:** A closed, sealed, rigid container is filled with 0.05833 ft3 of liquid water and 0.94167 ft3   
 of water vapor in equilibrium at 1.00 psia. The vessel is then heated until its contents  
 become saturated vapor  
 a) What is the quality in the vessel at the initial state?

b) What are the final temperature and pressure?  
c) What heat transfer is required for this process?  
d) Determine the total entropy produced for this process if the surface temperature of  
 the vessel is maintained constant at 300 °F. Is this process possible?  
e) Sketch this process on Pv and Ts diagrams. Show lines of constant T and x on the  
 Pv diagram. Show lines of constant P and x on the Ts diagram.

**21-3:** You’re looking at some bright bulbs for your house. You want each bulb to produce about 1600  
 lumens. One option is 100 W incandescent lightbulb, which will have a surface temperature of   
 around 60 °C. A second option is a 15 W LED bulb, which will have a surface temperature of   
 around 30 °C.   
 Calculate the steady state entropy production rate of each option. Comment on your results.

Answers1) Work required ~ -20.6 kJ, Heat is equal to work, entropy production ~ 0 (this is the reversible case)

2) x\_initial = 0.00078, T\_final ~600 °F, P\_final ~1500 psia, Q\_12 ~ 4000 Btu,   
Total entropy production ~ -0.516 Btu/°R 🡪 Can’t have negative entropy production, so this isn’t possible.   
To be possible T\_boundary must be larger than T\_final

3) Entropy production rate is about 0.3 W/K for incandescent, and 0.05 W/K for LED