1. A heat engine with an efficiency of 30% operates between a energy source at 500 K and an environmental sink at 200 K. Compare the entropy change of the source and sink for (a) this engine and (b) a reversible engine using the same source and sink when both extract 1000 kJ from the source. \(R = 8.314 \text{ J/mol-K}\). \(20\%\)

2. Calculate the molar enthalpy change for Fe as which is changed from state 1 (298 K, 1 atm) to state 2 (298 K, 100 atm)? The atomic mass of Fe is 55.85, the density is 7.87 g/cm\(^3\), and the volume thermal expansion coefficient is \(3.0 \times 10^{-5} \text{ K}^{-1}\) at 298 K. Assume these values are independent on the pressure in the range 1 \(~\sim\) 100 atm. \(15\%\)

3. A 0.01 m\(^3\) piston-cylinder device contains air at 100 kPa, 300 K. This device is now heated to 0.02 m\(^3\) in a constant pressure process. Determine the heat transfer to the air and work done by the air. \((C_v \text{ of the air is } 0.717 \text{kJ/kg-K})\) \(15\%\)

4. Determine the quality \((x)\) for H\(_2\)O at 300 kPa, 133.6 \(^\circ\)C and the specific volume of 0.5 m\(^3\)/kg? Assume the specific volumes of saturated liquid and vapor at 300 kPa are 0.001073 and 0.60582 m\(^3\)/kg, respectively. (The definition of quality: the vapor mass fraction in a saturated liquid-vapor mixture) \(15\%\)

5. Ideal gases A (300K, 1 atm, 2 m\(^3\)) and B (300K, 2 atm, 3 m\(^3\)) are mixed in a 6 m\(^3\) tank at constant temperature (300 K). What is the entropy change during mixing? \(15\%\)

6. (a). Draw the P–T phase diagram for H\(_2\)O.
   
   (b). Describe the characteristics of the P–T diagram above by using the Clapeyron equation. \(20\%\)