Chapter 5 Assignment
(Answers are in parenthesis)

1. Steam expands isentropically in a converging-diverging nozzle from inlet conditions of 1400 kPa, 598K, and negligible velocity to a discharge pressure of 140 kPa. At the throat the cross-sectional area is 6 cm². Determine the mass flow rate of the steam and the state of the steam at the exit of the nozzle. (1.08 kg/s, 0.966)

2. Steam expands adiabatically in a nozzle from inlet conditions of 9 bar, 488K, and a velocity of 70 m/s to a discharge pressure of 2.4 bar where its velocity is 609.6 m/s. What is the state of the steam at the nozzle exit? (0.987)

3. Carbon dioxide at upstream conditions T₁ = 350 K and P₁ = 80 bar is throttled to a downstream pressure of 1.2 bar. Estimate the downstream temperature and ΔS of the gas. (280 K, 31.5 J/mol K)

4. A steam turbine operates adiabatically at a power level of 3500 kW. Steam enters the turbine at 2400 kPa and 500 °C and exhausts from the turbine as saturated vapor at 20 kPa. What is the steam rate through the turbine, and what is the turbine efficiency? (4.1 kg/s, 0.819)

5. Isobutane expands adiabatically in a turbine from 5000 kPa and 250 °C to 500 kPa at the rate of 0.7 kmol/s. If the turbine efficiency is 0.80, what is the power output of the turbine and what is the temperature of the isobutane leaving the turbine? (4663 kW, 458 K)

6. Saturated steam at 125 kPa is compressed adiabatically in a centrifugal compressor to 700 kPa at the rate of 2.5 kg/s. The compressor efficiency is 78%. What is the power requirement of the compressor and what are the enthalpy and entropy of the steam in its final state? (3156.6 kJ/kg, 7.45 kJ/kg K, 1173 kW).

7. Derive an expression for enthalpy change of a gas during an isothermal process assuming that:

\[
P + \left(\frac{a}{TV^2}\right)(V - b) = RT
\]

\[Ans: \left(\frac{1}{V_1} \cdot \frac{1}{V_2}\right) + RTb\left(\frac{1}{V_2 - b} - \frac{1}{V_1 - b}\right)\]