14.68 Carbon dioxide (CO₂), oxygen (O₂), and nitrogen (N₂) enter a reactor operating at steady state with equal molar flow rates. An equilibrium mixture of CO₂, O₂, N₂, CO, and NO exits at 3000 K, 5 atm. Determine the molar analysis of the equilibrium mixture.

14.70 A closed vessel initially contains a gaseous mixture consisting of 3 lbmol of CO₂, 6 lbmol of CO, and 1 lbmol of H₂. An equilibrium mixture at 4220°F, 1 atm is formed containing CO₂, CO, H₂O, H₂, and O₂. Determine the composition of the equilibrium mixture.

14.71 Butane (C₄H₁₀) burns with 100% excess air to form an equilibrium mixture at 1400 K, 20 atm consisting of CO₂, O₂, H₂O(g), N₂, NO, and NO₂. Determine the balanced reaction equation. For \( \text{N}_2 + 2\text{O}_2 \rightleftharpoons 2\text{NO}_2 \) at 1400 K, \( K = 8.4 \times 10^{-10} \).

14.73 Steam enters a heat exchanger operating at steady state. An equilibrium mixture of H₂O, H₂, O₂, H, and OH exits at temperature \( T \), 1 atm. Determine the molar analysis of the exiting equilibrium mixture for

(a) \( T = 2800 \text{ K} \).
(b) \( T = 3000 \text{ K} \).
8.2 Water is the working fluid in an ideal Rankine cycle. Superheated vapor enters the turbine at 10 MPa, 480°C, and the condenser pressure is 6 kPa. Determine for the cycle:
(a) the heat transfer to the working fluid passing through the steam generator, in kJ per kg of steam flowing.
(b) the thermal efficiency.
(c) the heat transfer from the working fluid passing through the condenser to the cooling water, in kJ per kg of steam flowing.

8.4 Plot each of the quantities calculated in Problem 8.2 versus condenser pressure ranging from 6 kPa to 0.1 MPa. Discuss.

8.6 A Carnot vapor power cycle operates with water as the working fluid. Saturated liquid enters the boiler at 1800 lbf/in.², and saturated vapor enters the turbine (state 1). The condenser pressure is 1.2 lbf/in.². The mass flow rate of steam is $1 \times 10^6$ lb/h. Data at key points in the cycle are provided in the accompanying table. Determine:
(a) the thermal efficiency.
(b) the back work ratio.
(c) the net power developed, in Btu/h.
(d) the rate of heat transfer to the working fluid passing through the boiler, in Btu/h.

<table>
<thead>
<tr>
<th>State</th>
<th>$p$(lbf/in.²)</th>
<th>$h$(Btu/lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1800</td>
<td>1150.4</td>
</tr>
<tr>
<td>2</td>
<td>1.2</td>
<td>735.7</td>
</tr>
<tr>
<td>3</td>
<td>1.2</td>
<td>472.0</td>
</tr>
<tr>
<td>4</td>
<td>1800</td>
<td>648.3</td>
</tr>
</tbody>
</table>
8.28 Water is the working fluid in an ideal Rankine cycle with superheat and reheat. Steam enters the first-stage turbine at 1400 lbf/in.$^2$ and 1000°F, expands to a pressure of 350 lbf/in.$^2$, and is reheated to 900°F before entering the second-stage turbine. The condenser pressure is 2 lbf/in.$^2$. The net power output of the cycle is $1 \times 10^9$ Btu/h. Determine for the cycle

(a) the mass flow rate of steam, in lb/h.
(b) the rate of heat transfer, in Btu/h, to the working fluid passing through the steam generator.
(c) the rate of heat transfer, in Btu/h, to the working fluid passing through the reheater.
(d) the thermal efficiency.

8.34 Steam at 4800 lbf/in.$^2$, 1000°F enters the first stage of a supercritical reheat cycle including two turbine stages. The steam exiting the first-stage turbine at 600 lbf/in.$^2$ is reheated at constant pressure to 1000°F. Each turbine stage and the pump have an isentropic efficiency of 85%. The condenser pressure is 1 lbf/in.$^2$. If the net power output of the cycle is 100 MW, determine

(a) the rate of heat transfer to the working fluid passing through the steam generator, in MW.
(b) the rate of heat transfer from the working fluid passing through the condenser, in MW.
(c) the cycle thermal efficiency.