10.4 Consider a Carnot vapor refrigeration cycle with Refrigerant 134a as the working fluid. The cycle maintains a cold region at 40°F when the ambient temperature is 90°F. Data at principal states in the cycle are given in the table below. The states are numbered as in Fig. 10.1. Sketch the $T$–$s$ diagram for the cycle and determine the

(a) temperatures in the evaporator and condenser, each in °R.
(b) compressor and turbine work, each in Btu per lb of refrigerant flowing.
(c) coefficient of performance.
(d) coefficient of performance for a Carnot cycle operating at the reservoir temperatures.

Compare the coefficients of performance determined in (c) and (d), and comment.

<table>
<thead>
<tr>
<th>State</th>
<th>$p$ (lbf/in.$^2$)</th>
<th>$h$ (Btu/lb)</th>
<th>$s$ (Btu/lb · °R)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40</td>
<td>104.12</td>
<td>0.2161</td>
</tr>
<tr>
<td>2</td>
<td>140</td>
<td>114.95</td>
<td>0.2161</td>
</tr>
<tr>
<td>3</td>
<td>140</td>
<td>44.43</td>
<td>0.0902</td>
</tr>
<tr>
<td>4</td>
<td>40</td>
<td>42.57</td>
<td>0.0902</td>
</tr>
</tbody>
</table>

![Fig. 10.1 Carnot vapor refrigeration cycle.](image-url)
10.9 Figure P10.9 provides steady-state operating data for an ideal vapor-compression refrigeration cycle with Refrigerant 134a as the working fluid. The mass flow rate of refrigerant is 30.59 lb/min. Sketch the $T$–$s$ diagram for the cycle and determine

(a) the compressor power, in horsepower.
(b) the rate of heat transfer, from the working fluid passing through the condenser, in Btu/min.
(c) the coefficient of performance.
10.11 An ideal vapor-compression refrigeration cycle, with ammonia as the working fluid, has an evaporator temperature of \(-20^\circ C\) and a condenser pressure of 12 bar. Saturated vapor enters the compressor, and saturated liquid exits the condenser. The mass flow rate of the refrigerant is 3 kg/min. Determine

(a) the coefficient of performance.
(b) the refrigerating capacity, in tons.

10.16 Modify the cycle in Problem 10.9 to have an isentropic compressor efficiency of 83\% and let the temperature of the liquid leaving the condenser be 100\textdegree F. Determine, for the modified cycle,

(a) the compressor power, in horsepower.
(b) the rate of heat transfer from the working fluid passing through the condenser, in Btu/min.
(c) the coefficient of performance.
(d) the rates of exergy destruction in the compressor and expansion valve, each in Btu/min, for \(T_0 = 90^\circ F\).