1. A closed system undergoes a process in which there is no internal energy change. During this process, the system produces 1.6E6 ft-lbf of work. How much heat is added to this system during this process? (2057 BTU)

2. Complete the table below for a closed system undergoing a process.

<table>
<thead>
<tr>
<th>Q_{12} (kJ)</th>
<th>W_{12} (kJ)</th>
<th>E_1 (kJ)</th>
<th>E_2 (kJ)</th>
<th>m (kg)</th>
<th>e_2 - e_1 (kJ/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>280</td>
<td>____</td>
<td>1020</td>
<td>860</td>
<td>3</td>
<td>____</td>
</tr>
<tr>
<td>-350</td>
<td>130</td>
<td>550</td>
<td>____</td>
<td>5</td>
<td>____</td>
</tr>
<tr>
<td>____</td>
<td>260</td>
<td>300</td>
<td>____</td>
<td>2</td>
<td>-150</td>
</tr>
<tr>
<td>300</td>
<td>____</td>
<td>750</td>
<td>500</td>
<td>1</td>
<td>____</td>
</tr>
<tr>
<td>____</td>
<td>-200</td>
<td>____</td>
<td>300</td>
<td>2</td>
<td>-100</td>
</tr>
</tbody>
</table>

3. A closed system like that shown in Figure 1 is operated in an adiabatic manner. First, 15,000 ft-lbf of work are done by this system as the piston moves. Then, the internal energy of the system is raised by 10.28 BTU by stirring the system with the paddle wheel. What is the net increase in the internal energy of this system? (-9.00 BTU)

4. What is the change in the internal energy of the substance contained in the piston-cylinder device of Figure 1 when the system is adiabatic, the piston does not move, and 15 BTU of work are done by the stirring paddle wheel?

5. The piston-cylinder device of Figure 1 contains 1.5 kg of motor oil. What is the rate at which the specific internal energy of this motor oil increases when the piston does not move, 1.5 W of work are done on the oil by the stirring device, and 1 W of heat is added to the motor oil? (1.667 J/kg-s)

6. One cubic foot of nitrogen initially fills the piston-cylinder device of Figure 1 at 14.7 psia, 60°F. What is the final temperature of the nitrogen after 5000 ft-lbf of work are done by the stirring device?

7. A well-insulated, 4 m³ rigid container is divided into two equal volume chambers by a membrane. Initially, one of these smaller chambers is filled with oxygen at 1 MPa, 127 °C while the second chamber is evacuated. Determine the change in the internal energy of the oxygen and the final oxygen pressure after the membrane is removed. (0, 500 kPa)

8. Nitrogen in a rigid vessel is cooled by releasing 100 kJ/kg of heat. How much does the temperature of the nitrogen change?

9. An adiabatic, closed system is raised 100 m at a location where the gravitational acceleration is 9.8 m/s². What is the change in the specific energy of this system? (0.98 kJ/kg)

10. A rigid, 10 liter vessel originally contains a water liquid-vapor mixture at 100 °C with a quality of 12.3%. It is now heated until the temperature is 150 °C. How much heat is required for this process?
11. A rigid, 0.5 m³ container is filled with R-134a whose original temperature and quality are -20 °C, 18%. This container is now heated until the temperature is 40 °C. How much heat is required to do this? (3.6 MJ)

12. Two pounds-mass of saturated liquid water at 400 °F are heated in a piston-cylinder device arranged to maintain a constant pressure until the device is filled with saturated vapor. How much heat is required for this process?

13. Saturated water vapor at 300 kPa undergoes an isothermal process in a closed system until it becomes a saturated liquid. How much heat transfer is required for this process? (-2163 kJ/kg)

14. Water at 10 psia, 13% quality is contained in a spring-loaded piston-cylinder device that has an initial volume of 0.2 ft³. This device is now heated until the volume is 0.5 ft³ and the pressure is 40 psia. How much work is produced by and heat is added to this system?

15. One pound-mass of air at 10 psia, 70 °F is contained in a piston-cylinder device. The air is now reversibly compressed to 100 psia while its temperature is kept constant. How much heat must be added to this air during the compression? (-83.66 BTU)

16. One kilogram of air at 200 kPa, 127 °C is contained in a piston-cylinder device. This air is now allowed to expand to 100 kPa in a reversible, isothermal process. What is the total amount of heat added to the air during this expansion?

17. Saturated water vapor at 40 kPa is cooled at constant pressure until it is a saturated liquid. How much work and heat is required for this process? (-159.7 kJ/kg, -2319 kJ/kg)

18. Nitrogen at 15 psia, 70 °F is heated in a rigid container until its pressure is 50 psia. How much work and heat are required for this process?

19. Ten kilograms of nitrogen are heated from 20 °C to 250 °C in a closed system. How much heat is required when this is done in (a) a constant volume process, and (b) an isobaric process? (1704 kJ, 2387 kJ)

20. A closed system containing argon undergoes an isothermal process from 200 kPa, 100 °C to 50 kPa. This requires 1500 kJ of heat. What is the mass of this system and the amount of work produced by this system?

21. One kilogram of carbon dioxide is confined in a spring-loaded piston-cylinder device. This system is heated from 100 kPa, 25 °C to 1 MPa, 300 °C. How much heat and work transfer occurs during this heating? (-69.78, -250.1 kJ)

22. Air is contained in a piston-cylinder device like that shown in Figure 1. Initially, this air is at 500 kPa, 27 °C. This air is now heated while 50 kJ/kg of work are done by the stirring device until the volume of the air is tripled. How much heat is required for this process?