## Practice Problems

**Problem 17-1:** You are going to fill a 0.1m3 rigid tank with helium. The tank starts completely empty, and is filled adiabatically to 20 MPa. The reservoir supplying the helium is at 20 °C. Determine the final temperature of the helium in the tank after it is filled. Assume ideal gas behavior with constant specific heats (safe assumption for an inert gas).

**Problem 17-2:** You are going to empty a compressed air tank, but you want to do it in a way that results in the contents inside the tank remaining isenthalpic. If the initial state of air in the tank is 1500 psia and 100 °F, and it is emptied until the pressure is 14.7 psia, determine the heat transfer required to keep the air in the tank isenthalpic. The initial mass in the tank is 10 lbm and the final mass is 0.098 lbm. Assume ideal gas behavior.

**Problem 17-3:** A closed-system heat engine undergoes a cycle consisting of these processes:  
 Process 1 – 10 kJ of heat are added and 20 kJ of work are done by the system.  
 Process 2 – The energy inside the system increases by 30 kJ adiabatically.  
 Process 3 – 10 kJ of work are done on the system while the system gains 50 kJ of energy.  
 Process 4 – The system does 40 kJ of work while returning to its initial state.  
**(a)** Find the heat transfer, work transfer, and change in system energy for each process.  
**(b)** Find the net work transfer and net heat transfer for the whole cycle.  
**(c)** Calculate the thermal efficiency of this heat engine cycle.

## Preparatory Reading Questions

1. What is the Clausius statement of the 2nd law of thermodynamics? (p. 210)
2. What is the Kelvin-Planck statement of the 2nd law of thermodynamics? (p. 211)
3. What is meant by a reversible process? What are potential sources of irreversibility in a thermodynamic process? (p. 211)
4. What is the equation for the efficiency of a Carnot engine? Define all terms and restrictions on units. (p. 212-214)
5. What is the equation for COP of a Carnot refrigerator? Define all terms and restrictions on units. (p. 216–217)
6. What is the equation for the COP of a Carnot heat pump? Define all terms and restrictions on units. (p. 216-217)

## Answers

1. Tfinal­ = 216 °C
2. Q12 = 389 Btu
3. Remember what the change in internal energy is for a cycle.   
   The cycle efficiency (assuming this is Wnet / Qin) is ~40%