ME 201
Thermodynamics

Homework 13 Solution

1. A reversible process has been defined as a process, which having taken place, can be reversed and in so doing leaves no change in either the system or the surroundings. Six restrictions were imposed

a. no friction
b. heat transfer occurs only for infinitesimal temperature differences
c. unrestrained expansion does not occur
d. no mixing
e. no turbulence
f. no combustion

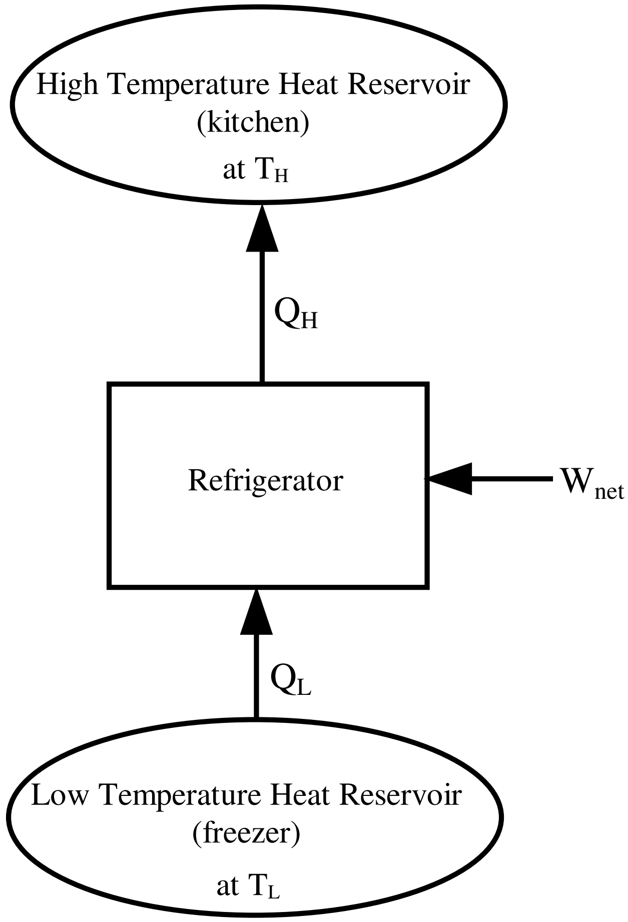
Choose a process for which one of these restrictions is relaxed and discuss how this process is not reversible. (5 pts)

<u>Solution:</u>
This will vary from student to student, but one needs to describe a process that includes one of the restrictions listed above and then describe the reverse of the process and show that the reverse can only occur if the system or surroundings are changed.

2. Thirty five (35) kilograms of chicken is to be frozen in a household freezer. The chicken is at 15°C when it is placed in the freezer and reaches -20°C (well below the freezing point) in 3 hours. If the COP of the freezer is 4.3 during this process, determine the required power input (in kW).

Solution:

We begin by drawing the interaction diagram for this refrigerator



By definition we have for our refrigerator

$$COP = \frac{Q_L}{W_{net}}$$

If we can determine the required heat transfer for freezing the chickens, Q_{chick}, then we can use

$$Q_L = -Q_{chick}$$

and solve for W_{net}, In the freezing process for the chicken, we have three processes:

Lowering the chicken temperature from 15°C to its freezing point

$$Q_1 = mc(T_2-T_1) = (35)(3.32)[(-2.8)-15] = -2068.4 \text{ kJ}$$

Freezing the chicken

$$Q_2 = m(\text{-latent heat of fusion}) = (35)(-247) = -8645$$

Lowering the chicken temperature from its freezing point to -20°C

$$Q_3 = mc(T_3-T_2) = (35)(1.77)[-20-(-2.8)] = -1065.5 \text{ kJ}$$

Then

$$Q_L = -Q_{chick} = -(Q_1+Q_2+Q_3) = 11{,}779 \text{ kJ}$$

and

$$W_{net} = \frac{Q_L}{COP} = \frac{11,779}{4.3} = 2739 \text{ kJ}$$

The power required is

$$\dot{W}_{net} = \frac{W_{net}}{\Delta t} = \frac{2739}{(3)(3600)} = 0.25 \text{ kW}$$