Answers – Week 14

14-1. In a reversible process the changes in the thermodynamic variables are carried out extremely slowly so that the system is in equilibrium at all intermediate points. One can therefore go both forward and backward.
In an irreversible process which is the usual laboratory process the system is in equilibrium in only the initial and the final states. Once the process is carried out there is no way possible to return to the original state.
Note that if we wish to represent a system by a point on the P-V diagram, the system must be in equilibrium. Hence the following picture:

14-3 For an adiabatic PV^{γ} constant. However, for a perfect gas

$$PV = (\text{const})\ T$$

So $$PV\ V^{\gamma-1} = Const$$

Yields $$TV^{\gamma-1} = \text{Const}$$

14-5. Carnot Cycle: Use 1 mol of gas.

(1) Isotherm at T_H. pickup DQ_H

$$DQ_H = R\ T_H \ln\frac{V_B}{V_A} \qquad \rightarrow (1)$$

(2) Adiabatic, DQ = 0, gas cools to T_C

$$T_C V_C^{\gamma-1} = T_H V_B^{\gamma-1} \qquad \rightarrow (2)$$

(3) Isotherm at T_C, Reject DQ_C

$$DQ_C = R\ T_C \ln\frac{V_D}{V_C} \qquad \rightarrow (3)$$

Note: DQ_C is negative.

(4) Adiabatic, DQ = 0, gas warms to T_H

$$T_H V_A^{\gamma-1} = T_C V_D^{\gamma-1} \qquad \rightarrow (4)$$

From (1) and (3)

$$\frac{DQ_H}{T_H} + \frac{DQ_C}{T_C} = R\ In\left(\frac{V_B V_D}{V_A V_C}\right)$$

From (3) and (4)

$$\frac{V_B V_D}{V_A V_C} = 1,\ \text{In } 1 = 0$$

So

$$\frac{DQ_H}{T_H} + \frac{DQ_C}{T_C} = 0$$

14-7. $\text{COP} = \dfrac{298}{25} \cong 12$

$Q_H = 12$ K J

We have assumed that the Heat Pump is essentially a Carnot Cycle. Most actual pumps have COP's around 5 or 6.