Summary of chapter 20

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1. Entropy, S, is a measure of the disorder.

2. Most of the processes in our life are irreversible, that is they happen in one-way.
   The change of entropy for an irreversible process in a closed system is always positive.

3. Entropy is a state function, just like the internal energy, i.e., it depends only on **the initial** and **the final** state of the system.

   So: ***The change in entropy, DS, for an irreversible process that takes the system from an initial state i to a final state f is EQUAL to the change in entropy for any reversible process that takes the system between those same two states.***

4. The change in entropy for any reversible process can be calculated by

$$\Delta S = \int \frac{dQ}{T} \quad T \text{ in Kelvin}$$

   The unit is J/K.

5. If an ***ideal gas*** is taken from state i to state f through a reversible process, then the change in entropy is

$$\Delta S = nc_v \ln\left(\frac{T_f}{T_i}\right) + nR \ln\left(\frac{V_f}{V_i}\right)$$

   For isothermal process, $T_i = T_f$ $\Rightarrow$ $\Delta S = nR\ln\left(\frac{V_f}{V_i}\right)$

   For isochoric process, $V_i = V_f$ $\Rightarrow$ $\Delta S = nc_v \ln\left(\frac{T_f}{T_i}\right)$

   For isobaric process, $Pi = Pf$ $\Rightarrow$ $\Delta S = nc_p \ln\left(\frac{T_f}{T_i}\right)$

   For adiabatic process, $Q = 0$ $\quad$ $DS = 0$

   For a cyclic reversible process, $\Delta S = 0$ (because $S_f = S_i$)

6. If a ***solid*** or ***liquid*** is heated or cooled, then the change in entropy is

(i) *change in temperature only* $\Delta S = mc\ln(\frac{T_f}{T_i})$

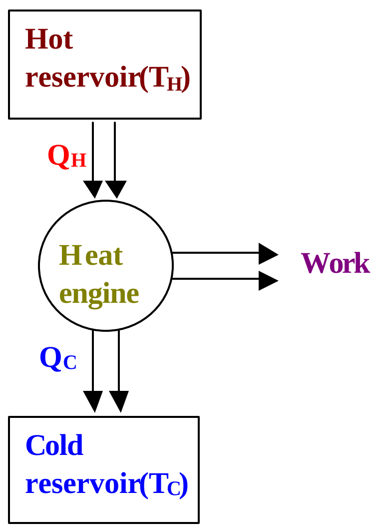
(ii) *change in phase only* $\Delta S = \frac{mL}{T}$

Solid $\rightarrow$ liquid L_f
Liquid $\rightarrow$ gas L_v

7. The second law of thermodynamics is expressed in the following way:

$$\Delta S \geq 0$$

8. A heat engine is a device that converts heat into mechanical or electrical energy.



Q_H is the heat absorbed

Q_c is the heat expelled

W done by the engine

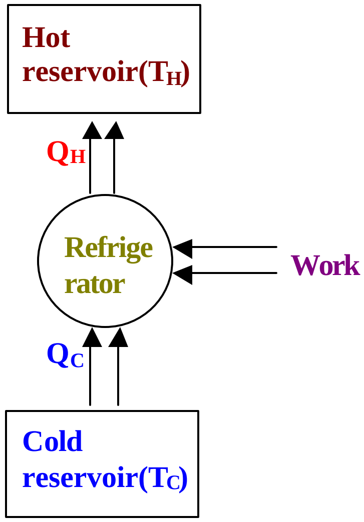
The efficiency of the any heat engine is $e = \frac{|W|}{|Q_H|}$

For an ***ideal*** heat engine (reversible cycle) $|Q_H| = |Q_c| + |W|$

$$e = 1 - \frac{|Qc|}{|Q_H|} = 1 - \frac{T_C}{T_H}$$ ***T*** in Kelvin

A perfect engine would have efficiency of 1. This would happen if T_C = 0 or T_H infinite which is impossible.

9. A refrigerator (or a heat pump) is a heat engine working in reverse.



Q_c is the heat absorbed

Q_H is the heat expelled

W done on the engine

The coefficient of performance of a refrigerator is defined as

$$K = \frac{|Q_C|}{|W|}$$

For an **ideal** refrigerator (reversible) the coefficient of performance is

$$K = \frac{|Q_C|}{|Q_H| - |Q_C|} = \frac{T_C}{T_H - T_C}$$

T in Kelvin

The coefficient of performance of a heat pump is defined as

$$K = \frac{|Q_H|}{|W|}$$

For an **ideal** heat pump (reversible) the coefficient of performance is

$$K = \frac{|Q_H|}{|Q_H| - |Q_C|} = \frac{T_H}{T_H - T_C}$$