
Basic Thermodynamics

Handout 2

The Carnot engine

Carnot engine An idealized heat engine which uses a perfect gas as the working substance and which operates between two temperatures. The engine operates the **Carnot cycle** which comprises simple isothermal and adiabatic processes. Carnot realized that the efficiency is maximized if all processes are reversible:

$$\eta_{\text{Carnot}} = \frac{W}{Q_2} = 1 - \frac{T_2}{T_1},$$

where T_1 is the temperature of the hotter reservoir, and T_2 is the temperature of the colder reservoir.

Carnot's theorem

No engine operating between two given temperatures can be more efficient than a Carnot engine.

A **refrigerator** built from a Carnot engine operating in reverse has efficiency

$$\eta_{\text{Carnot}} = \frac{Q_2}{W} = \frac{T_2}{T_1 - T_2},$$

A **heat pump** built from a Carnot engine operating in reverse has efficiency

$$\eta_{\text{Carnot}} = \frac{Q_1}{W} = \frac{T_1}{T_1 - T_2} > 1,$$

Clausius' theorem

For any closed cycle,

$$\oint \frac{dQ}{T} \leq 0,$$

where equality necessarily holds for a reversible cycle.