10/16 Lecture outline

• Clausius: *no device can be made that operates in a cycle and whose* **SOLE** *effect is to transfer heat from cooler to hotter body.* I.e. refrigerator efficiency $\omega = |Q_C|/|W| < \infty$. Picture seeming to violate it: must have $Q < 0$.

• Kelvin: *It is impossible to construct a device that operates in a cycle and produces no other effect other than the extraction of heat from a reservoir and the performance of an equal amount of work.* I.e. $\eta \equiv |W|/|Q_H| < 1$. Picture seeming to violate it: must have $W < 0$.

• Nothing beats a reversible engine! Because otherwise, in combination with the reversed engine (acting as a refrigerator) would violate Clauius' statement. Moreover, all reversible engines have the same efficiency. $\eta \leq \eta_{max} = \eta_{rev}$.

• Mention non-cyclic process, $A \to B$. Recall $\Delta U = \Delta Q - \Delta W = \Delta Q_R - \Delta W_R$. General result: $\Delta W \leq \Delta W_R$ and $\Delta Q \leq \Delta Q_R$. Illustrate with ideal gas for 2 cases: reversible isotherm and reversible adiabat, vs. irreversible counterparts.

• Work through examples of a Carnot engine (2 isotherms, 2 adiabats). Obtain $\eta = 1 - T_C/T_H$.

• Use Carnot engine to define temperature θ: $\eta = 1 - \Theta_C/\Theta_H$. Lots of C-engines in series, defines Θ temperature scale. Agrees with previous definition, $\Theta = T$ (!).