Thermal Processes and Sign Conventions: (Memorize these)

Isothermal – happens at same temperature (no temperature change);
$\Delta Q = W$ so $\Delta U = 0$. When heat or work is added slowly, the other is removed so that $\Delta U = 0$.

Isovolumetric – no change in volume; so,
$W = 0$ and $\Delta U = Q$.

Adiabatic – happens so rapidly that heat cannot enter or exit. This is what we did in class with the cylinder of air and the temperature probe (also the compressed air cylinder).
$\Delta U = -W$; and $Q = 0$.

Work done by a gas: $W = P\Delta V$, so any change of volume = work in or out.
If the gas expands, ΔV is + (bigger volume) = +W by the gas, but the temperature decreases ($-\Delta U$). $\therefore$ (therefore) $W = -\Delta U$ OR $\Delta U = -W$.
Gas is compressed, then –W by the gas = $+\Delta U$.

Laws of Thermodynamics:

0) If Object 1 and 2 are in thermal equilibrium and Object 2 and 3 are in thermal equilibrium, then Objects 1 and 3 are in thermal equilibrium. I think what this is telling us is that an object cannot be at thermal equilibrium and have different temperatures at different surfaces (I think).
1) $\Delta U = \Delta Q - W_{\text{done by gas}}$.
   So, V (gas) expands, W is positive; ΔU is negative; temperature decreases (if $Q = 0$);
   So, if V (gas) compresses, W is negative; ΔU is positive; temperature increases (if $Q = 0$).
2) In any process efficiency is always less than 100%: Law of Entropy.
   Or $\text{Eff} = 1 - Q_c/Q_h$
   Where Qc is heat lost by an engine and Qh is the heat gained by the engine.
   If Qc is zero (all heat gained does work) then it would be a 100% efficient engine (or process).

Entropy: amount of disorder:

Gases have high disorder: high entropy.
Solids have high order: low entropy.
To increase order (decrease entropy) requires external energy (work). (You pick up a group of pennies. There is very little chance that they will be all heads up. To order them as all heads up, you must do work to move the pennies.)
In the universe, since there can be no energy (work) external to the universe, entropy must always increase in any process.