Thermodynamics

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1 Criteria for spontaneous change

The 2nd law gave the Clausius inequality for spontaneous change

$$\mathrm{d}S > đq/T_{sur}, \tag{1}$$

and the 1st law gave us $\mathrm{d}U = đq + đw$.

Putting the two together, assuming only pV work, gives us the following general criterion for spontaneous change:

$$\boxed{\mathrm{d}U + p_{ext}\,\mathrm{d}V - T_{sur}\,\mathrm{d}S < 0}. \tag{2}$$

Equilibrium is when there is no possible change of state that would satisfy this inequality.