

$\Delta S_{\text{universe}} > 0 \Rightarrow \text{spontaneous Process}$

Examples

- 1) Melting of ice at 25°C
- 2) Freezing of water at -25°C
- 3) $\text{O}_2(\text{g}) + 2\text{H}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{g})$

$$\text{O}_2(\text{ini}) = 1 \text{ atm}$$

$$\text{H}_2(\text{ini}) = 2 \text{ atm}$$

$$T = 293 \text{ K}$$

$$\Delta S_{\text{universe}} = \Delta S_{\text{sys}} + \Delta S_{\text{sur}}$$

$$\Delta S_{\text{sur}} = q / T_{\text{sur}}$$

heat dissipated to the surroundings

assume

$$T_{\text{sur}} = T_{\text{sys}}$$

$$q_{\text{sur}} = -q_{\text{sys}}$$

$$\Delta S_{\text{sur}} = -q_{\text{sys}} / T_{\text{sys}}$$

$$\Delta S_{\text{universe}} = \Delta S_{\text{sys}} + \Delta S_{\text{sur}}$$

$$= \Delta S_{\text{sys}} - q_{\text{sys}} / T_{\text{sys}}$$

$$-q_{\text{sys}} = -\Delta H_{\text{sys}}$$

$$\Delta S_{\text{universe}} = \Delta S_{\text{sys}} - \Delta H_{\text{sys}} / T_{\text{sys}}$$

$$-T \Delta S_{\text{universe}} = \Delta H_{\text{sys}} - T \Delta S_{\text{sys}}$$

$$-T \Delta S_{\text{universe}} \equiv \Delta G \quad \text{Free Energy}$$