

$$\Delta G = \Delta H - T\Delta S$$

Reaction is spontaneous when  $\Delta G \leq 0$   $\Delta G < 0$

$\Delta H$	$\Delta S$	$\Delta G = \Delta H - T\Delta S$
- yes	+	- at any T
+ no	-	+ at any T
+	+	- $T\Delta S > \Delta H$ $\uparrow T$
-	-	- $\Delta H > T\Delta S$ $T \downarrow$

$$\Delta H = -35 \text{ kJ}$$

$$\Delta S = 100 \text{ J/K} = 0.100 \text{ kJ/K}$$

$$\Delta G = \Delta H - T\Delta S$$

$$= (-35 \text{ kJ}) - (294 \text{ K})(0.100 \text{ kJ/K})$$

$$T = 21^\circ\text{C} = 294 \text{ K}$$

$$\Delta G = -64.4 \text{ kJ}$$

spontaneous @ ANY T

$$\Delta H = 30 \text{ kJ}$$

$$\Delta S = 185 \text{ J/K}$$

$$T = 200 \text{ K}$$

$$\Delta G = 30 \text{ kJ} - (200 \text{ K})(0.185 \text{ kJ/K})$$

$$\Delta G = (+) 26.4 \text{ kJ}$$

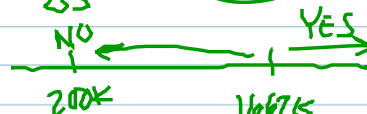
NONSPONTANEOUS

$$\Delta G = 0$$

$$0 = \Delta H - T\Delta S$$

$$T\Delta S = \Delta H \rightarrow T = \frac{\Delta H}{\Delta S}$$

$$T = \frac{30 \text{ kJ}}{0.185 \text{ kJ/K}} = 1667 \text{ K}$$



$$\Delta G = \Delta H - T\Delta S$$

Reaction is spontaneous when  $\Delta G < 0$

<u><math>\Delta H</math></u>	<u><math>\Delta S</math></u>	<u><math>\Delta G = \Delta H - T\Delta S</math></u>
- yes	+	- at any T
+ no	-	+ at any T
+	+	- $T\Delta S > \Delta H$ $\uparrow T$
-	-	- $\Delta H > T\Delta S$ $T \downarrow$

$$\Delta H = -35 \text{ kJ}$$

$$\Delta S = 100 \text{ J/K} = 0.100 \text{ kJ/K}$$

$$\Delta G = \Delta H - T\Delta S$$

$$= (-35 \text{ kJ}) - (294 \text{ K})(0.100 \text{ kJ/K})$$

$$T = 21^\circ\text{C} = 294 \text{ K}$$

$$\Delta G = -64.4 \text{ kJ}$$

spontaneous @ ANY T

$$\Delta H = 30 \text{ kJ}$$

$$\Delta S = 18 \text{ J/K}$$

$$T = 200 \text{ K}$$

$$\Delta G = 30 \text{ kJ} - (200 \text{ K})(0.018 \text{ kJ/K})$$

$$\Delta G = (+) 26.4 \text{ kJ}$$

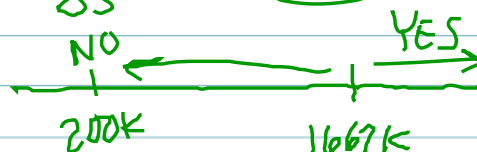
NONSPONTANEOUS

$$\Delta G = 0$$

$$0 = \Delta H - T\Delta S$$

$$T\Delta S = \Delta H \rightarrow T = \frac{\Delta H}{\Delta S}$$

$$T = \frac{30 \text{ kJ}}{0.018 \text{ kJ/K}} = 1667 \text{ K}$$



$$\Delta H = -5.0 \text{ kJ}$$

$$\Delta S = -310 \text{ J/K}$$

$$T = 294 \text{ K}$$

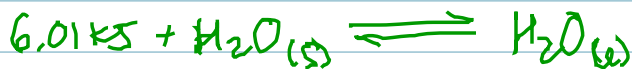
$$\Delta G = -5.0 \text{ kJ} - (294 \text{ K})(-0.31 \text{ kJ/K})$$

$$\Delta G = \oplus 86.14 \text{ kJ}$$

NONSPONTANEOUS

$$T = \frac{\Delta H}{\Delta S} = \frac{-5.0 \text{ kJ}}{-0.310 \text{ kJ/K}} = 16 \text{ K}$$

$$T < 16 \text{ K}, \Delta G (-)$$



$$\Delta H_{\text{fus}} = 6.01 \text{ kJ} \quad \Delta S (+)$$

$$\text{@ } \Delta G = 0 \quad T = 0^\circ\text{C} = 273 \text{ K}$$

$$T = \frac{\Delta H}{\Delta S} \Rightarrow \Delta S = \frac{\Delta H}{T}$$

$$\Delta H_{\text{vap}} = 40.1 \text{ kJ}$$

$$T_{\text{bp}} = 373 \text{ K}$$

$$\Delta S_{\text{vap}} = \frac{40.1 \text{ kJ}}{373 \text{ K}} = 108 \text{ J/K}$$

$$\Delta S_{\text{fus}} = \frac{6.01 \text{ kJ}}{273 \text{ K}} = 0.022 \text{ kJ/K}$$

$$\Delta S_{\text{fus}} = 22 \text{ J/K}$$

$$\Delta H_{\text{fus}}, \Delta S_{\text{fus}} \Rightarrow T_{\text{mp}}$$