

# Spontaneous Reactions:

- A chemical reaction that exists without a constant supply of energy.
  - >  $\text{C}_3\text{H}_8 (\text{g}) + 5\text{O}_2 (\text{g}) \rightarrow \text{CO}_2 (\text{g}) + \text{H}_2\text{O} (\text{g})$
- Two things to consider if a reaction will be spontaneous:
  - > entropy (disorder)  $\Delta S$
  - > enthalpy (heat)  $\Delta H$

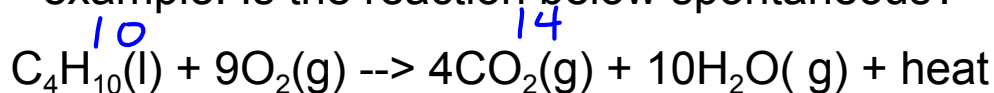
\*\*\*spontaneity does NOT determine rate\*\*\*

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# Determining Spontaneity:

- If entropy is increasing, it is likely to be spontaneous.
- If the reaction is exothermic, it is likely to be spontaneous.

example: Is the reaction below spontaneous?



$-\Delta H = \text{exo}$                       Spont.

$+\Delta S = \uparrow \text{disorder}$

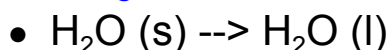
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# Practice:

	$-\Delta H$ (exo)	$+\Delta H$ (endo)
$+\Delta S$	always spontaneous	spontaneity depends on temperature
$-\Delta S$	spontaneity depends on temperature	never spontaneous



endo =  $+\Delta H$       never spont.  
 $\downarrow$  disorder =  $-\Delta S$



endo =  $+\Delta H$       depends on temp.  
 $\uparrow$  disorder =  $+\Delta S$

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## Gibb's Free Energy

- Quantitatively determines spontaneity

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

- >  $\Delta G$  = Gibb's Free Energy
- >  $\Delta H$  = enthalpy (kJ) - exo or endo
- > T = Temperature in K
- >  $\Delta S$  = entropy (J/K)
- >  **$-\Delta G$  = spontaneous**
- >  **$+\Delta G$  = not spontaneous**

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## Example:

- Ice melting

>  $\Delta H = 6.03 \text{ kJ/mol}$

>  $\Delta S = 22.1 \text{ J/K}\cdot\text{mol}$

- Calculate  $\Delta G$  at  $-10^\circ\text{C}$  and  $10^\circ\text{C}$

$$\Delta G = 6.03 - 263 \cdot 0.0221$$

$$= 0.218 \text{ not spont.}$$

$$22.1 \text{ J} \times \frac{1 \text{ kJ}}{1000 \text{ J}} = 0.0221 \text{ kJ/(K}\cdot\text{mol)}$$

$$\frac{\text{kJ}}{\text{mol}} - \text{K} \cdot \frac{\text{kJ}}{\text{mol}\cdot\text{K}}$$

$$\Delta G = 6.03 - 283 \text{ K} \cdot 0.0221 = -0.224 \text{ spont.}$$

Remember  $\Delta G$  &  $\Delta H$  are given in kJ

$\Delta S$  given in J

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## Check for Understanding:

Given the following information, determine if the reaction is spontaneous or non-spontaneous.

$$\Delta H = 365 \text{ kJ}, T = 388 \text{ K}, \Delta S = 55.2 \text{ J/K}$$

$$55.2 \text{ J} \times \frac{1 \text{ kJ}}{1000 \text{ J}} = 0.0552 \text{ kJ}$$

$$\Delta G = 365 - 388 \cdot 0.0552$$

$$= 344 \text{ non-spont.}$$

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