

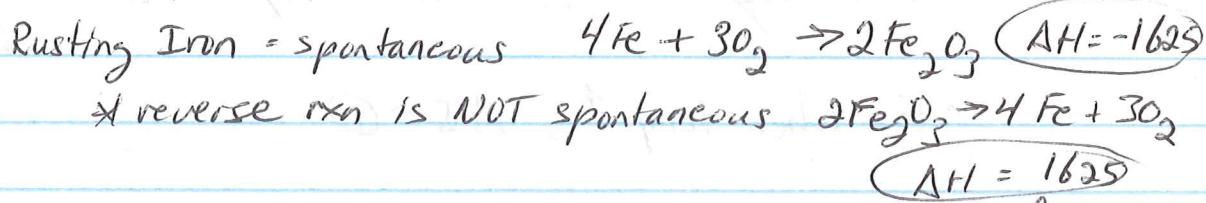
(1)

15-5 Reaction Spontaneity

* there is a natural tendency towards disorder!

Spontaneous Rxns = physical or chemical change that, once begun, continues w/out outside intervention.

- sometimes they are endothermic and need energy to get going ex) lighting a bunsen burner



ΔH does Not indicate if rxn is spontaneous endo

Entropy (S) - is a measure of the possible ways that energy of a system can be distributed - based on freedom of particles.

- The # of possible arrangements of atoms in a system \uparrow when: volume \uparrow , Energy \uparrow , # of particles \uparrow , or when freedom to move \uparrow .

2nd Law of Thermodynamics - states that spontaneous processes always proceed in such a way the entropy \uparrow

- measure of disorder or randomness
- particles that spread out have more entropy than close ones.

$$\Delta S_{\text{system}} = S_{\text{products}} - S_{\text{reactants}}$$

If $S_{\text{prod.}} > S_{\text{react}}$, $\Delta S_{\text{sys}} = +$

$S_{\text{prod.}} < S_{\text{react}}$, $\Delta S_{\text{sys}} = -$

Rules

1. Entropy \uparrow when states go up ($s \rightarrow l \rightarrow g$) $\Delta S = +$
2. Dissolving gas into solution \uparrow entropy $\Delta S = -$
3. Entropy \uparrow when # of gaseous products $>$ # of gaseous reactants $\Delta S = +$
4. Mostly Entropy \uparrow when Liq. or Sol. dissolve in Solution $\Delta S = +$
5. When temp \uparrow , $\Delta S = +$

Since the universe \uparrow in disorder, $\Delta S_{\text{univ}} > 0$ \oplus
when:

1. Rxn or process is exothermic ($\Delta H = -$)
2. Entropy of system \uparrow , so $\Delta S_{\text{sys}} = +$

* Exothermic chem. rxns followed by \uparrow in Entropy are spontaneous

Free energy = energy available to do work =
Gibbs Free Energy or G_{system} .

Free energy change (ΔG_{sys}) = diff. between system's
change in Enthalpy (ΔH_{sys}) and product of
Kelvin temp. & change in entropy ($T\Delta S_{\text{sys}}$)

$$\boxed{\Delta G_{\text{sys}} = \Delta H_{\text{sys}} - T\Delta S}$$

(3)

* Convert all units to kJ when solving

- ΔG_{sys}° = Spontaneous

+ ΔG_{sys}° = non-spontaneous

remember
 Δ° = known standard value



$$\Delta H_{sys}^{\circ} = -91.8 \text{ kJ} \quad \Delta S_{sys}^{\circ} = -197 \text{ J/K}$$

* Entropy \downarrow because gaseous products (moles) < reactants
 2 moles < 4 moles $\Delta S = \Theta$ & Exothermic

- convert ΔS_{sys}° to kJ

$$\frac{-197 \text{ J}}{1 \text{ K}} \times \frac{1 \text{ kJ}}{1,000 \text{ J}} = -.197 \text{ kJ/K}$$

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

$$= -91.8 \text{ kJ} - (298 \text{ K})(-.197 \text{ kJ/K})$$

$$= -91.8 \text{ kJ} - -58.7 \text{ kJ} = (-33.1 \text{ kJ})$$

$$\Delta G_{sys} = \Theta$$

- rxn is spontaneous

Table 15.6 pg 547

ΔH_{sys}	ΔS_{sys}	ΔG_{sys}	Reaction Spontaneity
-	+	always -	always spontaneous
-	-	-/+	spon. @ low temps
+	+	-/+	spon. @ high temps
+	-	always +	never spontaneous

(4)

* Determine if the following are Spontaneous

ex) In a reaction, $\Delta H_{sys} = -75.9 \text{ kJ}$

$$T = 535 \text{ K}$$

$$\Delta S_{sys} = 138 \text{ J/K}$$

ex) $\Delta H_{sys} = -27.6 \text{ kJ}$

$$T = 535 \text{ K}$$

$$\Delta S_{sys} = -55.2 \text{ J/K}$$