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**TABLE 17.2 Signs of Enthalpy, Entropy, and Free-Energy Changes and Reaction Spontaneity for a Reaction at Constant Temperature and Pressure**

$\Delta H$	$\Delta S$	$\Delta G = \Delta H - T\Delta S$	Reaction Spontaneity
-	+	-	Spontaneous at all temperatures
-	-	- or +	Spontaneous at low temperatures where $\Delta H$ outweighs $T\Delta S$ Nonspontaneous at high temperatures where $T\Delta S$ outweighs $\Delta H$
+	-	+	Nonspontaneous at all temperatures
+	+	- or +	Spontaneous at high temperatures where $T\Delta S$ outweighs $\Delta H$ Nonspontaneous at low temperatures where $\Delta H$ outweighs $T\Delta S$

## GIBBS FREE ENERGY

Reactions with a **positive  $\Delta H$**  and **positive  $\Delta S$**  all have a negative  $\Delta G$

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

$$(+) - T(+)$$

$\Delta G$  will be negative in temperature conditions where the value of  $T\Delta S$  is higher than the value of  $\Delta H$ . Thus the reaction is spontaneous only at higher temperatures.



This reaction is **spontaneous** at temperatures above 0°C (273K) and **nonspontaneous** below this temperature

Point	(molar)				
1	0.80	334 K	0.00299 K <sup>-1</sup>	2.048	0.711
2	0.49	321 K	0.00312 K <sup>-1</sup>	0.471	-0.754
3	0.91	312.1 K	0.00320 K <sup>-1</sup>	1.43	0.359
4	0.23	303 K	0.00330 K <sup>-1</sup>	0.9487	-3.023
5	0.11	293 K	0.00341 K <sup>-1</sup>	0.0819	-4.73

Show sample calculation for  $K_{sp}$  and  $\ln K_{sp}$  using data point 1 (see equation 6)

Use Excel to plot a graph of  $\ln K_{sp}$  (y-axis) vs.  $1/T$  (x-axis). Use the "Add Trendline" feature to draw a straight line through the five data points. The equation of the straight line should be shown on the graph along with the value of  $R^2$ . (If one of the data points does not lie on the line, remove it and re-do the straight line, the equation, and  $R^2$ .)

Equation of the straight line

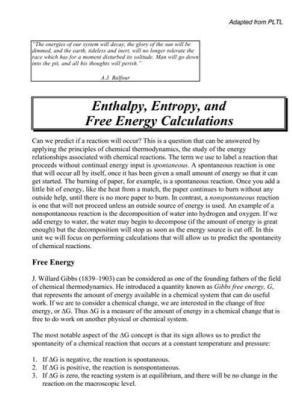
$$-12889x + 39.362$$

Enthalpy of dissolution,  $\Delta H^\circ$  \_\_\_\_\_ kJ/mol  
Show calculation:

Entropy of dissolution,  $\Delta S^\circ$  \_\_\_\_\_ J/mol.K  
Show calculation:

Gibbs free energy of dissolution,  $\Delta G^\circ$  \_\_\_\_\_ kJ/mol  
(at 25 °C)  
Show calculation:

Name: \_\_\_\_\_ Lab Day: M T W R F Instructor: \_\_\_\_\_  
Room: 103 109 117 125 Lab Time: \_\_\_\_\_



$$3\text{H}_2 + \text{S}\text{O}_2 \longrightarrow \text{H}_2\text{S} + 2\text{H}_2\text{O}$$

Equilibrium  
constant  $K = ?$

$\Theta$	-300	-33	-229	
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$$\Delta G_{\text{rxn}}^\circ = \sum \text{Products} - \sum \text{Reactants}$$

$$= [\text{H}_2\text{S} + 2\text{H}_2\text{O}] - [3\text{H}_2 + \text{S}\text{O}_2] \quad 8.314$$

$$= (-33) + 2(-229) - [0 + -300]$$

$$= -33 - 458 + 300 \quad \Delta G^\circ = -RT \ln(K)$$

$$= -191 \text{ kJ/mol.} \quad f_{\text{inl}}$$

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