CONCEPT: GIBBS FREE ENERGY (SIMPLIFIED)

● **Gibbs Free Energy (ΔG)** is a measure of _____ change of a chemical or physical process that can be used to do ____.

　　□ Sign of ΔG determines _____ of a reaction.

Sign of ΔG	Spontaneity of Reaction
ΔG < 0	_____
ΔG > 0	_____
ΔG = 0	_____

EXAMPLE: If ΔG is small and positive, which of the following statements is true?

a) the forward reaction is spontaneous and system is far from equilibrium

b) the forward reaction is spontaneous and system is near equilibrium

c) the reverse reaction is spontaneous and system is far from equilibrium

d) the reverse reaction is spontaneous and system is near equilibrium

Predicting Spontaneity

● When sign of ΔG is unknown, spontaneity of a reaction can be predicted from _____ of Enthalpy (ΔH) and Entropy (ΔS).

| Predicting Spontaneity		
	+ΔS	-ΔS
+ΔH	**Spontaneous** at _____ Temperatures	Always _____
-ΔH	Always _____	**Spontaneous** at _____ Temperatures

EXAMPLE: PCl_3 (g) + Cl_2 (g) $\rightleftharpoons$ PCl_5 (g) At 25°C, ΔH° = - 92.50 kJ. Which of the following statements is(are) true?

a. This is an endothermic reaction.

b. If the temperature is increased, the ratio of $[PCl_5]$ / $[PCl_3]$ $[Cl_2]$ will increase.

c. ΔS° for this reaction is negative.

d. ΔG° for this reaction has to be negative at all temperatures.

<u>**CONCEPT:**</u> GIBBS FREE ENERGY (SIMPLIFIED)

PRACTICE: What are the signs of ΔH, ΔS and ΔG for the spontaneous conversion of a solid into gas?
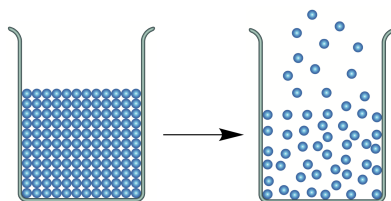
PRACTICE: You calculate the value of ΔG for a chemical reaction and get a positive value. Which would be the most accurate way to interpret this result?

a) If a mixture of reactants and products is created and left to equilibrate, the equilibrium mixture will contain more reactant than product.

b) If a mixture of reactants and products is created, we cannot say anything about its composition at equilibrium but we can say it will reach equilibrium very rapidly.

c) The reaction will not occur under any circumstances.

d) If a mixture of reactants and products is created and left to equilibrate, the equilibrium mixture will contain more product than reactant.

PRACTICE: Consider the combustion of butane gas and predict the signs of ΔS, ΔH and ΔG.

C_4H_{10} (g) + 13/2 O_2 (g) $\longrightarrow$ 4 CO_2 (g) + 5 H_2O (g)
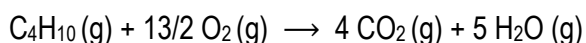
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Calculations of Gibbs Free Energy

● Gibbs Free Energy formula allows us to calculate the value of ΔG (kJ) by using ΔH (kJ), ΔS (J/K) and T (K) values.

Gibbs Free Energy Formula

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

EXAMPLE: For a particular reaction, ΔH = - 111.4 kJ and ΔS = - 25.0 J/K.

Calculate ΔG for this reaction at 298° K. What can be said about the spontaneity of the reaction at 298° K?

a) The system is at equilibrium

b) The system is spontaneous in the reverse direction.

c) The system is spontaneous as written.

PRACTICE: A particular reaction has ΔG = −350 kJ and ΔS = −350 J/K at 24C°. How much heat will be released/absorbed?

PRACTICE: For a reaction in which ΔH = 125 kJ and ΔS = 325 J/K, determine the temperature in Celsius above which the reaction is spontaneous.

a) 385 °C   b) 273 °C   c) 112 °C   d) 405 °C   e) 25 °C