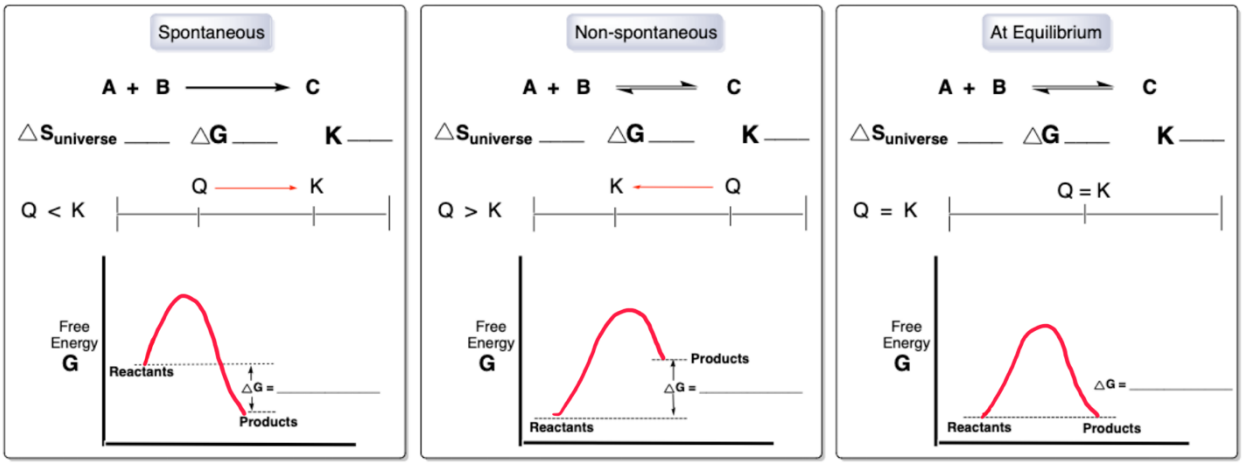
CONCEPT: GIBBS FREE ENERGY

Spontaneous reactions can occur without any outside energy being invested, while nonspontaneous reactions cannot.



Gibbs Free Energy can also be calculated through the use of various equations:

$$\Delta G = \Delta H - T\Delta S \qquad \Delta G = \Delta G^{o} + RT\ln Q \qquad \Delta G^{o} = -RT\ln K$$

$$R = \text{constant} = 8.314\ \frac{J}{mol \cdot K}$$

EXAMPLE: Which of the following is an example of a nonspontaneous process?

a) Ice melting at room temperature

b) Sodium metal reacting violently with water

c) Rusting of iron at room temperature

d) A ball rolling downhill

e) Water freezing at room temperature

PRACTICE: GIBBS FREE ENERGY CALCULATIONS 1

EXAMPLE 1: Consider the decomposition of a metal oxide to its elements, where M represents a generic metal.

$M_3O_4\,(s) \rightleftharpoons 3\,M\,(s) + 2\,O_2\,(g)$

Compound	M_3O_4	M	O_2
$\Delta G_f^\circ \left(\frac{kJ}{mol}\right)$	-9.50	0	0

i) What is the standard change in Gibbs energy for the reaction, as written, in the forward direction?

ii) What is the equilibrium constant of this reaction, as written, in the forward direction at 298 K?

iii) What is the equilibrium pressure of $0_2\,(g)$ over M (s) at 298 K?

EXAMPLE 2: For the reaction:

$$2\,C\,(graphite) + H_2\,(g) \longrightarrow C_2H_2\,(g)$$

$\Delta G° = +209.2$ kJ at 25°C. If $P_{H2} = 100$ atm, and $P_{C2H2} = 0.10$ atm, calculate ΔG for reaction.

a) +192.1 kJ

b) +266.3 kJ

c) -16.9 kJ

d) +207.8 kJ

e) +17.3 kJ

PRACTICE: GIBBS FREE ENERGY CALCULATIONS 2

EXAMPLE: Sodium carbonate can be made by heating sodium bicarbonate:

$$2\ NaHCO_3\,(s) \longrightarrow Na_2CO_3\,(s) + CO_2\,(g) + H_2O\,(g)$$

Given that $\Delta H° = 128.9$ kJ/mol and $\Delta G° = 33.1$ kJ/mol at 25°C, above what minimum temperature will the reaction become spontaneous under standard-state conditions?

a) 0.4 K

B) 3.9 K

C) 321 K

D) 401 K

E) 525 K

PRACTICE: The signs of ΔH, ΔS, and ΔG at 25°C are shown below for three chemical reactions.

	ΔH	**ΔS**	**ΔG**
a)	–	–	+
b)	+	+	+
c)	–	+	+

	+ ΔS	**- ΔS**
+ ΔH		
- ΔH		

Which reaction would go in the reverse direction at high temperatures?