

## Quick Review of Thermodynamics

### Study of Energy *Transfer*

#### What does a thermodynamic picture tell us?

Thermodynamics describes:

Thermodynamics provides no information about:

#### Key thermodynamic components:

Enthalpy:

Entropy:

Free Energy:

1

## Laws of Thermodynamics:

1st Law:

2nd Law:

3rd Law:

In order to develop a complete picture, we need to consider both the **system** and the **surroundings**.

2

## Thermodynamic Concepts

Thermodynamic parameters are **state functions**:

Thermodynamic parameters have magnitude and sign:

$\Delta H$ :

$\Delta S$ :

$\Delta G$ :

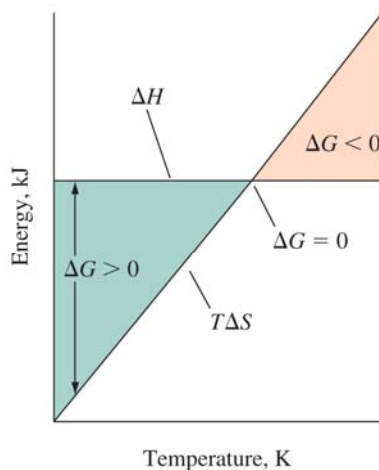
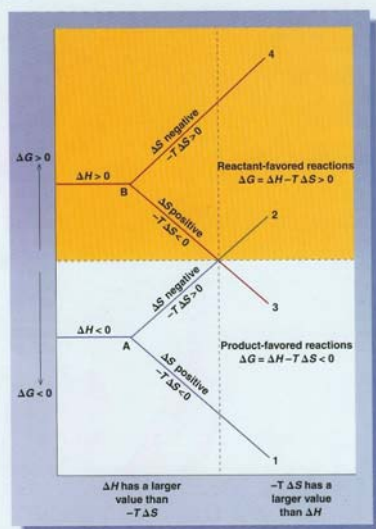
**TABLE 19.1** Criteria for Spontaneous Change:  $\Delta G = \Delta H - T\Delta S$

Case	$\Delta H$	$\Delta S$	$\Delta G$	Result	Example
1.	-	+	-	spontaneous at all temp.	$2 \text{ N}_2\text{O}(\text{g}) \longrightarrow 2 \text{ N}_2(\text{g}) + \text{ O}_2(\text{g})$
2.	-	-	$\begin{cases} - \\ + \end{cases}$	$\begin{cases} \text{spontaneous at low temp.} \\ \text{nonspontaneous at high temp.} \end{cases}$	$\text{H}_2\text{O}(\text{l}) \longrightarrow \text{H}_2\text{O}(\text{s})$
3.	+	+	$\begin{cases} + \\ - \end{cases}$	$\begin{cases} \text{nonspontaneous at low temp.} \\ \text{spontaneous at high temp.} \end{cases}$	$\text{NH}_3(\text{g}) \longrightarrow \text{N}_2(\text{g}) + 3 \text{ H}_2(\text{g})$
4.	+	-	+	nonspontaneous at all temp.	$3 \text{ O}_2(\text{g}) \longrightarrow 2 \text{ O}_3(\text{g})$

3

## Free Energy and Spontaneity

Kotz: Chemistry & Chemical Reactivity, 4/e  
Figure 20.8



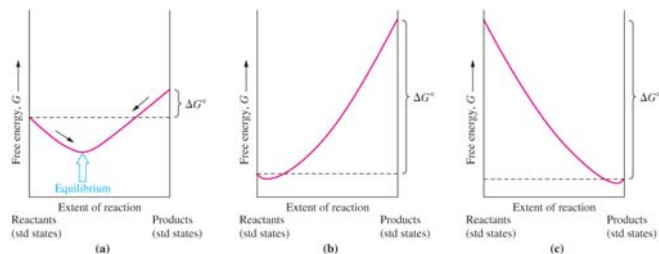
Copyright © 2007 Pearson Prentice Hall, Inc.

4

## Thermodynamic Parameters Depend (Somewhat) on Conditions

Often, parameters are tabulated (or calculated) at **standard state** (or under *standard conditions*):

What if you aren't working at standard state?



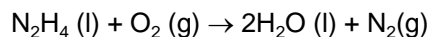
**Equilibrium constants** are also thermodynamic parameters, useful for predicting tendencies.

5

## Examples of types of thermodynamics calculations

- Often several approaches. These are only a few examples.

**Calculate the  $\Delta G^\circ$  for the oxidation of hydrazine below. Is the reaction favorable under standard conditions?**



Possible strategies:

**At what temperature does the oxidation of hydrazine become spontaneous?**

**What is the equilibrium constant for this reaction at 100°C?**

6