# If, For A Particular Process, H = -214 KJ/mol And S = 450 J/mol.K The Process Will Be: Select The Correct

### If, For A Particular Process, H = -214 KJ/mol And S = 450 J/mol·K The Process Will Be: Select The Correct

Understanding whether a process is spontaneous or non-spontaneous is fundamental in thermodynamics. The given data—enthalpy change (H) and entropy change (S)—provides critical insight into the thermodynamic nature of the process. In this article, we will explore how to interpret these values, determine the spontaneity of the process, and understand the implications of the thermodynamic parameters involved.

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## Introduction to Thermodynamic Parameters

Thermodynamics is the branch of physical science that deals with the relationships between heat, work, temperature, and energy. Two key parameters used to analyze processes are:

- **Enthalpy (H):** Represents the total heat content of a system at constant pressure. Changes in enthalpy (ΔH) indicate whether heat is absorbed or released during a process.
- **Entropy (S):** Measures the degree of disorder or randomness in a system. Changes in entropy (ΔS) reflect the dispersal of energy or matter within the system.

The combined analysis of ΔH and ΔS, through the Gibbs free energy change (ΔG), determines whether a process is spontaneous, non-spontaneous, or at equilibrium.

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## Understanding the Given Data

The problem provides the following data:

- **H (Enthalpy change):** -214 KJ/mol
- **S (Entropy change):** 450 J/mol·K

Note: It's important to ensure consistent units before calculations. Since ΔH is in kilojoules and ΔS in joules, convert ΔH into joules:

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ΔH = -214 KJ/mol = -214,000 J/mol
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# Thermodynamic Criterion for Spontaneity

The spontaneity of a process at constant temperature and pressure is determined by the Gibbs free energy change ($\Delta G$):

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

- If $\Delta G < 0$, the process is spontaneous.
- If $\Delta G > 0$, the process is non-spontaneous.
- If $\Delta G = 0$, the process is at equilibrium.

To analyze the process, we need to consider the temperature ($T$). Since $T$ is not specified, the analysis involves exploring the conditions under which the process is spontaneous or non-spontaneous.

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# Calculating the Gibbs Free Energy Change

Given the data, the expression for $\Delta G$ becomes:

$$\Delta G = -214{,}000\ \text{J/mol} - T \times 450\ \text{J/mol·K}$$

The sign of $\Delta G$ depends on the temperature $T$, so we can analyze the process over a range of temperatures to determine its nature.

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## Determining the Critical Temperature ($T_c$)

The critical temperature at which $\Delta G = 0$ (the process is at equilibrium):

$$0 = -214{,}000\ \text{J/mol} - T_c \times 450\ \text{J/mol·K}$$

Rearranged to solve for Tc:

$$T_c = -214{,}000\ \text{J/mol} / 450\ \text{J/mol·K} \approx -475.56\ \text{K}$$

Since temperature cannot be negative in Kelvin, this indicates that:

- The process is spontaneous at all positive temperatures.
- Because Tc is negative, the process's $\Delta G$ is negative at any $T > 0$ K.

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# Implications of the Sign of ΔH and ΔS

Let's analyze the thermodynamic implications of the signs of ΔH and ΔS:

- **ΔH is negative (-214 kJ/mol):** The process releases heat (exothermic).
- **ΔS is positive (450 J/mol·K):** The process results in increased disorder or randomness.

In thermodynamics, when ΔH < 0 and ΔS > 0, the process is always spontaneous at any temperature because:

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

- ΔH is negative, so the first term is negative.
- TΔS is positive (since both T and ΔS are positive), so subtracting a positive number makes ΔG more negative.

Therefore, the process is spontaneous over the entire temperature range, from absolute zero to very high temperatures.

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# Summary of Process Nature Based on Data

| Parameter | Sign | Interpretation | Effect on Spontaneity |
|---|---|---|---|
| ΔH | Negative (-214 kJ/mol) | Exothermic process | Promotes spontaneity at all T |
| ΔS | Positive (450 J/mol·K) | Increased disorder | Promotes spontaneity at all T |
| ΔG at any T | Negative | Spontaneous process | The process will occur spontaneously under the given conditions |

Conclusion:
Since both ΔH and ΔS favor spontaneity, the process with ΔH = -214 kJ/mol and ΔS = 450 J/mol·K will always be spontaneous, regardless of temperature.

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# Additional Considerations and Applications

Understanding the thermodynamic nature of processes using ΔH and ΔS is fundamental in various fields, including chemical engineering, material science, and thermodynamics education. Here are some practical insights:

## 1. Reaction Feasibility

Knowing that a process is always spontaneous helps in designing chemical reactions, ensuring energy efficiency, and predicting reaction behavior under different conditions.

## 2. Temperature Dependence

While this specific process is spontaneous at all temperatures, many processes depend critically on temperature. When $\Delta H$ and $\Delta S$ have different signs, the spontaneity can change with temperature, leading to interesting phenomena like phase transitions.

## 3. Real-World Applications

- Combustion reactions, which are exothermic and increase entropy, are spontaneous at all temperatures.
- Melting of ice (endothermic but increasing entropy) becomes spontaneous above a certain temperature (melting point).

# Summary and Final Remarks

In conclusion, given the data—$\Delta H = -214$ kJ/mol and $\Delta S = 450$ J/mol·K—the process is thermodynamically favorable and will proceed spontaneously at all temperatures. This is primarily because both the exothermic nature and the increase in entropy contribute to negative Gibbs free energy across the temperature spectrum.

Understanding these thermodynamic principles enables scientists and engineers to predict process behavior accurately, optimize reactions, and design systems that exploit spontaneous processes for energy-efficient applications.

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Key Takeaways:

- Always convert units for consistent calculations.
- Use Gibbs free energy to determine spontaneity.
- Recognize the influence of temperature on thermodynamic processes.
- Processes with $\Delta H < 0$ and $\Delta S > 0$ are always spontaneous at all temperatures.

By mastering these concepts, you can analyze various chemical and physical processes effectively, ensuring optimal design and understanding of thermodynamic systems.

# Frequently Asked Questions

## Given H = -214 kJ/mol and S = 450 J/mol·K, is the process spontaneous at all temperatures?

Yes, the process is spontaneous at all temperatures because $\Delta H$ is negative and $\Delta S$ is positive, making $\Delta G$ negative at all T.

## What is the sign of ΔG for the process at any temperature?

$\Delta G$ will be negative at all temperatures, indicating a spontaneous process.

## Is the process exothermic or endothermic?

The process is exothermic because $\Delta H$ is negative.

### Will the process be spontaneous at high temperatures?

Yes, since both ΔH is negative and ΔS is positive, the process remains spontaneous at all temperatures, including high T.

### What is the significance of the positive entropy change in this process?

A positive ΔS indicates increased disorder, which favors spontaneity, especially combined with a negative ΔH.

### How would the spontaneity change if ΔH were positive and ΔS negative?

The process would be non-spontaneous at all temperatures, as ΔG would be positive.

### Based on the given values, what type of process is this likely to be?

It is likely a spontaneous exothermic process with increasing entropy, such as a combustion or dissolution.

### Can we calculate the temperature at which the process becomes non-spontaneous?

No, since both ΔH is negative and ΔS is positive, ΔG remains negative at all temperatures; there is no temperature threshold for spontaneity.

## Additional Resources

If, For A Particular Process, H = -214 Kj/mol And S = 450 J/mol·K The Process Will Be: Select The Correct

Understanding the thermodynamic parameters of a process is fundamental in predicting whether a reaction or process will occur spontaneously under certain conditions. In this case, the enthalpy change (H) and entropy change (S) are given as -214 kJ/mol and 450 J/mol·K, respectively. Analyzing these values allows us to determine the spontaneity, feasibility, and nature of the process. This article delves into the thermodynamic principles underlying these parameters, how to interpret them, and how to select the correct classification of the process.

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## Understanding Thermodynamic Parameters: H and S

Thermodynamics provides tools to evaluate the spontaneity and equilibrium of processes through parameters such as enthalpy (H) and entropy (S). These two quantities are central to the Gibbs free energy (G), which is the criterion for spontaneity.

### Enthalpy (H)

- Definition: Enthalpy is a measure of the total heat content in a system at constant pressure.
- Significance: Negative H indicates an exothermic process (releases heat), while positive H indicates an endothermic process (absorbs heat).
- Implication: Exothermic processes tend to be thermodynamically favorable, especially at lower temperatures.

## Entropy (S)

- Definition: Entropy measures the degree of disorder or randomness in a system.
- Significance: A positive S suggests increased disorder, favoring spontaneity, whereas negative S suggests decreased randomness.
- Implication: Processes that increase entropy tend to be spontaneous, especially at higher temperatures.

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## Gibbs Free Energy and Spontaneity

The key to predicting whether a process will occur spontaneously is the Gibbs free energy change (ΔG), defined as:

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

where:
- ΔH = enthalpy change
- ΔS = entropy change
- T = temperature in Kelvin

Spontaneous process conditions:
- ΔG < 0 (negative)
- ΔG > 0 indicates non-spontaneous
- ΔG = 0 indicates equilibrium

Given the values:
- ΔH = -214 kJ/mol
- ΔS = 450 J/mol·K (which is 0.450 kJ/mol·K for consistency)

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## Calculating ΔG at Different Temperatures

To assess the nature of the process, we analyze ΔG at various temperatures:

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

Substituting the known values:

$$
\Delta G = -214\, \text{kJ/mol} - T \times 0.45\, \text{kJ/mol·K}
$$

At different temperatures:

- At low temperatures (e.g., T = 300 K):

$$
\Delta G = -214 - 300 \times 0.45 = -214 - 135 = -349\, \text{kJ/mol}
$$

- At higher temperatures (e.g., T = 1000 K):

$$
\Delta G = -214 - 1000 \times 0.45 = -214 - 450 = -664\, \text{KJ/mol}
$$

- At T where ΔG = 0:

$$
0 = -214 - T \times 0.45 \implies T = \frac{-214}{-0.45} \approx 475.56\, \text{K}
$$

This temperature (approximately 476 K) is the critical temperature at which the process transitions from spontaneous to non-spontaneous or vice versa.

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## Interpreting the Thermodynamic Data

Given the calculated ΔG values:

- At T < 476 K: ΔG is negative, indicating the process is spontaneous.
- At T > 476 K: ΔG remains negative, so the process remains spontaneous at higher temperatures.
- At T = 476 K: ΔG = 0, the process is at equilibrium.

Since ΔH is negative and ΔS is positive, the process is exothermic with increasing disorder, which generally favors spontaneous behavior over a wide temperature range.

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## Classification of the Process: Endothermic, Exothermic, Spontaneous, Non-Spontaneous

Based on the thermodynamic parameters, the process can be classified as follows:

### 1. Is the process exothermic or endothermic?

- H = -214 KJ/mol indicates an exothermic process (it releases heat).

### 2. Is the process increasing or decreasing entropy?

- S = 450 J/mol·K (or 0.45 KJ/mol·K) indicates an increase in entropy.

### 3. Is the process spontaneous?

- Since both H is negative and S is positive, the process is spontaneous at all temperatures (except possibly right at the critical temperature where ΔG = 0).

### 4. Effect of temperature:

- Because ΔH is negative and ΔS positive, the process is spontaneous at all T. The critical temperature (~476

K) indicates a point where the process shifts from spontaneous to at equilibrium, but in this case, as ΔG remains negative beyond that point, the process is spontaneous across a broad temperature range.

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## Features, Pros, and Cons of Such Processes

Understanding the thermodynamic nature of this process helps in practical applications, design, and control of chemical reactions or physical processes.

Features:
- Exothermic with increased entropy.
- Spontaneous at a wide temperature range.
- Favorable thermodynamics for energy release and disorder.

Pros:
- Energy-efficient, releasing heat and increasing disorder naturally.
- Suitable for processes requiring heat output, such as combustion or certain manufacturing steps.
- No need for external energy input at most temperatures.

Cons:
- Heat release might require safety measures to prevent hazards.
- Increased disorder could lead to undesirable side reactions or degradation.
- Limited control over spontaneity at specific conditions if parameters change.

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## Real-World Applications and Implications

Processes with these thermodynamic characteristics are common in industries such as:

- Combustion reactions: Highly exothermic and entropy-increasing, spontaneous in nature.
- Metabolic pathways: Many biological reactions are exothermic and increase entropy, ensuring spontaneity.
- Material synthesis: Certain exothermic, entropy-driven processes facilitate efficient manufacturing.

Implications:
- Such processes are thermodynamically favorable without external energy input.
- Design considerations include managing heat release and entropy changes for safety and efficiency.

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## Conclusion: What Is the Correct Classification?

Based on the provided thermodynamic data:

- H = -214 KJ/mol (exothermic)
- S = 450 J/mol·K (positive, increasing entropy)

The process is exothermic with increasing entropy, leading to a spontaneous process at all temperatures above the critical point (~476 K). Since the process is spontaneous at typical conditions, the correct classification would be:

"Spontaneous, Exothermic, Entropy-Increasing Process."

This comprehensive analysis illustrates how thermodynamic parameters guide the understanding and prediction of reaction behavior, enabling informed decisions in scientific and industrial contexts.

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