

Spontaneity and Energy

Read from **Lesson 1: Spontaneity and Energy** in the **Chemistry Tutorial** Section, **Chapter 17** of **The Physics Classroom**:

Part a: [What is Thermodynamics?](#)

Part c: [The First Law of Thermodynamics](#)

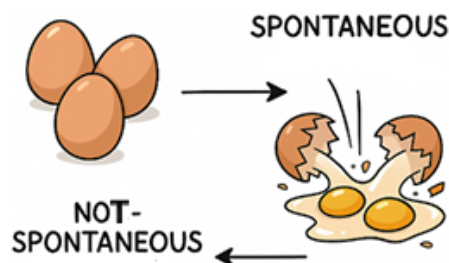
Part b: [Spontaneous Processes](#)

Part 1: What Is Thermodynamics?

- **Definition:** Thermodynamics is the study of energy transformations and the direction and extent of chemical and physical changes.
- **Focus Areas:**
 - Energy transfer between systems and surroundings
 - Predicting spontaneity and extent of reactions
- **System vs. Surroundings:**
 - *System:* Reactants and products under study
 - *Surroundings:* Everything else in the universe
- **State Functions:**
 - Properties dependent only on the current state, not the path taken
 - Examples: *Enthalpy (H)*, *Entropy (S)*, *Free Energy (G)*

Part 2: Spontaneous Processes

- **Spontaneous Process:** Occurs naturally without sustained external intervention
 - Example: Ice melting at room temperature
- **Non-Spontaneous Process:** Requires continuous energy input
 - Example: Photosynthesis (needs sunlight)
- **Directionality:**
 - A process spontaneous in one direction is not spontaneous in reverse under the same conditions
- **Common Examples:**
 - Spontaneous: Rusting, diffusion, combustion, eggs breaking
 - Non-Spontaneous: Battery charging, uphill motion



Part 3: First Law of Thermodynamics

- **Law of Energy Conservation:**
 - Energy cannot be created or destroyed—only transferred or transformed
 - Total energy of the universe remains constant
- **Energy Transfer Mechanisms:**
 - *Heat (Q):* Driven by temperature differences
 - *Work (W):* Mechanical energy transfer (e.g., compression or expansion)
- **Mathematical Form: $\Delta E = Q + W$**
 - Positive Q or W: Energy enters system
 - Negative Q or W: Energy leaves system
- **Exothermic vs. Endothermic:**
 - *Exothermic:* Heat flows out, surroundings warm up
 - *Endothermic:* Heat flows in, surroundings cool down

Questions

1. Does a spontaneous process always happen quickly? Explain your reasoning.

Chemical Thermodynamics

2. River Sibley and Aaron Agin are discussing spontaneous processes. Aaron says, "All exothermic reactions are spontaneous." Is this accurate? If not, how could River explain why this isn't always true using thermodynamic principles?

3. Why is it important to clearly define the boundaries of a system when analyzing energy changes?

4. A beaker of water is boiling on a hot plate in a chemistry lab at a pressure of 1 atm.
a. Is vaporization (boiling) classified as an endothermic or exothermic process? Explain your reasoning.



- b. At 1 atm of pressure, what temperature makes this process spontaneous?

- c. Which two phases of matter are in equilibrium at this temperature and pressure?

- d. What two phase changes occur spontaneously under these conditions?

5. A firework's explosion is a rapid, exothermic chemical reaction in which a fuel and an oxidizer burn quickly to release heat, light, and gas.



- a. Would this be considered a spontaneous process? Explain your reasoning.

- b. If we were analyzing the energy changes involved, what would we define as the system?

- c. What sign would Q (heat) have for this process? Justify your answer.

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6. Use the clues below to solve this word search puzzle based on this Chemistry Tutorial chapter. Each word is spelled using letters that appear only once and can zigzag through the puzzle. All letters will be used.

- A broad field of science focused on the relationships and transformations among different forms of energy is _____.
- A type of function whose value depends only on the current state of the system, not the path taken to reach is _____.
- The transfer of mechanical energy through force and motion is _____.
- The portion of the universe selected for study in a thermodynamic analysis is _____.
- The movement of energy from a region of higher temperature to one of lower temperature is _____.
- To spread out or scatter widely is _____.
- A system in which energy can cross the boundary, but matter remains contained within is _____.

E D S T E S

S C P A S Y

O I I S T E

L M A Y S M

C K N D I S

A R O O D T

E T W M R A

H T H E E T