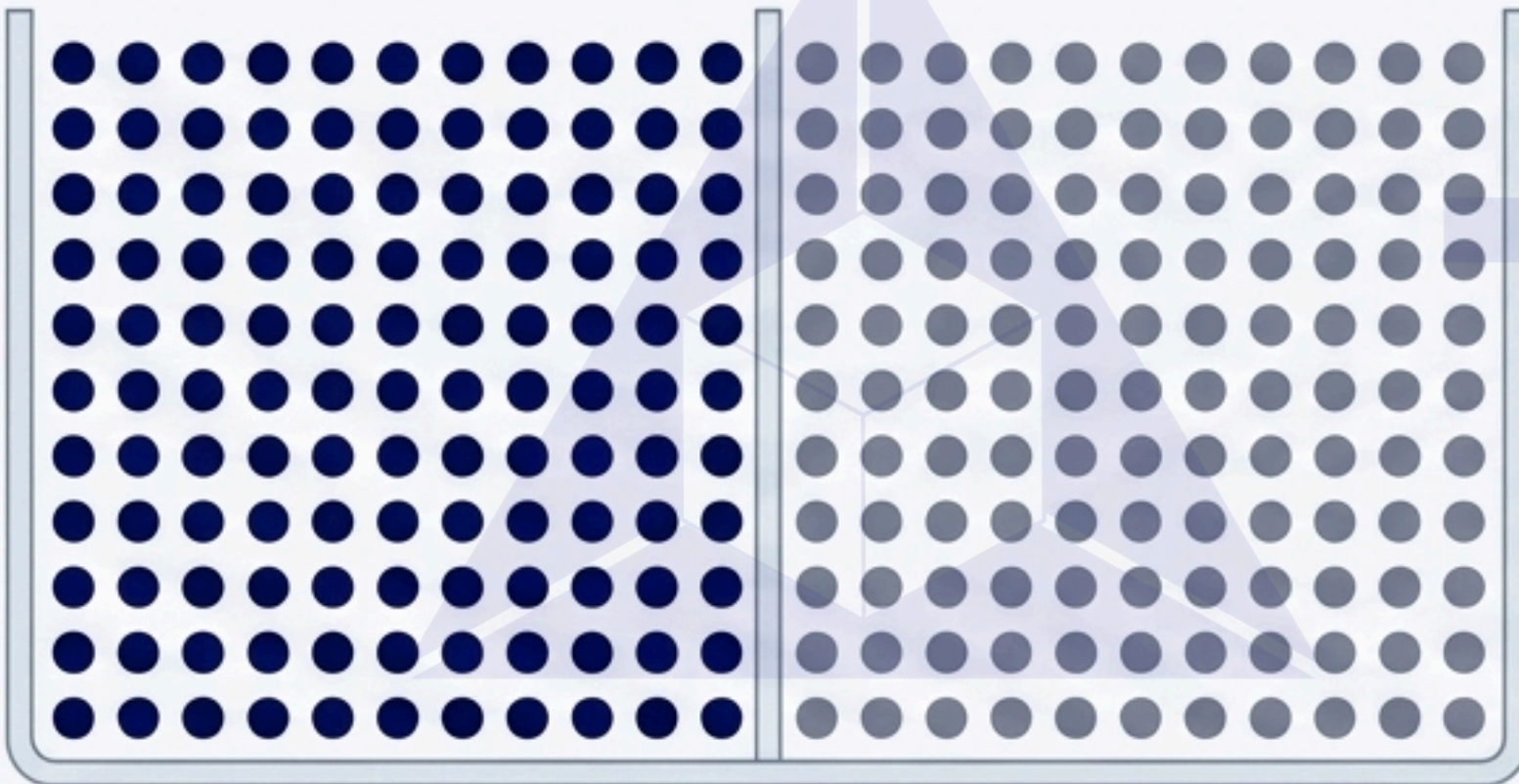


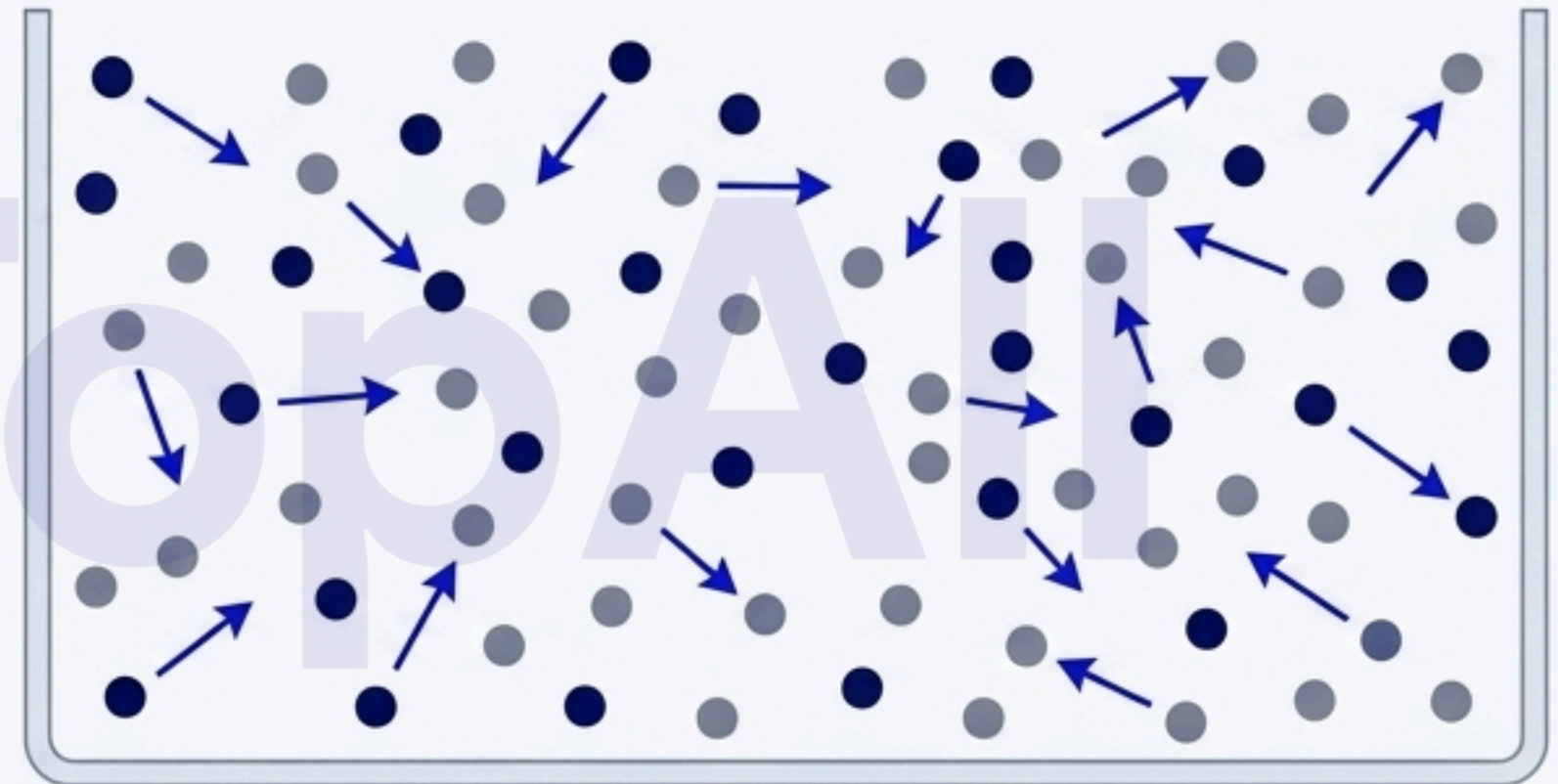
# Entropy & Spontaneity | $\Delta S$

## WHY DOES MIXING HAPPEN NATURALLY?

BEFORE MIXING (Ordered State)



AFTER MIXING (Disordered State)



### Observation:

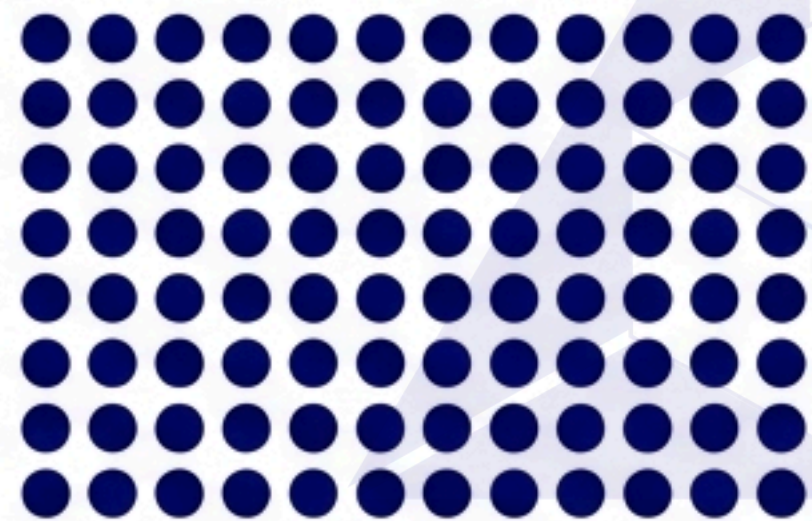
The gases mix spontaneously.

### The Problem:

There is **no heat exchange** ( $\Delta H = 0$ ). If chemical processes only happen to lower their internal energy, what is driving this change?

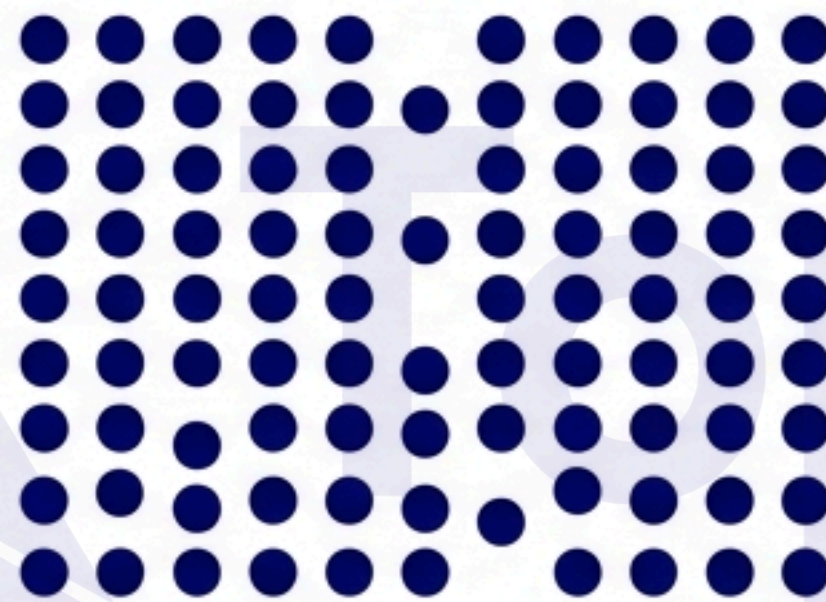
# ENTROPY ( $S$ ): THE MEASURE OF DISORDER

Entropy ( $S$ ) is a thermodynamic state function that measures the degree of randomness or chaotic distribution of energy in a system.



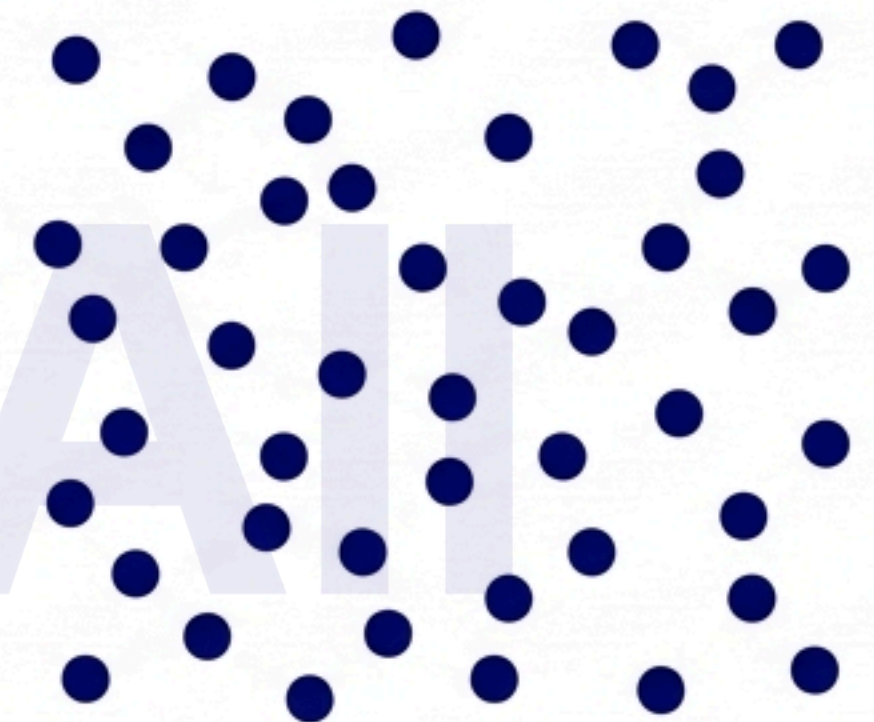
**Solid (Highly  
Ordered)**

Lowest  $S$



**Liquid  
(Moderate Disorder)**

Intermediate  $S$



**Gas (Highly  
Dispersed / Chaotic)**

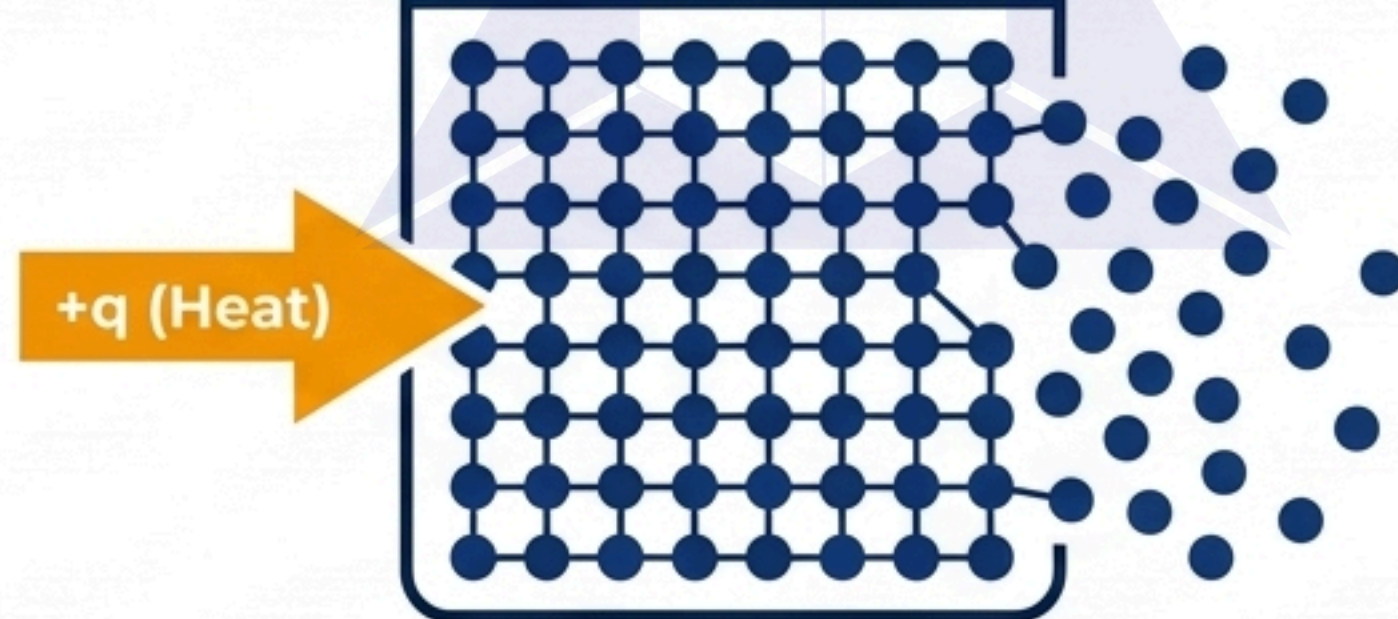
Highest  $S$

# QUANTIFYING RANDOMNESS

$$\Delta S = \frac{q_{rev}}{T}$$

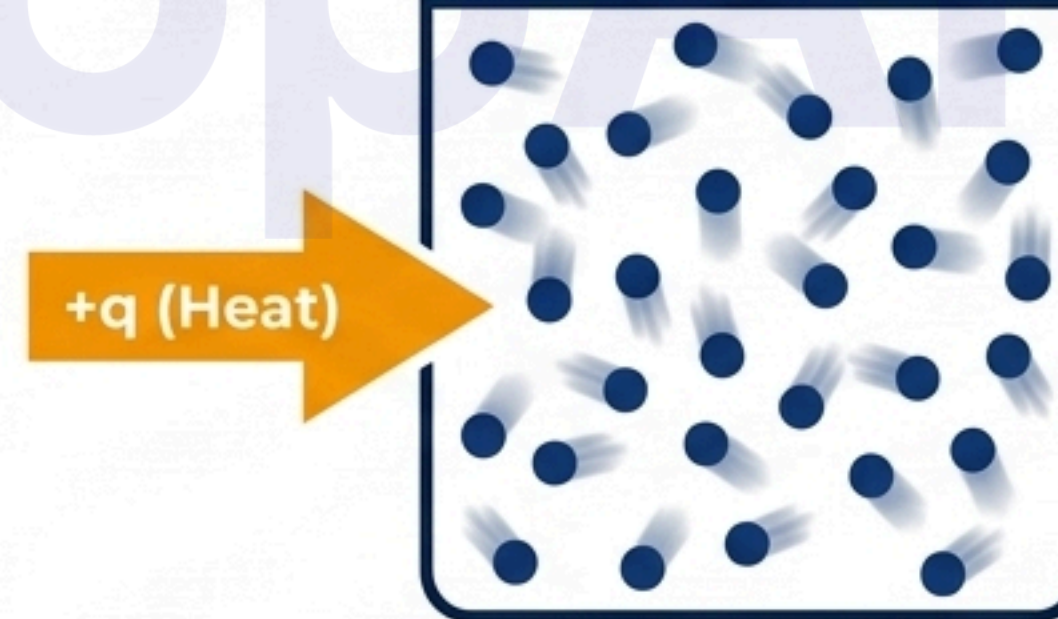
## The Temperature Effect Matrix

Low T



Heat added to a highly ordered state causes major randomness.

High T



Heat added to an already chaotic state causes minor randomness.



# You've Learned the Theory. Let's Test Them Now.

$$E=mc^2$$



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## Key Highlights

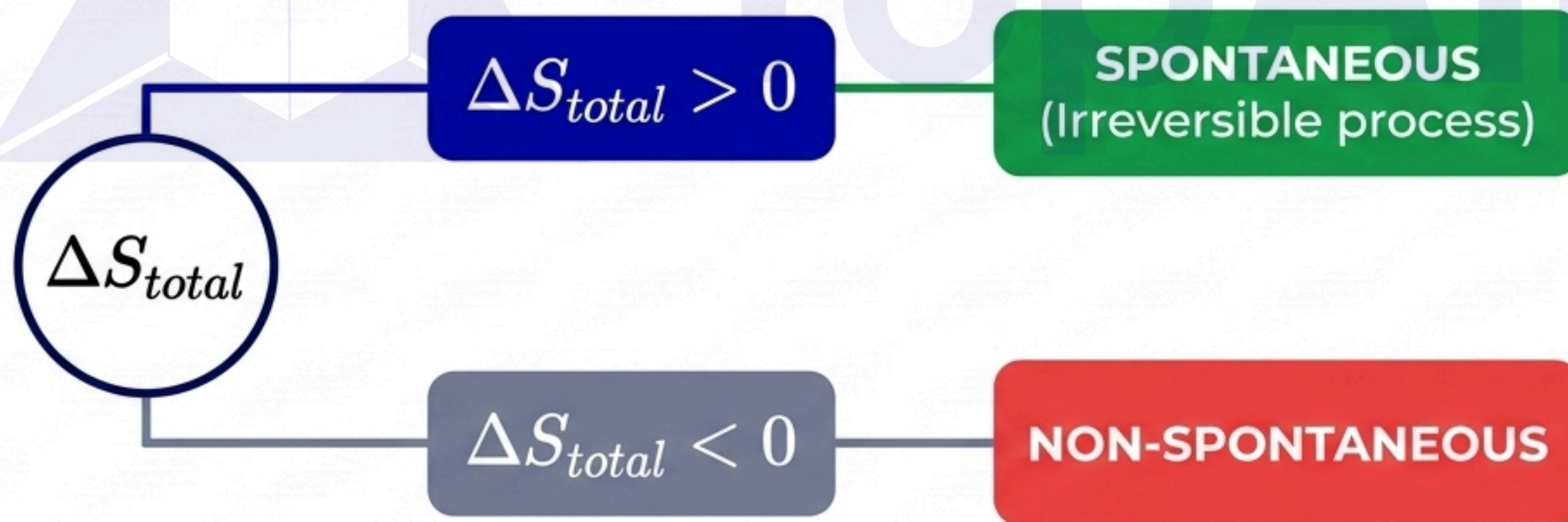
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# THE UNIVERSE DECIDES SPONTANEITY

The Second Law states that the entropy of an isolated system (the universe) always increases for a spontaneous change.

$$\Delta S_{\text{total}} = \Delta S_{\text{system}} + \Delta S_{\text{surroundings}}$$



# THE $\Delta S_{\text{sgm}}$ ILLUSION



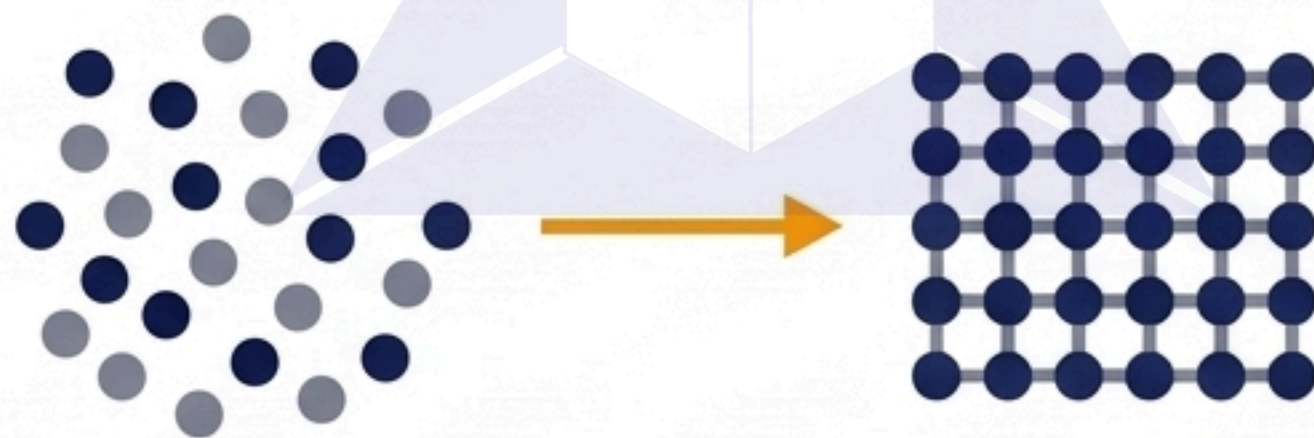
**NEVER judge spontaneity from  $\Delta S_{\text{sgnm}}$  alone!**

A system's entropy can decrease during a spontaneous process, as long as the surroundings overcompensate.

## Diagnostic Proof

Example: Water freezing at  $-10^\circ\text{C}$  (A spontaneous process).

System



$\Delta S_{\text{sm}} < 0$  (Entropy decreases)

Surroundings



Heat is released ( $\Delta H < 0$ ),  
causing massive chaos  
in the surroundings.

$\Delta S_{\text{ssh}} \geq 0$  (Entropy spikes)

## Total Verdict

The massive gain in the surroundings outweighs the loss in the system  $\rightarrow \Delta S_{\text{sp1}} > 0$

# THERMODYNAMIC VERDICT

|   | State                      | Condition              | Meaning                                             |
|---|----------------------------|------------------------|-----------------------------------------------------|
| 1 | Spontaneous (Irreversible) | $\Delta S_{total} > 0$ | The universe moves toward higher disorder.          |
| 2 | Equilibrium                | $\Delta S_{total} = 0$ | Entropy is maximized; system is in dynamic balance. |

## ✓ Key Takeaways

1. **S is a State Function:** Depends only on initial and final states, not the path taken.
2. **Temperature Scales Chaos:** T is the denominator because existing thermal chaos dampens the effect of added heat.
3. **The Universe Rules:** A reaction's spontaneity is dictated by  $\Delta S_{total}$ , never by  $\Delta S_{sys}$  alone.



# You've Learned the Theory.

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