

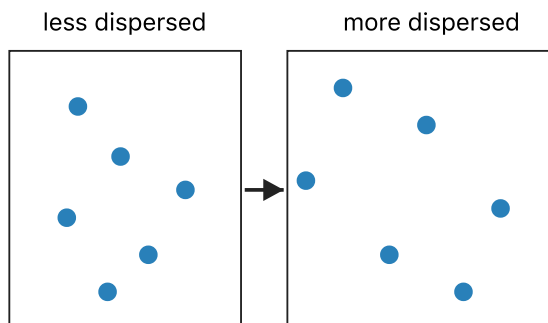
THERMO DAY 14: ENTROPY & THE SECOND LAW

CED 9.6 · Skill 3.C · FRQ: QQT · target: treating entropy as disorder without a system statement

SPONTANEOUS DIRECTION

WARMUP Remove the partition

A rigid insulated box has gas confined to its left half and vacuum on the right. Predict what happens when the partition is removed—and whether the gas later gathers back into the left half.



The accessible volume and number of possible particle arrangements increase. The reverse is not forbidden by energy conservation, but it is overwhelmingly improbable.

$$\text{Isolated system: } \Delta S \geq 0$$

QUICK For free expansion of an ideal gas into vacuum, find Q , W , and ΔU . Which quantity identifies the spontaneous direction?

ENTROPY TRANSFER AND GENERATION

For reversible heat transfer at absolute temperature T , $\Delta S = Q_{rev}/T$. For real irreversible processes, total entropy of system plus surroundings increases.

$$\Delta S_{universe} = \Delta S_{system} + \Delta S_{surroundings} > 0$$

WE DO 600 J enters a system reversibly at 300 K. Find its entropy change.

YOU DO 900 J leaves a hot reservoir at 450 K and enters a cold reservoir at 300 K. Find each entropy change and the total.

Use kelvin in Q/T . Entropy has units J/K; it is not an energy.

SECOND-LAW CONSEQUENCES

- Heat flows spontaneously from hot to cold.
- Free expansion is spontaneous.
- Friction converts organized mechanical energy into widely distributed internal energy.
- No cyclic heat engine can convert all absorbed heat into work.

EXPLAIN A 500 J quantity of energy moves from a 400 K object to a 300 K object. Calculate ΔS_{hot} , ΔS_{cold} , and ΔS_{total} . Why is the reverse transfer nonspontaneous?

System statement matters: one subsystem's entropy may decrease. The Second Law constrains the total entropy of an isolated system.

PRACTICE

1. Find ΔS when 750 J enters reversibly at 250 K.

2. Find ΔS when 1.20 kJ leaves a reservoir at 600 K.

3. 800 J transfers from 500 K to 320 K. Find total entropy change.

4. Explain why an engine that absorbs 1000 J and converts all 1000 J to work cannot operate cyclically.

5. A refrigerator moves heat from cold to hot. What compensating energy transfer is required?