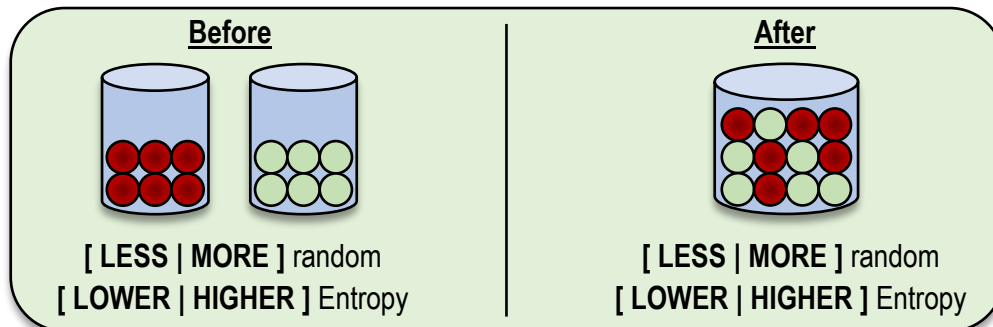
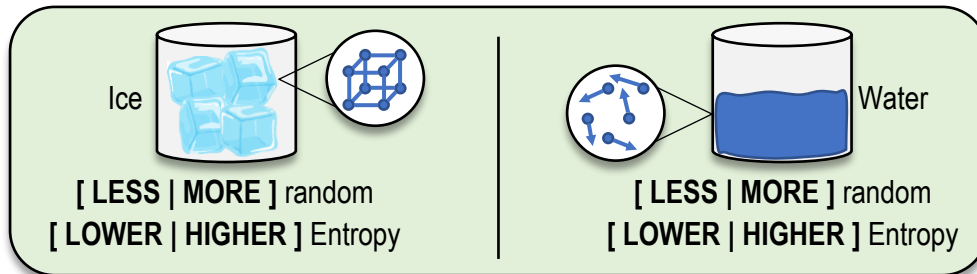


CONCEPT: INTRO TO ENTROPY

- **Entropy** is often called a measure of “disorder”, but a better definition is it’s a measure of a system’s _____.



- In thermodynamics, entropy measures how randomly a system’s _____ is spread out.
 - Because things with higher temperatures have more energy, they have _____ “randomness”/entropy.



- You’ll need to calculate the CHANGE in entropy in most problems, not the entropy itself.

$$\Delta S = \frac{Q}{T} \quad (\text{ONLY for isothermal processes, i.e. } \Delta T = 0)$$

- T must be in K

- Units: $\frac{J}{K}$

- The sign of ΔS is the same as Q .
 - If heat is added ($Q > 0$), entropy [INCREASES | DECREASES]
 - If heat is removed ($Q < 0$), entropy [INCREASES | DECREASES]

EXAMPLE: You add 2400 J to a body of water so large that its temperature remains constant at 27°C. Calculate the change in entropy of the water.

EXAMPLE: Calculate the change in entropy of 2 kg of water freezing completely to ice.

PHASE CHANGE

$$Q = mL$$

$$L_{f, \text{water}} = 3.34 \times 10^5 \text{ J/kg} \cdot \text{K}$$

$$L_{v, \text{water}} = 2.26 \times 10^6 \text{ J/kg} \cdot \text{K}$$

PROBLEM: 3 moles of an ideal gas are compressed isothermally at 20°C. During this compression, 1850 J of work is done on the gas. What is the change of entropy of the gas?

- A) -24.9 J/K
- B) 6.31 J/K
- C) -6.31 J/K
- D) -9158 J/K

ENTROPY

$\Delta S = \frac{Q}{T}$

PROBLEM: You have a block of ice at 0°C. Heat is added to the ice, causing an increase in entropy of 120J/K. How much ice melts into water in this process?

- A) 0.098 kg
- B) 0 kg
- C) 1.32×10^{-6} kg
- D) 1.47×10^5 kg

ENTROPY

$\Delta S = \frac{Q}{T}$

$L_f(\text{water}) = 3.34 \times 10^5 \text{ J/kg}$

PROBLEM: You're driving a 1,500 kg car at 20m/s when you slam on the brakes and come to a stop. The brakes cool off to the surrounding air, which remains at a constant temperature of 20°C. What is the entropy change in the air?

ENTROPY
$\Delta S = \frac{q}{T}$

CONCEPT: CALCULATING ENTROPY CHANGES FOR SYSTEMS OF OBJECTS

- In many problems, you'll have to calculate the entropy changes for a system of multiple objects, or the universe.

$$\Delta S_{tot} \text{ OR } \Delta S_{universe} = \text{_____} \dots \text{_____}$$

Second Law of Thermodynamics – “Entropy” Statement

- It is impossible for any process to cause an overall _____ in the entropy of a system (or the UNIVERSE).
 - If any part of a system **decreases** in entropy, another part must **increase** in entropy at least the same amount.
- Entropy is sometimes called “Time’s Arrow”, explains why processes happen irreversibly (Heat transfer, friction, etc..)
 - Time “flows” or “moves” in the direction of increasing entropy.

EXAMPLE: 400 J of heat is transferred from a hot reservoir at 200°C to a cold reservoir at 100°C. The reservoirs are so big that this heat exchange has no effect on their temperatures. What is the net change in entropy of the system?

ENTROPY PROBLEMS WITH MULTIPLE OBJECTS

- 1) Draw diagram
- 2) Write ΔS_{tot} EQ
- 3) Solve for Target

ENTROPY

$$\Delta S = \frac{q}{T} \quad (\text{isothermal only})$$

PROBLEM: A non-Carnot heat engine operates between a hot reservoir at 610K and a cold reservoir at 320K. In a cycle, it takes in 6400 J of heat and does 2200 J of work. What is the total change in entropy of the universe over the cycle?

- A) 2.6 J/K
- B) 9.5 J/K
- C) 16.3 J/K
- D) -2.6 J/K

ENTROPY PROBLEMS WITH MULTIPLE OBJECTS

- 1) Draw diagram
- 2) Identify objects changing entropy
(e.g. *objects, air, environment*)
- 3) Write ΔS_{tot} EQ
- 4) Plug in values & solve

HEAT ENGINES & ENTROPY

$$\Delta E_{int} = 0$$

$$|W| = |Q_H| - |Q_C|$$

$$e = \frac{W}{Q_H} = 1 - \frac{Q_C}{Q_H}$$

$$\Delta S = \frac{Q}{T}$$

$$\Delta S_{tot} = \Delta S_1 + \Delta S_2 + \dots$$

PROBLEM: A Carnot engine takes in 2000 J from a hot reservoir at 500K, then expels heat to a cold reservoir at 350K. What is the total change in entropy of the universe over the cycle?

ENTROPY PROBLEMS WITH MULTIPLE OBJECTS

- 1) Draw diagram
- 2) Identify objects changing entropy
(e.g. *objects, air, environment*)
- 3) Write ΔS_{tot} EQ
- 4) Plug in values & solve

HEAT ENGINES & ENTROPY

$$\Delta E_{int} = 0$$

$$|W| = |Q_H| - |Q_C|$$

$$e = \frac{W}{Q_H} = 1 - \frac{Q_C}{Q_H}$$

$$\left| \frac{Q_C}{Q_H} \right| = \left| \frac{T_C}{T_H} \right| \text{ (Carnot only)}$$

$$\Delta S = \frac{Q}{T}$$

$$\Delta S_{tot} = \Delta S_1 + \Delta S_2 + \dots$$

- Because Carnot engines are ideal and perfectly reversible, $\Delta S_{tot, Carnot} = \underline{\hspace{1cm}}$