

# What are the Laws of Thermodynamics?

## Worksheet

Law 0: systems in thermal contact reach equilibrium. Law 1: energy is conserved ( $U = q + w$ ). Law 2: entropy of isolated systems increases ( $S_{\text{univ}} > 0$ ). Law 3: absolute zero (0 K) is unattainable. Together, they govern all transformations.

## Questions

1. In a calorimeter, a reaction releases 50 J of heat. The surroundings absorb this heat. What is  $U$ ?

- A) +50 J
- B) 50 J
- C) 0 J
- D) Cannot determine

2. A spontaneous process has  $S_{\text{univ}}$  equal to

- A) Always negative
- B) Always zero
- C) Positive
- D) Depends on temperature

3. Why does ice melt at room temperature?

- A)  $H < 0$
- B)  $S_{\text{univ}} > 0$  (entropy of universe increases)
- C) Melting requires no energy
- D) Ice is colder than nothing

4. Which law explains why energy cannot be destroyed in a reaction?

- A) Zeroth Law
- B) First Law
- C) Second Law
- D) Third Law

5. A hot cup of tea cools down on a table. Which law does this obey?

6. Why is it impossible to cool a room by leaving a refrigerator door open?

7. Can we reach absolute zero (0 K)?

8. Define: What is the First Law of Thermodynamics?

9. Define: What is the Second Law of Thermodynamics?

10. Define: What is the Zeroth Law of Thermodynamics?

## Answer Key

1. B) 50 J - If the reaction releases heat,  $q = 50$  J (negative). With no work,  $U = q + w = 50 + 0 = 50$  J.
2. C) Positive - The Second Law: spontaneous processes have  $S_{\text{univ}} > 0$  (positive).  $S_{\text{sys}} + S_{\text{surr}} > 0$ .
3. B)  $S_{\text{univ}} > 0$  (entropy of universe increases) - Melting is endothermic ( $H > 0$ ), but entropy gain of liquid + surroundings ( $S_{\text{univ}} > 0$ ) makes it spontaneous.
4. B) First Law - The First Law of Thermodynamics: energy is conserved. It cannot be created or destroyed, only transformed.
5. Tea starts hot (high energy), table is cool (low energy). Heat flows from tea surroundings (Law 1:  $U_{\text{tea}} < 0$ ). The system + surroundings reaches thermal equilibrium (Law 0). Entropy increases: disorder of energy spreads (Law 2:  $S_{\text{univ}} > 0$ ). Spontaneous at room temperature ( $G < 0$ ).
6. A refrigerator takes heat from inside, uses energy (work), and releases heat outside. If the door is open, heat escapes the system. The work input exceeds the cooling (Law 1: work > heat removed from room). The room warms because: heat from outside + heat from fridge motor > cooling effect. This violates the desired outcome but not the laws.
7. Law 3 (Third Law) states that absolute zero is unattainable. Reason: at 0 K, all motion stops; entropy = 0 (perfect order). To reach 0 K requires infinite energy removal (impossible). Closest labs have reached ~10 K using laser cooling. But 0 K itself remains theoretically unreachable.
8. Energy is conserved:  $U = q + w$ . Change in internal energy = heat absorbed + work done on the system.
9. Entropy of an isolated system always increases:  $S_{\text{univ}} > 0$ . Spontaneous processes have  $S_{\text{univ}} > 0$ .
10. If A and B are in thermal equilibrium, and B and C are in equilibrium, then A and C are in equilibrium. It defines temperature.

### **Bounlu**

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