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Answer Key: Feeling the Heat: Tiny Particles and Towering Laws for 8th Grade

Entropy calculation, thermal equilibrium analysis, and enthalpy synthesis. Students perform high-level evaluation of energy transformations in complex closed systems.

1. An engineer designs a prototype cooling system where 450 J of work is performed on a gas while it simultaneously releases 150 J of thermal energy to its surroundings. Based on the First Law of Thermodynamics, what is the change in the internal energy (ΔU) of the system?

Answer: A) +300 J

According to $\Delta U = Q - W$, since work is done *on* the system, W is negative (-450). Since heat is *released*, Q is negative (-150). Thus, $-150 - (-450) = +300$ J.

2. In a closed system undergoing a spontaneous process, it is possible for the total entropy of the system and its surroundings to decrease if the temperature remains constant.

Answer: B) False

The Second Law dictates that the total entropy of an isolated system/universe must always increase or remain constant during a spontaneous process; it cannot decrease.

3. A scientist is testing a substance that exhibits 'superfluidity' near 0 Kelvin. This state of near-zero disorder is primarily governed by the _____ Law of Thermodynamics.

Answer: C) Third

The Third Law states that as a system approaches absolute zero, its entropy approaches a constant minimum, explaining why molecular motion and disorder nearly vanish.

4. Which scenario best synthesizes the concept of thermal equilibrium across three different objects (A, B, and C)?

Answer: B) If A is in thermal equilibrium with B, and B is in equilibrium with C, then A and C are in equilibrium.

This describes the Zeroth Law of Thermodynamics, which defines temperature and the transitive property of thermal equilibrium.

5. When designing a heat shield for a spacecraft, an engineer must account for _____, which is the only method of heat transfer that does not require a physical medium like air or metal.

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Answer: C) Radiation

Radiation transfers energy via electromagnetic waves, allowing heat to travel through the vacuum of space, unlike conduction or convection.

6. A 'Heat Death' scenario of the universe suggests that eventually, all energy will be distributed uniformly, resulting in maximum entropy and no more work being possible.

Answer: A) True

Heat death is a consequence of the Second Law; as entropy reaches a maximum, the energy gradient required to perform work disappears.

7. Analyze a Stirling engine: it converts thermal energy into mechanical work. Why can such an engine never be 100% efficient, even if friction were completely eliminated?

Answer: C) Some energy is always exhausted as waste heat to satisfy the Second Law.

The Second Law dictates that no heat engine can convert all input heat into work; some energy must always be lost to the environment to increase total entropy.

8. In a weather system, the movement of large air masses due to density differences caused by temperature variations is a primary example of _____.

Answer: C) Convection

Convection is the transfer of heat through the bulk movement of fluids (liquids or gases) driven by buoyancy and density changes.

9. A perfectly insulated thermos is an example of an open system because it allows for the exchange of matter but not energy.

Answer: B) False

A thermos is a localized attempt at an isolated system, which ideally prevents the exchange of both matter and energy.

10. You place a 50g block of copper at 80°C into a container of 50g of water at 20°C. Which statement accurately predicts the outcome based on thermodynamics?

Answer: C) The final temperature will be closer to 20°C because water has a higher specific heat capacity.

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Specific heat determines how much energy is needed to change temperature. Water's high specific heat means it resists temperature changes more than copper, pulling the equilibrium temperature closer to its original state.