

Name: _____ Date: _____

Answer Key: Why Does Hot Air Rise? 8th Grade Thermodynamics Challenge

Calculate thermal equilibrium and analyze entropy increases across 10 rigorous scenarios involving specific heat and the laws of energy conservation.

1. A 50g block of copper at 90°C is dropped into 50g of water at 20°C. Given that water has a much higher specific heat capacity than copper, which is the most likely equilibrium temperature?

Answer: A) 25°C

Because water's specific heat is nearly 10 times higher than copper's, a small temperature change in water absorbs a large amount of energy from the copper, pulling the equilibrium temperature closer to the water's initial state.

2. According to the Second Law of Thermodynamics, it is possible to build a machine that converts 100% of input heat directly into useful mechanical work.

Answer: B) False

The Second Law dictates that some energy is always dissipated as waste heat (increasing entropy), meaning no heat engine can ever be 100% efficient.

3. In a closed system, if 400 J of work is done ON a gas while it is simultaneously cooled, losing 150 J of heat, the change in internal energy (ΔU) is _____.

Answer: B) +250 J

Using $\Delta U = Q - W$, where work done ON the system is negative W (-400) and heat lost is negative Q (-150), we get $-150 + 400 = 250$ J.

4. Why does a pressurized aerosol can feel cold to the touch after the gas is released rapidly?

Answer: B) The gas undergoes adiabatic expansion, using its own internal energy to do work

As gas expands rapidly, it does work against the atmospheric pressure. Since this happens too fast for heat to enter from the surroundings, it uses its own internal energy, causing the temperature to drop.

5. Thermal equilibrium is reached when two objects in contact have the same amount of total internal energy, regardless of their mass.

Answer: B) False

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Thermal equilibrium is defined by the objects having the same temperature (average kinetic energy), not the same total internal energy.

6. When water transitions from a liquid at 100°C to steam at 100°C, the added energy is known as _____.

Answer: B) Latent Heat of Vaporization

Latent heat is the energy required to change the phase of a substance without changing its temperature.

7. In the vacuum of deep space, how does a satellite primarily dissipate the heat generated by its internal electronics?

Answer: C) Thermal radiation via infrared light

Since there is no medium (air or water) in a vacuum for conduction or convection, radiation is the only method for heat transfer in space.

8. Entropy can decrease locally within a system, such as when water freezes into highly ordered ice crystals, as long as the entropy of the surroundings increases even more.

Answer: A) True

The Second Law applies to the universe as a whole; local decreases in entropy are possible if energy is used to create order, resulting in a net increase in total disorder elsewhere.

9. An ideal gas is kept in a rigid, fixed-volume container. If heat is added to the system, the work (W) done by the gas is _____.

Answer: C) Zero

Work in thermodynamics is defined as pressure times the change in volume ($P\Delta V$). If the volume is fixed (rigid container), ΔV is zero, so no work is performed.

10. Two blocks (Lead and Aluminum) of equal mass are heated to 100°C and placed on a large block of ice. If Aluminum has a higher specific heat than Lead, what happens?

Answer: C) The Aluminum block melts more ice because it stored more thermal energy

Higher specific heat means a substance requires more energy to change temperature, and thus stores more energy at a given temperature compared to a substance with lower specific heat.