Physics I

Laws of Thermodynamics

Problem 1.- The first law of thermodynamics is sometimes whimsically stated as, "You cannot win" and the second law as, "You can't even break even". Explain how these statements could be equivalent to the formal statements.

Solution: The first law of thermodynamics says that the heat that you give to a system is transformed into work and change in internal energy. So, you don't win anything, you just get at best the same energy that you put in. The second law of thermodynamics tells you that there is no possibility of transforming heat into work with 100% efficiency, so there are always losses.

Problem 2.- State the zeroth law of thermodynamics.

Solution: According to the zeroth law of thermodynamics if object A is in thermal equilibrium with object B and object B is in thermal equilibrium with object C then object A will be in thermal equilibrium with object C. Basically this law allows us to assign temperature to an object.

Or: At equal temperatures you reach equilibrium, and the average heat exchange is zero.

Problem 3.- State the third law of thermodynamics.

Solution: The third law of thermodynamics tells us that the entropy of a system will tend to a constant as the temperature approaches zero.

Problem 4.- One mole of a monoatomic ideal gas expands adiabatically (Q=0) doing 5,000 J of work in the process. Calculate the change in temperature. *Suggestion*: Use the first law of thermodynamics to find ΔU and then use the heat capacity to find the change in temperature.

Solution:
First Law of thermodynamics: $Q = W + \Delta U$, so: $\Delta U = -W = -5{,}000J$

Heat capacity: $\Delta U = C_v \Delta T \rightarrow \Delta T = \dfrac{\Delta U}{C_v} = \dfrac{\Delta U}{\frac{3}{2}R} = \dfrac{-5{,}000J}{\frac{3}{2}(8.314)} =$ **-401 K**

Problem 5.- Regarding the "zeroth law of thermodynamics", why is a good emitter of radiation called a black body?

Solution: According to the zeroth law, a body at equal temperature as its surroundings reaches equilibrium and the average heat exchange is zero. So, good emitters are also good absorbers. At room temperature they emit infrared radiation but absorb visible light.