Temperature and Heat

In thermodynamics the two quantities, temperature and heat are very important and we need to understand these two quantities very clearly. Most of us already have a good understanding of what temperature is based on our interaction with cold or hot objects. As the object gets hotter we know the temperature increases and as the object gets colder we know the temperature decreases. And quantitatively we can measure these changes in temperature using any of the temperature scales we've discussed.

But what about heat? What is heat and how is it related to temperature?

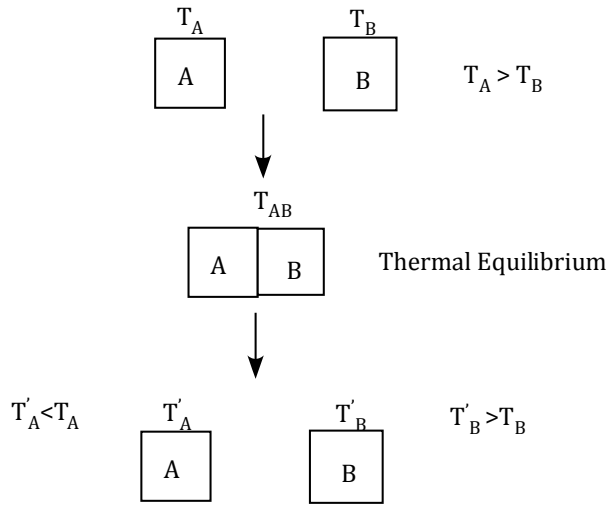
Here's how we define heat in thermodynamics:

Heat is the transfer of energy from one object to another due to the difference in temperature between the objects.

1. We use the symbol Q to denote the transfer of energy due to heat.
2. Q >0 when energy is transferred out of the system.
3. Q <0 when energy is transferred into the system.
4. Heat is a method of transferring energy into or out of a system due to temperature changes. It is analogous to work, which is a method of transferring energy into/out of a system by a force doing work on the system.
5. The transfer of energy shows up as a change in the internal energy of the system.

Internal Energy – The potential energy and kinetics energy of all the microscopic particles, atoms and molecules, making up the system.

Ex. Consider two different systems: system A and system B. The temperature of each system is as shown below.



1. Let's assume the systems are brought into contact until they reach thermal equilibrium at which point they have the same temperature $\mathbf{T_{AB}}$.
2. The systems are then separated once again and their new temperature are measured and given as shown above.
3. Experimentally we find that the temperature of system A has decreased and the temperature of system B has increased.
4. The decrease in temperature of system A is due to the transfer of energy (-Q) from system A to system B (+ Q).
5. Thus, system A loses energy (-Q) and system B gains an equal amount of energy (+Q).
6. This energy exchange shows up as change in the internal energy of the systems.
7. The internal energy of B increased and that of A decreased!
8. Internal energy is the sum of the KE and PE of ALL the particles making up the system.
9. Heat ALWAYS refers to energy in transit from one system to another. Never the amount contained in a system!
10. Thus, we can say that 15 J of heat was transferred (flowed) from system A to system B due the temperature difference. BUT YOU CANNOT SAY that system B has 15 J of heat!
11. The Si unit of heat is the same as energy – Joules (J)

$$1 \text{ cal} = 4.1868 \text{ J} = 3.968 \times 10^{-3} \text{ BTU}$$