Section Summary

12.1 Zeroth Law of Thermodynamics: Thermal Equilibrium

- Systems are in thermal equilibrium when they have the same temperature.
- Thermal equilibrium occurs when two bodies are in contact with each other and can freely exchange energy.
- The zeroth law of thermodynamics states that when two systems, A and B, are in thermal equilibrium with each other, and B is in thermal equilibrium with a third system, C, then A is also in thermal equilibrium with C.

12.2 First law of Thermodynamics: Thermal Energy and Work

- Pressure is the force per unit area over which the force is applied perpendicular to the area.
- Thermal expansion is the increase, or decrease, of the size (length, area, or volume) of a body due to a change in temperature.
- The ideal gas law relates the pressure and volume of a gas to the number of gas particles (atoms or molecules) and the absolute temperature of the gas.
- Heat and work are the two distinct methods of energy transfer.
- Heat is energy transferred solely due to a temperature difference.
- The first law of thermodynamics is given as $\Delta U = Q - W$, where ΔU is the change in internal energy of a system, Q is the net energy transfer into the system by heat (the sum of all transfers by heat into and out of the system), and W is the net work done by the system (the sum of all energy transfers by work out of or into the system).
- Both Q and W represent energy in transit; only ΔU represents an independent quantity of energy capable of being stored.
- The internal energy U of a system depends only on the state of the system, and not how it reached that state.

12.3 Second Law of Thermodynamics: Entropy

- Entropy is a measure of a system's disorder: the greater the disorder, the larger the entropy.
- Entropy is also the reduced availability of energy to do work.
- The second law of thermodynamics states that, for any spontaneous process, the total entropy of a system either increases or remains constant; it never decreases.
- Heat transfers energy spontaneously from higher- to lower-temperature bodies, but never spontaneously in the reverse direction.

12.4 Applications of Thermodynamics: Heat Engines, Heat Pumps, and Refrigerators

- Heat engines use the heat transfer of energy to do work.

- Cyclical processes are processes that return to their original state at the end of every cycle.
- The thermal efficiency of a heat engine is the ratio of work output divided by the amount of energy input.
- The amount of work a heat engine can do is determined by the net heat transfer of energy during a cycle; more waste heat leads to less work output.
- Heat pumps draw energy by heat from cold outside air and use it to heat an interior room.
- A refrigerator is a type of heat pump; it takes energy from the warm air from the inside compartment and transfers it to warmer exterior air.