Why it Matters

Refrigerators

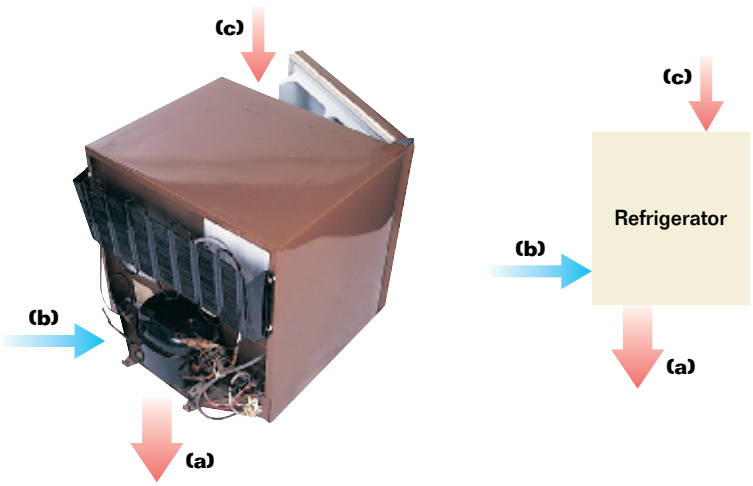
As shown in the photograph below, a refrigerator can be represented schematically as a system that transfers energy from a body at a low temperature **(c)** to one at a high temperature **(a).** The refrigerator uses work performed by an electric motor to compress the *refrigerant,* which is a substance that evaporates at a very low temperature. In the past, ammonia was used as a refrigerant in home refrigerators. However, ammonia leaks pose a risk because pure ammonia is highly toxic to people. In the 1930s, home refrigerators began using a newly developed, nontoxic class of refrigerants called *CFCs* (*chlorofluorocarbons*). Today, it is known that CFCs damage the ozone layer. Since the 1990s, home refrigerators have used refrigerants that are less harmful to the ozone layer.

The process by which a refrigerator operates consists of four basic steps, as illustrated in the diagram on the next page. The system to and from which energy is transferred is defined here as the refrigerant contained within the inner surface of the tubing. Initially, the liquid refrigerant is at a low temperature and pressure so that it is colder than the air inside the refrigerator. The refrigerant absorbs energy from inside the refrigerator and lowers the refrigerator's interior temperature. This transfer of energy as heat increases the temperature of the liquid refrigerant until it begins to boil, as shown in **(a).** The refrigerant continues to absorb energy until it has completely vaporized.

Once it is in the vapor phase, the refrigerant is passed through a *compressor.* The compressor does work on the gas by decreasing its volume without transferring energy as heat, as shown in **(b).** This adiabatic process increases the pressure and internal energy (and thus the temperature) of the gaseous refrigerant.

In the next step, the refrigerant is moved to the outer parts of the refrigerator, where thermal contact is made with the air in the room. The refrigerant gives up energy to the environment, which is at a lower temperature, as shown in **(c).** The gaseous refrigerant at high pressure then condenses at a constant temperature to a liquid.

The liquefied refrigerant is then brought back into the refrigerator. Just outside the low-temperature interior of the refrigerator, the refrigerant goes through an *expansion valve* and expands without absorbing energy as heat. The liquid then does work as it moves from a high-pressure region to a low-pressure region, and its volume increases, as shown in **(d).**



A refrigerator does work **(b)** in order to transfer energy as heat from the inside of the refrigerator **(c)** to the air outside the refrigerator **(a).**