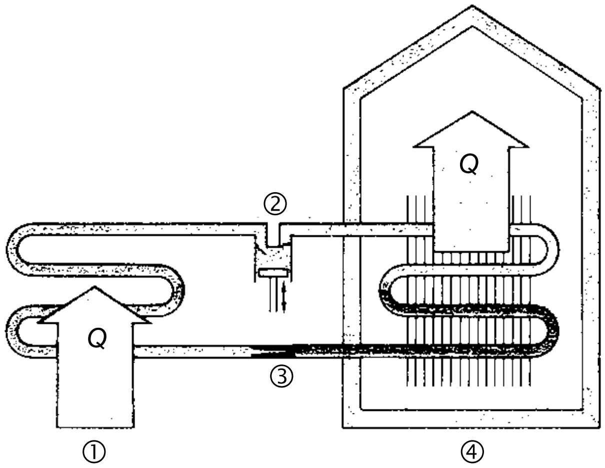
Heat pumps

The operating principle of a heat pump is the same as that of a refrigerator. Just as refrigerators, heat pumps move heat from a cooler region to a warmer region. The only difference is that heat pumps pump heat from the colder outdoors into the warmer house. The idea is not to cool the outdoors; it is to warm the house.

Task:

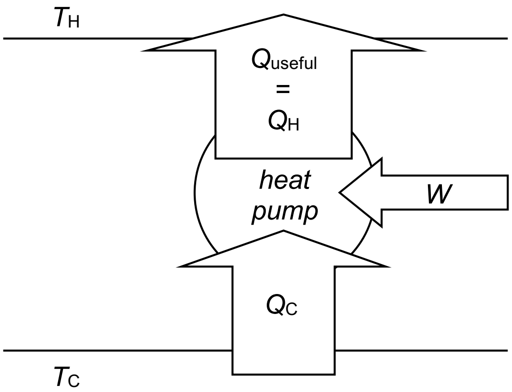
Describe the operating principle of a heat pump. It is the same as a refrigerator.
Write int the picture:

- ✯ Where does the refrigerant absorb heat, where does it release heat?
- ✯ Where does the refrigerant become gaseous, where does it become liquid?
- ✯ How do you get the refrigerant to vaporize, how do get it to condense?
- ✯ Where is the pressure high, where is it low?
- ✯ Where are the *evaporator*, the *condensor*, the *compressor* and the *expansion valve*?
- ✯ In which direction does the refrigerant circulate? Clockwise or counter clockwise?



Energy flow charts

Spontaneously, heat flows from a warmer object to a cooler object. A heat pump (or refrigerator) makes the heat flow in the opposite direction. To accomplish this, work needs to be done.
An energy flow chart shows the energy transfers. Wider arrows show larger amounts of energy while thinner arrows show smaller amounts of energy.



The work done W and the heat absorbed from the cooler region Q_C add up and flow into the heat pump.
The heat $Q_H = Q_{useful}$ is released to the warmer region.

The released heat Q_{useful} is greater than the work W done. The heat absorbed from the cooler region Q_C is "free of charge":

$$\boxed{Q_{useful} = Q_H = W + Q_C}$$

Coefficient of performance

The coefficient of performance of a heat pump

The coefficient of performance of an ideal heat pump is the useful heat released to the warmer region divided by the work done:

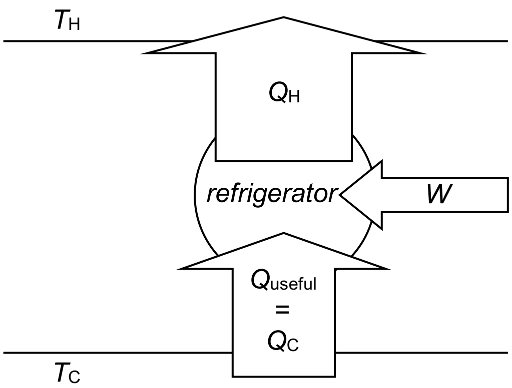
$$\boxed{\mathrm{COP}_{\text{heat pump}} = \frac{Q_{\text{useful}}}{W} = \frac{Q_H}{W} = \frac{Q_H}{Q_H - Q_C}}$$

The transferred heat is proportional to the temperature in Kelvin. Thus:

$$\boxed{\mathrm{COP}_{\text{heat pump}} = \frac{T_H}{T_H - T_C}}$$

The coefficient of performance of a refrigerator

In a refrigerator, the useful heat is the heat absorbed from the cooler region. The purpose is to cool the food in the fridge, not to heat the kitchen.



The work done W and the heat absorbed from the cooler region $Q_C = Q_{\text{useful}}$ add up and flow into the heat pump.
The heat Q_H is released to the warmer region.

$$\boxed{Q_{\text{useful}} = Q_C = Q_H - W}$$

The coefficient of performance of an ideal refrigerator (or air conditioner) is the useful heat absorbed from the cooler region divided by the work done:

$$\boxed{\mathrm{COP}_{\text{refrigerator}} = \frac{Q_{\text{useful}}}{W} = \frac{Q_C}{W} = \frac{Q_C}{Q_H - Q_C}}$$

The transferred heat is proportional to the temperature in Kelvin. Thus:

$$\boxed{\mathrm{COP}_{\text{refrigerator}} = \frac{T_C}{T_H - T_C}}$$