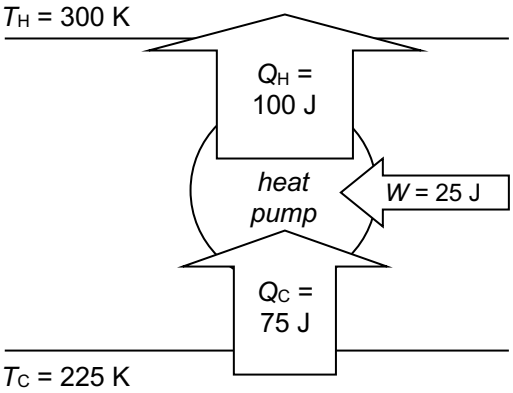
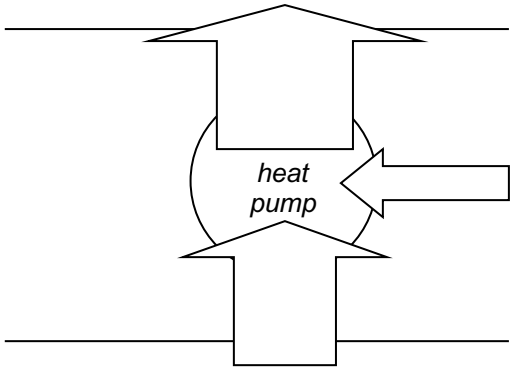
1. Here's an the energy flow chart for a heat pump.
   Calculate the coefficient of performance from
a) *Only* the useful heat and the work done on the heat pump
b) *Only* the useful heat and the heat absorbed from the region of lower temperature
c) *Only* the given temperatures of the two regions



2. Here's another energy flow chart for a heat pump:

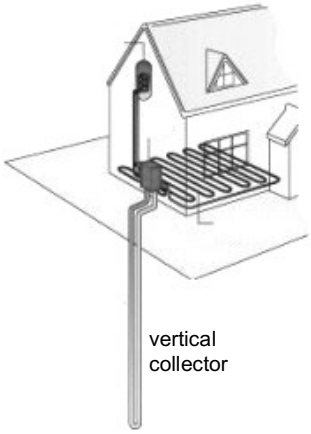


a) Write the following values in the diagram:
   Q_{useful} (= Q_H) = 150 J, W = 50 J, T_H = 300 K.
b) Calculate the heat absorbed by the heat pump and write your result in the diagram.
c) Calculate the coefficient of performance.
d) Calculate the temperature of the cool region and write your result in the diagram.

3. When is the coefficient of performance of a heat pump greater? If the difference between T_H and T_C is large or small? Give reasons for your answer.

4. A heat pump operates at an outside temperature of – 10.0 °C while the temperature in the house is + 20.0 °C. The (ideal) heat pump releases Q_{useful} = 6.00 MJ per hour into the house.
a) What is the (ideal) coefficient of performace?
b) What is the work W done per hour?
c) How much heat per hour does the heat pump absorb from the outside?
d) Calculate the electric power which is consumed by the heat pump.

5. Operating a heat pump with a vertical collector of 200 m, a little house can easily be heated including all the hot water supply. At this depth the temperature is approximately 15.0 °C year round.
   Assuming the heat pump is ideal with a coefficient of performance of 4.0, what is the temperature inside the house?



6. The operating principle of an air conditioner is the same as that of a refrigerator.

a) Complete the following sentences: “In order to cool a room, heat needs to flow from the ..... (*inside* / *outside*) of the room to the …….. (*inside* / *outside*) of the room. The heat is carried by a refrigerant, which ……..….. (*absorbs* / *releases*) heat on the inside and ……..….. (*absorbs* / *releases*) heat on the outside. Inside, you get the refrigerant to ..... (*vaporize*/*condense*) and outside you get it to ..... (*vaporize*/*condense*). Inside the room the pressure exerted on the refrigerant is ..... (increased/lowered) and outside it is ..... (*increased*/*lowered*). The increase in pressure is achieved using a ..... (*compromise*/*compressor*/*committee*).”

b) Why do air conditioners blow hot air to the outside?

c) Why should you keep all the windows closed if your air conditioning is on?

7. An (ideal) refrigerator has an inside temperature of 2.0 °C and is standing in a kitchen of a room temperature of 25.0 °C. Someone puts 5.00 kg of water of 60.0 °C into the fridge.

a) What is the refrigerator’s coefficient of performance?

b) How much heat does the water need to release to cool down to 2.0 °C?

c) What is the work done by the refrigerator’s compressor to absorb the required heat from the water?

d) How much heat does the fridge release to the kitchen?

e) What would have been a better option for cooling the water? Calculate the work done by the compressor in this (better) case.

8. An (ideal) refrigerator has an inside temperature of 4.0 °C and is standing in a kitchen of a room temperature of 25.0 °C. Someone puts 4.00 kg of water of 58.0 °C into the fridge. After a while, the fridge has cooled the water down to 4.0 °C.
What is the heat released to the kitchen?

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solutions:

1. a), b) and c) 4.0
2. b) 100 J c) 3.0 d) 200 K
4. a) 9.77 b) 614 kJ c) 5.39 MJ d) 170 W
5. 111 °C
7. a) 12 b) 1.2 MJ c) 101 kJ d) 1.3 MJ e) 40 kJ
8. 972 kJ