

4.42J Quiz 1
October 8, 2003
Open Book

1(50) One proposal for a combined heating and cooling system for a home is a so-called ice maker heat pump. It is shown in the sketch. The heat pump is operated using electricity during the heating season. It withdraws heat at 0°C from a pool of water, this is the low temperature heat source. It delivers heat at higher temperature to heat the house. As heat is transferred from the water, ice is formed. (In practice, there are series of pipes in the water. The pipes contain cold refrigerant; ice forms around the outside of the pipes.) Because of the rather low temperature of the ice and water the COP, ratio of heat delivered to electrical input, of the heat pump is only 2.5. To change phase from liquid water to ice, the internal energy change is approximately 334 kJ/kg. Neglect the change in volume for this process.

The home requires 60×10^6 kJ of heat during the winter and 30×10^6 kJ of cooling (amount of heat transferred for cooling) for the summer. In the summer the heat pump is turned off and the melting ice is used to provide cooling for the home.

- a) How much ice is formed over the heating season? Is it adequate to meet the cooling needs?
- b) Compare the electrical energy consumed for the ice maker heat pump system with a conventional system. In the latter the heat pump has a COP of 4.0, this is higher than the ice maker heat pump because the outside air is usually above the freezing point. In the conventional system the heat pump is also used as an air conditioner in the summer where the air conditioning COP is 3.0
- c) Comment on the feasibility of the ice –maker system for home heating and cooling.

2(50) In summer, one person leaves her room with a opened cooker in which fully contains water. Some days later, she comes back home and found that some of the water in the cooker has been evaporated.

The room volume is 50m^3 , and current indoor air temperature is 35°C . Assume the room façade is insulated so well that there is no heat transfer through the façade. Also, the room is sealed well with no air leakage.

- a). If the indoor air is saturated with vapor, how much vapor does the indoor air contain (kg)?

b). The person feels that the indoor air temperature too hot. She turns on the air conditioner to cool the air. Two hours later, the indoor air temperature becomes 25°C. How much water condensed from air during the two hours? Please don't consider the vapor generated by the person.

c). If the COP of the air conditioner is 3.0, how much electricity energy (kJ) was used to cool down the air from 35 °C to 25 °C? Assume that the person stayed in the room during the cooling two hours, and her heat amount that transferred to room air is 100W. Room air density between 35 °C to 25 °C assumes constant as 1.17 kg/m³, and specific heat of air $C_v=700\text{J/kg.K}$.