

17. (a) The final mass of ice is $(1773\text{ g} + 227\text{ g})/2 = 1000\text{ g}$. This means 773 g of water froze. Energy in the form of heat left the system in the amount mL_F , where m is the mass of the water that froze and L_F is the heat of fusion of water. The process is isothermal, so the change in entropy is $\Delta S = Q/T = -mL_F/T = -(0.773\text{ kg})(333 \times 10^3\text{ J/kg})/(273\text{ K}) = -943\text{ J/K}$.
- (b) Now, 773 g of ice is melted. The change in entropy is

$$\Delta S = \frac{Q}{T} = \frac{mL_F}{T} = +943\text{ J/K} .$$

- (c) Yes, they are consistent with the second law of thermodynamics. Over the entire cycle, the change in entropy of the water-ice system is zero even though part of the cycle is irreversible. However, the system is not closed. To consider a closed system, we must include whatever exchanges energy with the ice and water. Suppose it is a constant-temperature heat reservoir during the freezing portion of the cycle and a Bunsen burner during the melting portion. During freezing the entropy of the reservoir increases by 943 J/K. As far as the reservoir-water-ice system is concerned, the process is adiabatic and reversible, so its total entropy does not change. The melting process is irreversible, so the total entropy of the burner-water-ice system increases. The entropy of the burner either increases or else decreases by less than 943 J/K.