

## 4

- 4.1 (a) System = Ball (1) + Water (2)

$$\text{Energy balance: } M_1\hat{U}_1^f + M_2\hat{U}_2^f = M_1\hat{U}_1^i + M_2\hat{U}_2^i = 0$$

$$\Rightarrow M_1C_{v,1}(T_1^f - T_1^i) + M_2C_{v,2}(T_2^f - T_2^i) = 0; \text{ also } T_1^f = T_2^f. \text{ Then}$$

$$T^f = \frac{M_1C_{v,1}T_1^i + M_2C_{v,2}T_2^i}{M_1C_{v,1} + M_2C_{v,2}} = \frac{5 \times 10^3 \times 0.5 \times 75 + 12 \times 10^3 \times 4.2 \times 5}{5 \times 10^3 \times 0.5 + 12 \times 10^3 \times 4.2} = 8.31^\circ\text{C}$$

[Note: Since only  $\Delta T$ 's are involved,  $^\circ\text{C}$  were used instead of K].

- (b) For solids and liquids we have (eqs. 4.4-6). That  $\Delta S = M \int C_p \frac{dT}{T} = MC_p \ln \frac{T_2}{T_1}$  for the case in which  $C_p$  is a constant. Then

$$\begin{aligned} \text{Ball: } \Delta S &= 5 \times 10^3 \text{ g} \times 0.5 \frac{\text{J}}{\text{g} \cdot \text{K}} \times \ln \left( \frac{8.31 + 273.15}{75 + 273.15} \right) = -531.61 \frac{\text{J}}{\text{K}} \\ &= -531.61 \text{ J/K} \end{aligned}$$

$$\text{Water: } \Delta S = 12 \times 10^3 \text{ g} \times 4.2 \frac{\text{J}}{\text{g} \cdot \text{K}} \times \ln \left( \frac{8.31 + 273.15}{5 + 273.15} \right) = +596.22 \frac{\text{J}}{\text{K}}$$

and

$$\Delta S(\text{Ball} + \text{Water}) = 596.22 - 531.61 \frac{\text{J}}{\text{K}} = 64.61 \frac{\text{J}}{\text{K}}$$

Note that the system Ball + Water is isolated. Therefore

$$\Delta S = S_{\text{gen}} = 64.61 \frac{\text{J}}{\text{K}}$$

- 4.2 Energy balance on the combined system of casting and the oil bath

$$M_c C_{v,c}(T^f - T_c^i) + M_o C_{v,o}(T^f - T_o^i) = 0 \text{ since there is a common final temperature.}$$

$$20 \text{ kg} \times 0.5 \frac{\text{kJ}}{\text{kg} \cdot \text{K}} (T^f - 450)^\circ\text{K} + 150 \text{ kg} \times 2.6 \frac{\text{kJ}}{\text{kg} \cdot \text{K}} (T^f - 450)^\circ\text{K} = 0$$

This has the solution  $T^f = 60^\circ\text{C} = 313.15 \text{ K}$ .

Since the final temperature is known, the change in entropy of this system can be calculated

$$\text{from } \Delta S = 20 \times 0.5 \times \ln \left( \frac{273.15 + 60}{273.15 + 450} \right) + 150 \times 2.6 \times \ln \left( \frac{273.15 + 60}{273.15 + 50} \right) = 4.135 \frac{\text{kJ}}{\text{K}}$$

- 4.3 Closed system energy and entropy balances

$$\frac{dU}{dt} = \dot{Q} + \dot{W}_s - P \frac{dV}{dt}; \quad \frac{dS}{dt} = \frac{\dot{Q}}{T} + \dot{S}_{\text{gen}};$$

$$\text{Then, in general, } \dot{Q} = T \frac{dS}{dt} - P \frac{dV}{dt} \text{ and}$$

# Ashley Carter Thermodynamics Solutions Manual

**Puja Mehta**



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