

1. (5 pts) I place a cup containing 0.25 kg of water at 25 °C into the freezer. (a) What is the change in the entropy of the water ( $\Delta s$ ) as it slowly cools down to 0 °C? (b) What is the change in the entropy of the water as it slowly freezes? (c) What is the change in the entropy of the ice as it slowly cools down to -10 °C?
2. (2 pts) If I did the same process as described in the last problem, but instead the water was cooled into cold ice *rapidly* (not slowly), how would the total entropy change of the ice for the entire process differ from what we calculated in problem 1?
3. (3 pts) I place 3 mol of air with  $\gamma = 7/5$  at 25 °C into a rigid container. I then heat the gas to 45 °C. How much does the entropy of the gas change?
4. (3 pts) I place 3 mol of air with  $\gamma = 7/5$  at 25 °C into a balloon surrounded by air at atmospheric pressure. I then heat the gas in the balloon to 45 °C. How much does the entropy of the gas change?
5. (4 pts) Two identical samples of gas at the same initial temperature are compressed from the same initial to the same final volume, one isothermally, and one adiabatically. (a) Which sample has the greater final pressure? (b) Which sample has the largest final entropy?
6. (3 pts) A 0.145 kg piece of copper at 75 °C is dropped into a thermos containing 0.3 kg of water at 25 °C. How much does the entropy of the system change as it reaches thermal equilibrium?
7. (4 pts) (a) Explain why the entropy of an isolated system cannot change as it undergoes a reversible process. (b) What happens to the entropy of an isolated system as it undergoes an irreversible process?
8. (6 pts) Consider a gas of  $n$  moles of molecules with a molar heat capacity at constant volume of  $C_V$ .
  - (a) How much will the entropy of the gas change if it undergoes a constant volume process during which the temperature changes from  $T_A$  to  $T_B$ ?
  - (b) How much will the entropy of the gas change if it undergoes a constant pressure process during which the temperature changes from  $T_B$  to  $T_C$ ?
  - (c) Use the ideal gas law to find a relation between the ratio of the temperatures before and after the isobaric process ( $T_B/T_C$ ) and the ratio of the volumes before and after the process ( $V_B/V_C$ ).
  - (d) Use what you have found in parts (a) through (c) to derive the general formula for entropy change for any process (even irreversible ones) in an ideal gas:

$$\Delta s = nC_V \ln \frac{T_f}{T_i} + nR \ln \frac{V_f}{V_i}.$$

**Extra problems I recommend you work (not to be turned in)**

- What are examples of reversible and irreversible processes?
- Why is heat added to a system by a Bunsen burner (a flame) not a reversible process?
- What is the efficiency of the Carnot cycle if we start and end the cycle at point  $B$  instead of point  $A$ ?