

Assignment 3: Due 5 Sep 2024 before class

1. A sample of liquid water supercooled to  $-10^{\circ}\text{C}$  placed in a thermally insulated compartment undergoes a spontaneous crystallisation to form a mixture of ice and liquid water. Calculate  $q$ ,  $w$ ,  $\Delta T$ ,  $\Delta U$ ,  $\Delta H$ ,  $\Delta S$ ,  $\Delta G$  for the process (for some, you may not be able to calculate exactly - state if the quantity is positive, negative or zero).
2. When two bodies at different temperatures are placed in thermal contact, how can we extract maximum work from the two bodies? Assuming heat capacities to remain constant, find the change in temperature (Hint : use entropy relations) and the work obtained. What will be the final temperature if the heat capacities of the two bodies are the same? What is the final temperature if the process was spontaneous? Calculate the temperature for both cases if the initial temperatures of the bodies are 256K and 144 K respectively. Comment on the reasons for any difference in the two cases.
3. The temperature of the heat reservoirs of a Carnot cycle (reversible) engine are  $T_h = 1200\text{K}$  and  $T_C = 300$ .
  - (a) If  $w = -100$  kcal, calculate  $q_h$  and  $q_c$ . Explain the signs of  $w$ ,  $q_h$  and  $q_c$ .
  - (b) Operate the engine in reverse order :  $w = -100$  kcal, calculate  $q_h$  and  $q_c$ . Explain the signs.
4. When a sample of liquid, say water, is converted reversibly to its vapor at its normal boiling point, what can we say about  $q$ ,  $w$ ,  $\Delta p$ ,  $\Delta V$ ,  $\Delta T$ ,  $\Delta U$ ,  $\Delta H$ ,  $\Delta S$ ,  $\Delta G$ ? If the liquid is permitted to vaporize isothermally and completely into a previously evacuated chamber that is just large enough to hold the vapor at 1 bar pressure, then how will these quantities be affected?