CYL 110: Tutorial 2 – Entropy

SS

1. One mol of hydrogen occupies a volume of 0.1 m^3 at 300 K and one mol of argon also occupies the same volume but at 400 K. While isolated from their surroundings, each undergoes a free expansion, the hydrogen to 5 times and argon 8 times its initial volume. The two masses are then placed in contact with each other and reach thermal equilibrium. What is the total change in entropy? ($C_v^{H_2} = 10$ kJ/K/kg, $C_v^{Ar} = 10$ kJ/K/kg).

2. One mole of an ideal monatomic gas undergoes an irreversible adiabatic process in which the gas ends up at STP and for which ΔS is 21 $\mathrm{JK^{-1}}$ and w is 1.26 kJ. The entropy of the gas at STP is 270 $\mathrm{JK^{-1}mol^{-1}}$. CalculateΔU and ΔG for the process and also the initial state of the gas.

3. Represent the Carnot cycle on a temperature-entropy diagram and show that the area enclosed by the cycle is equal to the work done.

4. By a thermodynamic analysis show that the following familiar processes are spontaneous: (a) A book is pushed off a table and falls to the floor. (b) One mole of an ideal gas in a vessel that is connected to another identical evacuated vessel through a valve. The valve is opened and the gas occupies both vessels. (c) Melting of ice when brought in contact with an object at a temperature above 0 °C.

5. It is possible to cool liquid water below its freezing point of 273.15 K without the formation of ice if proper care is taken to prevent nucleation. A kilogram of sub-cooled liquid water at 263.15 K is contained in a well-insulated vessel. Nucleation is induced by the introduction of a speck of dust, and a spontaneous crystallization process ensues. Find the _nal state of the water and calculate the total entropy change for the process. (Heat of fusion is 334 $\mathrm{Jg^{-1}}$, $\mathrm{C_p(l) = 4.185\ Jg^{-1}K^{-1}}$; $\mathrm{C_p(s) = 2.092\ Jg^{-1}K^{-1}}$)

6. 100 g of ice at 0 °C is dropped into an insulated beaker containing 150 g of water at 100 °C. Calculate ΔS for this process.

7. Calculate the maximum work and the maximum non-expansion work that can be obtained from the freezing of supercooled water at −5 °C and 1.0 atm. The densities of water and ice are 0.999 and 0.917 g $\mathrm{cm^{-3}}$, respectively at −5 °C.

8. One mole of He is heated from 200 °C to 400 °C at a constant pressure of 1 atm. Given that the absolute entropy of He at 200 °C is 810 $\mathrm{JK^{-1}mol^{-1}}$, and assuming He is a perfect gas, comment on the spontaneity of the process.

9. Derive the relations: $(i) C_p - C_v = T\left(\frac{\partial p}{\partial T}\right)_V \left(\frac{\partial V}{\partial T}\right)_p$; $(ii) C_p - C_V = \frac{\alpha^2 TV}{\beta}$; $(iii) \mu_{JT} = -\left(\frac{V}{C_p}\right)\left(\beta C_V \mu_J - \beta p + 1\right)$; $(iv) \left(\frac{\partial H}{\partial V}\right)_S = \frac{\gamma}{\beta}$; $(v) \left(\frac{\partial V}{\partial T}\right)_p = \frac{C_V \beta}{T\alpha}$

10. Calculate the temperature change when the pressure on 1 kg of water is increased from 0 to 10^8 Pa reversibly and adiabatically. The initial temperature of water is 273.15 K, the specific volume is $10^{-3}\mathrm{m^3kg^{-1}}$, the coefficient of thermal expansion, $\alpha = 10^{-6}$/K and Cp is 4184 J/(kg K).