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CHEM 3410: Physical Chemistry I — Fall 2009

In-class Practice Problems

September 25, 2009

1. One mole of an ideal gas, with $C_v = \frac{3}{2}R$, is heated reversibly (a) at constant pressure and (b) at constant volume, from 298 K to 353 K. Calculate ΔS for the system in each case.

2. At 100°C 200 g of mercuty are added to 100 g of water at 20 °C. The specific heat capacities of water and mercury may be taken as constant at 4.18 and 0.140 J/K·g, respectively. Assuming the system is isolated calculate the entropy change of

   (a) the mercury

   (b) the water

   (c) the system

3. One mole of H_2O(l) is supercooled to -2.25°C at 1 bar pressure. The freezing temperature of water at this pressure is 0.00°C. The transformation H_2O(l) → H_2O(s) is suddenly observed to occur. By calculating ΔS_{system}, $\Delta S_{surroundings}$ and $\Delta S_{universe}$, verify that this transformation is spontaneous at -2.25°C.

   The heat capacities are given by $C_p(H_2O_{(l)}) = 75.3$ J K^{-1} mol^{-1} and $C_P(H_2O_{(s)}) = 37.7$ J K^{-1} mol^{-1}, and $\Delta H_{melting} = 6.008$ kJ mol^1 at 0.00°C. Assume that the surroundings remaing at -2.25°C.

   Hints:

   - Consider the two pathways at 1 bar: (a) H_2O(l, -2.25°C) → H_2O(s, -2.25°C), which you cannot solve and (b) H_2O(l, −2.25°C) → H_2O(l, 0.00°C) →H_2O(s, 0.00°C) → H_2O(s, -2.25°C). Because S is a state function, ΔS_{system} must be the same for both pathways.]
   - Pay attention to the **sign** of $\Delta H_{melting}$. As given it is for the transformation of solid to liquid, however this problem deals with the opposite: the transformation from liquid to solid. Also note the units are in kJ/mole.
   - For the surroundings you need to calculate the actual heat flow to the surroundings, which you can do using your roundabout process in (b). Another way of saying this is what is ΔH (heat flow at constant pressure) for the transformation of liquid water to solid ice at -2.25°C.