國立臺灣大學 102 學年度碩士班招生考試試題

1. In a process of mixing of ideal materials, the final common volume is the sum of the initial separate compartment volumes. There is no heat transfer and no work is done. The entropy of mixing is entirely accounted for by the diffusive expansion of each material into a final volume not initially accessible to it. (a) Prove the entropy of mixing two ideal compounds with similar size is always positive. (b) Prove the Gibbs free energy of mixing is always negative. (c) Thus, systems tend to get more "disordered" relative to their original "ordered" state over time, unless a directed influence outside the system reorganizes the system. Give an example that you encountered in your life experience. (20%)

2. Partially miscible solutions often exhibit two solubility boundaries, the upper critical solution temperature (UCST) and the lower critical solution temperature (LCST). At temperatures below LCST, the system is completely miscible in all proportions, whereas above LCST partial liquid miscibility occurs. For small molecules, the existence of an LCST is much less common than the existence of an UCST, but some cases do exist. For example, the system triethylamine-water has an LCST of 19 °C, so that these two substances are miscible in all proportions below 19 °C but not at higher temperatures. (a) Sketch briefly the phase diagram of the mixture components containing LCST, spinodal and binodal curves. (b) Based on $\Delta G = \Delta H - T\Delta S$, explain LCST is driven by favorable or unfavorable entropy of mixing? (20%)

3. All forms of energy transfer imply a loss of usable energy for future work. An increase in entropy can establish an orientation toward which the energy transformation is directed. An inventor claims a new ion seeding element will allow 70% efficiency in a Magneto Hydrodynamic (MHD) unit. Is this possible? Assume containing materials can handle a gas at 2100K. Assume minimum temperature at which the ions will allow the MHD unit to work is 1200K. An MHD device works by electromagnetic interaction of a magnetic field slowing down ions in a hot gas, which thus slows the hot gas, and producing the electric current for power. (20%)

4. Calculate the Gibbs free energy change for one molecule of supercooled water to ice at 101.3kPa and -15°C. Take C_p in J $mol^{-1}K^{-1}$ as 75.2 for the liquid and 34.6 for the solid and ΔH_{fus} =5961 $Jmol^{-1}$. (20%)

5. (a) How can you determine C_p from a temperature-entropy digram?
(b) How will you calculate the entropy departure from its ideal value if P-V-T data is given? (20%)

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