國立臺灣大學99學年度碩士班招生考試試題

Please mark your answers clearly.

1. True or false? (5% each)
   A. The increase in the internal energy of a system is equal to the amount of energy added by heating the system minus the amount lost as a result of the work done by the system on its surroundings.
   B. Internal energy and entropy are intensive state variables.
   C. For a reversible adiabatic process in a simple system, the final temperature is a single-valued function of the final volume for a given initial state.
   D. As a system approaches absolute zero, all processes cease and the entropy of the system approaches a maximum value.
   E. The energy of an isolated system remains constant when a reversible process occurs in the system.

Please provide derivation and calculations for the following questions:

2. For the truncated viral equation of state:

$$\left(\frac{\partial \bar{U}}{\partial \bar{V}}\right)_{T,n} = \frac{RT^2}{\bar{V}^2}\frac{dB_2}{dT} = \frac{RT^2 B'_2}{\bar{V}^2}$$

   where R is the gas constant and $\bar{V}$ is the molar volume. For argon gas at 298.15 K, B_2 is equal to -15.8 cm^3/mol and B'_2 is equal to 0.25 cm^3/mol·K. The molar constant-volume heat capacity of argon gas is nearly constant and equal to $3R/2$. Find the internal energy, heat, and work for a reversible isothermal expansion of 1.0 mole of argon at 298.15 K from a volume of 2 L to a volume of 20 L. Calculate also these values assuming ideal gas behavior (30%).

3. If 2 moles of supercooled liquid water at -15°C freezes irreversibly at a constant pressure of 1 atm to ice, calculate the entropy change of the system, the surroundings, and the universe. Assume the surroundings remain at equilibrium at -15°C and the molar heat capacity of liquid water to be constant and equal to 76.1 J/mol·K and that of ice to be constant and equal to 37.15 J/mol·K (30%).

4. Find the expression for the partial molar Helmholtz energy of a one-component ideal gas as a function of pressure (15%).

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