

科目 材料熱力學 科目代碼 3202 共 2 頁第 1 頁 *請在試卷【答案卷】內作答

1. The following questions are testing your understanding of thermodynamic laws. Read *carefully* and firstly determine whether the following statements are true or false, and then briefly indicate your thermodynamic reasoning. If you claim that a statement is false, you must state which law or laws of thermodynamics that it violates. You have to correct any false statement with a clarifying phrase that makes the statement true. (30%, 5% for each question)
- (1) If the thermal expansion is negative, the constant pressure heat capacity is smaller than the constant volume heat capacity.
 - (2) The only way to transfer heat from high temperature to low temperature is by an irreversible process.
 - (3) The increase of internal energy of an adiabatic system consisting of an incompressible diamagnetic material is the work performed on the system.
 - (4) If one mole of monatomic ideal gas increases its temperature by 1°C by a reversible process, the work *performed* on the gas by its surroundings must be numerically equal to the molar heat capacity at constant volume, c_v .
 - (5) If the total Gibbs free energy of two phases is equal at constant pressure and temperature, then the two phases are in equilibrium with each other.
 - (6) The chemical potential of any species that can be exchanged between two phases will always be equal.
2. Diamond is metastable at atmospheric pressures. Sketch how the Gibbs free energies curves for diamond and graphite would look like as a function of pressure at constant temperature. Consider that the molar volume of diamond is smaller than the molar volume of graphite. The sketch should be thermodynamically-sound. This means that you should pay attention to the slopes and curvatures of the curves. (20%)
3. For an exothermic reaction, A (reactant) \rightarrow B (product), according to the Le Chatelier's Principle, which will be the direction of the reaction as temperature increases? On the other hand, for a thermally activated reaction, the reaction rate is supposed to increase with increasing temperature. Does the answer you given earlier conflict this principle? Why or why not? Please draw a schematic figure to illustrate the variation of reaction rate with temperature for the exothermic reaction. (15%)

4. A beaker of water (100g) at 20°C (1 atm) is heated to a temperature of 100°C by placing it on a reservoir at 100°C. The reservoir is at constant temperature. (15%)
- (a) Calculate the entropy change of the beaker of water.
- (b) What is the entropy change of the universe?
- (c) Assume now that an ideal Carnot engine is inserted between the reservoir and the beaker of water. Calculate the entropy change of the universe in this case.

DATA: Heat capacity for water: 4.184J/g

Enthalpy of evaporation for water: 41kJ/mole

Molar mass for water: 18g/mole

5. Air is enclosed in a spherical soap bubble of radius r . The soap film does not let air molecules through. The pressure outside the bubble is p_o . Using the conditions of equilibrium, it is possible to show (you don't have to show) that the air pressure inside the bubble is

$$p_i = p_o + 2\sigma/r$$

where r is the radius of the film, and σ is the interfacial energy between the air and soap film.

What is the heat capacity of a collection of bubbles under constant outside pressure per mole of gas? Write in terms of properties of the gas and the interface (c_p , c_v , σ , etc.) Air can be treated as an ideal gas for this problem. (20%)