

CYL110 II Semester 2007 - 2008
MINOR Exam I Version

Date: Feb. 05, 2008

Time: 1 hour

1. Decide whether the following statements are true or false giving your reasoning. If the statement is false, you may either provide a counter example or any other physical reason. Finally, correct the false statement. (5 × 5 = 25 pts)
 - (i) If the total Gibbs energy of two phases are equal at constant pressure and temperature then the two phases are in equilibrium with each other.
 - (ii) The chemical potential of any species that can be exchanged between two phases will be equal at equilibrium.
 - (iii) The increase of internal energy of an incompressible dielectric material in an adiabatic enclosure is the work performed on the system.
 - (iv) Real gases may heat or cool when subjected to an adiabatic expansion against vacuum.
 - (v) The equation $dU = TdS - PdV$ is applicable to a closed system, subjected only to $P - V$ work.

2.
 - (i) Newton showed that the velocity of sound waves in a gas was determined by the compressibility. He reasoned that it was the isothermal compressibility but it was later shown by Laplace to be the isentropic compressibility. The isothermal and the isentropic compressibility are related with their ratio being the ratio of the heat capacities. Prove this equality. (15 pts)
 - (ii) A Sargent cycle consists of the following four steps: isochoric increase in pressure, adiabatic expansion, isobaric decrease in volume, and adiabatic compression. Sketch a diagram of this cycle in S, T coordinates when an ideal gas is carried through a reversible Sargent cycle. (10 pts)

3.
 - (i) Dry ice is frozen carbon dioxide. A block of dry ice has a surface temperature of $-78.5\text{ }^\circ\text{C}$. If you want to send something frozen across the country, you can pack it in dry ice. It will be frozen when it reaches its destination, and there will be no messy liquid left over like you would have with normal ice. Explain this phenomenon with the help of a phase diagram. Label the different regions of the diagram. (15 pts)
 - (ii) Consider a two-phase system of liquid water in equilibrium with water vapor in a constant temperature bath. Suppose we reversibly increase the system's volume, holding T and P constant, causing some of the liquid to vaporize. State whether each of ΔH , ΔS , ΔS_{total} , and ΔG is positive, zero, or negative. Justify your answer. (10 pts)

4. Ten grams of supercooled liquid water at $-10\text{ }^\circ\text{C}$ is contained in an adiabatic container. Crystallization is induced by some means (not relevant here) and the system reaches equilibrium at a fixed pressure of 1 atm.
 - (i) What is the final equilibrium state of the system? It could either be ice plus liquid at $0\text{ }^\circ\text{C}$ or ice below $0\text{ }^\circ\text{C}$. (Hint: What is the ΔH for the process?) (15 points)
 - (ii) Calculate ΔS for the process and comment on its sign. (10 pts)

The latent heat of fusion of water at the normal melting point is 334 J/g and the C_P of liquid water is 4.185 J/g/K .