

MME 2009 Metallurgical Thermodynamics I

Problem Set I

1 – Calculate the partial pressure of carbon monoxide, P_{CO} from the following equation

$$18.2P_{CO}^2 + 96.2 P_{CO} - 6.9 = 0$$

Hint: Use graphical and numerical methods and compare the solutions

2- Vapor pressure of Pb is related to temperature in the following form:

$$\log P_{Pb} = -10130/T - 0.985 \log T + 8.279$$

where P_{Pb} is in atmosphere and T is in Kelvin. Calculate the normal boiling point of lead

where $P_{Pb} = 1 \text{ atm}$

3 – The composition of Pb-Zn alloy for a special application was given by the following equation

$$2.08 X^2 - 1.81 X^3 + \log X = -0.4157$$

where X represents the mole fraction of zinc in the alloy ($0 < X < 0.5$). Find the mole fraction of Zn in a Pb-rich alloy that is suitable for the present application

4 – What pressure increase is needed to make a cubic block of magnesium metal retain its initial volume while it is being heated from 0 to 50⁰C? The average linear expansion coefficient $\alpha_L = 2.5 \times 10^{-7} \text{ K}^{-1}$, the isothermal compressibility factor $\beta = 2.95 \times 10^{-10} (\text{N/cm}^2)^{-1}$.

Hint: $dV = (\delta V / \delta T)dT + (\delta V / \delta P)dP$, $\alpha = 1/V(\delta V / \delta T)_P$, $\beta = -1/V(\delta V / \delta P)_T$

5 - A 5-g lead bullet moving at 200 m/s embeds itself into a wooden block. Half of its initial energy is absorbed by the bullet. What is the increase in temperature of the bullet?

6 - A solar collector has an area of 5 m² and the power of sunlight is delivered at 550 W/m². This power is used to increase the temperature of 200 g of water from 20⁰C to 50⁰C. How much time is required?

- 7 - How many grams of steam at 100°C must be added to 30 g of ice at 0°C in order to produce an equilibrium temperature of 40°C ?
- 8 - A large, insulated container holds 120 g of coffee at 85°C . How much ice at 0°C must be added to cool the coffee to 50°C ? Now, how much coffee at 100°C must be added to return the contents to 85°C ? How many grams are finally in the container?
- 9 - What equilibrium temperature is reached when 2 lb of ice at 0°F is dropped into a 3-lb aluminum cup containing 7.5 lb of water? The cup and water are initially at 200°F .
- 10 - In an experiment to determine the latent heat of vaporization for water, a student measures the mass of an aluminum calorimeter cup to be 50 g. After a quantity of water is added, the combined mass of the water and cup is 120 g. The initial temperature of the cup and water is 18°C . A quantity of steam at 100°C is passed into the calorimeter, and the system is observed to reach equilibrium at 47.4°C . The total mass of the final mixture is 124 g. What value will the student obtain for the heat of vaporization?
- 11 - Four 200-g blocks are constructed out of copper, aluminum, Silver, and Lead so that they have the same mass and the same base area (although of different heights). The temperature of each block is raised from 20°C to 100°C by applying heat at the rate of 200 J/s. Find the time required for each block to reach 100°C .
- 12 - Each of the blocks in the previous example are placed on a large block of ice. Find out how much ice is melted by each block when all reach equilibrium at 0°C ? Which sinks deepest and which sinks the least?