

Problem Set 3
3.20 MIT
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Problem 1

It is found that a certain liquid boils at a temperature of 95°C at the top of a hill, whereas it boils at a temperature of 105°C at the bottom. The latent heat is 1000 cal/mol . What is the approximate height of the hill?

Problem 2

The boiling point of Li is 1620 K .

- (a) What is the vapor pressure of liquid Li at 1000 K ?
- (b) Estimate the melting point of lithium from the data given.

Data:

Enthalpy of evaporation is 156 kJ/mol

Vapor pressure above solid Li is given by:

$$\ln(P) = 13.049 - \frac{19,314}{T}$$

Problem 3

(a) A chamber at 1500 K with a volume of one cubic meter contains one gram of Ag. What is the status of the silver in the chamber? Is it all vapor, all liquid, or part liquid and part vapor? If the latter, what fraction of the silver is in the vapor phase?

(b) How much heat is required to evaporate one mole of Ag from a very large quantity of a silver-copper liquid solution at 1500 K containing $x_{\text{Ag}} = 0.25$. Assume the solution is ideal.

Data for Silver:

Melting point = 1235 K

Vapor pressure of liquid given by

$$\ln(P) = -\frac{30671}{T} + 12.5 \text{ [P in atm, T in K]}$$

Enthalpy of melting for Ag = 11.3 kJ/mol

Heat capacity for liquid Ag = 33 J/mol-K

Problem 4

A container kept at a constant temperature of 70°C (see figure) contains a small amount of liquid water. The total gas pressure in the container is 1 atm . This gas phase consists of the water vapor in equilibrium with the liquid water and inert N_2 gas. What is the total pressure in the container when the volume of the container is isothermally reduced to half of the original volume? You may assume that the liquid water takes up a negligible amount of volume. Also, you may neglect the effect of total pressure on the vapor pressure of water.

Data:

Enthalpy of evaporation for water at 40°C is 43.54 kJ/mol

Vapor pressure of water at 70°C is 0.3 atm



Problem 5

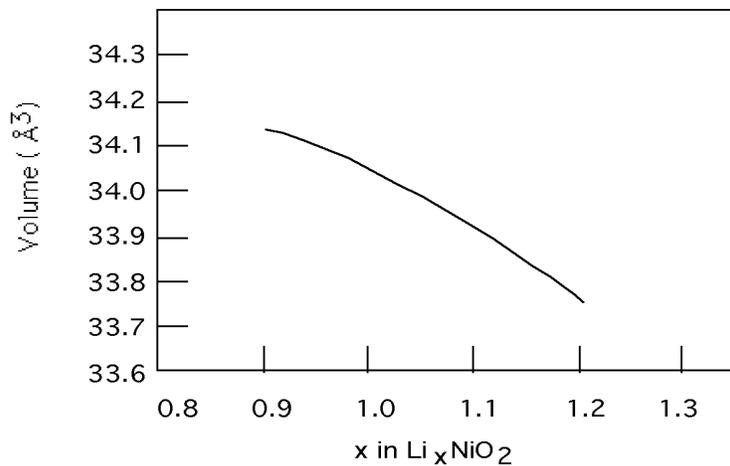
- (a) What is the vapor pressure of H_2O at 100°C (the boiling point of water) ?
(b) The weather forecast tells me that it is 59°F (15°C) outside with a relative humidity of 65%. What is the dew point of that air?

Data:

Enthalpy of evaporation for H_2O at 100°C = 40.6 kJ/mol

Problem 6

Below is the volume of the unit cell of Li_xNiO_2 as a function of x . When x increases Li is accommodated inside the unit cell of the material. What is the partial molar volume of Li in this material for $x = 1$? Look carefully at what exactly this graph gives you!



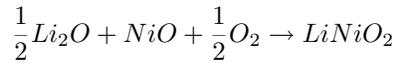
Problem 7

The vapor pressure of pure B at 1000 K is 5×10^{-4} atm. If B is in an ideal solution with another species at 1000 K, its vapor pressure will be:

- Higher than 5×10^{-4}
 Lower than 5×10^{-4}
 Equal to 5×10^{-4}
 Impossible to say

Problem 8

LiNiO_2 is an important material for rechargeable lithium batteries. It is made by reacting Li_2O and NiO in an oxygen atmosphere. The desired reaction is:



However, one finds that when synthesizing in air, the material always ends up being rich in Ni and deficient in Li, i.e. one ends up with $\text{Li}_{1-x}\text{Ni}_{1+x}\text{O}_2$ where x is greater than zero.

What do you suggest to change the synthesis? Should P_{O_2} be increased or reduced from its value in air (0.21) to make more stoichiometric $\text{Li}_{1-x}\text{Ni}_{1+x}\text{O}_2$? (i.e. make x smaller). Justify your answer briefly.

Problem 9

A long vertical column is closed at the bottom and open at the top; it is partially filled with a particular liquid and cooled to -5°C . At this temperature the fluid solidifies below a particular level, remaining liquid above this level. If the temperature is further lowered to -5.2°C the solid-liquid interface moves upward by 40cm . The latent heat (per unit mass) is 2 cal/g and the density of the liquid phase is 1g/cm^3 . Find the density of the solid phase. Neglect thermal expansion of all materials.

(Hint: Note that the pressure at the original position of the interface remains constant)

Problem 10

What is the maximum amount of water that can fall out of a standing air mass over the earth (per unit area)? To calculate, assume that all air is saturated with water. The temperature of the earth's surface may be taken as 25°C and the decrease of temperature with height is about 6.5°C/km . At 25°C the vapor pressure of water is 3200 Pa . The enthalpy of boiling for water is about 42 kJ/mole .