Exam III

CH 353 Sumer 2007

Vanden Bout

Name: KEY

You can use anything to answer the following except someone else.
Carefully read all the problems. The exam should have 4 questions on 6 pages. The first page has potentially useful information. The last page is for extra writing space.

R = 8.314 J K^{-1} mol^{-1} R = 8.314x10^{-2} L bar K^{-1} mol^{-1} R = 8.206x10^{-2} L atm mol^{-1} K^{-1}

1 atm = 1.01325 bar T/K = T/°C + 273.15 1 atm-L = 101.325 J 1 bar-L = 100 J

g = 9.8 m s^{-2} $\Pi = \rho g h$

$$\frac{dP}{dT} = \frac{\Delta S}{\Delta V} = \frac{\Delta H}{T\Delta V} \qquad \ln\left(\frac{P_2}{P_1}\right) = \frac{-\Delta H}{R}\left[\frac{1}{T_2} - \frac{1}{T_1}\right]$$

$$\Delta T = KX_B \quad K \equiv \frac{RT_b^{*2}}{\Delta_{VAP}H} \qquad \Delta T = K'X_B \quad K' \equiv \frac{RT_m^{*2}}{\Delta_{FUS}H}$$

$$\Pi = \frac{n_B}{V}RT = [B]RT$$

$$\left(\frac{\partial \mu}{\partial P}\right)_T = V_M \qquad \left(\frac{\partial \mu}{\partial T}\right)_P = -S_M$$

Please sign at the bottom to certify that you have worked on your own.
I certify that I have worked the following exam without the help of others, and that the work I am turning in is my own.

Signed: --

Signature Date

1. True/False Circle either T or F for each statement (10 points each)

(T) F The vapor pressure of a solid can never be higher than the pressure at the triple point.

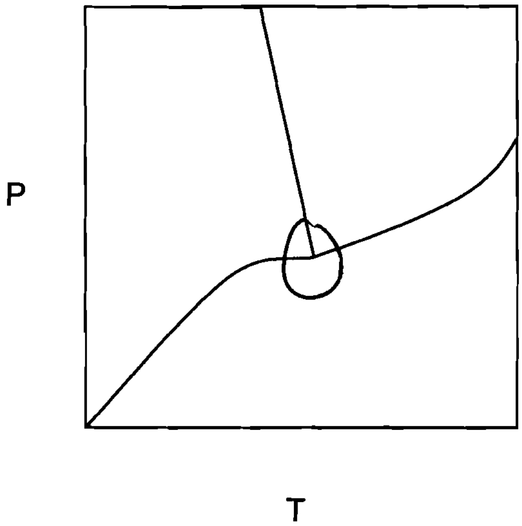
T (F) The melting temperature of solids always increases when the pressure is increased. H_2O

(T) F The chemical potential always increases with increasing pressure. $\left(\frac{\partial \mu}{\partial P}\right)_T = V_m > 0$

(T) F The chemical potential of an undissolved grain of salt in water, is higher than the chemical potential of water in a dilute salt water solution. it will dissolve

T (F) For a pure substance at its melting temperature, the solid and the liquid have the same enthalpy same G, same μ $\Delta H_{fus} > 0$.

2A. (25 points)



The picture at left shows a possible phase diagram for a pure substance around its solid, liquid, vapor triple point. Based on the slopes and curvatures of the lines, it is possible that this a diagram for an actual substance? Why or why not?

NO

slope for sublimation < slope for vaporization

$\text{slope} = \frac{\Delta S}{\Delta V}$ $\quad \Delta V_{sub} \approx \Delta V_{vap} \approx V_{gas}$

$\Delta S_{sub} > \Delta S_{vap}$

∴ sublimation must have ~~have~~ a greater slope

2B. (25 points)

What is the difference in Gibb's Free Energy between 3 moles of benzene at a temperature of 25°C and pressure of 1 bar, and 3 moles of benzene at a 25°C and a pressure of 10 bar?.

benzene
density = 0.88 g cm^{-3}, MW = 78.11 g mol^{-1}, S°= 173.1 J K^{-1} mol^{-1}, $\Delta_f G°$ = -124.3 kJ mol^{-1}

Benzene (25°C, 1 bar) ⟶ Benzene (25°C, 3 bar)

$$\Delta G = \int \left(\frac{\partial G}{\partial P}\right)_T dP = \int V\, dP = V \Delta P$$

3 moles × 78.11 g mol^{-1} = 234.33 g

$\frac{234.33\ g}{.88\ g\ cm^{-3}}$ = 266.3 cm^3 = .266 L

ΔG = (.266 L)(2 bar) = .532 L-bar = 53.2 J

3. (50 points)

A mixture of 1 liter of a solvent **A** with a non-volatile solute **B** forms an ideal solution that has an osmotic pressure that is measured as 2 bar at 25°C. The density of **A** is 1.0 g cm^{-3}, the molecular weight 30 g mol^{-1}, and its pure vapor pressure at 25°C is 50 Torr. The density of **B** is 2.5 g cm^{-3} and the molecular weight is 50 g mol^{-1} (it has no vapor pressure).

What is the vapor pressure of the solution?

Need to know the mole fraction of A.

$$\Pi = CRT$$

$$C = \frac{\Pi}{RT} = \frac{2 \text{ bar}}{(.08314 \text{ L-bar } K^{-1} mol^{-1})(298)}$$

$$C = 0.083 \text{ M}$$

1 L ~ all A → 1000 g A → 33.33 moles

0.083 moles B

$$\chi_A = \frac{33.33}{33.33 + .083} = 0.9976$$

$$P_A = P_A^* \chi_A = (50)(.9976) = 49.88 \text{ Torr}$$

4. (50 points)

Substance **X** has a triple point at 25°C with a vapor pressure of 250 Torr. The vapor pressure of the liquid is 500 Torr at 40°C. What is $\Delta_{VAP}H°$? What is $\Delta_{FUS}H°$? What is the melting temperature of **X** at 500 bar?

$\Delta_{SUB}H° = 48$ kJ mol^{-1}
denstiy (s) = 3.2 g cm^{-3}
density (l) = 3 g cm^{-3}
MW = 40 g mol^{-1}

$P_1 = 250 \quad T_1 = 298.15$

$P_2 = 500 \quad T_2 = 313.15$

$$\ln\left(\frac{P_2}{P_1}\right) = -\frac{\Delta H}{R}\left[\frac{1}{T_2} - \frac{1}{T_1}\right]$$

$$\ln(2) = -\frac{\Delta H}{R}\left[\frac{1}{313.15} - \frac{1}{298.15}\right]$$

$$\Delta H_{VAP} = 35.14 \text{ kJ mol}^{-1}$$

$$\Delta H_{fus} = \Delta H_{sub} - \Delta H_{VAP} = 48 - 35.14 = 12.86 \text{ kJ mol}^{-1}$$

$$\frac{\Delta P}{\Delta T} = \frac{\Delta H_{fus}}{T \Delta V}$$

$$\Delta V = \frac{1}{\text{den liq}} - \frac{1}{\text{den sol}} = \frac{1}{3} - \frac{1}{3.2}$$

$$= .0208 \text{ cm}^3 \text{ g}^{-1}$$

$$= 2.08 \cdot 10^{-5} \text{ L g}^{-1}$$

$$= 8.16 \cdot 10^{-4} \text{ L mol}^{-1}$$

$$\frac{\Delta P}{\Delta T} = \frac{12{,}860 \text{ L-bar mol}^{-1}}{(298)(8.16 \cdot 10^{-4} \text{ L mol}^{-1})}$$

$$= 528.8 \text{ bar K}^{-1}$$

$$\Delta T = \frac{\Delta P}{\text{slope}} = \frac{499}{528.8}$$

$$\Delta T = 0.94$$

$$T_m = 25.9$$