UNIVERSITY CEU SAN PABLO
SCHOOL OF PHARMACY
DEPARTMENT OF CHEMISTRY AND BIOCHEMISTRY

COMPLEMENTARY PROBLEMS OF PHYSICAL CHEMISTRY

2018-19

LESSON 3

8. Calculate the melting temperature of mercury at 100 atm and 500 atm, knowing that its normal melting temperature is -38.9 ^{o}C.

Data: ρ ($Hg_{(l)}$, - 38.9 ° C and 1 atm) = 13,690 g·cm^{-3};
ρ ($Hg_{(s)}$, - 38.9 ° C and 1 atm) = 14,193 g·cm^{-3}; $\overline{\Delta H}_{fus}$ (Hg) = 2.82 cal·g^{-1}

Solution: T_{melt} (100atm) = 234.51 K; T_{melt} (500atm) = 236.61 K

9. To sterilize laboratory equipment, the boiling point of water must be 150 ^{o}C. Indicate the pressure that should be inside the autoclave. Determine the pressure when water boils at 90^{o}C.

Data: R = 0.082 atm·l·K^{-1}·mol^{-1} = 1.987 cal·K^{-1}·mol^{-1}= 8.314 J·K^{-1}·mol^{-1};
ΔH_{vap} (H_2O) = 539.4 cal·g^{-1}

Solution: P (150ºC) = 4.683 atm; P (90ºC) = 0.693 atm

10. Vapour pressure of Acetonitrile changes 0.03 atm per ^{o}C when the system is closed to the normal boiling point (80 ^{o}C). Calculate the heat of vaporization of acetonitrile.

Data: R = 0.082 atm·l·K^{-1}·mol^{-1} = 1.987 cal·K^{-1}·mol^{-1}= 8.314 J·K^{-1}·mol^{-1};

Solution: $\Delta\overline{H}_{vap}$ =7339.43 cal·mol^{-1}

11. The vapour pressure of diethyl ether is 0.247·10^{5} N·m^{-2} at 0 °C and 1.228·10^{5} N·m^{-2} at 40 ^{o}C. Calculate:

a) The enthalpy of vaporization, assuming that it remains constant throughout the temperature range.
b) The boiling point of diethyl ether at 1.013·10^{5} N·m^{-2}
c) The normal entropy of vaporization.
d) Has diethylether a trend of self-association? (Check using Toruton's Rule)

Data: 1 atm = 1.013·10^{5} N·m^{-2};
R = 0.082 atm·l·K^{-1}·mol^{-1} = 1.987 cal·K^{-1}·mol^{-1}= 8.314 J·K^{-1}·mol^{-1}

Solution: a) $\Delta\bar{H}_{vap} = 6791.388\ cal\cdot mol^{-1}$; **b)** $T_b^o = 307.658\ K$;

c) $\Delta\bar{S}_{vap} = 22.071\ cal\cdot K^{-1}\cdot mol^{-1}$ **d)** Yes, it has.

12. The following table shows the values of vapour pressure of neon at different temperatures:

T (°C)	-228.7	-233.6	-240.2	-243.7	-245.7	-247.3	-248.5
P (mmHg)	19800	10040	3170	1435	816	486	325

Determine the:

a) molar vaporization enthalpy.

b) normal boiling point.

c) standard molar entropy of vaporization.

Data: $R = 0.082\ atm\cdot l\cdot K^{-1}\cdot mol^{-1} = 1.987\ cal\cdot K^{-1}\cdot mol^{-1} = 8.314\ J\cdot K^{-1}\cdot mol^{-1}$;
$M_{Ne} = 20.79$ a.m.u.

Solution: a) $\Delta\bar{H}_V^o = 447.168\ cal\cdot mol^{-1}$; **b)** $T_b^o = 27.07\ K$; **c)** $\Delta\bar{S}_V^o = 16.519\ cal\cdot K^{-1}\cdot mol^{-1}$

13. The sublimation pressure of Cl_2 (solid) is 352 Pa at -112 °C and 35 Pa at -126.5 °C. The vapour pressures of Cl_2 (liquid) are 1590 Pa at -100 °C and 7830 Pa at -80 °C. Determine the triple point.

Data: $R = 0.082\ atm\cdot l\cdot K^{-1}\cdot mol^{-1} = 1.987\ cal\cdot K^{-1}\cdot mol^{-1} = 8.314\ J\cdot K^{-1}\cdot mol^{-1}$;
$1\ atm = 1.013\cdot 10^5\ Pa$

Solution: a) $T_{triple} = 168.918\ K$. $P_{triple} = 1096.304\ Pa$

14. 20 moles of an equimolecular mixture of A and B are distilled, this mixture begins to boil at 65 ºC until the boiling point of the residue reaches 75 ºC. Draw approximately the phase diagram T vs. X, and answer each of the following questions:

a) What is the composition of the residue?

b) What is the composition of the distillate?

c) How many moles does the distillate contain?

Data: The boiling temperature of A is greater than B.

Solution: a) $x_B^L \approx 0.44$; **b)** $x_B^V \approx 0.87$; **c)** $n^V \approx 12.12$ moles

15. Water and phenol are partially miscible at 55 C. When these two liquids are mixed, at 55 °C and 1 atm., the mole fraction of water in both phases in equilibrium are 0.9 and 0.4:
If 4 moles of phenol and 6 moles of water are mixed, at 55 ° C and 1 atm. calculate the number of moles of phenol and water in each of the phases that are in equilibrium.

Solution: $n_{H_2O}^{L,1} = 2.4$; $n_{phenol}^{L,1} = 3.6$; $n_{H_2O}^{L,2} = 3.6$; $n_{phenol}^{L,2} = 0, 4$

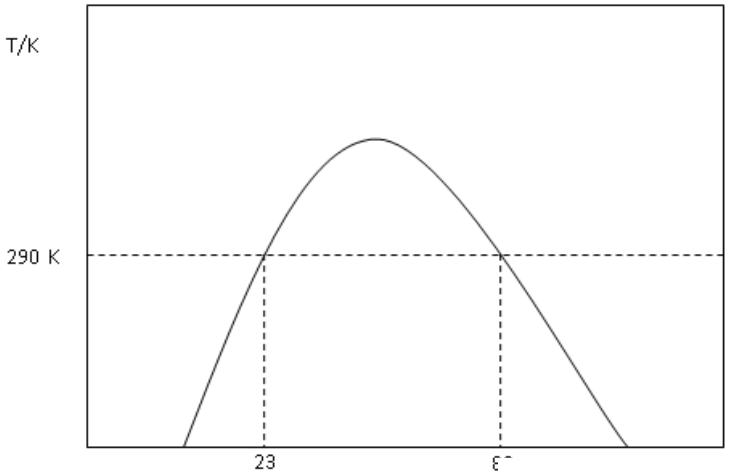
16. For a liquid-liquid, partially miscible system containing 0.050 kg of A and 0.050 kg of B, calculate, at a temperature T, the masses of the phases in equilibrium. At this temperature the compositions of B in both phases are 30 and 85.5% (w/w), respectively.

Solution: $m^{L,1} = 0.064$; $m^{L,2} = 0.036$

17. According to the following phase diagram, a mixture of 50 g of n-hexane and 50 g of nitrobenzene is heated to 290 K.

a) What is the mass of each phase?

b) What is the mass of each component in each of the phases?



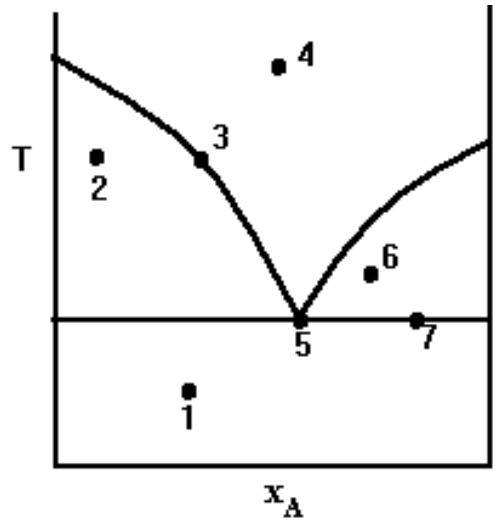
Solution: a) $w_I = 55$ g; $w_{II} = 45$ g; **b)** $w_{I,A} = 12.65$ g; $w_{I,B} = 42{,}31$g; $w_{II,\,A} = 37.35$ g; $w_{II,\,B} = 7.65$ g

18. A system presents the solid-liquid phase diagram of the figure. Determine:

a) the phases and components that are present in every region of the diagram.

b) the degrees of freedom and the thermodynamic properties required to define the system state in the points.

c) What would be the maximum number of moles of pure A that can be obtained by crystallization from an initial melted mixture of 80 moles and $X_A = 0.9$?



Solution: c) $n_A^s = 63.2566$ *moles*