INSA Lyon
SCAN 2nd 2008 November, 6th

CHEMISTRY 2

Test n°1 (1 h 30)

No document allowed. Only « collège » type calculators are authorized.

The 4 exercices can be solved independently

Data : R = 8.314 J K^{-1} mol^{-1}
For each exercice, other data are available at the end of the corresponding exercice.

The number of moles and molar fractions will be computed to within 10^{-3} USI,
The weights will be given in g, to within 0,1 g.

<u>Part 1 : Liquid/vapor diagrams</u>

Exercice 1 : *(2.5 points)*

Let's consider 2 liquids A and B which mixture is considered as an ideal solution. The saturated vapor pressure of the pure compounds A and B at a given temperature will be noted as p^*_A and p^*_B, respectively.

1/ Give the definition of an ideal solution.
Does the volume vary, and is there an exchange of heat when mixing the liquids ?
2/ Let's consider the liquid-vapor equilibrium of the A-B mixture at a given temperature T, under a given total pressure p_T.
Show that the composition of each phase is perfectly defined as the pressure and temperature are fixed.
Give the expressions for x_B and y_B, the mole fractions of B for the liquid and the vapor phase in equilibrium, respectively, as a function of p^*_A, p^*_B and p_T.

Exercice 2 : Isobaric diagram (p_t = 760 Torr) *(8 points)*

Let's consider a two-phase liquid mixture of two components C and D. When heating the mixture of the two liquids under the given pressure (p_T = 760 torrs), the temperature gets stable at 95°C, temperature for which 3 phases coexist : two liquid phases noted as L_1 and L_2, and a vapor phase noted as V. The mole fraction of D for each phase were determined by gas chromatography and are gathered in the table below.
Moreover, mixtures of C and D brought to 80°C, 65°C and 50°C, are two-phases liquid systems which compositions are also given in the table below :

	Mole fraction of D		
θ(°C)	x_{L_1}	x_{L_2}	x_V
95	0.30	0.80	0.55
80	0.20	0.90	
65	0.13	0.95	
50	0.09	0.98	

1/ Thanks to the corresponding data, plot on the front page of the attached graph paper the isobaric L-V phase diagram under 760 torrs, with respect to the mole fraction of D noted as x_D. Without any other precision, the frontier curves between different phase domains will be represented as straight lines.

2/ Give the nature of the phases and the value for the variance on each domain of the diagram. Name the curves and the particular point(s) of the diagram.
3/ Under 760 Torrs, let's consider 2 moles of a mixture which global mole fraction is $x_D = 0.40$. Compute the number of moles and the weights for each of the two liquid phases at 80°C.
4/ Let's consider 100 g of a mixture which global weight fraction is $w_D = 0.07$ at 65°C. How much of D has to be added to this mixture to get a cloudy solution at the same temperature θ = 65°C ?
5/ In a closed system and at the same pressure, three mixtures which global mole fraction x_D = 0.05 ; $x_D = 0.55$ and $x_D = 0.70$ are heated from 50 up to 180°C. Represent schematically the three thermal analysis curves, pointing out the nature of each phase existing on each segment of the given curve.

Data :
Normal boiling temperature (under 760 torrs) of C and D : $\theta^*_C = 150°C$; $\theta^*_D = 170°C$
Molar masses : $M_C = 125$ g.mol^{-1} ; $M_D = 160$ g.mol^{-1}

Part 2 : Isobaric Solid/Liquid phase Diagrams

Exercice 1 : *(2 points)*

Water (index 1) and a molecular compound M (index 2) give an isobaric S-L phase diagram with a eutectic point with a total immiscibility (or nil-miscibility) at the solid state.

1/ Recall the definition of a eutectic point (specify the existing phases and the variance value).
2/ Give the expression of the Raoult's law regarding cryometry, with the composition expressed as the molality of M noted as m_2 (no demonstration required).
Under which conditions does this law apply?
3/ When dissolving P_2 = 1 g of M in 10 mL of water, the lowering of the congelation temperature of water equals 1.45°. Deduce the value for the molal cryoscopic constant of water.

Data : Molar masses : $M_1 = 18$ g.mol^{-1} ; $M_2 = 128$ g.mol^{-1}

Exercice 2 : *(7.5 points)*

Under p_T = 1 atm, gold (Au) and silicon (Si) lead to a sol/liq phase diagram with a eutectic point with a total immiscibility at the solid state. The simplified isobaric diagram is plotted on the backpage of the attached graph paper, diagram on which specific points (1, 2, 3) and phase domains (4, 5, 6, 7) are annotated.
1/ Give the nature of the phases existing at the 1 to 7 points and domains (Recall the names of the specific points).
2/ Recall the definitions of the liquidus and the solidus curves. Represent them clearly on the graph by using colors (specify the legend !!).
3/ Let's consider a mixture M made of 98.5 g of gold and 14 g of silicon.

- **a)** Represent schematically the thermal analysis curve obtained when cooling from 1500 K down to 500 K. Point out the nature of the phases existing on each segment and explain the discontinuities on the slopes.
- **b)** How does the composition of the liquid phase vary along this cooling?
- **c)** Determine the (minimum and maximum) mass of gold to be added to the mixture M in order to end up with a one-phase mixture at 780 K.
- **d)** Determine the mass of gold to be added to the mixture M at 780 K in order to end up with two phases with exactly the same amount (in moles).
- **e)** Determine the mass of gold to be added to the mixture M in order to get new mixtures which <u>first</u> crystals are made of pure gold among the existing phases.

Data : Molar masses : $M_{Au} = 197$ g.mol^{-1} ; $M_{Si} = 28$ g.mol^{-1}