Test – solutions

1) At all temperatures in the marked points there is a 2-phase system made up of both α and β phases.

For the data points’ determination see the phase diagram, they are ca. x1=0.08, x2=0.13, x3=0.26, x4=0.71, x5=0.82, and x6=084.

The points of interest lie on the cH=0.5 isopleth. From the tie lines we get the deviations from the overall composition as *l*1=0.42, *l*2=0.37, *l*3=0.24, *l*4=0.21, *l*5=0.32, and *l*6=0.34.

To calculate the compositions, we need to use the lever rule, *n*α*l*α=*n*β*l*β, for the different pressures. *l*1 belongs with *l*6, *l*2 with *l*5 and *l*3 with *l*4. From the lever rule we can then establish that *n*1/*n*6=*l*6/*l*1=0.81, *n*2/*n*5=l5/*l*2=0.86, and *n*3/*n*4=*l*4/*l*3=0.88. This means that the proportions of the α and β phases are the same, i.e. at 0 °C, it is 45% α of c=0.08 and 55% β of c=0.84; at 25 °C, this is 46% α of c=0.13 and 54% β of c=0.82; and at 100 °C, this corresponds to 47% α of c=0.26 and 53% β of c=0.71.

*T*c – is the critical temperature above which only one phase is present.

2) In reverse osmosis, a solution is separated from pure solvent by a semipermeable membrane only penetrable for the solvent molecules. When pressure is applied on the solution side a flow of the pure solvent molecules is generated into the pure solvent side until equilibrium is reached.

The driving force behind this is that the system is striving to reach equilibrium, i.e. the chemical potential of the solvent should become the same on both sides. When pressure is applied on the solution side, the chemical potential of the solvent in this side increases. This is a consequence of the chemical potential being the molar Gibbs free energy of a pure substance, i.e. as , at constant temperature , and as → (molar volume of the pure substance, which is positive i.e. the chemical potential increases with increasing pressure). To re-adjust the equilibrium the chemical potential increase needs to be compensated by an additional term, in which it decreases. As the pure solvent side is at ambient pressure, we cannot change the chemical potential on this side so we need to decrease the chemical potential on the solution side. According to , and Raoult’s law (), . As *x*A is the molar fraction of the solvent, in a solution it is always <1, *i.e.* ln*x*A<0, and therefore the chemical potential of a solvent in its pure form will always be higher than that in a solution. The higher the solute concentration, the lower the chemical potential of the solvent. Therefore, by increasing the solute concentration the system may counteract chemical potential increase on the application of pressure. Finally, as the membrane is only permeable to the solvent molecules, the only way to increase the solute concentration is the removal of solvent molecules from the solution side via their flow into the pure solvent side.

Semi-permeable membrane



Applied pressure

Pure solvent

Solution

3) If *p* does not change significantly during the period *t*, the mass loss equals the effusion mass loss multiplied by the time period *t:* *m*loss=(rate of effusion)\**t*\**m*=(rate of effusion)\**t*\**M*/*N*A.

4) The diffusion equation solution for these boundary conditions provided in with

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*A*=5.0 cm2; *D*=5.216\*10-9 m2 s-1; and *x*=10 cm.

At *t*=24 h=24\*3600s=8.64\*104 s;