Chalmers University of Technology
Department of Applied Physics
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Exam in Soft Matter Physics TIF015/FIM110

Time: Friday January 15, 14.00-18.00 2010.
Examiners: Aleksandar Matic (0730-346294), Johan Sjöström (0737279624)
Allowed material: Physics Handbook or equivalent, dictionary and pocket calculator
Grading: 24 points, is required for a passed.
Review of the exam: Contact Aleksandar Matic or Johan Sjöström after 22/1 2010
Note: All answers must be in English. Motivate all answers carefully. Answers without motivation give no credit.

1a) The viscosity of a glass forming liquid is found to follow the Vogel-Fulcher-Tamman equations with the parameters $\eta_0=1.1\cdot10^{-10}$ Pas, B=41359 and T_0=0 K. Determine the glass transition temperature for this glass (3p)

b) Glasses are important materials for technological applications. Discuss two unique properties of glasses that can be exploited technologically. (2p)

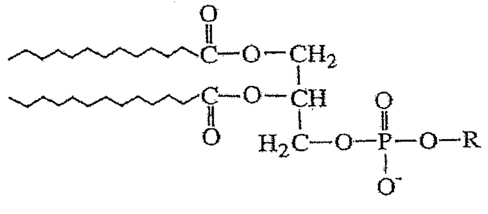
c) How is the glass transition manifested in density and thermal expansivity? Discuss this in relation to thermodynamic aspects of the glass transition (5p).

2) Sodium dodecyl sulphate (SDS) is a common surfactant. It has the chemical formula $C_{12}H_{25}$-OSO_3Na.

a) To which class of surfactants does SDS belong? (1p)

b) Assuming that the critical chain length is given by $l_c\approx(0.154+0.1265n)$ nm, that the hydrocarbon volume is given by $v\approx(27.4+26.9n)\times10^{-3}$ nm^3 and that the head group area is 0.5 nm^2, determine the optimal size of micelles formed by SDS (motivate your answer). (3p)

c) Phospholipids, see example of the molecular structure below, are surfactant molecules found in our cell membranes. Explain why this type of surfactants are suitable for forming cell membranes. (2p)



d) Explain what microemulsions are and why they are of technological importance? (4p)

3) a) Suspensions, emulsions and foams are all colloidal systems. Describe the difference between these systems in terms of the dispersed phase and the continuous medium. Give an example of each type of colloidal system. (3p)

b) By coating charged colloids with polymers the interaction between the particles can be changed. How thick should the polymer layer at least be so that the electrostatic interaction can be regarded as negligible? Sketch the interaction energy as a function of distance from the surface of the colloidal particle. (4p)

c) Discuss the dynamics of a colloidal suspension in the limits $Pe<<1$ and $Pe>>1$ where Pe is the Peclet number. (3p)

4) Explain the terms homogeneous and heterogeneous nucleation. Can you give an example from everyday life or science of heterogeneous nucleation? (5p)

5) Sketch how the strain rate (time derivative of strain) varies with the shear stress for

a) a shear thickening liquid (2p)
b) a shear thinning liquid (2p)

6) The mixing of the molecular liquid A with the molecular liquid B can be described by the regular solution model:

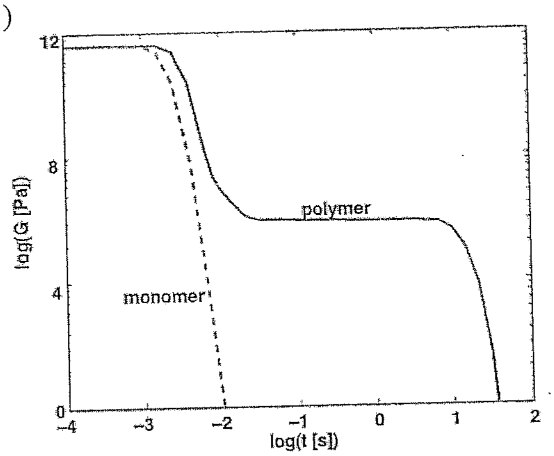
$$\frac{F_{mix}}{k_B T} = \phi_{Al} \ln \phi_A + \phi_B \ln \phi_B + \chi \phi_A \phi_B ,$$

where the interaction parameter can be written: $\chi = 600\text{K}/T$, and T is the temperature in Kelvin. The two liquids are mixed at T=20°C in the proportions of $\phi_A = 0.25$.

Discuss how the mix behaves when the temperature

a) is held at 20 °C after mixing.
b) decreases to 0 °C and is held constant.
c) decreases further to -20 °C and is held constant. (5p)

7) The figure shows the stress relaxation modulus for a melt of Polyethylene glycol (HO-[C2H4O]$_N$-H), where N>1000 and the corresponding monomeric material, Ethylene glycol (N=1)



a) For what time scales are the two systems glassy and liquid-like? (3p)
b) Explain the different behaviours of the two systems. (4p)
c) Estimate the viscosity of the polymeric system. (3p)

8) The figure below shows the phase diagram of a polymer solution. When phase separation occurs the phase with a high concentration forms a gel. Below you see three characteristic structures of phase separated systems formed by rapidly cooling the solution from a temperature above 83 °C.

a) What is the difference between the two dispersed phases 1 and 3? (3p)

b) Obviously there is a difference in the characteristic length scale of the heterogeneities in the bicontinuous network (2) compared to the other dispersed phases (1 and 3). What are the mechanisms behind these different length scales? Hint: How do they separate (3p)

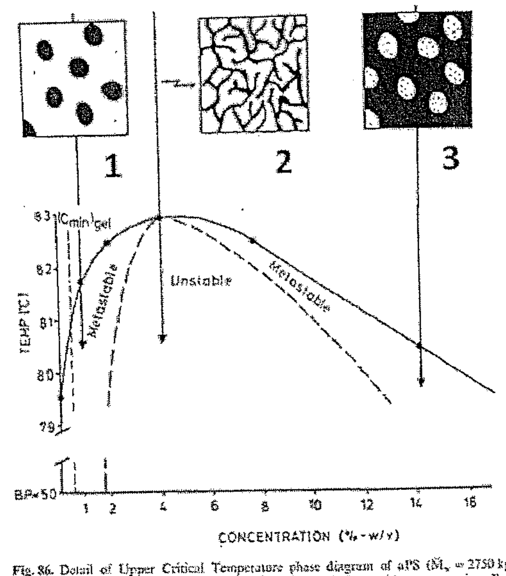


Fig. 86. Detail of Upper Critical Temperature phase diagram of aPS ($\bar{M}_w$ = 2750 kg/mol) in cyclohexanol, including expected variation in (gel) morphology with concentration. Reproduced from Makromol Chem [Ref. 276] by the courtesy of the authors and of Hüthig & Wepf Verlag Publishers, Zug, Switzerland