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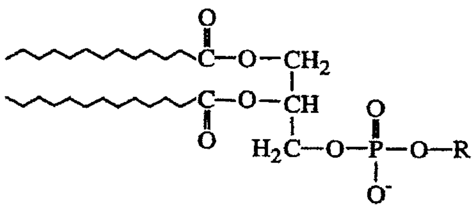
Exam in Soft Matter Physics TIF015/FIM110

Time: Tuesday August 24, 2010,14.00-18.00.
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 3/9 2010
Note: All answers must be in English. Motivate all answers carefully. Answers without motivation give no credit.

1) a) Sodium stearate ($C_{17}H_{35}$-COONa) is a common component in soaps. What kind of micelles are expected to form in a sodium stearate water solution assuming that the critical chain length is given by $l_c \approx (0.154+0.1265n)$ nm, that the hydrocarbon volume is given by $v \approx (27.4+26.9n) \times 10^{-3}$ nm^3 and that the head group area is 0.5 nm (motivate your answer). (4)

b) 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)



c) Explain what the critical micellar concentration (CMC) is! (4p)

2) a) What is the typical value of the viscosity and relaxation time at the glass transition? What is the high temperature limit of the same parameters. Give a motivation to your answers! (2p)

b) Discuss the glass transition based on thermodynamic considerations and sketch the behaviour of relevant thermodynamic quantities. (4p)

c) What arguments can be raised against thermodynamic models for the glass transition? (2p)

d) What general properties of glasses are unique and useful from an application point of view? (2p)

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. (4p)

b) For an ideal hard sphere colloidal system crystallization occurs at a volume fraction of ϕ=0.494 and a transition to a disordered glassy state at $\phi \approx 0.58$. Consider now a colloidal suspension of charged spheres of radius 100 nm in an aqueous solution of sodium chloride at room temperature (20° C). The volume fraction of particles in the solution is ϕ=0.35 and the salt concentration in the solution is 10^{-4} mol/dm^3. Which phase do you expect this system be in, solid or liquid? Make reasonable assumptions and motivate carefully. (6p)

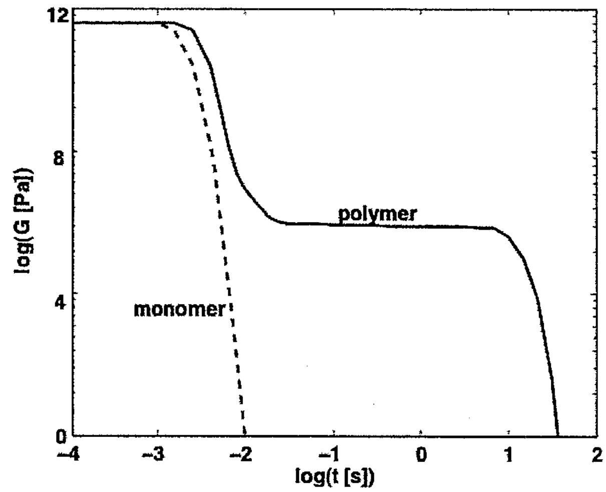
You might want to use the expression for the Debye screening length:

$$\kappa^{-1} = \left(\frac{2e^2 n_0 z^2}{\varepsilon\varepsilon_0 k_B T}\right)^{-\frac{1}{2}}$$

4) Explain the terms "critical nucleation radius", "homogeneous nucleation" and "heterogeneous nucleation". Can you give an example from everyday life or science of heterogeneous nucleation? (6p)

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 figure shows the stress relaxation modulus for a melt of Polyethylene glycol ($HO\text{-}[C_2H_4O]_N\text{-}H$), where N>1000 and the corresponding monomeric material, Ethylene glycol (N=1), both at T = -100 °C.



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. (4p)

7a) Consider a polymer solution. There are several interactions that influence the root mean square of the end-to-end distance $\langle r^2\rangle^{1/2}$. Below are three energies corresponding to different phenomena. Identify the different energies and explain their origin. Discuss if they are attractive (want to shrink the polymer chain) or repulsive (want to expand the chain).

i. $F(r) = \dfrac{3k_BTr^2}{2Na^2}$+constant

ii. $F(r) = k_BTv\dfrac{N^2}{r^3}$

iii. $U = -k_BTv2\chi\dfrac{N^2}{r^3}$+constant,

where r is the end-to-end distance, N is the number of monomers in the chain, a is the monomeric length, v is the volume of a monomer and χ is an interaction parameter. (6p)

b) By summing the three energies one obtains the total free energy of the chains. Explain how the dependence of $\langle r^2\rangle^{1/2}$ on N changes when the interaction parameter is varied (perhaps by changing the temperature) from $\chi = 0.2$ to $\chi = 0.8$. Motivate your answer. (3p)