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

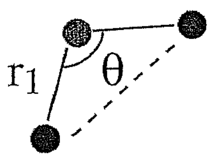
Time and place: Tuesday August 19 14.00-18.00 2008, Väg och Vatten.
Examiners: Aleksandar Matic (0730-346294), Johan Sjöström (0737279624)
Allowed material: Physics Handbook or equivalent, dictionary and pocket calculator
Grading: 26 points, is required for a passed.
Exam results: Exam results are displayed 23/1 outside office S2046.
Review of the exam: Contact Aleksandar Matic or Johan Sjöström after 28/8
Note: All answers must be in English. Motivate all answers carefully. Answers without motivation give no credit.

1. a) Sketch the behaviour of the volume and specific heat as a function of temperature around the glass transition. Compare to the case of crystallization. (4p)

b) Explain the Kauzman paradox, or the entropy crisis, associated with the glass transition? (2p)

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

d) Sketch the pair distribution function, g(r), of a glass and a crystal built up of the same coordinating structure below, with r_1=1.4 Å and θ=135°. (2p)



2. a) Derive the limits for formation of spherical and cylindrical micelles respectively of amphiphilic molecules in terms of characteristics of the molecule. (4p)

b) What is the driving force behind the formation of infinite sheets of bilayers of amphiphilic molecules? Give a motivation to your answer! (2p)

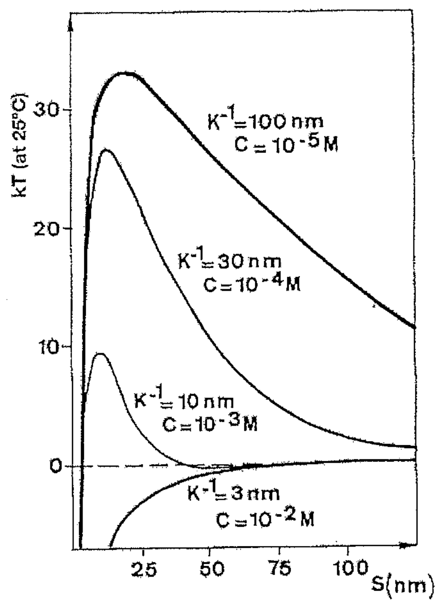
d) Sketch the distributions of aggregate sizes (Volume fraction in aggregate – X_M vs. aggregation number – N). Explain the different behaviours. (4p)

3. a) What mechanisms can be used to tune the interactions in a colloidal suspension? Discuss the origin of these mechanisms. (2p)

b) Discuss the dynamics of a colloidal suspension in the limits $Pe \ll 1$ and $Pe \gg 1$ where Pe is the Peclet number. (4p)

c) In the figure below the energy, E, as a function of separation, S, is given for two colloidal particles for a range of salt concentrations.

- Which are the two main contributions building up this curve?
- Sketch the behaviour of each contribution!
- Why is the change in salt concentration reducing the maximum energy barrier (discuss this in term of parameters given in the figure)? (4)



4. a) Explain the three fundamental deformations of a liquid crystal: splay, twist and bend. (3p)

b) What are the basic components of a liquid crystal display? (4)

c) Describe the basic physical principles in action in a liquid crystal display. (3)

5. An entangled melt of a linear polymer shows viscoelastic behavior. The zero shear viscosity η_0 depends on the degree of polymerisation (N) and the temperature (in Kelvin) (T) according to:

$$\eta_0 = 3.68 \times 10^{-3} \exp\left(\frac{1404}{T-128}\right) N^{3.4} \text{ Pa s.}$$

The statistical step length is a=0.65 nm.
The plateau value of the shear modulus 1.15×10^6 Pa.
The relative molecular mass of the monomer unit is 54 g mol^{-1}.

a) Explain why the viscosity has this functional form. (4)
b) ***Estimate*** the self-diffusion coefficient, D_{self}, at T=298 K of the polymer if the relative molecular mass is 100000 g mol^{-1}. (6)
c) Imagine that the degree of polymerisation was doubled. How would that affect the plateau modulus value of the shear modulus? (2)

6. The mixing of two molecular liquids (A and B) can be described by the regular solution model. At room temperature the interaction parameter is χ=3.

a) The liquids are mixed and thoroughly stirred in a proportion ϕ_a that corresponds to a metastable composition. Given that you stop stirring and wait a long time, what will happen to the binary mixture? Please give a qualitative answer. (3)
b) The temperature is thereafter decreased which results in an increase of the interaction parameter. What is the effect on the phase/phases in the binary mixture? (3)

7. a) Sketch how the effective viscosity depends on the strain rate for a
- Newtonian fluid
- shear thickening fluid
- shear thinning fluid.

Also, give one example each of these (3)

b) Imagine that you apply a constant shear to a viscoelastic material at time t=0. Make a diagram with shear strain on the y-axis and time on the x-axis and sketch the shear strain as a function of time. Can you indicate where you can find the instantaneous modulus (the elastic response for very short times) and the characteristic relaxation time? (3)