

Question 1 (6p)

Which two forces / interaction energies are accounted for in the DLVO theory of colloidal suspension stability? Describe what happens when the ionic strength of the continuous phase is increased!

The two forces are van der Waals attraction and electrostatic/osmotic repulsion due to the double layer. When the ionic strength is increased the Debye screening length is shortened so there is less repulsion and the colloids aggregate more easily.

Question 2 (6p)

Many polymers have a melting temperature above room temperature, but a glass transition temperature below room temperature. In such cases, how does the degree of crystallinity influence the material properties (at room temperature)? Also give one example of how the degree of crystallinity can be changed.

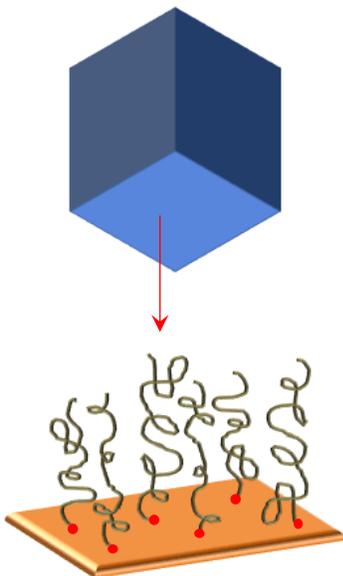
The material will consist of hard (crystalline) domains and soft regions in between. Higher degree of crystallinity makes the material brittle and lower more makes it easier to deform. Degree of crystallinity is reduced for instance by branching and random stereochemistry.

Question 3 (8p)

A sharp tip is being pushed into a polymer brush. Assume the tip has the shape of a block with a planar surface with an area of $10 \times 10 \mu\text{m}^2$ at the end. Calculate the force necessary to compress the brush to 90% of its equilibrium height at room temperature. The Kuhn length is 2 nm and the grafting density is 0.2 nm^{-2} .

You may use the Alexander – de Gennes brush model where the free energy per coil is:

$$G(h) = \frac{3k_B T h^2}{2N a^2} + \frac{\Gamma k_B T N^2 a^3}{h} + \text{constant}$$



The equilibrium height H can be solved for by deriving G which is also the force:

$$F = \frac{\partial G}{\partial h} = \frac{3k_B T h}{Na^2} - \frac{\Gamma k_B T N^2 a^3}{h^2}$$

This gives H just like in the lecture notes:

$$H = \left[\frac{\Gamma}{3} \right]^{1/3} a^{5/3} N$$

Inserting $0.9H$ into the expression for F and simplifying gives a quite simple expression:

$$F(0.9H) = 3^{2/3} k_B T \left[\frac{\Gamma}{a} \right]^{1/3} \left[0.9 - \frac{1}{0.9^2} \right]$$

For rescaling we just need to use the Kuhn length for a . Inserting all vales should give 1.3×10^{-21} N. Multiply with the number of coils the tip will push (2×10^7) to get 27 fN.

Helpful constants and data

Boltzmann's constant: $1.381 \times 10^{-23} \text{ JK}^{-1}$

Avogadro's number: $6.022 \times 10^{23} \text{ mol}^{-1}$

Permittivity of free space: $8.854 \times 10^{-12} \text{ m}^{-3} \text{ kg}^{-1} \text{ s}^4 \text{ A}^2$

Planck's constant: $6.626 \times 10^{-34} \text{ m}^2 \text{ kgs}^{-1}$

Speed of light in vacuum: $2.998 \times 10^8 \text{ ms}^{-1}$

Kelvin temperature scale: $0 \text{ }^\circ\text{C} = 273.15 \text{ K}$

Elementary charge: $1.602 \times 10^{-19} \text{ C}$

Properties of water at room temperature

Density: $1.0 \times 10^3 \text{ kgm}^{-3}$

Dynamic viscosity: $1.0 \times 10^{-3} \text{ Pas}$

Relative permittivity (static field): 80

Refractive index (at 589 nm): 1.333

Interfacial energy (against air): $7.2 \times 10^{-2} \text{ Jm}^{-2}$

B = Solids

Hg = Liquids

Kr = Gases

Pm = Not found in nature

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87 (223) Fr	88 (226) Ra	103 (262) Lr	104 (261) Rf	105 (262) Db	106 (263) Sg	107 (262) Bh	108 (265) Hs	109 (266) Mt	110 (269) Ds	111 (272) Rg	112 (277) Cn	113 (277) Uut	114 (277) Uuq	115 (277) Uup	116 (277) Uuh	117 (277) Uut	118 (277) Uuq	119 (277) Uup	120 (277) Uuh	121 (277) Uut	122 (277) Uuq	123 (277) Uup	124 (277) Uuh	125 (277) Uut	126 (277) Uuq	127 (277) Uup	128 (277) Uuh	129 (277) Uut	130 (277) Uuq	131 (277) Uup	132 (277) Uuh	133 (277) Uut	134 (277) Uuq	135 (277) Uup	136 (277) Uuh	137 (277) Uut	138 (277) Uuq	139 (277) Uup	140 (277) Uuh	141 (277) Uut	142 (277) Uuq	143 (277) Uup	144 (277) Uuh	145 (277) Uut	146 (277) Uuq	147 (277) Uup	148 (277) Uuh	149 (277) Uut	150 (277) Uuq	151 (277) Uup	152 (277) Uuh	153 (277) Uut	154 (277) Uuq	155 (277) Uup	156 (277) Uuh	157 (277) Uut	158 (277) Uuq	159 (277) Uup	160 (277) Uuh	161 (277) Uut	162 (277) Uuq	163 (277) Uup	164 (277) Uuh	165 (277) Uut	166 (277) Uuq	167 (277) Uup	168 (277) Uuh	169 (277) Uut	170 (277) Uuq	171 (277) Uup	172 (277) Uuh	173 (277) Uut	174 (277) Uuq	175 (277) Uup	176 (277) Uuh	177 (277) Uut	178 (277) Uuq	179 (277) Uup	180 (277) Uuh	181 (277) Uut	182 (277) Uuq	183 (277) Uup	184 (277) Uuh	185 (277) Uut	186 (277) Uuq	187 (277) Uup	188 (277) Uuh	189 (277) Uut	190 (277) Uuq	191 (277) Uup	192 (277) Uuh	193 (277) Uut	194 (277) Uuq	195 (277) Uup	196 (277) Uuh	197 (277) Uut	198 (277) Uuq	199 (277) Uup	200 (277) Uuh	
57 138.9055 La	58 140.116 Ce	59 140.50765 Pr	60 144.24 Nd	61 (145) Pm	62 150.36 Sm	63 151.964 Eu	64 157.25 Gd	65 158.92534 Tb	66 162.50 Dy	67 164.93032 Ho	68 167.26 Er	69 168.93421 Tm	70 173.04 Yb	71 174.967 Lu	72 178.49 Hf	73 180.9479 Ta	74 183.84 W	75 186.207 Re	76 190.23 Os	77 192.217 Ir	78 195.078 Pt	79 196.56655 Au	80 200.59 Hg	81 204.3833 Tl	82 207.2 Pb	83 208.58038 Bi	84 (209) Po	85 (210) At	86 (222) Rn	87 (223) Fr	88 (226) Ra	89 232.0381 Ac	90 232.0381 Th	91 231.035888 Pa	92 238.0289 U	93 (237) Np	94 (244) Pu	95 (243) Am	96 (247) Cm	97 (247) Bk	98 (251) Cf	99 (252) Es	100 (257) Fm	101 (258) Md	102 (259) No																																																							