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.

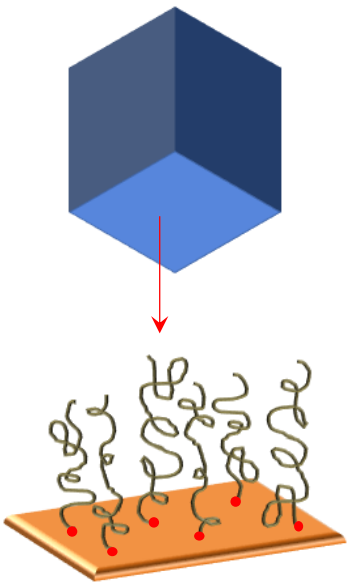
The material will consist of hard (crystalline) domains and soft regions in between. Higher degree of crystallinity makes the material brittle and lower more makes it easier to deform. Degree of crystallinity is reduced for instance by branching and random stereochemistry.

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 × 10 μm^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:

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



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

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

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: 1.381×10^{-23} JK^{-1}

Avogadro's number: 6.022×10^{23} mol^{-1}

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

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

Speed of light in vacuum: 2.998×10^{8} ms^{-1}

Kelvin temperature scale: 0 °C = 273.15 K

Elementary charge: 1.602×10^{-19} C

Properties of water at room temperature

Density: 1.0×10^{3} kgm^{-3}

Dynamic viscosity: 1.0×10^{-3} Pas

Relative permittivity (static field): 80

Refractive index (at 589 nm): 1.333

Interfacial energy (against air): 7.2×10^{-2} Jm^{-2}

B = Solids Hg = Liquids Kr = Gases Pm = Not found in nature

1																	18
1 H 1.00794	2											13	14	15	16	17	2 He 4.002602
3 Li 6.941	4 Be 9.012182											5 B 10.811	C 12.0107	7 N 14.00674	8 O 15.9994	9 F 18.9984032	10 Ne 20.1797
11 Na 22.989770	12 Mg 24.3050	3	4	5	6	7	8	9	10	11	12	13 Al 26.581538	14 Si 28.0855	15 P 30.973761	16 S 32.066	17 Cl 35.4527	18 Ar 39.948
19 K 39.0983	20 Ca 40.078	21 Sc 44.955910	22 Ti 47.867	23 V 50.9415	24 Cr 51.9961	25 Mn 54.938049	26 Fe 55.845	27 Co 58.933200	28 Ni 58.6534	29 Cu 63.545	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.92160	34 Se 78.96	35 Br 79.504	36 Kr 83.80
37 Rb 85.4678	38 Sr 87.62	39 Y 88.90585	40 Zr 91.224	41 Nb 92.90638	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.90550	46 Pd 106.42	47 Ag 196.56655	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.760	52 Te 127.60	53 I 126.90447	54 Xe 131.29
55 Cs 132.90545	56 Ba 137.327	71 Lu 174.967	72 Hf 178.49	73 Ta 180.94.79	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.217	78 Pt 195.078	79 Au 196.56655	80 Hg 200.59	81 Tl 204.3833	82 Pb 207.2	83 Bi 208.58038	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	103 Lr (262)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 Ds (269)	111 Rg (272)	112 Cn (277)	113 Uut (277)	114 Uuq (277)	115 Uup (277)	116 Uuh (277)		118 Uuo (277)

57 La 138.9055	58 Ce 140.116	59 Pr 140.50765	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.964	64 Gd 157.25	65 Tb 158.92534	66 Dy 162.50	67 Ho 164.93032	68 Er 167.26	69 Tm 168.93421	70 Yb 173.04
89 Ac 232.0381	90 Th 232.0381	91 Pa 231.035888	92 U 238.0289	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)