Questions for Colloid chemistry lecture exam
In case of expressions, equations or graphs always give the meaning of symbols, and the unit!

Minimum questions

1. Give the Einstein-Stokes expression, which describes the relation between the diffusion coefficient and particle radius:
   Equation: Where the symbols are:

2. **Langmuir isotherm** describes the process of …………. in quantitative way, and it gives the relationship between ………………… and ………………….
   Equation: Give the sketch of the isotherm, and indicate what on the axes are!
   Meaning of the symbols:

   The expression is valid under the following conditions:
   ………………………………………………………………………………………………………
   ………………………………………………………………………………………………………

3. The **Gibbs equation** specifies the surface excess concentration as a function of concentration and surface tension in the following way:
   Equation: Give a sketch of the surface excess for a surface active compound! Indicate what on the axes are!
   Meaning of the symbols:

4. The **Kelvin equation** describes the relation between the vapor pressure over the curved surface as a function of …………………….. by the following equation:
   Equation: Meaning of the symbols:

5. The **diffuse double layer or Gouy-Chapman model** gives the expression of …………………… as a function of ………………… by the following:
   Equation: Give the sketch of the curve, and indicate what on the axes are!
   Meaning of the symbols:
6. **The Stern model** describes the ……………………as a function of …………………… by the following:
   Equation:

   Give the sketch of the curve, and indicate what on the axes are!

   Meaning of the symbols:

7. Give the two definitions of **surface tension** (for pure liquid, and generally) with the equations and units!

   **Definitions (drawings are accepted, as well)**

1. In a certain sense colloid chemistry can be considered as the physical chemistry of ……….. systems. *Fill in the gap to complete the statement!*
2. What is the definition of **coherent system**?
3. What is the definition of **incoherent system**?
4. What is the definition of **colloid system**?
5. What is the definition of **particle**?
6. What is the definition of **degree of dispersion**?
7. What is the definition of **polydispersity**? (It is enough to give one equation and the meaning of the symbols).
8. Give the definition of the **number average**. (It is enough to give one equation and the meaning of the symbols)
9. Give the definition of the **mass weighted average**. (It is enough to give one equation and the meaning of the symbols)
10. Give the definition of **Gibbs’ phase rule** applied for heterogeneous systems. (It is enough to give the equation and the meaning of the symbols)
11. Define the **diffuse spatial distribution**.
12. Define the **homogeneous spatial distribution**.
13. Define the **heterogeneous spatial distribution**.
14. Define the **nematic spatial distribution**.
15. Define the **smectic spatial distribution**.
16. Define the **tactoid spatial distribution**.
17. What are the **aerosols**? Give their **subcategories** based on inner/outer phases.
18. What are the **lyosols**? Give their **subcategories** based on inner/outer phases.
19. What are the **xerosols**? Give their **subcategories** based on inner/outer phases.
20. What is the definition of **adsorption**?
21. What is the definition of **interface**?
22. What is the definition of **Brownian motion**?
23. What is the definition of **Hardy-Harkins principle**?
24. Characterize the **physisorption**.
25. Characterize the **chemisorption**.
26. Give the conditions of use of the **BET isotherm**.
27. What is the **capillary condensation**? Give its conditions.
28. Define the **stability ratio**. (equation is accepted, as well).
29. Define the **viscosity** with one equation using the shear stress and shear rate.
30. Define the **spreading coefficient**. (or spreading tension).
31. Give the definition of the **Stokes radius**.
29. Define the principles of the sedimentation.
30. Give the definition of the zero charge.
31. Give the definition of the diffusion coefficient.
32. Mention some diffusion measurement methods.
33. What is the definition of the Donnan potential?
34. Give the definition of the ideal fluid.
35. What is the definition of the elastic material?
36. Give the definition of the viscoelastic material.
37. What is the definition of the hysteresis?
38. Give the definition of the light scattering phenomena.
39. Give the definition of surface inactive compounds.
40. Give the definition of surface active compounds (surfactants).
41. What is the definition of amphiphilic molecules? Give an example by drawing the structure formula of the substance.
42. What are the micelles? Define the critical micelle concentration (cmc).
43. How would you determine the cmc of an association colloid?
44. How does change the cmc of association colloids composed of ionic amphipiles when small salt molecules are added, and what is the explanation of the phenomenon?
45. What is solubilization? (Give the answer in two sentences.)
46. What is the HLB value? What does it mean when the HLB value of a surfactant is low (1-3), and when it is high (15-18)?
47. What are the emulsifiers and what is their role in making emulsions?
48. What are the main surfactant components of modern washing detergents? (compound name and simplified structure)
49. Briefly summarize the washing effect (type of contamination, wetting, dissolution, solubilization, chemical composition of modern washing detergents).
50. What is the definition of colloid macromolecules?
51. What is the definition of semi-permeable membrane?
52. What is the definition of osmosis?
53. What is the definition of dialysis?
54. Give the kinetic energy of a molecule that has a weight of m at a given temperature.
55. What is the definition of sedimentation?

Examples

1. What is the definition of lyophobic colloids? Give two examples.
2. What is the definition of lyophilic colloids? Give two examples.
3. Give an example for lyophobic sol.
4. Give an example for colloid macromolecule system.
5. Give an example for association colloid system.
6. Give an example for spongoid coherent system.
7. Give an example for smectic orientation colloid system.
8. Give an example for anionic surfactant.
9. Give an example for cationic surfactant.
10. Give an example for nonionic surfactant.
11. Give an example for surface inactive agent.
12. Give an example for association colloid.
13. Give 3 examples for measurement techniques to determine particle size.
14. List 3 chromatographic techniques.
15. List the conditions to be met to use the Langmuir isotherm.

16. List 5 techniques that are suitable to the study solid surfaces.

17. Mention 3 methods which are suitable to determine the diffusion coefficient.

18. Give practical application examples for thixotropic materials.

19. Give examples for shear thinning materials.

20. Give examples for shear thickening materials.

21. Mention 3 methods which are suitable to determine the diffusion coefficient.

22. Give practical application examples for thixotropic materials.

23. Give examples for polypeptides.

24. Give examples for artificial homopolymers.

25. Give examples for polysaccharides.

26. Give example for cross-linked polymers.

27. Give example for methods which are suitable to determine the molecular weight of dissolved polymers.

Test (simple choice)

1) Which of the following statements is true for colloid chemistry?
   a) Colloid chemistry is the science of the microscopic size range.
   b) The change of internal energy is of significant importance to explain the changes describing colloid systems.
   c) Colloid systems do not have a particular role in biological systems.
   d) One of the most important phenomena studied in colloid chemistry is the surface tension.

2) Which of the followings does not belong to colloid systems?
   a) Gelatin solution.
   b) Red gold sol.
   c) Potassium chloride solution.
   d) Soap solution.

3) Which of the following statements is not true for normal distribution?
   a) The differential function of normal distribution is a bell-shaped curve.
   b) 95,5 % of the particles can be found in the range of the mean value ±σ.
   c) The average size equals to the x coordinate of the peak maximum of the differential distribution curve.
   d) The frequency of particles larger than the average size by a given δ value equals to the frequency of particles smaller than the average size by the same δ value.

4) Which particle shape is not anisometric?
   a) Prolate.
   b) Oblate.
   c) Octahedral.
   d) Rod.

5) Which of the followings does not indicate a colloidal system?
   a) Lyophobic sol.
   b) Lyogel.
   c) Lyotropic series.
6. Which method is not a sedimentation method?
   a) Ultracentrifugation.
   b) Sedimentation.
   c) Gel filtration.
   d) Centrifugation.

7. Which method is not suitable for determine the size of a polymer?
   a) Light scattering measurement.
   b) Sedimentation methods.
   c) Light microscopy.
   d) Viscosity measurement.

8. Which method is not suitable for determine the size of a polymer?
   a) Diffusion measurement.
   b) Gas adsorption.
   c) Gel filtration.
   d) Electron microscopy.

9. Which instrument is not suitable to measure viscosity?
   a) Ostwald viscometer.
   b) Tensiometer.
   c) Rotational viscometer.
   d) Rheometer.

10. From the followings which statement is true for light scattering measurements?
    a) The frequency of the irradiating light is different from the frequency of the scattered light.
    b) It is possible to determine the size of macromolecules with a light scattering method.
    c) The intensity of the scattered light is equal in any direction.
    d) The light scattering phenomena only exist in case of laser light irradiation.

11) From the followings which statement is true for micelles?
    a) Micelles are particles that are formed by the association of amphiphilic molecules in a thermodynamically unstable state.
    b) The polar head group of the amphiphilic molecules is inside the micelle in case of inverted micelles.
    c) Cylindrical micelles are called vesicles.
    d) The shape of the surfactant has no effect on the structure of the formed micelle.

12) From the below mentioned compound categories which belongs not to the nonionic surfactants?
    a) Fatty acid esters.
    b) Ethers.
c) Alkylsulfonic acids.
d) Fatty acid amides.

13) From the followings which statement is true for surfactants above the Krafft temperature?

a) The solubility increases for all types of surfactants.
b) It has an effect only on the solubility of nonionic surfactants.
c) The solubility of ionic surfactants increases.
d) The solubility of nonionic surfactants increases.

14) What is the contact angle ($\theta$) in case of perfect wetting?

a) $\theta = 180^\circ$
b) $\theta = 90^\circ$
c) $\theta < 30^\circ$
d) $\theta \sim 0^\circ$

15) From the followings which is a non existing micelle structure?

a) Cylindrical micelle.
b) Bipyramidal micelle.
c) Vesicle.
d) Inverted micelle.

16) In which case has the change of surfactant concentration around the cmc value the lowest effect on the physical properties of a surfactant solution (e.g. Na dodecylsulfate)?

a) washing effect
b) density
c) osmotic pressure
d) surface tension

17) From the following statements which is false for polymers?

a) They can usually be synthesized cheaper than metals and ceramics.
b) Their properties can change in a wide range.
c) They are composed of monomers.
d) They have not gained any application in microelectronics yet.

18) From the following statements which is true for the Donnan-equilibrium?

a) The equilibrium concentration of the ions on the two sides of the membrane is the same.
b) Macromolecule ions „hinder” the diffusion of small molecules.
c) Potential difference can be measured between the solutions on the two sides of the semi-permeable membrane.
d) In Donnan equilibrium the small cations diffuse in a smaller extent due to their larger hydrate shell compared to the diffusion of small anions.
19) From the following statements which is true for polymers?
   a) The cross-linked polymers belong to the group of macromolecular colloids.
   b) The characteristic of alternating polymers is the branching chain structure.
   c) Linear polymers retain the shape of statistic coil in solutions.
   d) The net amount of steel produced exceeds the amount of polymers produced.

20) In which case are the two mentioned properties not directly connected?
   a) The degree of branching of the macromolecule and its molecular weight.
   b) The average end-to-end distance of a linear polymer and the segment length.
   c) Hydrodynamic radius of the macromolecule and its diffusion coefficient.
   d) The average molecular weight of a polymer with given structure and the viscosity of its solution.

21) Which of the followings is not influenced by the hydrodynamic radius of the macromolecular colloid?
   a) The retention time measured by size exclusion chromatography.
   b) The number of end groups.
   c) The extent of light scattering.
   d) The value of the diffusion constant.

22) Which of the following statements is false for size exclusion chromatography?
   a) The principle of size exclusion chromatography is the distribution equilibrium between the stationary and moving phases.
   b) The larger molecules are eluted earlier from the column than small molecules.
   c) Size exclusion chromatography is suitable for determining not only the size, but also the size distribution of a polymer.
   d) The retention time depends on the hydrodynamic radius of the molecules, not directly on their molar mass.

Data

1. Match the following substances with the given surface tension values expressed in mn/m. Explain your answer.

<table>
<thead>
<tr>
<th>Substance</th>
<th>Surface Tension (mn/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>water</td>
<td>21.8</td>
</tr>
<tr>
<td>octanol</td>
<td>485</td>
</tr>
<tr>
<td>hexane</td>
<td>72.8</td>
</tr>
<tr>
<td>octane</td>
<td>27.5</td>
</tr>
<tr>
<td>mercury</td>
<td>18.4</td>
</tr>
</tbody>
</table>

1. Pair the following electrolyte concentrations with the thickness of double layer, and explain it.

<table>
<thead>
<tr>
<th>Concentration (mol·dm⁻³)</th>
<th>Thickness of Double Layer (nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>2.56</td>
</tr>
<tr>
<td>0.10</td>
<td>25.6</td>
</tr>
<tr>
<td>0.01</td>
<td>0.256</td>
</tr>
<tr>
<td>0.0001</td>
<td>0.811</td>
</tr>
</tbody>
</table>
2. Proteins are being separated by Gel electrophoresis (SDS-PAGE), where the time between the injection and the detection is measured (migration time). Pair the following proteins with their migration times and explain it. (Molecular weights of the proteins are given in kDa units between parentheses.)

<table>
<thead>
<tr>
<th>Protein</th>
<th>Migration Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>albumin (67)</td>
<td>2.3 min</td>
</tr>
<tr>
<td>ferritin (450)</td>
<td>10.9 min</td>
</tr>
<tr>
<td>cytochrome-c (12)</td>
<td>18.1 min</td>
</tr>
<tr>
<td>catalase (250)</td>
<td>31.2 min</td>
</tr>
</tbody>
</table>

3. Connect the following particle diameter–diffusion coefficient – displacement values. Justify the answer.

<table>
<thead>
<tr>
<th>Diameter (a)</th>
<th>Diff. coeff. (D)</th>
<th>Displacement in 1 hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1 \times 10^{-9}$</td>
<td>$2 \times 10^{-13}$</td>
<td>1230</td>
</tr>
<tr>
<td>$1 \times 10^{-8}$</td>
<td>$2 \times 10^{-12}$</td>
<td>390</td>
</tr>
<tr>
<td>$1 \times 10^{-7}$</td>
<td>$2 \times 10^{-11}$</td>
<td>123</td>
</tr>
<tr>
<td>$1 \times 10^{-6}$</td>
<td>$2 \times 10^{-10}$</td>
<td>39</td>
</tr>
</tbody>
</table>

**Figures**

1. Draw the integral and differential particle size distribution curves of a monodisperse and a polydisperse system.

2. The following graph shows the surface excess concentration of isopropanol as a function of its concentration. Interpret the curve.

3. Give the name of the following isotherms.
4. In the following graph the surface tensions of five alcohols (ethanol, propanol, butanol, pentanol, hexanol) is plotted as a function of their concentrations. Write the name of the alcohols on the corresponding curves.

5. In the following graphs the adsorption isotherms of organic acid solutions are plotted. Write the characteristic properties of the adsorbent and the solvent (that is hydrophobic or hydrophilic) under the graphs.

6. Interpret the linearized form of the Langmuir isotherm based on the following graph. Calculate the value of monolayer capacity ($a_m$).

7. Interpret the following figure on the basis of Hardy-Harkins principle.
8. What is the type of the isotherm shown in this figure? Which equation should you use to describe it?

![Isotherm Graph]

9. Interpret the isotherm shown in the first figure and explain the process using the second figure.

![Isotherm and Process Diagram]

10. The surface potential of a given quartz nanoparticle is -240 mV which further decreases with increasing distance from the surface; this phenomenon is caused by the presence of sodium dodecylsulfate (SDS). After a given distance the potential begins to decay exponentially. What phenomena had been described? Which model can be used to characterize the double layer (equation!)? Give the sketch of the graph that gives the potential change as a function of distance from the surface.

11. The surface potential of a given Al₂O₃ nanoparticle is +120 mV which decreases to -70 mV in Na₃PO₄ solution in a certain (more distant) layer, while it begins to decay exponentially at an even higher distance from the
surface. What phenomena had been described? Which model can be used to characterize the double layer (equation!)? Give the sketch of the graph that gives the potential change as a function of distance from the surface.

12. The following graph shows the change of the potential as a function of the distance from the colloid particles in a solution with an electrolyte concentration of 0.1 M. How does this curve change if we increase the inert salt’s concentration? Give the sketch of the new curve on the graph, and explain it.

13. Draw the typical flow and viscosity curves of different types of materials. (There are six rheological subcategories!)

15. Draw the flow and viscosity curves of shear thinning materials.
17. Draw the flow and viscosity curves of shear thickening materials.
18. Explain and illustrate the light scattering phenomena.
19. Draw the change of surface tension as a function of surfactant concentration in an aqueous solution of a surfactant (e.g. Na dodecylsulfate). The curve should start from the y axis. Give the labels of the axes.
20. Draw the change of specific conductivity as a function of surfactant concentration in an aqueous solution of a surfactant (e.g. Na dodecylsulfate). The curve should start from the y axis. Give the labels of the axes.
21. Draw the schematic structure of a random copolymer, alternating copolymer, and a block copolymer, if we suppose each of the polymers consist of two kinds of monomers.
22. Draw the schematic sketch of a dialysis device and give the name of its parts.

True or false?
1. Colloid systems contain discontinuities in the size range of 1-500 nm.
2. Colloid systems are heterogeneous systems, since they don’t have isotropic properties.
3. The ultramicroscope designed by Zsigmondy and Siedentopf proved the validity of the solution theory.
4. The color of the gold sol is determined only by the size of the gold particles.
5. The surface plays an important role in the case of colloid systems and heterogeneous systems.
6. By definition, particle is the set of molecules which form a kinetic unit.
7. The colloid state depends on the degree of dispersity and on the chemical properties.
8. The number average of the particles of a polydisperse system is always smaller than the mass weighted average of the particles.
9. Every colloid system is thermodynamically unstable and it can be only kinetically stable.
10. Sols are coherent systems where the continuous phase is liquid.
11. The higher the degree of dispersity of a colloid system, the higher the size of particles it contains.
12. Incoherent systems contain individual particles.
13. The colloid solutions of macromolecules are thermodynamically stable.
14. Gels with reticular structure belong to coherent systems.
15. Colloid systems formed by surfactants are also called dispersion colloids.
16. The opal and the real pearl are L/S dispersions (solid emulsions).
17. Gel is the short name of coherent systems with spongoid structure.
18. The change of free enthalpy during the formation of a thermodynamically stable system is negative.
19. Kinetically stable systems can also be thermodynamically stable.
20. The order of mixing of the components is of no significance during the formation of a colloid system.
21. The shape of the particles in a colloid system has no significant influence on the properties of the system.
22. Normal distribution is called Poisson distribution with other words.
23. The variance \( \sigma \) can be determined at the 16 and 84 % of the maximum height of the bell curve in case of normal distribution.
24. The size of particles that can be determined by electron microscopy is smaller than the size of particles measurable by optical microscopy.
25. Light scattering photometry can be used for the determination of the average size of sol particles.
26. Wetting is enhanced by the use of surfactants.
27. The surface tension of water is increased by the addition of alcohols.
28. The value of surface excess concentration is always a positive number.
29. \( \Delta G \) is negative for adsorption, thus it always occurs spontaneously.
30. The degree of adsorption of butyric acid on the surface of activated charcoal from aqueous solution is smaller than the degree of adsorption of acetic acid.
31. The sorption property depends on the number of carbon atoms of the sorbate.
32. The components to be separated are transported in two phases (one is the stationary, the other is the moving phase) during chromatographic techniques.
33. The diffusion coefficient is inversely proportional to the viscosity and the temperature of the media.
34. The surface activity is decreasing with the number of carbon atoms.
35. The Freundlich isotherm describes the relationship between surface concentration and equilibrium concentration for solutions.
36. Sodium chloride is a surface active agent.
37. The determination of the specific area of an adsorbent from the adsorption of indigo carmine and nitrogen gas respectively provides the same result.
38. Ethanol is a surface inactive compound.
39. The chemical structure and the degree of freedom of adsorbate is not changing during physisorption.
40. The adsorption of gases on solid surfaces is not an equilibrium process.
41. The adsorption of gases on solid surfaces is an equilibrium process, but it is independent of temperature.
42. BET isotherm is used for the characterization of multilayer adsorption processes; the distribution of adsorbate among the layers is constant.
43. The conditions of validity for the Langmuir isotherm are: monolayer adsorption, inhomogeneous surface, dynamic equilibrium between adsorption and desorption.
44. The surface tension of a solid surface is increasing during adsorption.
45. Van der Waals interaction is always of attractive nature.
46. The degree of dispersion interaction depends on the shape of the molecules.
47. The structure of proteins is influenced by hydrophobic interactions.
48. The SI unit of the $V_{\text{max}}$ potential energy characteristic to the sol-gel conversion is $m^3$.
49. The Gibbs phase rule is applicable to colloid systems as well; the regularities of the interfaces are derived from this rule.
50. The stability of colloids dispersed in liquid media is influenced by the material properties of the media.
51. The kinetic stability of the colloids decreases with the decrease of the temperature.
52. Polymers in small concentrations exert a stabilizing effect on lyophobic sols.
53. The stabilizing or sensitizing property of a polymer depends on the concentration of the polymer.
54. The potential barrier ($V_{\text{max}}$) is higher than the thermal energy in case of gels.
55. The stability of gels is independent of the volume of the solution.
56. Stability ratio is influenced by viscosity.
57. During electroosmosis the neutral particles also move.
58. Thickness of the double layer of a charged colloid particle depends on the temperature.
59. In electrophoresis we measure the pressure change caused by the movement of charged particles.
60. The thickness of an electrical double layer can be increased by using a more diluted electrolyte solution.
61. Silver iodide gives neutral particles in aqueous media because the concentration of silver and iodide ions is equal.
62. Charged particles can not be formed by the adsorption of water molecules.
63. Surface tension value of sodium dodecylsulfate is negative because it forms micelles with a negative charge.
64. The charge of a colloid particle can increase (in numerical value) in a certain distance.
65. At isoelectric pH the charge of the protein does not depend on the electrolyte present in the solution.
66. Stern potential can be determined by the streaming potential method.
67. Electrophoretic mobility of a charged colloid depends on its electrokinetic (zeta)-potential.
68. During electroosmotic measurements the liquid moves in the capillary by a force exerted by an external electric field.
69. Electric potential gradient is being used in the isoelectric focusing technique.
70. Nanoparticles of magnetite ($\text{Fe}_3\text{O}_4$) with an isoelectric point of 6.9 are positively charged in alkaline media.
71. Charged nanoparticles can be prepared by mixing $\text{AgNO}_3$ and $\text{KI}$ solutions of the same volume and molar concentration.
72. Particles with an electrical double layer cannot coagulate.
73. The charge of a nanoparticle with a positive value of surface potential can be further increased by the adsorption of a neutral surfactant.
74. In case of sedimentation potential technique we measure the change of surface tension caused by the motion of the particles.
75. All proteins have an isoelectric point.
76. The isoelectric point can be measured in the shear plane.
77. Sedimentation as size determination method is only suitable for measuring particles in the colloid size range.
78. Centrifugal force is the driving force during centrifugation.
79. Gravity is the driving force during ultracentrifugation.
80. NMR techniques are not suitable for determining the diffusion coefficient.
81. Shear stress and shear rate correlate linearly in case of Newtonian fluids.
82. Drilling mud is a thixotropic material.
83. Creams are shear thickening materials.
84. Viscosity measurements have an important role in food industry.
85. The rheological class of a disperse system does not depend on the shape of the dispersed particles.
86. The viscosity of the materials does not depend on the temperature.
87. The viscosity of an O/W emulsion is decreasing when it is diluted with water.
88. The viscosity is determined with a ball in the Höppler viscometer.
89. The Ostwald viscosity measurement method is not sensible to the temperature change.
90. With viscosity measurement we can determine the $M_w$ of a polymer in solution.
91. The diffusion coefficient of the particles can be determined with a light scattering method.
92. We can determine the $M_w$ of a polymer in solution with the Dynamic Light Scattering method.
93. We can determine the diffusion coefficient of the dispersed particles in a dispersion with the Dynamic Light Scattering method.
94. Colloid systems can be made only from organic substances.
95. The solution of a soap is a colloidal system at any concentrations.
96. The surface tension increases with the increase of the concentration of a nonionic surfactant.
97. $\Delta G$ is negative for the formation of micelles.
98. The cmc increases when the number of carbon atoms is increased in an amphiphilic molecule.
99. The HLB value of Na dodecylsulfate is 40, thus it stabilizes W/O emulsions.
100. The wetting is improved when surfactants are used.
101. NaCl is an amphiphilic compound, while NaI is not.
102. The HLB value of a surfactant characterizes its kinetical stability.
103. Emulsions can be stabilized sterically.
104. The driving force of micelle formation is the decrease in surface tension.
105. The driving force of micelle formation is the rearrangement of the structure of water.
106. The driving force of micelle formation is the decrease of Gibbs free energy of the system.
107. Sodium stearate is a cationic surfactant.
108. Cetyltrimethyl ammonium bromide is a cationic surfactant.
109. Zwitterionic surfactants have zero surface charge under any circumstances.
110. Heating delays the formation of micelles in case of ionic surfactants.
111. Each electrolyte that reduces the degree of dissociation of nonionic surfactants reduces the cmc as well.
112. When ionic surfactants are heated, they get cloudy (Krafft point).
113. When nonionic surfactants are heated, they get cloudy (cloud point).
114. Micelles are composed of two layers of amphipathic molecules, while vesicles consist of one layer of amphipathic molecules.
115. The washing effect is increasing as the concentration of detergent is decreasing.
116. The washing effect is linearly increasing with the increase of concentration of the detergent.
117. Calgon contains polyphosphoric acid among others that protects the washing machine from scale formation.
118. The contamination on the clothes is always hydrophilic from the aspect of colloid chemistry.
119. The average density of polymers is lower than the density of metals, by this way polymers are softer than metals.
120. The distribution of monomers is statistic along the polymer chain in the case of random copolymers.
121. The hydrodynamic radius and the molecular weight of a polymer are not always related to each other.
122. The shape of linear polymers in theta-solvent is the same as in bulk phase.
123. The fully extended length of a linear polymer equals to the average end-to-end distance.
124. Even the cross-linked polymers can be dissolved in appropriate solvents.
125. The number-averaged molecular weight of a polydisperse polymer is always smaller than the mass-weighted average of its molecular weight.

126. Each of the polymers can be sedimented using high enough gravitational acceleration.

127. Osmosis is the process where the solute goes through a semi-permeable membrane.

128. Diffusion can occur only in the direction of the concentration gradient.

129. An animal cell is contracted in hypertonic solution due to water discharge from the cell.

130. Isotonic solutions can be prepared only from electrolytes.

131. Osmotic pressure depends on the molecular weight of the dissolved macromolecule.

132. Light scattering photometer is used for the qualitative and quantitative determination of materials which partially absorb the light of the irradiation source.

133. Blue color of the sky is caused by light scattering phenomena: the red rays of sunlight are scattered on the gas molecules of the atmosphere to a higher extent than the blue rays.

**Calculation problems**

1. The size of particles in a lyophobic sol was determined and the concentration of the individual particles was calculated. The result is the following:

<table>
<thead>
<tr>
<th>Diameter of particles (nm)</th>
<th>Number of particles per ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>$10^6$</td>
</tr>
<tr>
<td>4</td>
<td>$3.5 \cdot 10^8$</td>
</tr>
<tr>
<td>5</td>
<td>$4.2 \cdot 10^8$</td>
</tr>
<tr>
<td>6</td>
<td>$2 \cdot 10^7$</td>
</tr>
<tr>
<td>7</td>
<td>$7 \cdot 10^5$</td>
</tr>
</tbody>
</table>

Calculate the average particle diameter and the volume average in the sol, assuming spherical particle shape (the volume of a sphere: $V=\frac{4}{3}\pi r^3$).

2. Calculate the size of a spherical macromolecule that has a diffusion coefficient of $5.5 \times 10^{-11}$ m$^2$s$^{-1}$ in aqueous solution (viscosity $\eta=1.001$ mPa s), at 20°C.

3. Calculate the specific adsorbed amount of indigo carmine on the surface of 0.1 g of aluminum oxide, if the volume of the indigo carmine solution is 50 ml, and the starting concentration of 0.25 mmol/dm$^3$ has changed to 0.21 mmol/dm$^3$ after the adsorption.

4. What is the diffusion rate of a particle that has a radius of 8 nm in aqueous solution at room temperature (the viscosity of water is 1.001 mPas)?

5. Calculate the sedimentation rate of a spherical gold particle that has a diameter of 100 nm and its density is 20 g·cm$^3$ in water. The density of water is 1 g·cm$^3$, its viscosity is $10^{-3}$ Pa·s, the Brownian motion is neglected, $k_B=1.38 \times 10^{-23}$ J·K$^{-1}$. 
6. Compare the rate of Brownian motion with the rate of sedimentation in case of silver colloid particles, if the diameter of silver is 20 µm and its density is 10 g·cm⁻³. For the calculations suppose an aqueous medium, where the density of water is 1 g·cm⁻³ and its viscosity is 10⁻³ Pas, \( k_B = 1.38 \times 10^{-23} \text{ J·K}^{-1} \).

7. Calculate the specific area of a colloid particle with a diameter of 10 nm and the specific area of a dispersed particle with a diameter of 10 µm, respectively. For the calculations we suppose that the particles are spherical and their density is 1 g·cm⁻³.

8. Calculate the surface tension on the interface of water and carbon tetrachloride, if \( \gamma_{\text{water}} = 72 \text{ mN·m}^{-1} \) and \( \gamma_{\text{CCl}_4} = 45 \text{ mN·m}^{-1} \). The two liquids are practically immiscible.

9. Calculate the height by which the column of liquid is lifted in a capillary, if the capillary having a diameter of 1 mm is placed in water (\( \delta_{\text{water}} = 1 \cdot \text{gcm}^{-3} \)) and the wetting is perfect. The surface tension of water is 72 m·Nm⁻¹.

10. The coagulation of an electrostatically stabilized macromolecular colloid system is promoted by cations. The critical coagulation concentration for \( \text{CaCl}_2 \) is 0.01 mol·dm⁻³. What should be the concentration of an \( \text{AlCl}_3 \) solution to reach the same coagulation effect, where only the electrostatic stabilization effects are considered for both ions (there are no specific interactions)?

11. The coagulation of an electrostatically stabilized macromolecular colloid system is promoted by anions. The critical coagulation concentration for \( \text{NaCl} \) is 0.01 mol·dm⁻³. What should be the concentration of a \( \text{K}_2\text{SO}_4 \) solution to reach the same coagulation effect, where only the electrostatic stabilization effects are considered for both ions (there is no specific interactions)?

12. Calculate the surface area of an adsorbent if the monolayer capacity is \( 4 \times 10^{-5} \text{ mol·g}^{-1} \), and the area occupied by the adsorbed molecule on the surface is \( \varphi = 1.34 \text{ nm}^2/\text{molecule} \).

13. A colloid particle has a -240 mV surface potential in a given salt solution and the thickness of the double layer is 10 nm. Calculate the potential in a distance of 10 nm from the particle according to the Gouy-Chapman double layer model.

14. A colloid particle has a +300 mV surface potential in a given salt solution and the thickness of the double layer is 15 nm. Calculate the potential at a distance of 15 nm from the particle surface according to the Stern double layer model if the Stern potential is +200 mV and the distance of the Stern layer from the particle is 8 nm.

15. At pH=7 TiO₂ nanoparticles have a surface potential of -60 mV. What pH value has to be set to obtain neutral particles?

16. The isoelectric point of insulin is 5.3. Calculate the „surface“ potential of the protein in blood (pH\(_{\text{blood}}\)=7.4).

17. The isoelectric point of albumin is 5.7. This protein is partially secreted via the urine. Calculate the „surface potential“ of the protein, if the pH of the urine is 6.9.

18. We disperse silica in water. Give the speed of the sedimentation of the particles if their diameter is 20 µm, and their density is 2600 kg/m³. The viscosity of water is 0.001 Pa·s, \( g = 9.81 \text{ m/s}^2 \).
19. We disperse silica in water. Give the diameter of the particle if its density is 2600 kg/m³, the viscosity of water is 0.001 Pa·s, \( g = 9.81 \text{ m/s}^2 \), and a particle sedimented 20 cm in 30 minutes.

20. Give the HLB value of a mixture of surfactants that contains 90% of Span 80 (HLB = 4.3) and 10% of Tween 80 (HLB = 15.0). Can we use this mixture for the stabilization of W/O emulsions?

21. We want to prepare a mixture from Tween 20 (HLB = 16.7) and Span 20 (HLB = 8.6), where the HLB of the mixture is 12.2. What should be the ratio of Tween 20 and Span 20 in the solution expressed in % (m/m)?

22. For the emulsification of a strongly apolar substance (e.g. oil) a solubilizing agent with HLB = 14 is needed. How to prepare such mixture from Span 80 (HLB = 4.3) and Tween 80 (HLB = 15.0)? (What should be the m/m % of the components in the solution?)

23. Calculate the diffusion constant of a macromolecule that has a hydrodynamic radius \( r_H = 2.5 \text{ nm} \) in water at 25 °C. For the calculations use the Stokes-Einstein equation. (\( k = 1.3806 \times 10^{-23} \text{ m}^2 \cdot \text{kg} \cdot \text{s}^2 \cdot \text{K}^{-1} \), \( \eta = 0.001 \text{ Pa} \cdot \text{s} \)). Give also the equation used for the calculation.

24. A vessel is separated into two parts in the middle with a semi-permeable membrane. In one side of the membrane we add a 0.2 mol·dm⁻³ KCl solution to the vessel, while the other side of the membrane contains 0.1 mol·dm⁻³ of potassium proteinate solution. The protein acts in this particular case as an anion with three negative charges and it cannot penetrate the membrane due to its size in contrast to the \( \text{K}^+ \) and \( \text{Cl}^- \) ions which do penetrate. What will be the concentration of the ions on the two sides of the membrane after the equilibrium has been attained?

25. Calculate the molarity of a protein solution that has an osmotic pressure of 2.33 kPa at 37 °C, supposing the ideal case for the calculation. What is the molar weight of this protein, if the concentration of its solution is 0.060 g·cm⁻³? Pay attention to the use of proper units of measurement for the calculations. (All of the given values should be converted to SI units).

**Others**

1. What is the principle of ultramicroscopy?
2. Give the Gibbs phase rule. What is the reason that it is not true for colloid systems?
3. Use the \( X/Y \) indication to identify the group of the following colloid systems. (\( X \) and \( Y \) can be \( G, L \) and \( S \))

- Beer foam
- Silver colloid
- Colored polyethylene
- Cream
- Toothpaste
- Bordeaux mixture
- Hydrate of lime
- Polyurethane foam
- Meat-jelly
- Fog
4. Classify the following systems with its appropriate group. (lyophylic or lyophobic, and coherent or incoherent).

- Aqueous solution of soap
- Soap
- Butter
- Cream
- Real pearl
- Aqueous solution of a protein
- The fluid of fish soup

5. Write a letter T after the name of the listed colloid systems if they are thermodynamically stable and a letter K if they are kinetically stable.

- Emulsions
- Sols
- Gels
- Association colloids
- Macromolecular colloids
- Foam
- Smoke
- Fog
- Microemulsion

6. The average molar weight of the macromolecular colloid is determined by measuring the osmotic pressure. What kind of average is it?

7. The average size of a sol is determined by measuring diffusion (dynamic light scattering). What kind of average is it?

8. List basic particle shapes.

9. What are the three ordered structures that we usually distinguish?

10. Give the equation of the spreading coefficient expressed by the adhesion and cohesion work.

11. What is the temperature where the surface tension becomes zero?

12. What is the change in critical micelle concentration when we increase the concentration of an indifferent electrolyte?

13. What is the surface charge of glass when it is immersed in water? Explain your answer.

14. What are the determining factors of the electrophoretic mobility? (An equation and the meaning of the symbols)

15. The Hamaker equation describes the interaction among the spherical particles of dispersion colloids as a function of the distance. Give the equation.

16. What is the relation between osmotic pressure and concentration for ideal colloid systems?

17. What are the possible physical states (4) of two dimensional monolayers at various monolayer compressions?

18. What is the difference between vesicles and micelles with respect to the solvent?

19. Give the equation that describes the energy of ion-ion interaction as a function of distance. What is the value of its effective range? (Coulomb interaction)
20. Give the equation that describes the energy of dipole-dipole interactions as a function of the distance at „high” temperature. What is the value of effective range?

21. Give the equation that describes the dispersion interaction. What is the value of effective range?

22. Give the equation of the energy of dipole-dipole interaction at „low” and „high” temperatures.

23. What kind of defects can occur on a solid surface?

24. A dispersion colloid can be coagulated with the following electrolytes: 51 mmol·dm\(^{-3}\) NaCl, 0.65 mmol·dm\(^{-3}\) CaCl\(_2\) and 0.095 mmol·dm\(^{-3}\) AlCl\(_3\). What is the charge of the dispersed particle? Explain your answer.

25. Which of the following electrolytes can be used at the lowest concentration for the coagulation of a positively charged sol? CaCl\(_2\), NaCl, Na\(_2\)SO\(_4\), MgSO\(_4\), AlCl\(_3\); Al\(_2\)(SO\(_4\))\(_3\), Na\(_3\)PO\(_4\)? Explain it.

26. We have to separate the following proteins in solution: albumin (67 kDa, pI=5.7); pepsin (34.6 kDa, pI=1.0); cytochrome-c (12kDa, pI=9.2), and catalase (250 kDa, pI=6.7) (pI: isoelectric point). What technique(s) can be used for the separation? What this method is based on? What are the expected results?

27. How can we determine the isoelectric point of a colloid particle? Describe shortly the theory of the determination.

28. How can charged colloid particles be formed without using any external electric field?

29. Solid silver chloride nanoparticles are being dispersed in distilled water, 1 M AgNO\(_3\) and 1 M KI solutions. After equilibration how the particles will be charged (positive, negative or neutral)? Explain it.

30. Clay minerals are frequently used for water purification (e.g. lowering the ion concentration). What is it based on? Describe the processes in these systems.

31. Fill in the empty cells.

<table>
<thead>
<tr>
<th>Technique</th>
<th>What is measured?</th>
<th>What moves?</th>
<th>What causes the movement?</th>
</tr>
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<tbody>
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<td>Electrophoresis</td>
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<tr>
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<tr>
<td>Sedimentation potential</td>
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32. How does the stability of the electrostatically stabilized aqueous colloid system changes, if we
   a, dilute the mixture with distilled water
   b, add large amount of inert salt to it
   c, warm up the sample?
   Explain it.

33. Which direction (toward the cathode or anode) does the liquid flow in an untreated quartz capillary in case of electroosmosis? Explain it.

34. The surface potential of a given colloid particle is a negative value, while the electrokinetic (zeta) potential is positive. What causes this phenomenon and what is the sign of the Stern potential in this system?

35. The surface potential as well as the Stern potential of a colloid particle is positive. What is the sign of the zeta (electrokinetic) potential? Explain it.

36. We want to determine the rheological class of a colloid system. Mention a method which is suitable for this task. Describe the procedure.

37. What is the change in the viscosity of an O/W emulsion if,
   a, We dilute it with water
   b, We add a high excess of inert salt
   c, We heat the sample
38. What is the difference between the „normal” and the ultracentrifugation?