Department of Physics
Examination paper for TFY4310 - Molecular Biophysic
Examination date: 29.11.2021
Examination time (from-to): 9.00 - 13.00
Permitted examination support material:
- Simple calculator in accordance with current NTNU rules and regulations;
- K. Rottmann: Matematisk formelsamling;
- Angell & Lian: Fysiske størrelser og enheter;

Academic contact during examination: Rita de Sousa Dias
Phone: 47155399

OTHER INFORMATION

Get an overview of the question set before you start answering the questions.
Read the questions carefully and make your own assumptions. If a question is unclear/vague, make your own assumptions and specify them in your answer. Only contact academic contact in case of errors or insufficiencies in the question set. Address an invigilator if you wish to contact the academic contact. Write down the question in advance.

InsperaScan: For questions 4.1, 5, 6, and 7.1 it is possible to submit the entire/some parts of the answer as handwritten sheets. At the bottom of the question you will find a seven-digit code. Fill in this code in the top left corner of the sheets you wish to submit. We recommend that you do this during the exam. If you require access to the codes after the examination time ends, click “Show submission”.

Weighting: The weight of each question is indicated. The exam has a max of 80 points.

Notifications: If there is a need to send a message to the candidates during the exam (e.g. if there is an error in the question set), this will be done by sending a notification in Inspera. A dialogue box will appear. You can re-read the notification by clicking the bell icon in the top right-hand corner of the screen.

Withdrawing from the exam: If you become ill or wish to submit a blank test/withdraw from the exam for another reason, go to the menu in the top right-hand corner and click “Submit blank”. This cannot be undone, even if the test is still open.

Access to your answers: After the exam, you can find your answers in the archive in Inspera. Be aware that it may take a working day until any hand-written material is available in the archive.

1 Justify **five** of the following statements:

1. The folding of a globular protein possessing hydrophobic amino acids in water is entropically favorable.

Skriv ditt svar her

2. In an aqueous salt free solution, the critical micellar concentration of ionic surfactants is higher than that of nonionic surfactants.

Skriv ditt svar her

3. Flory-Huggins theory is not applicable to describe the thermodynamics of polyelectrolytes (polymer with charged groups).

Skriv ditt svar her

4. Chromophores, groups of atoms that absorb light in the visible region, are typically conjugated systems (alternating single and double bonds).

Skriv ditt svar her

5. Infra-red spectroscopy and Raman scattering are considered complementary techniques.

Skriv ditt svar her

6. In a COSY spectrum the number of peaks is always equal or larger than those in the corresponding 1D spectrum.

Skriv ditt svar her

7. The Monte Carlo technique is useful in determining the conformational properties of polymer molecules.

Skriv ditt svar her

Maks poeng: 25

2 Double stranded DNA in solution can be denaturated (double to single strand transition) by
i. increasing the temperature of the solution;
ii. adding ethanol to the aqueous solution.

Shortly explain the mechanism behind each of these situations.

Skriv ditt svar her

Maks poeng: 5

3 Match the statements in the rows, with the values in the columns.

Match the values:

	8 um	1.0 kT	0.5 kT	2.5 kT	2.0 nm	0.1 nm	170 kT	56 nm
Magnitude of the potential energy between freely rotating dipoles	○	○	✔	○	○	○	○	○
Magnitude of the London dispersion potential energy between two small molecules	○	✔	○	○	○	○	○	○
Length of H-O bond in water	○	○	○	○	○	✔	○	○
Covalent bond energy in H-H	○	○	○	○	○	○	✔	○
Bjerrum length in vacuum	○	○	○	○	○	○	○	✔
Magnitude of the potential energy between a sodium and a chloride ion in contact in aqueous solution	○	○	○	✔	○	○	○	○
Diameter of a red blood cell	✔	○	○	○	○	○	○	○
Diameter of a DNA molecule in aqueous solution	○	○	○	○	✔	○	○	○

Maks poeng: 4

4 Polyethylene oxide (PEO), $(\text{-CH}_2\text{-O-})_n$, is often used to coat drug carriers to prevent the interaction of the carrier with proteins that impede the delivery of the drugs to the wanted target.

1. The experimental chain dimensions of PEO are given by $\left\langle R_{ee}^2 \right\rangle_0 / M \approx 0.80$ Å^{2}mol/g. Calculate the characteristic ratio of PEO.

M(EO monomer) = 40 g/mol ; EO length = 4.1 Å.

(Use Scantron paper if necessary)

Skriv ditt svar her

2. The Kuhn length of PEO is 6.0 Å. Discuss the differences between this value and the monomer (EO) length.

Skriv ditt svar her

Maks poeng: 7

5 An enzyme with molar mass of 310 kg/mol undergoes a change in shape when the substrate (molar mass of 500 g/mol) binds. This change can be characterized by ultracentrifugation. In the absence of the ligand the sedimentation coefficient of the enzyme in water at 20 ^{o}C is 11.7 S (1 S = 10^{-13} s). The partial specific volume of the protein is 0.732 cm^3/g.

a) Determine the hydrodynamic radius of the enzyme, assuming it is spherical.
(use Scantron paper)

b) Upon the binding of the substrate, the sedimentation coefficient increases by 3.5 %. What is the (hydrodynamic) radius of the bound enzyme? Assume that there are no changes in the partial specific volume of the protein.
(use Scantron paper)

c) X-ray analysis showed that the ligand causes a contraction of the enzyme of about 12 Å along one axis. Why did the radius not change as much?

Skriv ditt svar her

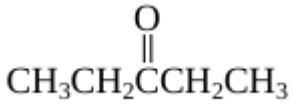
Maks poeng: 15

6 1. Discuss the (two) molecular mechanisms behind the changes to the magnetization vector, $\boldsymbol{M}$, when a rf-pulse of 90^o is applied to a sample, during a nuclear magnetic resonance experiment. Namely:

$\boldsymbol{M_z}: \bar{M}_z \rightarrow 0$ and $\boldsymbol{M_{xy}}: 0 \rightarrow \overline{M}_{xy}$

Skriv ditt svar her

2. Predict the ^{1}H-NMR spectrum of the molecule below, justifying your answer in terms of relative areas, peak splitting and chemical shifts.



Skriv ditt svar her

3. What is the hybridization of the carbons and the oxygen in the molecule of the exercise above? Justify your answer by describing the hybrid orbitals for each of the mentioned atoms and how these combine to form the molecular orbitals present in the molecule.

Skriv ditt svar her

(Use Scantron paper, if needed)

Maks poeng: 15

7 1. Above a certain concentration, the (measured) intensity of an aqueous solutions of the surfactant sodium dodecyl sulfate (SDS), was found to change with the surfactant concentration. Use the following data to calculate the apparent molar mass of the species giving rise to the scattering. Light polarized in the *z*-direction is used in these experiments.

concentration $\times 10^3$ (g cm^{-3})	2.7	4.2	7.7	9.7
measured intensity $\times 10^4$ (cm^{-1})	1.10	1.29	1.71	1.98

$\lambda_0 = 550\ \mathrm{nm};\ n_0 = 1.4;\ \mathrm{d}n_0/\mathrm{d}c = 0.15\ \mathrm{cm}^3/\mathrm{g}.$

(Use Scantron paper)

2. Knowing that the molar mass of the SDS is 288 g/mol, comment the result obtained in the question above as well as the increase in intensity with concentration observed only above a certain concentration.

Skriv ditt svar her

Maks poeng: 9