

Soft Matter Exercise - Chapter 3: Micelles

1. Mixing

The change in free energy at 298 K caused by taking one molecule of n-pentane from pure pentane and putting it into water is 4.1×10^{-20} J.

- How does that compare to the thermal energy
- Explain why pentane is considered to be insoluble in water.
- 85% of this interaction arises from a decrease in entropy. How can the insertion of a foreign molecule into water cause a decrease in entropy?

2. Critical Micelle Concentration

- What is the critical micelle concentration?
- Draw the concentration of free molecules in a solution as a function of molecules added for $0 < \text{CMC} < c_{max}$.

3. Amphiphiles

You are working for a detergent company and are asked to design molecules with a lower CMC than currently used detergents.

- Why are surfactants useful as detergents? Why can they remove water-insoluble dirt?
- Why could it be beneficial for a detergent company to design molecules with a lower CMC?
- How can the composition of hydrocarbon-based amphiphiles be changed to decrease their CMCs?

4. Micelles

Amphiphiles with a molecular weight of 500 g/mol are dispersed at 2.5 wt% in water. They form cylindrical micelles. You measure a critical micelle concentration of 5×10^{-8} mol/L.

- What is the excess energy, ΔE , of these micelles in terms of $k_B T$?
- You change the composition and structure of the amphiphiles such that they form spherical micelles with an excess energy $\Delta E = 20 k_B T$. What is the percentage of aggregates containing 2 molecules? What are the other molecules that are not assembled in these aggregates?

5. Surface Tension

The surface tensions of aqueous solutions containing different concentrations of sodium dodecyl sulfate (SDS), which has 12 C atoms in its hydrophobic chain, were measured at 20°C:

c (mmol/L)	γ (mN/m ⁻¹)
0	72
2	50
4	38
5	20
6	10
7	5.5
8	5.0
9	4.9
10	4.8
12	4.8

- Determine the CMC.
- Assuming the packing density of SDS at the liquid-liquid interface is 1.6 molecules/nm². What is the average area occupied by each SDS molecule?
- What would be the shape of an aggregate made up of this molecule?