Introduction to Colloids and Surfaces – Lista 2

1. At 20 °C the surface tensions of water and n-octane are, respectively, 72.8 and 21.8 mN m^{-1}, while the interfacial tension of the n-octane–water interface is 50.8 mN m^{-1}. Calculate:
   a. the work of adhesion between n-octane and water;
   b. the work of cohesion for (1) n-octane and (2) water;
   c. the initial spreading coefficient of n-octane on water. Will octane initially spread on water?

2. The surface tension of liquid metals reaches rather high values. For Na it is (at 403 K) equal to 198 mN m^{-1} and for Ag it is (at 1373 K) 878.5 mN m^{-1}. In contrast, many liquids like hydrocarbons and alcohols have surface tensions of 18–30 mN m^{-1}. How can you explain why there is such a large difference between the values of the surface tensions for these fluids? Why is the surface tension of water higher (72.1 mN m^{-1} at 298 K) than that of most other liquids? Mention three consequences or applications of the high surface tension of water.

3. The surface tension of n-hexanol is 24.8 mN m^{-1} (at 20 °C). The interfacial tension of the water–n-hexanol liquid–liquid interface is 6.8 mN m^{-1}. Describe what happens over a period of time (at the start and after some time) when a small amount of n-hexanol is dropped onto a clean water surface at 20 °C. The surface tension for a saturated solution of hexanol in water is 28.5 mN m^{-1}.

4. Which of the following systems are not colloids?
   a. a latex composed of polymer molecules dissolved in water;
   b. sugar in water;
   c. milk from the local farm;
   d. micelles of a non-ionic surfactant in an aqueous solution.

5. Wetting is most difficult for:
   a. clean metals
   b. plastics
   c. ceramics
   d. clean glasses.

6. Determine the correct type of dominant intermolecular forces for the following compounds based on the reported values of surface tensions:

Liquid	Surface tension (mN m^{-1})
Mercury	485
Water	72.8
Pentanol	25.2
Benzene	29
Ethylene Glycol	47.7
Perfluoro-octane	12
Hexane	18.4

7. What is the increase in vapor pressure (over that of a flat surface) for droplets of water and n-hexane at 20 °C? For which liquid is the effect more pronounced and why? Make an application for the following droplet radii values: 10^{-7} and 10^{-9} m. The physical data for water and n-hexane, which are required, are given in the following table:

Liquid	Surface tension (mN m^{-1})	Liquid volume (cm^3 mol^{-1})
Water	72.8	18.0
n-Hexane	18.4	130

8. The Gibbs adsorption equation is a fundamental tool in surface science, which enables us to calculate adsorption phenomena on both solid and liquid surfaces.

a. What is the Gibbs adsorption equation?

b. Explain briefly how the area of a surfactant molecule can be calculated using the Gibbs adsorption equation.

9. When a solid (which originally is not in contact with a liquid) is completely immersed in a liquid, then the liquid–gas interface remains unchanged. This happens, for example, for powders immersed in liquids. For this process, which is often called immersional wetting, we define the work of immersion (W_{im}) as the difference between the initial and the final energy of the system. Show that the work of immersion is related to the spreading coefficient via the equation:

$$W_{im} = S + \gamma_{liq}$$

10. Measurements of contact angles for several liquids on a poly(ethylene terephthalate) surface (PET) at the same temperature gave the following results:

Liquid	Contact angle (°)	Surface tension (mN m^{-1})
Water	83.8	71.99
Pyridazine	34.8	49.51
Formamide	51.4	57.03
Benzonitrile	0.0	35.79
Adiponitrile	12.3	45.45
Hydrazine	75.2	66.39
Ethylene glycol	30.1	47.99
Diethylene glycol	9.7	44.77
1,2-Dichloroethane	0.0	39.55

a. Estimate the critical surface tension of PET using the Zisman plot. Is it easier to wet a PET or a polystyrene (33.0 mN m^{-1}) or a Teflon (18.0 mN m^{-1}) surface? Which of the three polymers is easiest to wet and which is the most difficult to wet? Explain briefly your answer. The values in parentheses are the critical surface tension at 20 C.

b. b. Which of the following liquids will completely wet PET: acetone (23.3 mN m^{-1}), glycerol (63.3 mN m^{-1}), hexachloro-butadiene (35.5 mN m^{-1}) and methylene iodide (50.8 mN m^{-1}). Explain briefly your answer. The values in parentheses are the surface tensions at 20 C.

c. Can we use a paint with surface tension equal to 55 mN m^{-1} in order to paint a PET surface? Justify your answer.

11. A foam consists of bubbles with diameters of 2 and 4 mm and a liquid/air surface tension of 40 mN m^{-1}.

a. Calculate the pressure difference between the bubbles and the Plateau borders for a foam consisting of only 2 mm bubbles.

b. Calculate the pressure difference between the 2 mm and the 4 mm diameter bubbles.