Exercise 1

Question 1.1

Explain the composition of the following systems:

- Suspension
- Emulsion
- Foam

Are these systems thermodynamically stable or kinetically stable ?

- Suspension: A solid phase dispersed in a liquid phase
- Emulsion: A liquid phase dispersed in a liquid phase
- Foam: A gas phase dispersed in a liquid phase
- They are all kineticclly stable, given enough time, they will separate.

Question 1.2

You have the following ingredients available:

- Oil (liquid)
- Polymer (a low molecular hydrophobic liquid)
- Water

You can mix two ingredients into one sample. Which binary blends could be classified as colloids? State why/why not for each system. Explain a criterion that can be used to judge whether the blend is a colloid or not.

- One criterion one can use is the particle size of the dispersed phase in the continous phase. If the particles are "molecular sized", the blend is a solution, if they have one (or more) linear dimensions between 1 nm and 1 µm, the blend is a colloid.

- Oil - polymer
  - Is a solution, not a colloid. They are both hydrophobic and will mix on a molecular level, creating a (microscopically) homogenous solution.

- Oil - water
  - Is a colloid. Oil is hydrophobic, and will not mix with water, by applying energy, the oil will break into small droplets which will be dispersed in the water, forming an emulsion. Over time, the phases will completely separate.

- Water-polymer
  - Is a colloid. Polymers are hydrophobic, and similerily to oil, will not mix. The polymer molecules will bind together creating drops/particles of colloidal size. Over time, the phases will separate.

Question 1.3

The specific surface area of polluting dust particles has been determined by gas adsorption

	Treatment	A_{sp} (m^2g^{-1})
a)	4 h under vaccum at 200 °C	5.61
b)	8h under vaccum at 25 °C	2.81

Assume that the particles are monodisperse spheres of density ρ = 2.2 g/cm3.

Calculate the radius of the particles in cm.

a) Assuming spherical particles: $A_{sp} = \frac{3}{\rho R_s}$

$$\frac{m^2}{cm^3} = \frac{(100 \cdot cm)^2}{cm^3} = \frac{10^4 cm^2}{cm^3}$$

$$\Rightarrow R_s = \frac{3}{\rho A_{sp}} = \frac{3}{2{,}2\, g/cm^3 \cdot 5{,}61\, m^2/g}$$

$$R_s = \frac{3}{2{,}2\, g/cm^3 \cdot 5{,}61 \cdot 10^4\, cm^2/g}$$

$$R_s = 2{,}43 \cdot 10^{-5}\ cm$$

b) $R_s = \frac{3}{2{,}2\, g/cm^3 \cdot 2{,}81 \cdot 10^4\, cm^2/g} = 4{,}85 \cdot 10^{-5}\ cm$

c) Propose an explanation for the effect of degassing on particle size.

I do not understand this question, what is degassing?

↳ Assuming the question is "Why does particle size decrease in vaccuum?"

- Because the adsorbed molecules on the surface desorbes, leaving a smaller particle.

Question 1.4

A suspension of spherical polymer particles contains Np = $4 \cdot 10^{13}$ particles/dm^3. The total surface of particles in one dm^3 dispersion is measured to A_{tot} = 820 m^2.

a) Based on the information provided, which type of average diameter can be calculated?

The surface average diameter

b) Calculate this type of diameter. Answer should be in µm.

Surface area of spheres: $A = 4\pi r^2 = 4\pi\left(\frac{d}{2}\right)^2 = \frac{4}{4}\pi d^2 = \pi d^2$

$$\Rightarrow d = \sqrt{\frac{A}{\pi}}$$

Average surface area: $\bar{A} = \frac{A_{tot}}{V \cdot N_p}$

$$\Rightarrow \bar{d}_s = \sqrt{\frac{A_{tot}}{\pi \cdot V \cdot N_p}} = \sqrt{\frac{820 \text{ m}^2 \cdot \text{particles}}{\pi \cdot 1 \text{ dm}^3 \cdot 4 \cdot 10^{13} \frac{\text{particles}}{\text{dm}^3}}} = \underline{\underline{2{,}55 \cdot 10^{-6} \text{ m} = 2{,}55 \text{ µm}}}$$

c) If we know that the suspension contains 60 vol% water, another averagediameter can be calculated. Calculate this average diameter. Answer should be in µm

Volume average: $\bar{V} = \frac{V_{particles}}{V_{tot} \cdot N_p}$

Volume of a sphere: $V = \frac{4\pi r^3}{3} = \frac{4\pi\left(\frac{d}{2}\right)^3}{3} = \frac{4\pi d^3}{8 \cdot 3} = \frac{\pi d^3}{6}$

$$\Rightarrow d = \sqrt[3]{\frac{6V}{\pi}}$$

$$\Rightarrow \bar{d}_v = \sqrt[3]{\frac{6\bar{V}}{\pi}} = \sqrt[3]{\frac{6 \cdot V_{particles}}{V_{tot} \cdot N_p \cdot \pi}} = \sqrt[3]{\frac{6 \cdot 0{,}4 \text{ dm}^3 \text{ particles}}{1 \text{ dm}^3 \cdot 4 \cdot 10^{13} \text{ particles/dm}^3 \cdot \pi}} = 2{,}67 \cdot 10^{-5} \text{ dm} = \underline{\underline{2{,}67 \text{ µm}}}$$

d) Are the particles in the suspension monodisperse? Justify your answer.

No it is polydisperse, for monodisperse suspensions: $\bar{d}_s = \bar{d}_v$

for polydisperse suspensions: $\bar{d}_s < \bar{d}_v$, which is what we have in this case

Question 1.5

How much does the surface diminish if two spherical droplets with radius r coalesce?

Mass balance gives that $V = 2V_0$

$$\frac{4\pi r^3}{3} = 2 \cdot \frac{4\pi r_0^3}{3}$$

$$r^3 = 2r_0^3$$

$$r = \sqrt[3]{2}\, r_0$$

$$\frac{A}{2 \cdot A_0} = \frac{4\pi r^2}{2 \cdot 4\pi r_0^2} = \frac{(2^{1/3})^2 r_0^2}{2 r_0^2} = \frac{2^{2/3}}{2} = \frac{1}{\sqrt[3]{2}} = 0{,}79$$

Answer: $\frac{1}{0{,}79} = \underline{\underline{1{,}26}}$

Question 1.6

a. List the 3 different types of van der Waals forces and explain their origin.

b. What is characteristic for the van der Waals forces

a) 1. Polar interactions, Keesom. Permanent dipole - permanent dipole interactions

2. Induced interactions, Debye. Permanent dipole - induced dipole interactions

3. Dispersion interactions, London. Induced dipole - induced dipole interactions

b) The characteristics of Van der Waals forces:

- They are usually attractive
- Long-ranged
- Strong over short distances