1. Consider an experiment to study the adsorption of hydrocarbons onto silica gel. The amount of butane adsorbed onto the gel surface is measured at various gas pressures at 303K and summarized in the following table.

P (bar)	0.1	0.2	0.3	0.4	0.5
N (mmol)	0.36	0.68	0.98	1.24	1.49

a) What is the coverage θ?

b) Demonstrate that the adsorption follows a Langmuir isotherm. Hints: write a linear relation between 1/n as a function of 1/P.

c) Determine the total number of adsorption sites.

d) Determine the Langmuir adsorption constant k.

e) Assuming θ=1, how many butane molecules do you need to cover the available surface fully?
Hints: the Avogadro number N_A is 6.022×10^{23} mol^{-1}.

f) Maintaining the temperature constant at T = 303K, determine the pressure of gas required to achieve a surface coverage of 30%.

g) Start from a fully covered surface and allow the butane to desorb by decreasing the pressure to that corresponding to coverage θ = 0.5. What is the volume of the gas produced?

2. The Gibbs adsorption isotherm relates the changes in surface tension of a mixture to the change in the chemical potential (or concentration) of a solute:

$$d\gamma = -RT\frac{\Gamma}{c}dc$$

Consider the concentration dependence of the surface tension of a water/ethanol mixture at 20 °C:

$x_{ethanol}$	0.020	0.042	0.065
γ(mN/m)	56.41	48.14	42.72

a) Find out the relation between the surface excess Γ and the surface tension of the solution at two different concentrations.

b) Compute the surface excess of ethanol Γ considering the interval between 2% and 4% molar concentration.

c) Compare it with the excess computed using the interval between 4% and 6.5% molar concentration. How does the surface excess change as a function of concentration?

d) Is the ethanol concentration in the vicinity of the surface larger or smaller than in the bulk of the solution?